Time-Reliability-Power (TRP) Space for designing data dissemination algorithms in WSNs

Deva Prasad D[#1], P.Murugan[*2]

[#]Assistant Professor, Dept of CSE, Sivaji College of Engineering and Technology

[*]Associate Professor, Dept of CSE, PSN Engineering College,

Abstract*— Data Dissemination (multicast/broadcast) is a critical problem in duty-cycled wireless sensor networks (WSNs), as its energy efficiency and reliability are of paramount importance. Achieving these two goals together is highly nontrivial, as the situation is exacerbated if WSN nodes are duty-cycled (DC) and their transmission power is adjustable. The proposed method focus on minimizing the expected total transmission power for reliable data dissemination in DC-WSNs. The proposed method designs an efficient approximation algorithm, Energy-efficient Reliable Data Dissemination (ERDD) for Multicast (MC) and Broadcast (BC) with provable performance bounds for it. To facilitate the algorithm design, a novel concept of Time-Reliability-Power (TRP) space is used as a general data structure for designing data dissemination algorithms in WSNs, and the performance ratios of our algorithms based on the TRP space are proven to be high for both multicast and broadcast. The simulations of the ERDD firmly demonstrate the efficiency of the ERDD algorithm.

I.INTRODUCTION

Wireless Sensor Networks (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analyzed. A sink or base station acts like an interface between users and the network. One can retrieve required information from the network by injecting queries and gathering results from the sink. Typically a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, storage capacity, and communication bandwidth. After the sensor nodes are deployed, they are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication with them. Then the onboard sensors start collecting information of interest. Wireless sensor devices also respond to queries sent from a “control site” to perform specific instructions or provide sensing samples. The working mode of the sensor nodes may be either continuous or event driven. Global Positioning System (GPS) and local positioning algorithms can be used to obtain location and positioning information. Wireless sensor devices can be equipped with actuators to “act” upon certain conditions.

Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints. Owing to the requirement for low device complexity together with low energy consumption (i.e. long network lifetime), a proper balance between communication and signal/data processing capabilities must be found.

II. RELATED WORK

Energy consumption is the most important factor to determine the life of a sensor network because usually sensor nodes are driven by battery. Sometimes energy optimization is more complicated in sensor networks because it involved not only reduction of energy consumption but also prolonging the life of the network as much as possible. The optimization can be done by having energy awareness in every aspect of design and operation. This ensures that energy awareness is also incorporated into groups of communicating sensor nodes and the entire network and not only in the individual nodes.

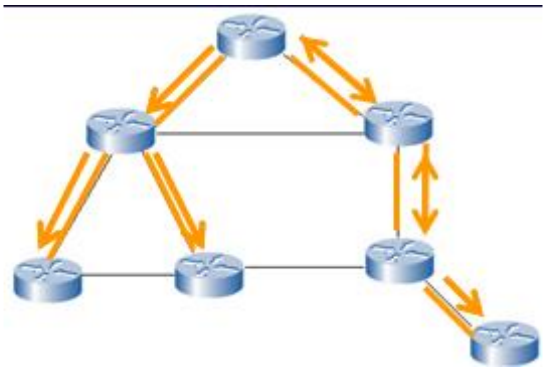


Fig. 1 : Broadcasting in WSN

In DC-WSNs, however, new challenges arise. More specifically, the network topology is now intermittently connected, and a forwarding node may transmit the same data packet many times to reach its neighboring nodes. Therefore, to design energy efficient multicasting algorithms in DC-WSNs, not only the forwarding nodes should be selected appropriately to construct a multicast tree, but also the transmissions of each forwarding node need to be scheduled intelligently to cover the receiver nodes and reduce the transmission redundancy. These two problems must be handled holistically so that the total energy cost can be reduced.

III. PROPOSED SYSTEM

Sensor nodes are battery powered devices and the main issue is how to reduce the energy consumption of nodes so that the networks lifetime can be increased to a sufficient level. Energy can be conserved using three schemes: duty cycling, data driven and mobility based. Data dissemination is central importance to Wireless Sensor Networks (WSNs), and hence its energy-efficiency and reliability are the parameters to be focused much. To efficiently use the energy the wireless sensor network is duty-cycled. The data structure Time-Reliability-Power (TRP) space is used for designing data dissemination algorithms in WSNs, and the performance ratios of proposed method based on the TRP space are proven to be O(log Δ log k) for both multicast and broadcast, where Δ is the maximum node degree in the network and k is the number of source/destination nodes involved in a data dissemination session.

A set V of DC-WSN nodes are considered; they switch between active/sleeping states periodically. The set of active time slots in a working period of any node u 2 V is denoted by A(u) _ I = f1; 2; :::; Ig, where I is the length of the working period. Assuming that all nodes in V are time synchronized, and a node can wake up its transceiver to transmit data at any time slot, but can only receive data when it is active. Also it is assumed that each node u 2 V can adjust its tx-power to several levels, which are "min = "1 _ "2 _ ::: _ "d = "max. As opposed to some other work on topology control, it is assumed that both the number of power levels (i.e., d) and the power values (i.e., "1; "2 _ _ _ "d) are predefined constants, because commercial sensor nodes can only adjust their power to a few predefined levels. Let L = f"1; "2; :::; "dg. When u’s tx-power is adjusted to l 2 L, let the link quality puv(l) 2 (0; 1] denote the success ratio of data transmission on link (u; v). And it is assumed that puv(l) increases with l 2 L, and the link qualities considered in the network are independent.

To conduct a data dissemination session in a DC-WSN, it need not only to find a valid power assignment L and a data dissemination tree T, but also to select the transmission time slots of the forwarding nodes in T, in order to avoid transmitting data to sleeping nodes.

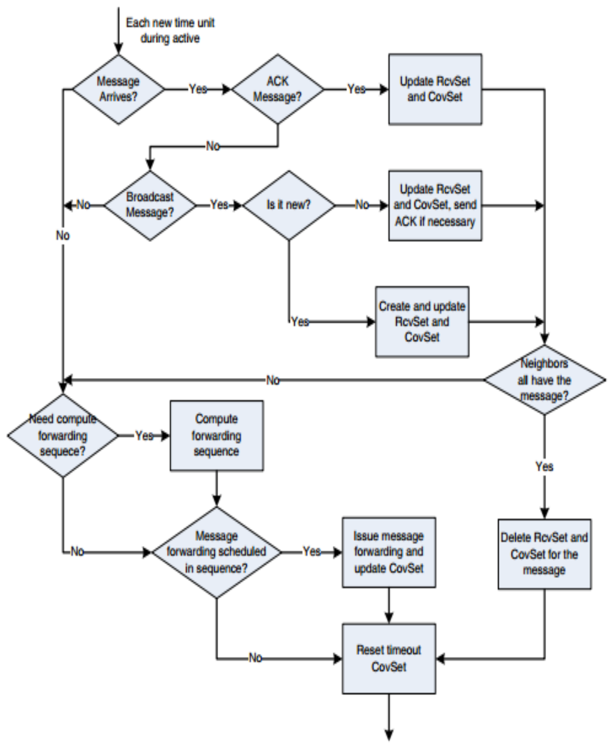


Fig. 2 : Data Dissemination in Duty-Cycled WSN

IV. ALGORITHMS

There are two sub-modules of the algorithm: The Setup and Reconfiguration Phase and the Steady State Phase.

The Setup and Reconfiguration Phase: It is initialization of the network to update the network routes and queries. This phase is relatively short; its goal is to set up the schedules that will be used during the steady state phase. The setup and reconfiguration algorithm is independent of the underlying routing algorithm. Therefore, many of the algorithms available for routing in ad hoc and sensor networks can be used. Power aware routing algorithms may be preferable, as they have been shown to provide substantial increases in network lifetime.

The Steady State Phase:It is similar to forwarding phase. It utilizes the Schedule established in the setup and reconfiguration phase to forward the data to the base station. Each node stores a schedule table. The scheduling for sleep and active states are calculated according to the packets that the nodes will transfer. Three different actions considered in this paper are: Sample, Transmit, and Receive.

The self scheduling phase is divided into three subsections. At the beginning of the first duty cycle, the roles for the deployed nodes are not assigned. Each node considered as knowing its coordinates, dimensions of the deployment region, and the coordinates of the sink. The deployed nodes decide to be a regular node or a leaf regular node according to their coordinates. The nodes on edges of the deployment area are considered as leaf regular nodes, the other nodes are regular nodes.

After deciding to be leaf regular node or regular node not, each node broadcasts a “Hello” packet to its neighbors including the information of its coordinates with source ID, its residual energy and its role. At the same time every node listens for its neighbors’ “Hello” packet for a designated time and records its neighbors to its neighbor list. Coming to the end of the designated hello waiting time, all nodes hear from their neighbors and the second sub phase starts.

The second sub phase is selection of head leaf nodes. The main idea is selecting the possible most distant neighbor node as the next node instead of making a random selection.

Therefore the number of the head leaf nodes namely awake leaf nodes is minimized. The selection starts with the sink. Sink chooses a leaf node with maximum distance but obviously the selected leaf node is sink’s neighbor. Sink node sends a request packet to the selected node in order to inform that it will be the next head leaf node. Receiving the request packet, the selected head leaf node selects another node to be the next head leaf node among its neighbors considering the distance between them then informs by sending a head leaf node request packet. This procedure is repeated through the subsequent selections. The selections are done through a predefined direction, encircling the square deployment region, as shown in the The leaf nodes selected as head leaf nodes will be awake and rest of the nodes will be asleep. If sink or any head leaf node cannot find a neighbor through the predefined direction, the algorithm will terminate immediately. This causes no node is put to sleep state. This means that network is not connected so it will not be healthy to run the algorithm and to put some nodes to sleep state. For this reason, for small node densities in which the network has large number of blind points, it is not possible to get acceptable sleep sensor ratio.

The last sub-phase is the selection of central head nodes. Similarly, the aim is to select the possible most distant neighbor node directed to the sink as the next node instead of making a random selection. The selection is initiated by the head leaf nodes residing at the edges that are not adjacent to the sink corner, shaded edges. The selection starts with a randomly determined delay in each node, the value of delay has different value for each node. Each leaf node finds the possible most distant neighbor node directed to the sink, informs it by sending head node request packet. The node receiving the request packet becomes a head node. Then the node selected to be head node finds the possible most distant neighbor node directed to the sink.

The selection procedure is not started concurrently by each head leaf node residing at the edges that are not adjacent to the sink corner, because as mentioned before a randomly determined delay is established before starting the head node selection procedure. If a neighbour has been selected as head node by another node and this neighbour is closer than itself to the sink, the node would not select any node. The traffic that will be sent to the sink will be forwarded through the neighbor node that was selected as head, previously. Thus the number of awake nodes will be minimized. The selected nodes namely nodes receiving requests will be active, rest of the nodes will be turned off, in order to minimize the overall power consumption. Completing the selection of the head nodes, the self scheduling phase will be over and a data transfer phase will start.

The details of this forwarder selection procedure are provided in the following. This algorithm is performed whenever node i generates a message or receives it from one of its neighbors:

Recall that V (i) and {Vi(j)}j∈Ni are set to current priority values calculated by the priority update procedure. The current active neighbors of node i, Ai , is also given in priority update.

When node i receives a message, it obtains the list of candidate forwarders. If it is on the list, go to step 3. Otherwise, it does not forward the message and returns to the receiving mode.

If node i is listed as a potential forwarder, it calculates a time period D based on its priority on the list. If it is the k-th highest priority node on the list with a total of M nodes on the list, it randomly selects D as proportional to k − 1. Or an ACK is repeated like the multiple duplicated ACKs as robust acknowledgement introduced.

If node i receives ACKs from higher priority nodes, it transmits an ACK with the identity (ID) of the highest priority node, and it does not forward the message. During the period D, if node i does not receive an ACK from any of the higher priority nodes, node i decides to forward and transmits an ACK with its own ID. The message contains the priority list of the next forwarders according to V (i), {Vi(j)}j∈Ni , Ai .

If node i decides not to forward under the policy π and receives no ACK during M · Ts period, it goes to step 3, unless it was already repeated for R times. If so, the message is removed.

If node i has transmitted the message, it waits ACKs from neighbors for at most R · Ts. If it receives no ACK, it retransmits the message.

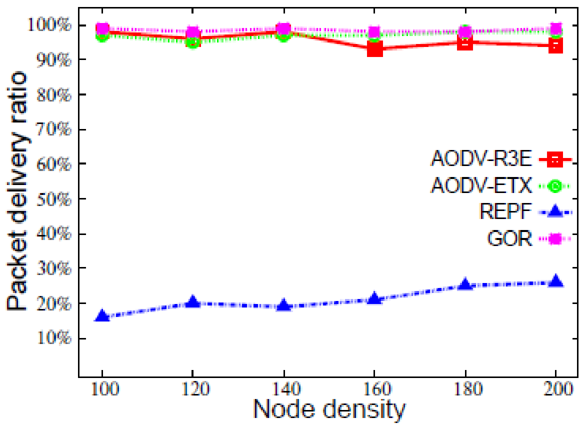
V.RESULTS AND DISCUSSION

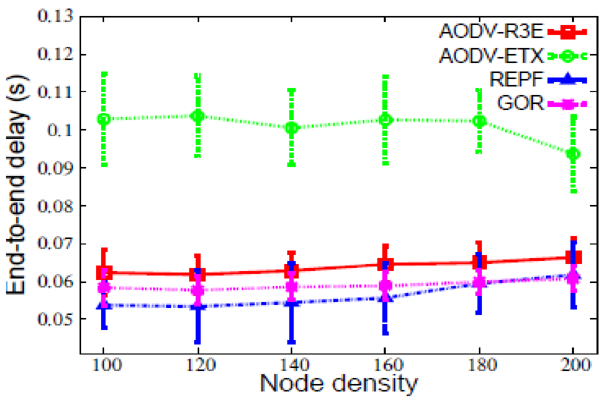
The parameters that are used in this work of simulation to show the reliable packet delivery are the following:

(i) End-to-end Delay: This protocol simulates on-time packet delivery ratio.
(ii) Packet Delivery Ratio: The evaluation shows good packet delivery ratio.
(iii) Control Message Cost: The total number of control messages used are reduced.
(iv) Single-hop Packet Progress: No.of hops are rapidly increased.
(v) Link Quality Per Hop: Link quality is estimated in advance

This protocol is designed to improve the routing performance by utilizing local path diversity. The route discovery phase finds an efficient primary path (composed of a set of primary forwarding nodes)

And the evaluation results of the implementation minimizes the number of end-to-end data transmissions. All the one-hop neighbors that are nearer from the destination than the current forwarding node and can hear from each other are selected as helper nodes and the nodes closer to the destination are given higher relay priorities.





(b) End-to-end delay

VI. CONCLUSION AND FUTURE WORK.

The energy-efficient reliable data dissemination problem in DC-WSNs with unreliable links are focused in the thesis work. This work seeks to minimize the total expected tx-power consumption for reliable multicasting/broadcasting. Due to the NP-hardness of the problem, an approximation algorithm are proposed with provable performance ratios. To the best of our knowledge, these algorithms are the first, one hand, to holistically take into account various aspects including duty-cycling, wireless broadcast advantage, unreliable links and power-adjustability, and on the other hand, to provide guaranteed performance bounds for energy-efficient reliable data dissemination in DC-WSNs.

REFERENCES

[1]. S. Ahluwalia and E. Modiano. On the complexity and distributed construction of energy-efficient broadcast trees in wireless ad hoc networks. IEEE Transactions on Wireless Communications, 4(5):2136{2147, 2005.

[1]. S. Banerjee and A. Misra. Minimum energy paths for reliable communication in multi-hop wireless networks. In Proc. ACM MobiHoc, pages 146{156, 2002.

[2]. S. Guo, Y. Gu, B. Jiang, and T. He. Opportunistic flooding in low-duty-cycle wireless sensor networks with unreliable links. In Proc. ACM MobiCom, pages 133{144, 2009.

[3]. K. Han, Y. Liu, and J. Luo. Duty-cycle-aware minimum-energy multicasting in wireless sensor networks. IEEE/ACM Transactions on Networking, 21(3):910{923, 2013.

[4]. K. Han, J. Luo, Y. Liu, and A. Vasilakos. Algorithm design for data communications in duty-cycled wireless sensor networks: a survey. IEEE Communications Magazine, 51(7), 2013.]

[5]. P. Klein and R. Ravi. A nearly best-possible approximation algorithm for node-weighted Steiner trees. Journal of Algorithms, 19(1):104{115, 1995}

[6]. S. Kulkarni and L. Wang. Energy-efficient multihop reprogramming for sensor networks. ACM Transactions on Sensor Networks, 5(2):1{40, 2009.}

[7]. D. Li, X. Jia, and H. Liu. Energy efficient broadcast routing in static ad hoc wireless networks. IEEE Trans. on Mobile Computing, 3(2):144{151, 2004. }

[8]. X. Y. Li, Y. Wang, H. Chen, X. Chu, Y. Wu, and Y. Qi. Reliable and energy-efficient routing for static wireless ad hoc networks with unreliable links. IEEE Transactions on Parallel and Distributed Systems, 20(10):1408{1421, 2009.}

[9]. J. Luo, P. Eugster, and J.-P. Hubaux. Route driven gossip: probabilistic reliable multicast in ad hoc networks. In Proc. of the 22nd IEEE INFOCOM, pages 2229{2239, 2003.}

[10]. J. Luo, P. Eugster, and J.-P. Hubaux. Probabilistic reliable multicast in ad hoc networks. Elsevier Ad Hoc Networks, 2(4):369{386, 2004.

[11]. L. Su, B. Ding, Y. Yang, T. F. Abdelzaher, G. Cao, and J. C. Hou. Ocast: optimal multicast routing protocol for wireless sensor networks. In Proc. IEEE ICNP, pages 151{160, 2009.}

[12]. V. V. Vazirani. Approximation Algorithms. Springer-Verlag, Berlin, 2001.