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Understanding a Broadcast Service in Low Duty-Cycle Wireless Sensor Network

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Abstract:- In low-duty-cycle networks, sensors stay dormant most of time to save their energy and wake up based on their needs. Such a technique, while prolonging the network lifetime, sets excessive challenges for efficient broadcast within the network. Broadcast service is widely used during the life time of a wireless sensor network (WSN), such as networking setup, data collection/storage and query answering. In the past few years, many works have been done to improve its efficiency by reducing redundant broadcast messages. However, most of these works assume that all sensor nodes are active throughout a broadcast process and thus are difficult to be deployed in low duty-cycled WSNs where sensor nodes alternate between active and dormant states, so as to conserve energy and extend the network lifetime. These conventional approaches could easily fail to cover the whole network in an acceptable time frame. To this end, we conclude the paper with insights for research directions about broadcast service in low duty cycle wireless sensor network(WSN).

Keyword:- Broadcast, duty cycle, wireless sensor networks

I. INTRODUCTION

Wireless sensor networks (WSNs) have been used in many long-term sustainable applications such as environment monitoring, target tracking and infrastructure protection [7]. To guarantee service continuity, a sensor network normally operates at a very-low-duty-cycle (e.g., 5% or less), in which a sensor node schedules itself to be active briefly and then stays dormant for a long time. While the lifespan of a network is greatly prolonged, such low-duty-cycle operation significantly reduces the performance of many network operations including flooding [4], [6], an important networking primitive for code dissemination, system configuration, and routing tree formation. Due to the loss of connectivity when sensor nodes are sleeping, the performance of flooding degrades significantly. It has been studied [4] that the flooding coverage ratio of a pure flooding process drops to less than 10% as the duty cycle of the network decreases to 5%, showing strong evidence of the demand for a tailored flooding design for low-duty-cycle networks.

One of the most essential services in wireless sensor networks is broadcast [1], which facilitates sensor nodes to efficiently propagate messages among the whole network. During networking setup, control messages may be propagated from the sink to all sensor nodes. For data collection, interest messages may be flooded from the sink. On observing an event, a sensor node may broadcast a message to coordinate with other nodes to trace the event and store sensing data. For query answering, the sink may flood the query message among the whole network to retrieve result data. Thus the efficiency and reliability of broadcast service greatly affects the overall performance of WSN. Generally, if we assume all sensor nodes are active during a broadcast (referred as all-node-active assumption), then ideally every node needs to forward the broadcast message at most once to accomplish the broadcast. Based on this assumption, two basic approaches named flooding and gossiping [1] were proposed in early stage. To overcome the unstable nature of wireless communication, where a forwarded message may get lost and only arrive at a subset of a node’s neighbors, many efforts have been done to improve the reliability of the broadcast service while still keeping efficient. Two past works among them are Smart Gossip [12] and RBP [13].

However, due to energy constraints, in many applications, sensor nodes are expected to work under low duty cycle [14], where they may turn down for a while to save energy, then turn up to perform sensing tasks and necessary communications and then turn down again. By this means, the energy of sensor nodes may be saved and the lifetime of the whole network thus may be largely extended.

In a low duty-cycled WSN, if the number of nodes is very small, the previous all-node-active assumption for broadcast may still be kept valid by using global synchronization so that all nodes can wake up together at some time point, or to pre-determine a rigid schedule so that node waking up and broadcast message forwarding can be pre-computed. However, for large-scale WSNs, synchronization itself is still an open issue and to pre-determine a rigid schedule is sometimes too complicated with the consideration of the application and environment specifics.

The broadcast problem is revisited under a more realistic scenario, where sensor nodes are deployed in large scale and work in low duty-cycle. To solve this problem, several issues need to be considered. First, because nodes may turn up and down before and during the broadcast process, the topology of active nodes may change frequently and dramatically. Also, the large number of sensor nodes makes it impossible to pre-determine a rigid schedule and use global synchronization to keep all nodes active during broadcast. Furthermore, the up-down patterns are generally application-specified and dynamically affected by the deployed environment, and thus can not be determined beforehand. As a result it is impossible for a sensor node to find an optimal time point for forwarding so that all its neighbors are active and ready to receive the message. Even with such oracle knowledge, waiting for such time point may still take too much time and leave the message out-of-date.

With above considerations, we propose further research of broadcast service in low duty cycle wireless sensor network.

II RELATED WORK

Under low duty cycle conventional broadcast strategies assuming all-node-active would either suffer from poor performance or simply fail to cover the network. Flooding and gossiping [1] are two basic approaches used for broadcast in wireless sensor networks. In a WSN, flooding lets every node forward the received broadcast message and thus may cause message implosion in the network. To solve this problem, gossiping instead lets a node forward a received broadcast message only with some probability, where the challenge lies in how to determine the forwarding probability for each node so as to keep the broadcast still efficient and reliable. Many improvements have been proposed based on these two basic approaches. One work is Smart Gossip [12]. To determine the forwarding probability for each sensor node, the algorithm depends on previous broadcasts and adaptively adjust the probability to match the topological properties among sensor nodes. Another work is RBP [13], which is essentially a flooding-based approach. It lets each node flood the received broadcast message only once, and then by overhearing and explicit ACKs, a node may do some retransmissions for local repairs. Both the retransmission thresholds and the number of retries depend on the node density and topology information gathered from previous broadcasts.

There have been recent works investigating low duty cycle wireless sensor networks [2], [3], [4], [5], [6], [7],[8],[10]. Work in [2] remodeled broadcast problem in new context and showed that it is equivalent to shortest path problem in a time-convergence graph. Accordingly presented an optimal centralized solution. In [3], propose L2 practical design of data forwarding in low duty cycle wireless sensor networks. L2 addresses link burstiness using multivariate Bernoulli link model.L2 enables sensor nodes to work in lazy mode, keep their radios off as long as they can, and allocates the precious energy for only a limited number of promising transmissions.

The work introduces in [4] Opportunistic Flooding is a flooding method specially designed for low-duty-cycle wireless sensor networks. Its main objective is to reduce redundancy in transmission while achieving fast dissemination.

A dynamic data forwarding(DDF) scheme for low-duty-cycle wireless sensor networks, which combines a realistic link model with asynchronous duty cycle. The results show that DDF can reduce end-to-end delay, guarantee delivery ratio and improve network lifetime[6]. Correlated flooding, an energy-efficient flooding design for low-duty-cycle WSNs that solves the problem caused by both low-duty-cycle operation and ACK implosion[7]. The goal of Correlated Flooding is to exploit link correlation in the construction of an energy efficient flooding tree, to save the energy consumption on both data packets and ACKs. First the energy consumption on transmitting data packets can be reduced compared with flooding tree that only considers limk quality. ALOHA- like neighbor discovery algorithm solves the problem of neighbor discovery in low duty cycle WSNs[8].

The flooding algorithm is a commonly used algorithm intended for network-wide dissemination of data, commands and configurations, but its energy consumption is usually high which conflicts with the limited resource feature of WSNs.The unreliable and reliable implementation methods of opportunistic flooding to provide a reference to further optimize the energy cost of flooding. Depending on different network densities, different data packet sizes and duty cycles, the two implementation methods present different characteristics in terms of energy cost flooding delivery ratio[9].

III. PROPOSED WORK

In proposed work, we revisit the broadcast problem under a more realistic scenario, where sensor nodes are deployed in large scale and work in low duty-cycle. To solve this problem,
several issues need to be considered. First, because nodes may turn up and down before and during the broadcast process, the topology of active nodes may change frequently and dramatically. Also, the large number of sensor nodes makes it impossible to pre-determine a rigid schedule and use global synchronization to keep all

nodes active during broadcast. Furthermore, the up-down patterns are generally application-specified and dynamically affected by the deployed environment, and thus can not be determined beforehand. As a result it is impossible for a sensor node to find an optimal time point for forwarding so that all its neighbors are active and ready to receive the message. Waiting for such time point may still take too much time and leave the message out-of-date.

With above considerations, we are proposing an approach which will provide efficient broadcast service in low duty cycle wireless sensor network. We describe the basic network model and introduces the assumption used in the paper. In this section, we reformulate the broadcast problem in low duty-cycle wireless sensor networks. To reflect the operation nature of real sensor products and also to simplify exposition, we divide time into equal-length slots. The active and dormant periods are both integer multiples of time slots, and in each slot, an active node can either receive or forward one message only. We make following assumptions in our network model :

Slotted time model: the time axis is divided into time slots with equal length. The duration of each time slot is appropriate for the transmission of one packet. Local synchronization: the system works in a locally synchronized mode. With local synchronization, a sender knows when it shall wake up to transmit a packet to each of its neighbors according to their working schedules.

Radio model: the radio equipped in each sensor is semiduplex, i.e., a sensor can either transmit or receives a packet at any given time slot, but not both.

Unreliable links: a transmission may fail and a retransmission is needed to compensate this failure. The delay increases accordingly. In Fig. 1, sensor 3 fails its transmission to sensor 4 at time slot 2. It needs to wait one more slot before sensor 4 wakes up again.

Unicast: in low-duty-cycle WSNs, it is easy for us show that it is rare for multiple neighboring sensors waking up at the same time period. As a result, to flood one packet, a sensor needs to transmit the same packet to each of its neighbors one by one. Thus the flooding is achieved via a number of unicasts [11].

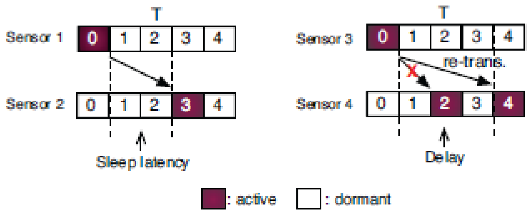

Fig 1 Illustration of working schedule

A formal description of the duty-cycle-aware broadcast problem in wireless sensor networks. The focus on the broadcast of a single message with a unique identifier (ID) from one source to all other nodes. By assigning different identifiers, our solution can be easily extended to broadcast a series of messages or broadcast messages from multiple sources. Assume there are n nodes in the network, indexed from 1 to n. For node i, Xi(t) denotes its active/dormant state at time t, where Xi(t)= 1 if it is active and Xi(t)=0 if it is dormant. Represent the set of 1-hop neighbors of node i by Ni, i.e., those that can be directly covered by a message forwarding from node i if they are active. Here, we call 1-hop message broadcast from a node to its neighbors as “forward,” so as to distinguish from our interest of networkwide broadcast (or broadcast in short). Without loss of generality, assume that the message is to be broadcast from node s, starting from time t0. Let (ui,ti) denote the ith forwarding, where node ui forward the message at time ti, and Ci be the set of nodes that receive the broadcast message in the ith forwarding.

IV. SIMULATION RESULT AND DISCUSSION

In this section, we will evaluate the performance of proposed approach via simulation. The proposed broadcast approach was evaluated using NS-2, a network simulator works on Fedora 7/Windows Platform. A simulation model is presented that allows performance studies in Low-duty cycle wireless sensor networks. Basically, consider the following scenario: a total 40 number of Mobile Station (MS) nodes are deployed in a given area. Following are the simulation results of broadcast in low duty cycle wireless sensor network.

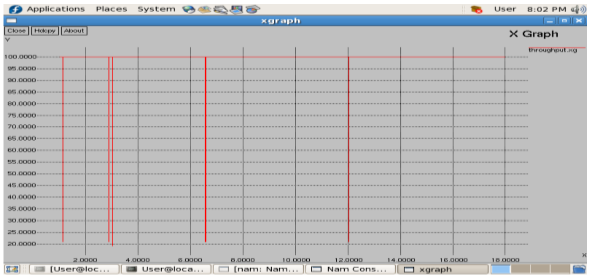

Fig 2 Performance Analysis for Throughput.

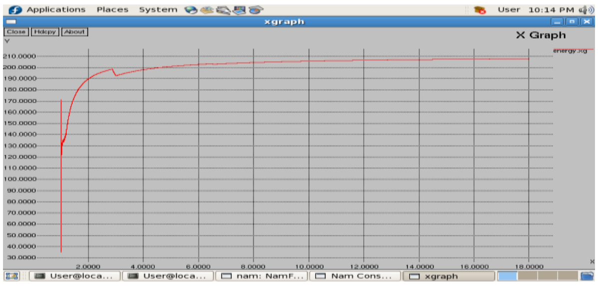

Fig 3 Performance Analysis for Energy.

V. CONCLUSION AND FUTURE WORK

In this paper we have studied performance of broadcast in low duty cycle wireless sensor networks. We discussed that under low duty cycle conventional broadcast techniques assuming all-node-active would either suffer from poor performance or simply fail to cover the network. In this paper we revisited broadcast issues in low duty cycle wireless sensor networks with active/dormant cycles.

In future work, we will try to enhance Qos(Quality of service) of broadcast in low duty cycle wireless sensor network.

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