Journal of Engineering and Applied Sciences 7 (3): 249-253, 2012
ISSN: 1816-949X


# Optimal Selective Forwarding for Energy Saving in Wireless Sensor Networks

R. Raghul and S. Kannan
SNS College of Technology, Coimbatore, Tamil Nadu, India

**Abstract:** In the context of wireless sensor networks, nodes have limited energy and forward messages of different importance. An algorithmic technique called Band-based Directional Broadcast is used to control the direction of broadcasts that originate from the sensor nodes. A key challenge is how to gather the sensor data in a manner that is energy efficient with respect to the sensor nodes that serve as sources of the sensor data. In the project, an optimal selective forwarding scheme is introduced in order to save energy in wireless sensor networks. The goal is to direct each broadcast of sensor data toward the mobile sink, thus reducing costly forwarding of sensor data packets. The technique is studied by simulations that consider energy consumption and data deliverability.

**Key words:** Sensor data sampling, mobile object, directional broadcast, sensor networks, energy, India

## INTRODUCTION

Recently, the concept of employing mobile objects (sometimes referred to as mobile sinks) to query a sensor network has been proposed (Ekici *et al*., 2006; Li and Shatz, 2008; Lilien, 2007). Applications can exploit this mobility to dynamically sample a sensor field. One high-level application scenario is shown in Fig. 1. A mobile object (car) is traveling along a path and at some time and location (for example, T0), it decides to take a sample of the sensor field, i.e., collect sensor data from near-by sensor nodes. The larger circle denotes the sampling region. Each sensor in that region will consequently be activated and reply with its locally sensed data. As the mobile object continues its travel, it reaches another location at time T1 from which it initiates another sampling task.

There are three interesting features associated with the task of sensor field data sampling. First, due to the mobility of the sampling object, there are many options for selecting a sampling region as opposed to the static sampling region associated with a static sink. Second, it is possible to employ commonly existing mobile objects, for example, taxis or buses to help increase the coverage of the sensor field. So, it is possible to deliberately choose a mobile object and finely tailor its sampling regions to optimize a sampling task. Finally in comparison to sensor nodes, mobile objects have relatively large (and adjustable) transmission ranges. Thus, they can trigger sampling region sensors by the single-hop transmission of a sampling signal. An implied requirement for sensor field sampling is that there is a time constraint imposed by the mobility of the sink object. To facilitate the collection of sensor data from the sampling region, it is helpful if all sensor data can be routed to the mobile object before the object has deviated significantly from the location at which it initiated the sampling task.

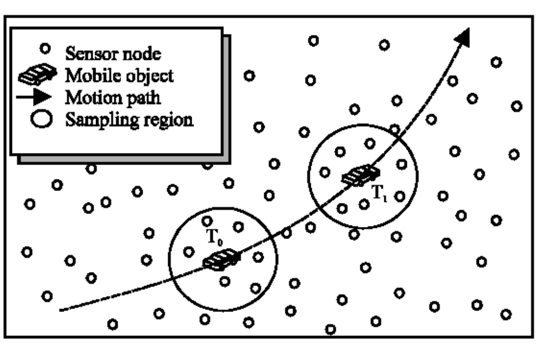

Fig. 1: Sensor field sampling

This suggests that sensors should respond quickly upon receiving a sampling request and the sensor data propagation method should be highly efficient. In this study, researchers make no assumptions about the nature of the sensor data, allowing for the possibility that sensors are heterogeneous with regard to data type (e.g., each sensor measures a different environmental property). Broadcast is to be generally avoided in sensor networks due to the problems associated with message flooding, there are significant advantages to using this basic mechanism, especially for the application at hand, sensor field sampling: broadcast is simple and does not require that sensor nodes be configured with special dedicated hardware; broadcast can be initiated immediately after receiving the sampling task since it requires no routing table or tree setup and broadcast can naturally handle the

**Corresponding Author:** R. Raghul, SNS College of Technology, Coimbatore, Tamil Nadu, India

mobile sink scenario since a sensor-data packet can reach the mobile object as long as the object is within transmission range of some broadcast or rebroadcast of that packet.

The primary problem with using broadcast for gathering sensor data is that broadcast does not consider direction and left unchecked would flood an excessively large geographic region. Note that this flooding could even extend beyond the intended sampling region which means the omni-directional broadcast suffers from very low energy efficiency. In this study, researchers discuss a new broadcast-based sensor data gathering mechanism along with optimal selective forwarding. The mechanism is optimized for the purpose of sensor-field data sampling by a mobile object. It is called Band-based Directional Broadcast, since it uses the concept of bands created by partitioning the sampling region using multiple concentric circles as in Fig. 2.

These bands are used to help control the direction of data flow of sensor data packets without the need for sensor nodes having any sophisticated directional antenna (Dai and Wu, 2006; Gossain *et al*., 2006). The key idea is that the approach will reduce the propagation of packets that flow away from the sink mobile object thus reducing broadcast events and sensor node energy consumption. This is accomplished by preventing packets that originate from a sensor in any band from being propagated (rebroadcast) by sensors in a higher numbered band.

**Related works**

**Broadcast mechanisms and scheduling:** Since, the sensor-data routing protocol is based primarily on broadcast, researchers now summarize several popular broadcast based mechanisms and examine their applicability to the problem of sensor field data sampling by a mobile object. Simple flooding serves as the baseline of all broadcast mechanisms. In this protocol, a node rebroadcasts exactly once each message it receives. The

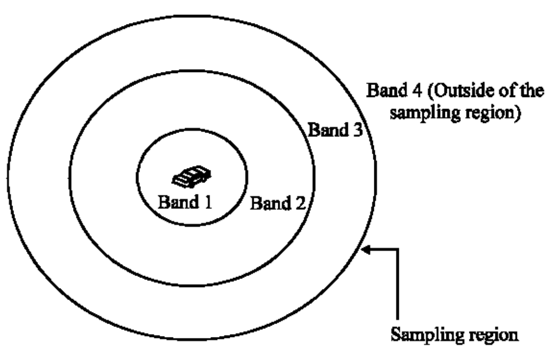


Fig. 2: A 4-band configuration

rebroadcast (relaying) terminates when there are no more messages to broadcast. Generally, simple flooding has the best reliability and deliverability but the worst efficiency in terms of energy consumption (Williams and Camp, 2002). A generalization of simple flooding is Probability-based broadcast (Williams and Camp, 2002). Upon receiving a packet that it has not previously received, a node rebroadcasts the packet with a probability of p but discards it with probability (1 - p). Simple flooding sets p = 1. It is believed that there is an inverse relationship between the number of times a packet is received at a node and the probability of the node being able to reach additional areas on a rebroadcast (Lilien, 2007). So in Counter-based broadcast, a node maintains a counter and a timer for each unique packet it receives. The timer is used to control how long the node holds a packet before considering rebroadcast of the packet. When the timer expires, the node checks how many duplicate copies of this specific packet have been received. If this number exceeds a previously assigned threshold, the packet is dropped, otherwise a rebroadcast is initiated.

In general for a dense network, nodes will be less likely to rebroadcast packets in comparison to sparse networks (Lilien, 2007). However, Counter-based broadcast is inherently slow in terms of reaction time due to the need to wait for timer expiration before any rebroadcasts. Another type of optimized broadcast can be collectively referred to as directional broadcast. These methods generally require enhanced sensor nodes-nodes equipped with dedicated directional antenna, GPS or other localization devices. For many applications, such a requirement may not be feasible due to cost issues or deployment methods. In this study, researchers propose a directional broadcast scheme that does not rely on sensor nodes having location information via any special hardware or complex localization algorithms. The network environment in this study is a heterogeneous architecture with mobile objects on an upper layer injecting sampling signals into the underlying sensor-node layer to request retrieval of sensor data. Thus, the proposed scheduling approach exploits this unique characteristic by using the sampling signal as a basis for sensor nodes to self-determine their broadcast schedules.

**Use of bands in sensor networks:** Bands are introduced to help measure and compare the energy consumption of sensors at different distances from a sink. An algorithm is then proposed to avoid the sink-hole problem. Sensors are statically deployed into specific bands with adjusted transition ranges to achieve uniform energy depletion. In contrast to that research, the research focuses on dynamic band-computation and on using band knowledge to reduce rebroadcast of sensor-data. In Tian *et al.* (2009), an idea for using bands to help conduct routing is introduced. The sensor field is divided into many slices (formed by coronas which are like the bands and wedges which cut across bands).

Routing trees are then constructed with the help of these slices. The research of Tian *et al.* (2009) mainly focuses on a static sink, fixed query region and continuous monitoring. In that context, such overhead might be reasonable but for a sequence of one-shot, highly dynamic sampling tasks such overhead can not be justified. The mobility of sink nodes further demands a rapid response by sensor nodes.

**Collision handling:** The problems associated with packet collisions in wireless systems have been broadly studied and motivated different Collision Handling Methods, applicable to various situations (Williams and Camp, 2002). From the perspective of collision handling, what is unique about the research is that it addresses collision handling within the specific context of the band-based broadcast mechanism. In particular, researchers demonstrate that this approach reduces the probability of packet collisions by explicitly reducing packet broadcast/rebroadcast events and by providing a natural mechanism for scheduling the transmission of packets based on band identification.

Within each collision domain (each band), researchers employ a fairly conventional means for packet collision reduction-using random delays before broadcast (Williams and Camp, 2002). It is useful to note that a range of other, more sophisticated collision avoidance protocols such as the techniques used in (Chen *et al.*, 2008) could also be adopted to handle intraband collisions.

## MATERIALS AND METHODS

### Proposed model

**Formation of wireless sensor network with mobile sink:** User initializes the simulator parameters. Such as, number of nodes, mobile sink and sampling region radius. Mobility Model of sink use random way point. In Communication Model with collision-receiving side if any packet collision occurs that packet will be detected and discarded. Communication Model without collision-distance between sensors to sensor is 50 m the packet transmission success rate is 95% otherwise success rate is 0%.

**Creation of band based sampling region:** Mobile sink broadcasting the SIS message to sensor node for gathering locally accessible sensor data with sampling region. It has 3 tuples ST_ID, MO_ID, BMF. Sensor node computes the band number using BMF function. Sensor node sends the response message with location stamp to mobile sink. If bs<br sensor node discard the message.

**Band-based broadcast scheduling technique:** The sampling task is to route sensor data to the mobile object, messages from higher bands must still propagate through lower bands where collisions can still occur. By scheduling the sensor nodes to begin their broadcasts at different time slots, it can extend band scheme to also reduce the negative impact of such packet collisions by reducing the time-correlation of the broadcast packets. To achieve this, the objective is to introduce the concepts of stage and band-scheduling. By using band scheduling to introduce an explicit time lag between the broadcasting of packets sent by nodes in two different bands which consequently weakens the impact of the second condition for causing packet collisions. In between a sensor node and mobile sink to reducing time correlation by band scheduling. ORT (Overall Reaction Time) and characterized the duration stage.

**Overview of band-based directional broadcast:** Upon receiving a request for sensor data, sensors in the sampling region will immediately react by broadcasting their sensed data. However, a fundamental problem here is that broadcast does not consider direction and left unchecked would flood an excessively large geographic region. Considering Fig. 3 as an example, sensor b will flood its reply in all directions,showed by the nine different arrows.

Note that although, it is not explicitly shown, this flooding could even extend beyond the intended sampling region. Intuitively, it makes sense to try and control this flooding so that it is directed toward the mobile object to minimize energy consumption associated with transmitting and receiving messages. For example ideally, researchers would like to constrain the flooding to the directions of D2 and D3. A closer look at the flooding situation is shown in Fig. 3. Note that only some of the

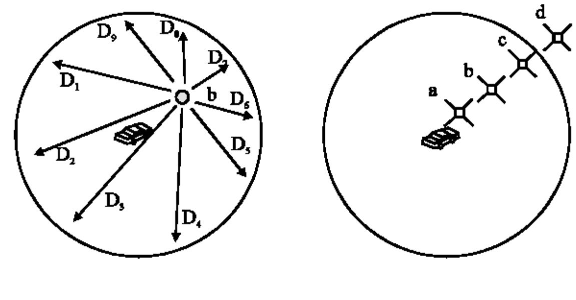


Fig. 3: Broadcasting sensor-data

sensor nodes and their broadcast/rebroadcast are depicted. To simplify the presentation of the general idea, researchers initially assume that the mobile object is static. As desired, sensor b's response will be rebroadcast by sensor a and received by the mobile object but b's packet will also propagate to other sensor nodes for example, c or even node d which is outside of the sampling region. The rebroadcasts of b's data by nodes other than node a are not of direct benefit in terms of delivering the sensor data to the mobile object. Ideally, it would be desirable if each broadcast could avoid sending packets in a direction that is away from the location of the mobile object (those directions depicted by the dotted line segments). However, without the support of a directional antenna on individual sensor nodes, a packet broadcast propagates in all directions. Despite this, we can seek to control the flooding at the receiver side. For example, upon receiving a packet from b, node c can choose to discard the packet rather than initiating a rebroadcast. The challenge is for nodes to distinguish the arrival of packets from nodes that are located closer to the mobile object without the assumption that nodes are location aware. In the solution, we only rely on nodes knowing their own bands. Thus, any node can identify received packets that originated from a different band, i.e., those packets that moved between bands. Given a specific sampling task, researchers partition the entire sampling region into multiple concentric circles. The center of the circles is the mobile object's location at the time it initiates a sampling task. Each band has two radii associated with it-an inner radius and an outer radius that define the width of the band. We denote the innermost band as Band 1 and the outermost band as Band N. Note that there are two special cases: Band 1's inner radius is 0 and Band N's outer radius is 1 and its inner radius defines the boundary for the sampling region. Each sensor node has an associated band number corresponding to the band that contains the location of that sensor node. All bands within the sampling region, i.e., Band i for i<N have the same width. Now when a node broadcasts a packet, it should also attach its band number. Upon receiving a packet, a node will make the rebroadcast decision based on the band number attached to the packet. If the node's band number is less than or equal to the packet's band number, the node will rebroadcast that packet otherwise the node discards the packet. Note that in achieving this directional broadcast property, there is a chance for packet-loss due to routing paths that are not allowed by the method.

**Band identification and sensor protocol:** While various methods can be used to associate sensor nodes with bands including the techniques used in (Tian *et al*., 2009), we suggest an alternative method that is highly efficient and natural for the sensor-sampling problem. Each time, a mobile object decides to sample a region of the sensor field, it issues a Sampling-Initiation Signal (SIS) which is broadcast with an intended sampling range, RMOBILE. Using this sampling signal, sensors obtain partial and relative knowledge of their locations and thus determine a band number. It is well-known that a radio signal attenuates as the distance between the transmitter and receiver increases (Dai and Wu, 2006). Thus when a mobile object issues a SIS, it can attach a function that maps signal strengths to band numbers. We assume that the mobile object has knowledge of its own signal's attenuation pattern in its environment and the object also defines the number of bands to be used. When a sensor node receives the SIS, it calculates its own band number based on the signal strength of the received signal and the mapping function attached to that signal. For now, we simply assume an ideal open-air environment, resulting in perfect circular bands as shown in Fig. 2. A Sampling-Initiation Signal (SIS) is a message broadcast by a mobile object in order to initiate the gathering of locally accessible sensor data within a given sampling region. The signal is represented as a 3-tuple:

SIS = (ST_ID, MO_ID, BMF)

Where:

ST_ID = A unique identifier for the sampling task
MO_ID = The identifier of the mobile object
BMF = A band mapping function that maps signal strength to band number (i.e., BMF (SIS_ Strength)→Band_ Number)

**Upon receiving a Sampling-Initiation-Signal, SIS (st_id, mo_id, bmf):** Calculate band number bn based on received SIS strength and bmf:

```
If (bn≠ N)
{
//N is the largest band number in the bmf.
 Generate a sensor data reply packet, p;
 Broadcast the generated packet P(st_id, bn);
}
//only broadcast a reply packet if located within the sampling region
```

**Upon receiving a sensor data packet P(st_id,bn)by sensor sn:** If((sn has received a SIS with id st_id)&(bn = band number of sn))

```
    Rebroadcast the packet;
Else
    Discard the packet;
```

A key idea is the way that bands are used to control flooding. Researchers describe core behavior of sensor

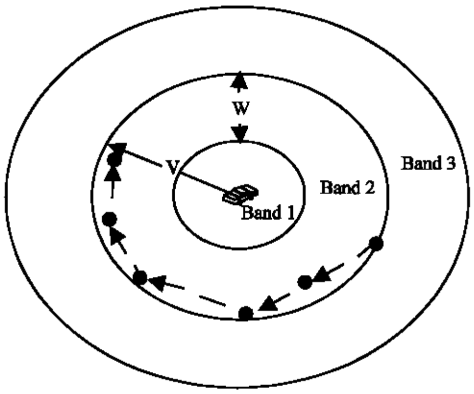


Fig. 4: A packet propagation path

nodes by giving the sensor node broadcast protocol. To simplify the presentation, we only consider one sampling task handling multiple simultaneous tasks is straightforward due to the unique task ID in each SIS. Sensor nodes react to 2 events: reception of a SIS sent by a sampling mobile object and reception of sensor-data packets sent by other sensor nodes. In response to a SIS, a sensor node computes its own band number which is then used to determine if the sensor is located within the sampling region. It is interesting to note that sometimes, there is no neighbor node with band number same as or less than the current node yet there may be a route to the sampling mobile object via a neighbor node in a higher band. To use such a route, the node may have to send the packet to neighbor nodes in higher bands to see if they can find routes toward the mobile object as in Fig. 4.

**Band based scheduling with selective forwarding through DSR routing algorithm:** Mobile sink and sensor node with sampling region that will be schedule into number bands. Each sensor node maintains the routing table using DSR routing algorithm. If neighbor node is not available means selectively forward the packets to next neighbor (if route is available) node to reach the packets until mobile object in the sampling region. If route is not available means does not forward the packets unnecessarily. In this way avoid the packet loss and also reduce the energy consumption.

## CONCLUSION

The concept of bands exploited to limit the propagation of sensor data broadcasting, providing a form of directional broadcast along with optimal selective forwarding. Methods for defining and using bands are presented with optimal selective forwarding and simulation results are provided to show the effectiveness of the approach. Since, the scheme prunes many rebroadcast packets, it reduces opportunities for packet collisions. The optimal selective forwarding scheme with broadcast scheduling is designed for two different cases: To broadcast the sensor data in a controlled way to the mobile sink within the sampling region and to collect the data from the sensor nodes that are present outside the sampling region. Hence, this research is to save the energy in wireless sensor network and avoid collisions during packet transmission.

## REFERENCES

Chen, C.C, E. Seo, H. Kim and H. Luo, 2008. SELECT, Self-Learning collision avoidance for wireless networks. Trans. Mobile Comput., 7: 305-321.

Dai, F. and J. Wu, 2006. Efficient broadcasting in ad hoc wireless networks using directional antennas. IEEE Trans. Parallel Distributed Syst., 17: 335-337.

Ekici, E., Y. Gu and D. Bozdag, 2006. Mobility-based communication in wireless sensor networks. IEEE Comm., 44: 56-62.

Gossain, H., C. Cordeiro and D.P. Agrawal, 2006. Minimizing the effect of deafness and hidden terminal problem in wireless ad hoc networks using directional antennas. Wireless Commun. Mobile Comput., 6: 917-931.

Li, J. and S.M. Shatz, 2008. Sampling sensor fields using a mobile object: A band-based approach for directional broadcast of sensor data. Proceedings of 9th IASTED International Conference on Biomedical Engineering, November, 2008, Beijing, China -.

Lilien, L., 2007. A taxonomy of specialized ad hoc networks and systems for emergency applications. Proceedings of the 1st International Workshop Mobile and Ubiquitous Context Aware Systems and Applications, August 6, 2007, Philadelphia, PA., USA.

Tian, S., S.M. Shatz, Y. Yu and J. Li, 2009. Querying sensor networks using Ad-Hoc mobile devices: A two layer networking approach. Ad Hoc. Networks, 7: 1014-1034.

Williams, B.T. and T. Camp, 2002. Comparison of broadcasting techniques for mobile ad hoc networks. Proceedings of the 3rd ACM International Symposium on Mobile Ad hoc Networking and Computing, June 9-11, 2002, ACM, New York, pp: 194-205.