An Enhanced Optimal Selective Forwarding in Band Based Broadcast Scheduling for Effective Energy Saving in Wireless Sensor Networks

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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 research, 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, consumption, India

INTRODUCTION

Recently, the concept of employing mobile objects (sometimes referred to as mobile sinks) to query a sensor network has been proposed (Eikici et al., 2006; Li and Shatzi, 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 nearby sensor nodes. The larger circle denotes the sampling region. Each sensor in that region will consequently be activated and relay 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.

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

Fig. 1: Sensor field sampling

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Fig. 2: A 4-band configuration

immediately after receiving the sampling task since, it
requires no routing table or tree setup and broadcast can
naturally handle the 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 research, 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.

LITERATURE REVIEW

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
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. As by 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 cannot 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 work is that it addresses collision handling within the specific context of the band based broadcast mechanism. In particular, researchers demonstrate that the 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.

**PROPOSED MODEL**

**Formation of wireless sensor network with mobile sink:** User initializes the simulator parameters. Such as number of nodes, mobile sink, 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 three tuples ST_ID, MO_ID and 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) 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 illustrated 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 we would like to constrain the flooding to the directions of D2 and D3. A closer look at the flooding situation is provided in Fig. 3.

Note that only some of the 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
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. Researchers 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), researchers 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, R_{mobile}. 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 strength 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 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:

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Fig. 3: Broadcasting sensor data
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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:

\[
\text{If} \ (bn-N) \\
\{ \\
\quad /N \text{ is the largest band number in the BMF.} \\
\quad \text{Generate a sensor data reply packet;} \\
\quad \text{Broadcast the generated packet P(ST_ID, BN);} \\
\}
\]
\[
\quad /\text{only broadcast a reply packet if located within the sampling region}
\]

Upon receiving a sensor data packet P(ST_ID, BN) by sensor sn:

\[
\text{If} \ ((\text{sn has received a SIS with id ST_ID}) \ \text{and} \ (bn = \text{band number of sn})) \\
\quad \text{Rebroadcast the packet;} \\
\text{Else} \\
\quad \text{Discard the packet;}
\]

A key idea is the way that bands are used to control flooding. We now describe the core behavior of sensor 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 two 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
- 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**