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# SMESRT: A PROTOCOL FOR MULTIPLE EVENT-TO-SINK RELIABILITY IN WSN

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## ABSTRACT

A wireless sensor network (WSN) consists of numerous distributed, self-sufficient micro sensor nodes to agreeably monitor physical or environmental circumstances, such as temperature, sound, vibration, pressure, moisture, traffic, motion, pollutants or habitat monitoring etc. Event based WSN rely on the combined effort of a number of micro sensor nodes. Reliable event detection at the sink is based on combined information provided by source nodes, not on any individual report. Hence, conventional end-to-end reliability description and solution are unsuitable in Wireless Sensor Network (WSN). Moreover simultaneous multiple event detection is an issue for a large sensor field consisting of thousands of sensor nodes which is discussed in Event-to-Sink Reliable Transport protocol with some issues needed to resolve. In order to address those need, a new simultaneous multiple event reliable transport scheme for wireless sensor network (WSN), is proposed in this paper. SMESRT is a transport solution designed to accomplish simultaneous multiple reliable event detection in wireless sensor network (WSN) with minimum energy expenses. It includes a combined payload control component that serves the dual purpose of less traffic at the sink and conserving energy.

**Key words:** *Wireless Sensor Networks, Reliable Transport Protocols, Event-to-Sink Reliability, Energy Conservation*

## 1. INTRODUCTION

ESRT protocol is a transport solution that tries to attain reliable event detection solution with minimum energy expenditure and congestion resolution [6] [7]. Depending on the current network state, it configures the reporting frequency rate f for the next time interval [6][7].In a sensor field with multiple event occurring at the same time, the adjustment of same reporting frequency *f* for all the sensor nodes will not perform better as the events are independent to each other and also the event occurring area may not be the same. Each event may need different reporting frequency to achieve reliability. In order to address this need, a new simultaneous multiple event reliable transport scheme for Wireless Sensor Network, the simultaneous multiple event-to-sink reliable transport (SMESRT) protocol has been proposed in this paper which minimizes energy expenses by combining a payload control component that serves the dual purpose of less traffic at the sink and conserving energy.

The main objective of this is to ensure reliability for simultaneous multiple event to sink communications with less energy expenses. Also solve the problems of ESRT and update different reporting frequency for different events.

The organization of the paper includes the background study and ESRT limitations in chapter 2. Chapter 3 discusses on proposed scheme. Chapter 4 shows some analytical results using network simulator-2 (NS-2) to examine the efficiency of our proposed model, limitations of the proposed model and presents some suggestions. Finally the paper concludes in chapter 5.

## 2. BACKGROUND STUDY

The Wireless Sensor Network (WSN) [1][2][3] is an event driven paradigm that relies on the group effort of numerous sensor nodes. The sink tries to identify an event occurs or not. For this, to achieve ene-to-end reliability is not needed, only the successful event detection is enough. ESRT is the first paper discussed these issues.

### 2.1 ESRT

Event-to-Sink Reliable Transport (ESRT) [6][7] aims at providing reliability from sensors to sink while congestion control simultaneously.

Sensor nodes send the event packets to the sink in one predefined reporting interval and must listen to the sink broadcast with a separate channel (one hope) at each decision interval. Nodes then update their reporting rates f for next reporting interval. The protocol tries to configure the reporting rate f of source nodes to achieve the required event detection reliability R at the sink with minimum resource utilization.

#### 2.1.1 ESRT limitations

ESRT also describes multiple event detection technique but with the same reporting frequency for all sensor nodes for a certain time interval leads to a problem

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when sink is reported with multiple events simultaneously. In the network with multiple events occurring at the same time can create different congestion state for different event occurrence area. As the sensor nodes detection area often overlaps and also nodes life time may vary due to resource constrains, congestion condition may also vary over time. For detecting multiple events simultaneously the same reporting rate f, cannot guarantee reliability for all the events. Also a dedicated channel is required for the sink to broadcast the reporting frequency f to all the sensor nodes [4][5].

## 2.2 Cluster formation

Low Energy Adaptive Clustering Hierarchy (LEACH) aims at providing a distributed algorithm for sensor networks in which the sensors elect themselves as CHs with some probabilities and broadcast their decisions by assuming that all nodes can hear each other [16].

Power Information Gathering in Sensor Information Systems (PEGASIS) scheme is an enhancement of LEACH. The key plan is to form a chain among the sensor nodes so that each node will communicate with its close neighbors. The gathered data gets aggregated and travel from node to node, and finally a leader node transmits it to the sink. The leader node will turn around in each round to evenly distribute energy consumption among the sensor nodes [15].

An Energy-Aware and Intelligent Cluster-based Event Detection Scheme in Wireless Sensor Networks proposed a cluster based, energy-aware event-detection scheme where events are reliably relayed to a sink in the form of aggregated data packets [13].

Event-to-Sink Directed Clustering in Wireless Sensor Networks aims clusters formation when and where they are needed and in the direction of data flow from event location to the sink [14].

## 3. PROPOSED SCHEME

Simultaneous multiple event-to-Sink reliable transport protocol (SMESRT) is a transport solution designed to accomplish simultaneous multiple reliable event detection in WSN with minimum energy expenses. It includes a combined payload control component that serves the dual purpose of less traffic at the sink and conserving energy.

## 3.1 Assumptions

SMESRT mainly run on the sink, with minimal functionality required at resource constrained sensor nodes and a payload control component at the elected cluster head (CH) of the event. An application specific time interval (reporting period) is needed for the sensors to report to the sink and a predefined decision interval is needed for the sensors to achieve reporting frequency for next time interval. A predefined threshold value is assumed for minimum event sensing nodes and for minimum number of packets to ensure reliability.

## 3.2 Protocol operations

As soon as an event is detected by a sensor node it generates an event ID and forms a cluster [13][14]. Event Ids can be obtained or distributed by using any existing high level network information collection mechanisms such as the existing in-network data aggregation method or location-aware routing for data aggregation or dynamically random Event ID assignment strategy [6] or using the cluster-based event identification method [7]. After the cluster formation a cluster head (CH) is elected [8][9][10].

All the nodes detecting the same event send their event packets to the CH at a predefined reporting frequency for one reporting period. At the decision interval the nodes wait for the adjusted reporting frequency sent by the CH. If no reporting frequency is adjusted during this time the nodes continue to send data packets at the same reporting frequency for the next reporting period.

When a node is elected as a cluster head it continues to receive event packets in reporting period. If the CH detects that the minimum event sensing node or the minimum number of packets is less than the threshold value, it will not report to the sink. Otherwise in the decision interval CH aggregates the packets by a payload control component, send only one aggregated packet to the sink (figure 1) and waits for the acknowledgement and next reporting period's reporting frequency (figure 2). If CH can detect that the gathered event information is enough, it continues to drop packets coming from the event sensing nodes for that reporting period.

When Sink gets an aggregated event packet, it calculates the reliability and acknowledges the packet with next reporting period's reporting frequency in the decision interval.

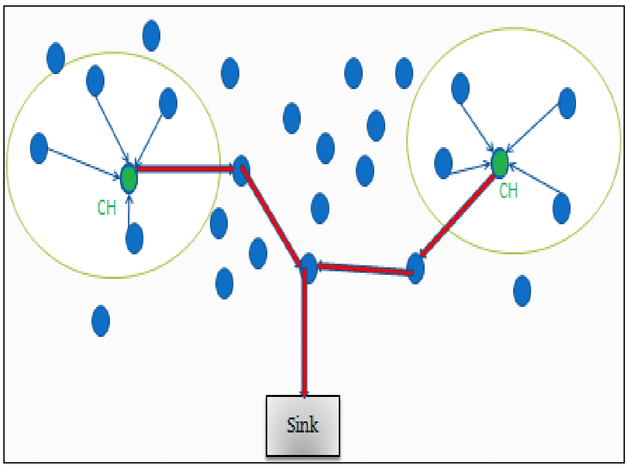



**Figure 1: SMESRT operations (downstream)**

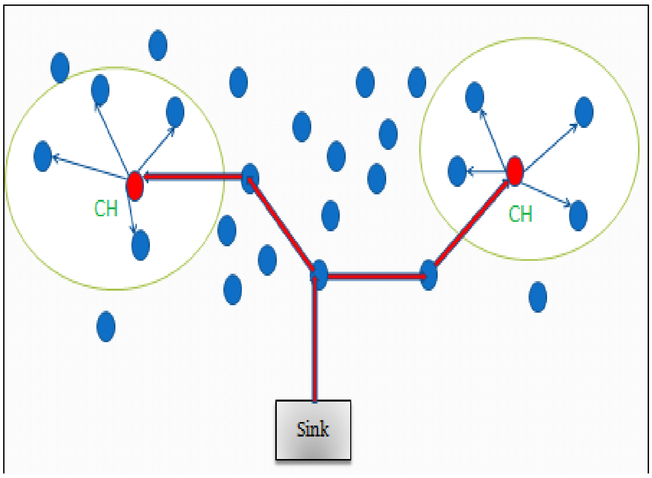



Figure 2: SMESRT operations (upstream)

## 3.3 Event-triggered, Cluster Formation

Cluster formation is discussed by several papers mentioned in section 2.2 in this paper. When an event take place only that time the event detecting nodes forms a cluster consisting of the nodes in the event occurring area[7] and share a common event ID for that particular event while cluster formation. They elect a CH for that cluster in this case for an event. If an event detecting area is large for one CH to handle then hierarchical clustering can be used [9][10][11]. After a while the rotation of the CH take place for preserving energy [12][13]. When the phenomenon is over the cluster dismisses to preserve energy.

Preset clustering technique consumes more energy than event-triggered clustering as maintaining a cluster needs some levels of packet transaction. For event--triggered clustering the event detection may delay a bit but to ensure same event ID for an event also needs some levels of packet transaction which can be done while forming a new cluster.

## 3.4 Sensor to CH event packets

After event-triggered cluster formation the event detecting nodes sends events packets at a reporting period with prefixed reporting frequency for the first time. At the decision interval the nodes waits for the next reporting frequency broadcasted by the CH. Sensor nodes then adjust their reporting frequency and continue sending event packets to the CH until the event dismisses (figure 3).

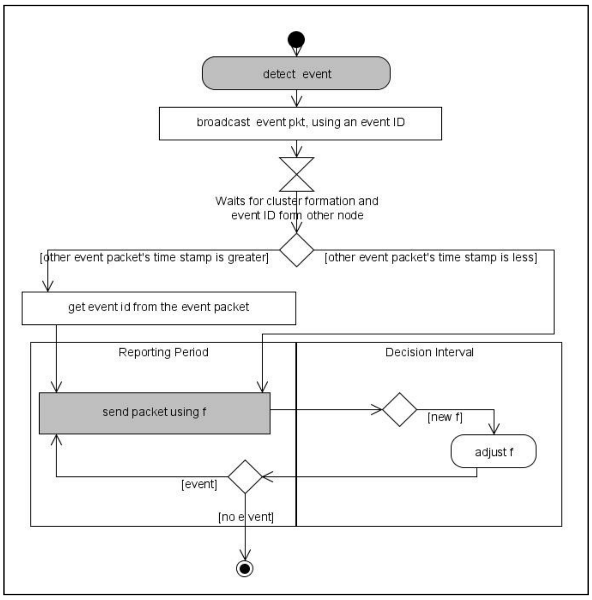



Figure 3: SMESRT operation at the sensor

## 3.5 Payload control at cluster head

When a node is elected as a cluster head it continues to receive event packets in reporting period. If the CH detects that the minimum event sensing node or the minimum number of packets is less than the threshold value, it will not report to the sink. Otherwise in the decision interval CH aggregates the packets by a payload control component, send only one aggregated packet to the sink and waits for the acknowledgement and next reporting period's reporting frequency. If CH can detect that the gathered event information is enough, it continues to drop packets coming from the event sensing nodes for that reporting period (figure 4).

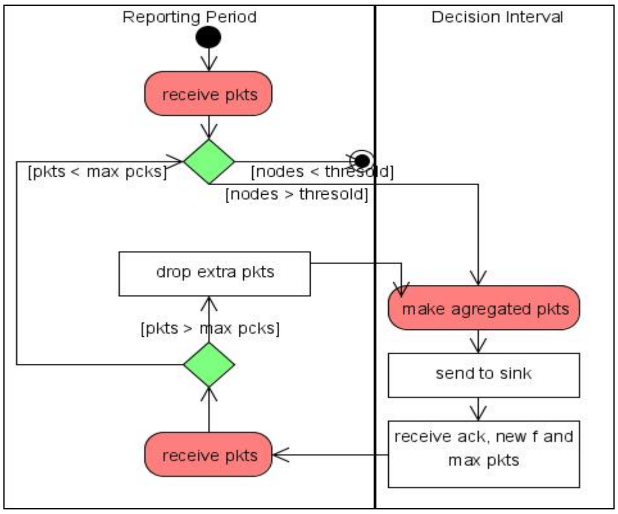



Figure 4: SMESRT operation at the Cluster Head

### 3.6 Event forwarding

Cluster heads forward the event packets to the sink at decision interval. Sink then calculates the reliability and piggyback the reporting frequency for the next time interval and also sends the maximum number of packets to reach reliability (figure 5).

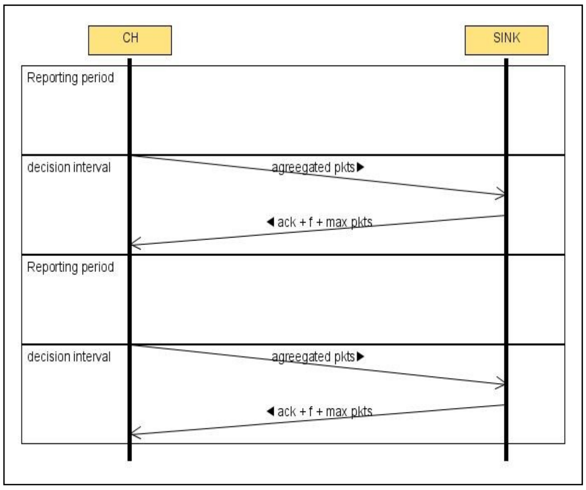



**Figure5: SMESRT operation at the Sink**

### 3.7 Event packets

In cluster event packet formation is the same as ESRT. But for the CH to Sink aggregated event packet formation is different. The aggregated event packet contains number of event sensing nodes and number of packets as extra which is proposed in ESRT (figure 6).

ESRT packet, SMESRT event packet

| Event ID | CN (1 bit) | Destination | Time Stamp | Payload | FEC |
|---|---|---|---|---|---|

SMESRT aggregated event packet

| Event ID | # of Sensors | # of pkts | CN (1 bit) | Destination | Time Stamp | Payload | FEC |
|---|---|---|---|---|---|---|---|

**Figure 6: SMESRT event packets**

## 4. RESULTS AND DISCUSSION

SMRSRT is an extension of ESRT. No operation is different but the processes of the communications are different.

### 4.1 Achievements

- SMESRT solved for the problem of generated data flows from sensor nodes to the sink passing through any common node.
- It can assign different reporting frequency for different events.
- No additional channel for broadcast the reporting frequency for the sink is needed.
- Less energy consumption then ESRT.

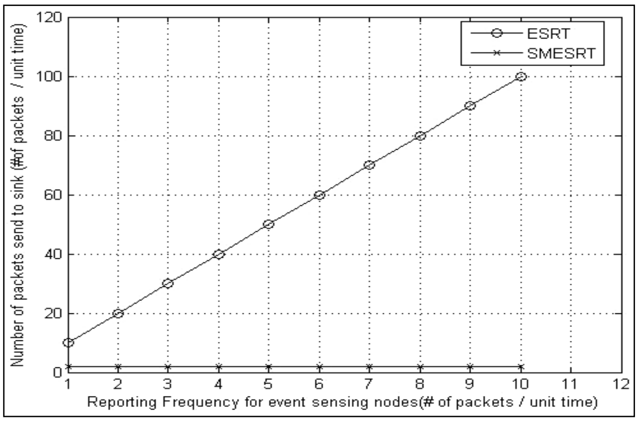
### 4.2 Analysis and comparison

SMESRT injects fewer packets to the network then ESRT. As the payload control mechanism is there for the CH to aggregate the event packets, each event will send just one aggregated event packets to the sink in one decision period.

SMESRT needs extra time at start up for cluster formation. Initially it may look that this protocol overhead may consumes much time but it is needed for better performance afterwards.

After reaching OOR in SMESRT additional nodes can join the event detection/cluster. As the event gets bigger actually the additional event sensing nodes just joins the cluster, but if the reliability is already achieved the CH can drop some extra packets to consume less energy.

The graph below describes how the performance can be better using SMESRT (figure 7).




**Figur7: SMESRT: for two simultaneous event where n=10**

As we can see from the graph that for two events SMESRT always sends two aggregated event packets to the sink thus less packets are in the network, but within a cluster the event packets are the same as ESRT.

As less traffic in the network, the network may not get congested, but within an event a node can face congestion. Also, energy consumption rate is very less because of neighboring nodes forward a small amount of packets.

No additional channel is needed to update the reporting frequency which is needed in ESRT.

As in sink different events are treated separately, every event gets its own reporting frequency for a time interval.

## 5. CONCLUSIONS

SMESRT mainly run on the sink like ESRT with minimal functionality required at resource constrained sensor nodes and a payload control component at the elected cluster head (CH) of the event. Instead of sending all the packets at the sink, SMESRT combine all payloads at the CH and sent only one packet to the sink. With the acknowledgement for that particular packet, the sink notifies the event's CH with the reporting frequency for next time interval. The proposed scheme is simple without any dependence on the topology of the network or making any assumptions about the underlying transport infrastructure.

We hope the proposed scheme will help researchers to look at the event detection with a new direction. The proposed scheme will be very useful to be implemented in scenarios of monitoring disaster prone areas or monitoring wildlife environment and so on. SMESRT is an add-on to the ESRT with less power consumption, scalable and robust in nature.

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