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Threshold Sensitive Energy Efficient Sensor Network Protocol

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***Abstract**: Wireless sensor networks are expected to find wide applicability and increasing deployment in the near future. In this paper, we propose a formal classification of sensor networks, based on their mode of functioning , as proactive and reactive networks. Reactive networks ,as opposed to passive data collecting proactive networks, respond immediately to changes in the relevant parameters of interest. We also introduce a new energy efficient protocol for temperature sensing application, TEEN (Threshold sensitive Energy Efficient sensor Network protocol) for reactive networks. In terms of energy efficiency, our protocol has been observed to outperform existing conventional sensor network protocols.*

Keywords: TEEN(Threshold sensitive Energy Efficient sensor Network protocol) ,BS (Base Station) , CH (Cluster Head) , WSN (Wireless Sensor Network).

1. INTRODUCTION

In recent years , the use of wired sensor networks is being advocated for a number of applications. Some examples include distribution of thousands of sensors and wires over strategic locations in a structure such as an airplane, so that conditions can be constantly monitored both from the inside and the out side and a real-time warning can be issued when the monitored structure is about to fail. Sensor networks are usually unattended and need to be fault-tolerant so that the need for maintenance is minimized. This is especially desirable in those applications where the sensors may be embedded in the structure or are in inhospitable terrain and are inaccessible for any service. The advancement in technology has made it possible to have extremely small, low powered devices equipped with programmable computing ,multiple parameters sensing and wireless communication capability. Also, the low cost of sensors makes it possible to have a network of hundreds or thousands of these wireless sensors, there by enhancing the reliability and accuracy of data and the area coverage as well. Also, it is necessary that the sensors be easy to deploy Protocols for these networks must be designed in such a way that the limited power in the sensor nodes is efficiently used. In addition, environments in which these nodes operate and respond are very dynamic, with fast changing physical parameters. The following are some of the parameters which might change dynamically depending on the application:

- Power availability.
- Position (if the nodes are mobile).
- Reachability.
- Type of task (i.e. attributes the nodes need to operate on).

So, the routing protocol should be fault-tolerant in such a dynamic environ ment. The traditional routing protocols defined for wireless ad hoc networks are not well suited due to the following reasons:

1. Sensor networks are “data centric” i.e., unlike traditional networks where data is requested from aspecific node ,data is requested based on certain attributes such as, which area has (temperature > 50°F).
2. The requirements of the network change with the application and so, it is application-specific [3]. For example, in some applications the sensor nodes are fixed and not mobile, while others need data based only on one attribute (i.e., attribute is fixed in this network).
3. Adjacent nodes may have similar data. So, rather than sending data separately from each node to the requesting node, it is desirable to aggregate similar data and send it.
4. In traditional wired and wireless networks, each node is given a unique id, used for routing. This cannot be effectively used in sensor networks. This is because, these networks being data centric, routing to and from specific nodes is not required. Also, the large number of nodes in the network implies large ids [2], which might be substantially larger than the actual data being transmitted.

Thus ,sensor networks need protocols which are application specific, data centric, capable of aggregating data and optimizing energy consumption. An ideal sensor network should have the following additional features: Attribute based addressing is typically employed in sensor networks. The attribute based addresses are composed of a series of attribute-value pairs which specify certain physical parameters to be sensed. For example, an attribute address may be (temperature > 100° F, location = ??). So, all nodes which sense a temperature greater than 100F should respond with their location. Location awareness is another important issue. Since most data collection is based on location, it is desirable that the nodes know their position when ever needed.

2. Related Work

In this section, we provide a brief overview of some related research work. DaWei et. al[1] Comparison Study to Hierarchical Routing Protocols in Wireless Sensor Networks. Discuss and survey in details Routing Protocols in Wireless Sensor Networks Shio Kumar et. al in [2]. Apneet et. al [3] introduce Implementation of LEACH, Hetero-LEACH, SEP and EEHC Protocols using MATLAB in Wireless Sensor Network. Yanhong et. Al[4] Optimization on TEEN routing protocol in cognitive wireless sensor network.

3. Motivation

In the current body of research done in the area of wireless sensor networks , we see that particular attention has not been given to the time criticality of the target applications. Most current protocols assume a sensor network collecting data periodically from its environment or responding to a particular query. We feel that there exists a need for networks geared towards responding immediately to changes in the sensed attributes. We also believe that sensor networks should provide the end user with the ability to control the trade-off between energy efficiency, accuracy and response times dynamically. So, in our research, we have focussed on developing a communication protocol which can fulfill these requirements.

4. Classification of Sensor Networks

Here, we present a simple classification of sensor networks on the basis of their mode of functioning and the type of target application.

4.1 Proactive Networks

The nodes in this network periodically switch on their sensors and transmitters, sense the environment and transmit the data of interest. Thus, they provide a snapshot of the relevant parameters at regular intervals. They are well suited for applications requiring periodic data monitoring.

4.2 Reactive Networks

In this scheme the nodes react immediately to sudden and drastic changes in the value of a sensed attribute. As such, they are well suited for time critical applications.

5. Sensor Network Model

We now consider a model which is well suited for these sensor networks. It is based on the model developed by Yanhong et. al. in [4]. It consists of a base station(BS), away from the nodes ,through which the end user can access data from the sensor network. Al l the nodes in the network are homogeneous and begin with the same initial energy. The BS however has a constant power supply and so, has no energy constraints. It can transmit with high power to all the nodes. Thus, there is no need for routing from the BS to any specific node. However, the nodes cannot always reply to the BS directly due to their power constraints, resulting in asymmetric communication. This model uses a hierarchical clustering scheme. Consider the partial network structure shown in Fig. 1. Each cluster has a cluster head which collects data from its cluster members, aggregates it and sends it to the BS or an upper level cluster head.

For example, nodes 1.1.1, 1.1.2, 1.1.3, 1.1.4 , 1.1.5 and 1.1 form a cluster with node1.1 as the cluster head. Similarly there exist other cluster heads such as 1.2, 1 etc. These cluster-heads, in turn, form a cluster with node 1 as their cluster-head. So, node 1 becomes a second level cluster head too. This pattern is repeated to form a hierarchy of clusters with the upper most level cluster nodes reporting directly to the BS. The BS forms the root of this hierarchy and supervises the entire network. The main features of such an architecture are:

- All the nodes need to transmit only to their immediate cluster-head , thus saving energy.
- Only the cluster head needs to perform addition a computations on the data. So, energy is again conserved.

Disadvantage: Combined with the extra computations CHs perform, they end up consuming energy faster than the other nodes.

Solution : *Cluster period.*: In order to evenly distribute CHs consumption, all the nodes take turns becoming the cluster head for a time interval *T, called the cluster period.*

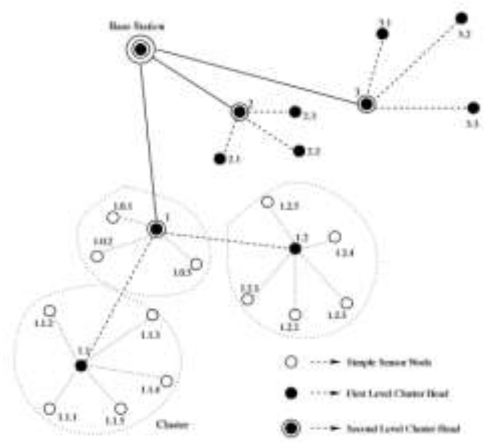

Figure 1. Hierarchical Clustering

6. Sensor Network Protocols

- Proactive Network Protocol: **LEACH**
- Reactive Network Protocol: **TEEN**

6.1 Functioning of Proactive Network Protocol :

At each cluster change time, once the cluster-heads are decided, the cluster-head broadcasts the following parameters:

Report Time (TR)
Attributes (A)

Report Time : Time period between successive reports sent by a node.

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Attributes : A set of physical parameters which the user is interested in obtaining data about. At every report time, the cluster members sense the parameters specified in the attributes and send the data to the cluster-head. The cluster-head aggregates this data and sends it to the base station or the higher level cluster-head, as the case may be. This ensures that the user has a complete picture of the entire area covered by the network.

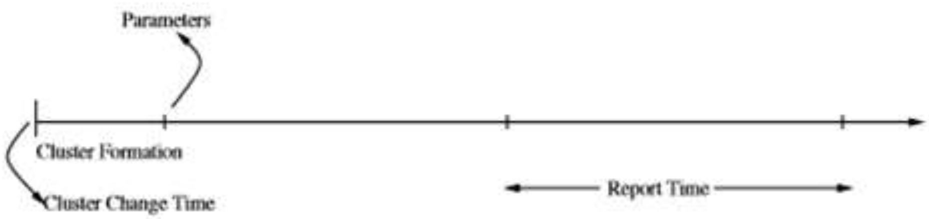

Figure 2. Time line for proactive protocol

7. Important Features of Proactive Network Protocol:

7.1 Energy Conservation

The nodes switch off their sensors and transmitters at all times except the report times**(RT) .** At every cluster change time, Report time(RT) and *A are transmitted* afresh and so, can be changed. User can decide what parameters to sense and how often to sense them by changing *A and TR* respectively.

7.2 This scheme drawback.

Not very suitable for time-critical data sensing applications . Because of the periodicity with which the data is sensed, it is possible that time critical data may reach the user only after the report time.

8. LEACH (Proactive Network Protocol) with some minor differences

Once the clusters are formed, the cluster heads broadcast a TDMA schedule giving the order in which the cluster members can transmit their data. The total time required to complete this schedule is called the frame time (TF). Every node in the cluster has its own slot in the frame, during which it transmits data to the cluster head. When the last node in the schedule has transmitted its data, the schedule repeats.The *report time discussed in TEEN is equivalent to the frame time in LEACH. The frame time is not broadcast by* the cluster head, though it is derived from the TDMA schedule. However, it is not under user control. Attributes are predetermined and are not changed midway.

8.1 Example Applications

This network can be used to monitor machinery for fault detection and diagnosis. It can also be used to collect data about temperature change patterns over a particular area.

9. TEEN (Threshold sensitive Energy Efficient Network protocol)

Reactive, event-driven protocol for time-critical applications A node senses the environment continuously, but turns radio on and transmission only if the sensor value changes drastically , No periodic transmission , Don’t wait until the next period to transmit critical data ,Save energy if data is not critical

9.1 TEEN Functioning (First Reactive Network Protocol)

Ever y node in a cluster takes turns to become the CH for a time interval called cluster period , At every cluster change time, in addition to the attributes, the cluster-head broadcasts to its members, a hard & a soft threshold .

- ***Hard Threshold(HT)***

Threshold value for the sensed attribute. A Cluster member only reports/sends data to CH by switching on its transmitter, only if data values are in the range of interest .

- ***Soft Threshold(ST)***

Small change in the value of the sensed attribute .A Cluster member only reports/sends data to CH by switching on its transmitter, if its value changes by at least the soft threshold .

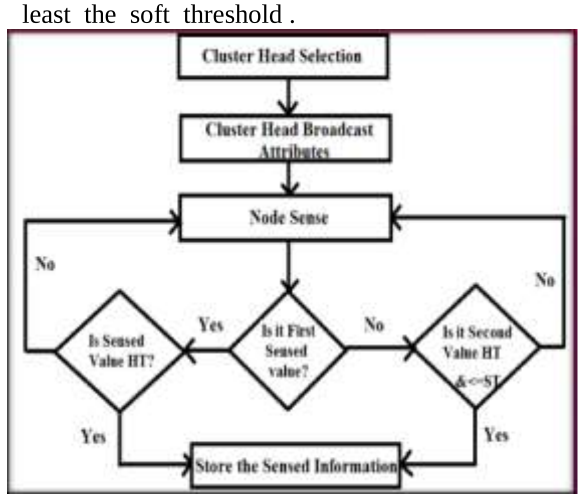

Figure. 3: Operational Flow of TEEN

9 .2 TEEN Functioning:

The nodes sense their environment continuously. First time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is stored in an internal variable in the node, called the *sensed value (SV).* The nodes will transmit data in the current cluster period only when the following conditions are true:

- The current value of the sensed attribute is greater than the hard threshold.
- The current value of the sensed attribute differs from SV by an amount equal to or greater than the soft threshold ,Whenever a node transmits data, *SV is set equal to the current* value of the sensed attribute.
- Hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest.
- Soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold.

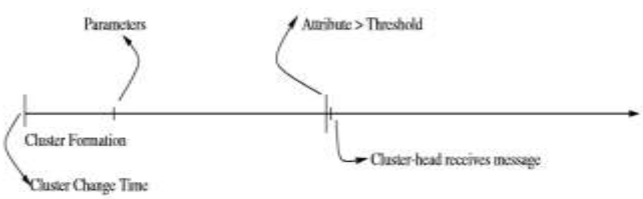

Figure 4. Time Line for TEEN

9.3 Important Features

The main features of this scheme are as follows:

1. Time critical data reaches the user almost instantaneously. So, this scheme is eminently suited for time critical data sensing applications.

2. Message transmission consumes much more energy than data sensing. So, even though the nodes sense continuously, the energy consumption in this scheme can potentially be much less than in the proactive network, because data transmission is done less frequently.

3.The soft threshold can be varied, depending on the criticality of the sensed attribute and the target application.

4. A smaller value of the soft threshold gives a more accurate picture of the network, at the expense of increased energy consumption. Thus, the user can control the trade-off between energy efficiency and accuracy.

5. At every cluster change time, the attributes are broadcast afresh and so, the user can change them as required.

9.4 TEEN Drawback

The main drawback of this scheme is that, if the thresholds are not reached, the nodes will never communicate, the user will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this scheme is not well suited for applications where the user needs to get data on a regular basis. Another possible problem with this scheme is that a practical implementation would have to ensure that there are no collisions in the cluster. TDMA scheduling of the nodes can be used to avoid this problem. This will however introduce a delay in the reporting of the time-critical data. CDMA is another possible solution to this problem.

10. Results

Figure 5 Shows distributed of nodes in the area 100*100.

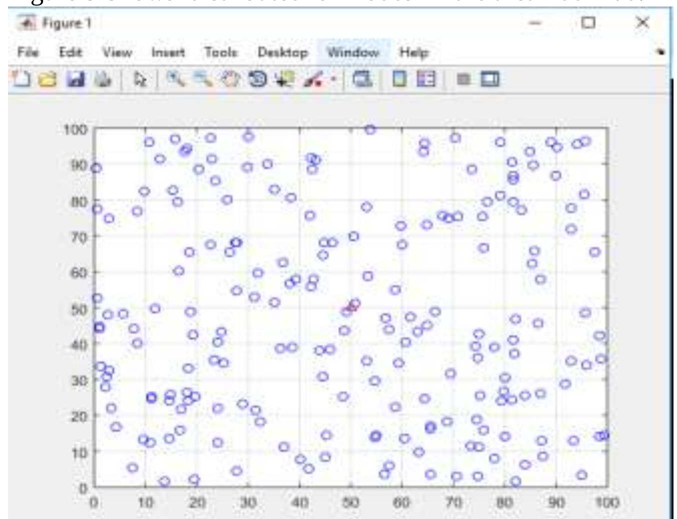

Figure 5. Distributed Nodes in The Zoon 100*100

Figure 6. As shown that the first node die at The round 4003.

Figure 6. First Node Dead at The round 4003

Figure7. Shows the number of death nodes in TEEN protocol, As show at Fig.7 All nodes die at the round 4800.

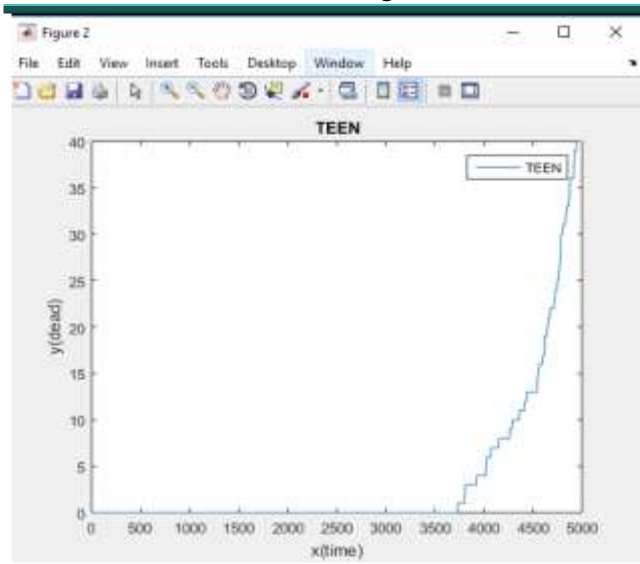

Figure 7. Death Nodes Number (5000 rounds)

11. Acknowledgment

IN THIS PAPER, WE PRESENT A FORMAL CLASSIfiCATION OF SENSO R NETWORKS. WE ALSO INTRODUCE A NEW NETWORK PROTOCOL, TEEN FOR REACTIVE NETWORKS. TEEN IS WELL SUITED FOR TIME CRITICAL APPLICATIONS AND IS ALSO QUITE EFfiCIENT IN TERMS OF ENERGY CONSUMPTION AND RESPONSE TIME. IT ALSO ALLOWS THE USER TO CONTROL THE ENERGY CONSUMPTION AND ACCURACY TO SUIT THE APPLICATION.

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