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Technical Review of Energy Management Mechanisms in Wireless Sensor Network

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ABSTRACT
Wireless Sensor Network (WSN) is a set of various wireless sensor nodes. WSN require in rural, remote area and at such place where human dealings is required. But wireless sensor network has many issues like energy consumption, security, etc. Wireless sensor network is widely used in different field like battle-field, education and organization etc. This paper review different types of protocols and methods of energy management in routing. Here comparison of few methods which are related to energy efficient routing in WSNs. This study indicates the possible research on energy saving during routing in WSNs.
Keywords:- Wireless Sensor Network (WSN), Energy Management, Sensor lifetime**.**

I. INTRODUCTION

A wireless sensor network is distributed autonomous sensors to monitor physical or environmental conditions, such as sound, temperature, pressure, etc. The major components [10] of a typical sensor network are: sensor nodes, gateway sensor node, sensor field and the task manager.

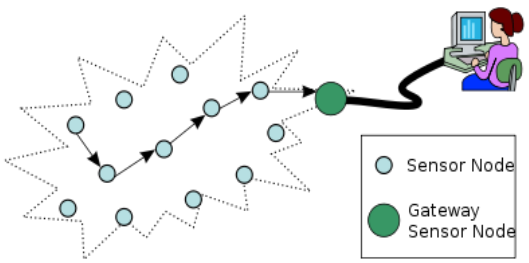

Figure 1: Example of Wireless Sensor Network [9]

WSNs architecture is shown in Figure 1 which contains all major components. A sensor node [11] is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A sensor field is the location where the nodes are organized. A gateway sensor node is a sensor node with the specific task of transceiver and managing data from the other sensor nodes.

Where the human existence is not possible in that situation wireless sensor network is use for surveillance and monitoring. Some applications of wireless sensor network [5]:

- Healthcare management
- Earth sensing
- Vehicular telemetric
- Military application
- Commercial purpose

Some benefits of wireless sensor network:

- Reduce cabling cost
- Monitor device with GPS
- Autonomous node
- Easy, fast and reliable communication
- Flexibility for new device deployment
- Controlling through gateway or sink node

Some drawbacks of wireless sensor network:

- High cost infrastructure
- Atmospheric effects
- Maximum error possibility
- Energy management for sensor node

Next section 2 includes reviews of different papers, in section 3 complete clarifications of energy management methods for WSNs is specified. Section 4 contains

comparison of energy management methods for WSN, where section 5 is conclusion of technical review of energy management mechanisms in WSN.

II. RELATED WORK

Secure routing is primary issue in the wireless sensor network; this research paper includes detection based path hopping technique. Using master node or authenticate node data transmitted over medium, where the network key is remain unique in network. With this unique key identification of malicious node can be done. Via distance formula shortest path is calculated and packets securely transmit. This method [6] simulated in mat lab, implementation can be done by combining this method with any routing protocol.

The inattentive nature of sensor nodes and unsafe sensing environments exclude battery replacement as a feasible solution. Another way [8], the surveillance nature of many sensor network applications requires a long lifetime; thus, it is a very important research issue to provide a form of energy-efficient surveillance service for a geographic area. Much of the current research focuses on how to provide full or partial sensing coverage in the context of energy conservation.

WSNs have discovered a wide range of applications in the recent period. Here researchers classify [3] the routing protocols in WSNs into data-centric, hierarchical and location based depending on the network structure. Data-centric protocols use the metadata structure to transmit the sensed information to the BS. Naming the data helps to construct a query which requests for only certain attributes of the data, thus known as data-centric routing techniques. Hierarchical routing protocols adopt the clustering approach by grouping sensor nodes. This is highly scalable and thus used in a number of applications. Location based protocols use the information of sensor nodes position to route data.

Energy consumption is a one of the main challenge in wireless sensor network. Medium access control (MAC) [2] has a significant effect on the energy consumption; energy efficiency is one of the fundamental researches in the design of MAC protocols for WSNs. In this paper, describe an energy efficiency of IEEE 802.11 MAC protocol.

This review highlights the way of power saving and energy optimization techniques in WSNs, by enhances the available methods to save energy. The energy can be saved efficiently is only by clustering and cluster head election, by using many techniques [1]. In this paper detail demonstration of clustering mechanism and how to implement clustering mechanisms in TEEN protocol for energy optimization in WSNs.

Energy management for sensor node is very tedious task to implement. The lifetime of sensor is highly depended on battery used by node. There are several steps [4] mentioned in this paper for energy management of wireless sensor network. Smart dust nodes, LEACH (Low-Energy Adaptive Clustering Hierarchy) protocol, TD-DES (Topology-Divided Dynamic Event Scheduling) protocol, shorter higher quality links. These steps must perform appropriately because energy management mechanism directly affects routing algorithm.

III. MECHANISMS

Mechanism 1: Energy Management Methods

ENERGY MANAGEMENT:

Smart dust nodes are designed to be disposable, making it more cost effective to deploy additional new nodes rather than replace batteries in existing nodes [4]. Many wireless sensor applications require the sensors to be operational for many years. Instead of energy management, replacing battery is smarter and easier to do.

METHODS OF ENERGY MANAGEMENT:

Energy management techniques include reduce communication and increase computation, power down certain components of the node or the entire node, nodes that cover smaller areas, and renewable sources of energy. The desire to save energy has also affected routing algorithms, scheduling, data collection and aggregation and MAC protocol research.

DATA REDUCTION TECHNIQUES:

LEACH (Low-Energy Adaptive Clustering Hierarchy) [4] is a cluster based protocol that uses hierarchy to overcome the data collected by the sensors before sending it on to a central base node. The energy load is evenly distributed among the sensors in the network.

EVENT BASED COMMUNICATION:

An event scheduler [12] dynamically schedules time slots for each type of event. There is a master node that acts as the base station with greater computational, transmission and storage capability. Nodes save power by powering down their radio during those time slots that do not match the events they are interested in. The Topology-Divided Dynamic Event Scheduling (TD-DES) [4] protocol organizes the wireless network into a multi-hop network

tree. The result of the study indicated that TD-DES was efficient for conserving power, but has the disadvantage of introducing latency in the form of more multi-hop events.

REDUCE THE POWER CONSUMED BY THE SENSING NODE:

There is still an opportunity to reduce power consumption by the sensing task by decreasing the coverage area of a particular sensor and the number of sensors used by the application needs to be increased. This method can greatly increase the life of a particular sensor.

SHORTER HIGHER QUALITY LINKS vs. LONGER LOSSY LINKS:

Many network routing algorithms try to send packets to the neighbor node that is closest to the sink node. This seems efficient because fewer hops are required to deliver the packet. The problem occurs when the links to these nodes are loss, meaning they have a high amount of data loss. Unreliability in wireless links can cause energy loss, because packets need to be retransmitted.

Lifetime vs. Sensor firing

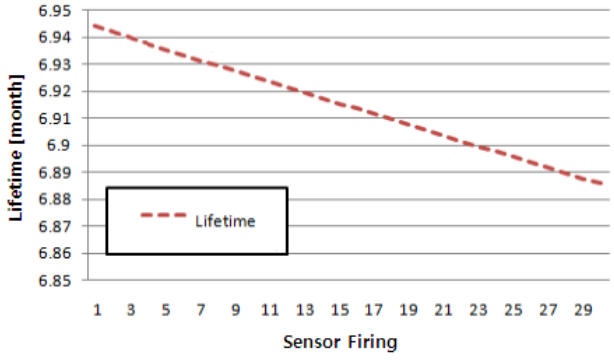

Figure 2: Lifetime vs. sensor firing [4]

Mechanism 2: Cluster based Hierarchical Routing Protocols

Clustering can be defined as a notional arrangement of the active nodes into different groups. The CH (Cluster Head) selection and cluster formation procedures should generate the best possible clusters. WSN clustering [1] scheme to preserve secure communication is ever more important when considering these networks for military applications. Sensor nodes normally apply one-off the power by limited capacity. When node is free and node does not have some data then transmit and receive performed by ideal mode. Cluster head nodes support to control function such as channel access, routing, power control and bandwidth allocation.

The main design goal of clustering due to limited energy, limited capability, network lifetime. All the CH performs the data gathering and check whether other nodes are send data simultaneously or not.

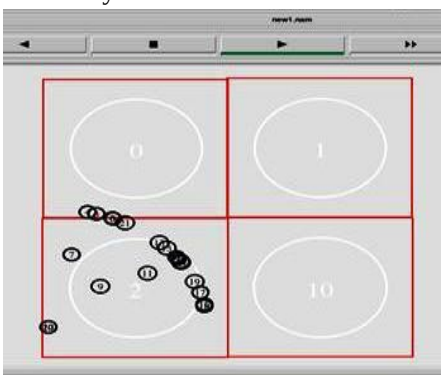

Figure 3[a]: Nodes without clustering [1]

Figure 3[b]: Nodes with clustering [1]

The small circles in the Figure 1 represent the individual wireless nodes in the network and the lines joining the circles show the sequential single hops of the wireless link among the wireless nodes.

If the request is given from the node N i to node N j, N j and to calculate the cost of the path follow:

$$CNjNi = CostNi + MetricNj \quad [1]$$

Hierarchical Protocol –TEEN (Threshold sensitive Energy Efficient sensor Network protocol):

After the groups are formed[1], the cluster head transfers two thresholds to the nodes. These are soft and hard thresholds for sensed characteristic. Hard threshold is the lowest possible value of an attribute to activate a sensor node to change on its transmitter and transmit to the group head. Thus, the hard threshold permits the nodes to transfer only when the sensed characteristic is in the range of interest, thus decreasing the amount of transmissions importantly. Once a node senses a value at or without the hard threshold, it transmits data only when the values of that characteristic changes by an amount greater than or equal to the soft threshold.

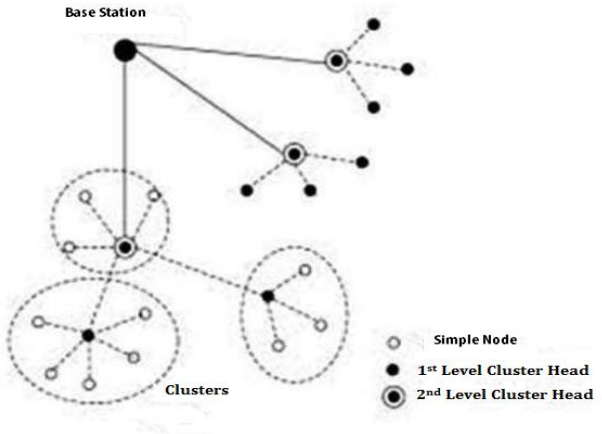

Figure 4: TEEN [1]

Mechanism 3: IEEE 802.11 MAC Protocol

IEEE 802.11 provides two modes of operation for wireless devices:

1. An infrastructure mode

Devices communicate [2] through a central entity called an access point (AP) using the point coordination function (PCF).PCF provides mechanisms for collision-free transmission and devices synchronization with the AP.

2. An ad-hoc mode

Devices communicate [2] with each other directly using the distributed coordination function (DCF). It use back-off algorithm. An IEEE 802.11 device performs the back-off algorithm by randomly selecting a number of time slots to wait and storing this value in a back-off counter. For each time slot where the device senses no activity on the channel, it decrements its back-off counter and transmits a frame when the count reaches zero. If the device DCF Backup Algorithm and Message Transfer detects activity on the channel before the back-off counter reaches zero. it halts the countdown, defers access to the current transmission, and continues the countdown after the channel becomes idle for a DIFS. Devices that successfully receive a data message respond by transmitting and acknowledgment after a short inter frame space (SIFS).IEEE 802.11 defines a SIFS shorter than a DIFS so that other devices do not physically sense an idle channel and cause a collision by transmitting over a control message.

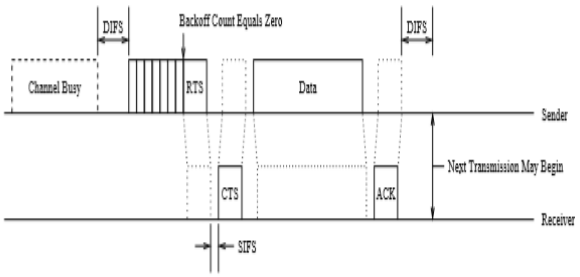

Figure 5: IEEE 802.11[2]

Thus, collision is avoided so that retransmission doesn't require and we can save energy and increase battery life.

Mechanism 4: Energy Efficient Routing Protocols

Routing protocols [3] in WSNs based on data transmission. Limited battery power and bandwidth is main constraints in order to facilitate efficient working of the network, which also reduce lifetime of the network. There are mainly 3 types of routing protocols which used in WSN applications which can be classified in three techniques.

1. Data Centric

2. Hierarchical

3. Location Based

1) Data-Centric Routing Technique.

Large numbers of sensor nodes are deployed over a region which is[3] difficult to identify particular node globally. This led to development of Data Centric Protocol which also known as query based routing technique. In this the base station sends a query to a certain region in the network whose data it requires. And all sensors will also send data which it has sensed through reverse path.

Various protocols of this technique:-

- Sensor Protocols for Information via Negotiation. (SPIN)
- Direct Diffusion
- Rumor Routing
- Active Query forwarding In sensor networks (ACQUIRE)
- Gradient based routing – Routing on fingerprint Gradient in sensor networks (RUGGED)
- An energy efficient ANT based routing algorithm (EEABR)

2) Hierarchical Routing Technique.

Hierarchical routing [3] is the procedure of arranging routers in a hierarchical manner. Hierarchical protocols make an effort to keep local traffic local, that is, they will not forward traffic to the backbone if it is not necessary to reach a destination.

Various protocols of this technique:-

- Low energy adaptive clustering hierarchy (LEACH)
- Power efficient gathering in sensor Information system (PEGASIS)
- Threshold sensitive energy efficient protocols (TEEN)
- Energy Aware routing Protocol (EAP)
- Ring based Energy Adaptive Protocol (REAP)

3) Location Based Routing Technique.

Routing algorithms use location information to guide routing discovery and maintenance as well as packet forwarding, thus enabling the best routing to be selected,

reducing energy consumption and optimizing the whole network.

Various protocols of this technique:-

- Geographic Adaptive Fidelity (GAF)
- Minimum Energy Communication Network (MECN)
- Greedy Perimeter Stateless Routing (GPSR)
- Geographic and Energy Aware Routing (GEAR)

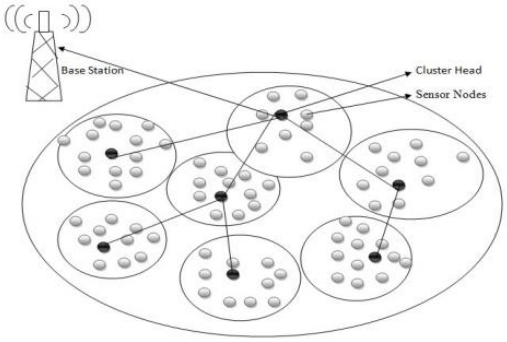

Figure 6: Hierarchical structure [3]

IV. MECHANISMS COMPARISON

Mechanism	Technique	Pros	Cons	Ref.
Energy Management Methods	Smart dust nodes, LEACH protocol, TD-DES protocol	1. Easier, reliable and faster communication 2. Save battery life 3. Event based communication	1. Higher cost 2. Problem occurs in multi-hop communication	4
Cluster based Hierarchical Routing Protocols	Clustering, TEEN protocol	1. Data aggregation 2. Easy to reuse of resources 3.Communication coordination	1. Less secure 2. More time consuming	1
IEEE 802.11 MAC Protocol	PCF, DCF, Back-off algorithm.	1. Avoid collision 2. Improve Accuracy	1.Least time efficient	2
Energy Efficient Routing Protocols	Data-centric, Hierarchical, Location Based	1. It provide unique identity to each node 2. Prevent collision 3. Use to trace sensor as per location 4. Time saving and save energy	1. Not cost friendly 2. If one sensor fails, may network also shatter 3. Complex to establish	3

Table I: Comparison of Energy Management Mechanisms for WSNs

Table I express different methods of energy management methods of WSNs with techniques, pros and cons. After studding many methods of energy management in WSNs, we found that routing takes much energy for complete transmission, So that we are in chain to develop method or mechanism that can save energy and time during routing.

V. CONCLUSION

One of the main challenges in the WSNs is energy efficiency, due to the constant insufficient energy resources of sensors. The ultimate objective behind the routing mechanism design is to keep the sensors operating for as long as possible, thus extending the network lifetime. The energy consumption of the sensors is dominated by data transmission. Energy efficient routing is not only limited to time it takes for complete transmission but this directly affect lifetime of sensor node. Therefore, routing mechanism designed for WSNs should be as energy efficient as possible to expand the lifetime of individual sensors, and hence the network lifetime.

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