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A Review on Secured and Energy- Efficient Routing Protocols in Wireless Sensor Networks (WSNs)

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***Abstract*:- In wireless sensor networks (WSNs), the energy supply of sensor devices is limited. One of the basic architecture problems in WSNs is sensor dies due to dissipating battery capacity. As a result, it is argued that energy conservation is the most significant criterion for any protocol built for WSNs. Thousands of lightweight, inexpensive sensors can be randomly distributed in open and harsh environments to gather data in Wireless Sensor Networks (WSNs). The low battery life of battery-operated sensors, as well as hostile conditions, require the development of energy-efficient, secure and reliable sensor network protocols. Routing, out of the broad range of network protocols, is the most critical in terms of energy consumption, as data transmission absorbs 70% of total energy in WSNs. As a result, energy-efficient routing systems must be built in order to save energy and increase the network's lifespan. However, resource-limited sensors, the lack of a global solution scheme and the application-specific nature of WSNs pose a challenge to routing. Furthermore, security is yet another critical problem in WSNs, as sensors are typically installed in insecure areas and susceptible to security attacks. Many of the current routing protocols have various security measures in place to meet security objectives. We present a brief review on various secure and energy-efficient routing protocols in wireless sensor networks, outlining their underlying principle and operations.**

Keywords:- Wireless Sensor Networks- Routing Protocols- Energy Efficient Protocols - Review

1. INTRODUCTION

A number of sensor nodes, such as temperature, pressures, humidity, motion and sound, compose Wireless Sensor networks [1], which regulate physical phenomena. This sensors are basic computing devices with limited computing power, memory and transmission ability. WSN will include thousands of such lightweight, inexpensive sensors that are randomly installed in open, vulnerable and harsh environments for prolonged periods of time to collect data. These nodes either continuously or regularly relay the collected information to the base station (BS) through an optimized radio transmitter.In WSNs, the nodes depend on each other to supply their packets to the target node. A routing protocol is used to find the route between the source and the destination node to carry out this operation. In introducing a protocol for WSNs, the most significant restriction is low power consumption. Of course it is not effective to locate routes in WSNs using conventional routing protocols and can lead to sensor catastrophes. The process of transferring packets from sensor to sensor requires significant energy to collect and transfer packets. There is also no best performance when depending on one means of delivering packets. The advance of wireless technology improves the ubiquity of sensor networks and poses more obstacles in the design and application of the WSN. For several WSN applications such as industrial controls, efficiency, life and costs are three major design considerations[20]. Reliability and lifespan for the consumers are among these qualities. Cost is not yet a priority for consumers without delivering options for lifetime and reliability problems. Therefore, a successful trade-of between those two attributes is one of the principal design priorities of many WSN applications. In this paper the impacts of energy consumption and safety issues play an important role in the design of routing protocols are also examined. The value of protocols as a core mechanism for WSN's service unfortunately attracts the attention of opponents to the purpose of breaching the network. This makes it impossible for sensors to effectively and fairly safely distribute and route packets by their limited resources. Early battery exhaustion that substantially deactivates those sensors affects network topology and lowers output (e.g., reducing throughput or disconnecting nodes if the network is partitioned). The time taken for the battery energy of the first node to run out [2], that is, the node dies, is a common description of the lifetime of WSN.

It is strongly recommended that you use multiple paths between source and target nodes instead of depending on a single route, in order to increase the WSN reliability, fault toleration, stability, quality of service (QoS) and throughput[3]. There are therefore numerous multiday routing protocols that researchers[3,4] proposed for the detection of routes between two WSN nodes. In addition, multipath routing protocols avoid denial-of-service attacks and can defend the network availability against malicious or faulty nodes, enhancing network security.

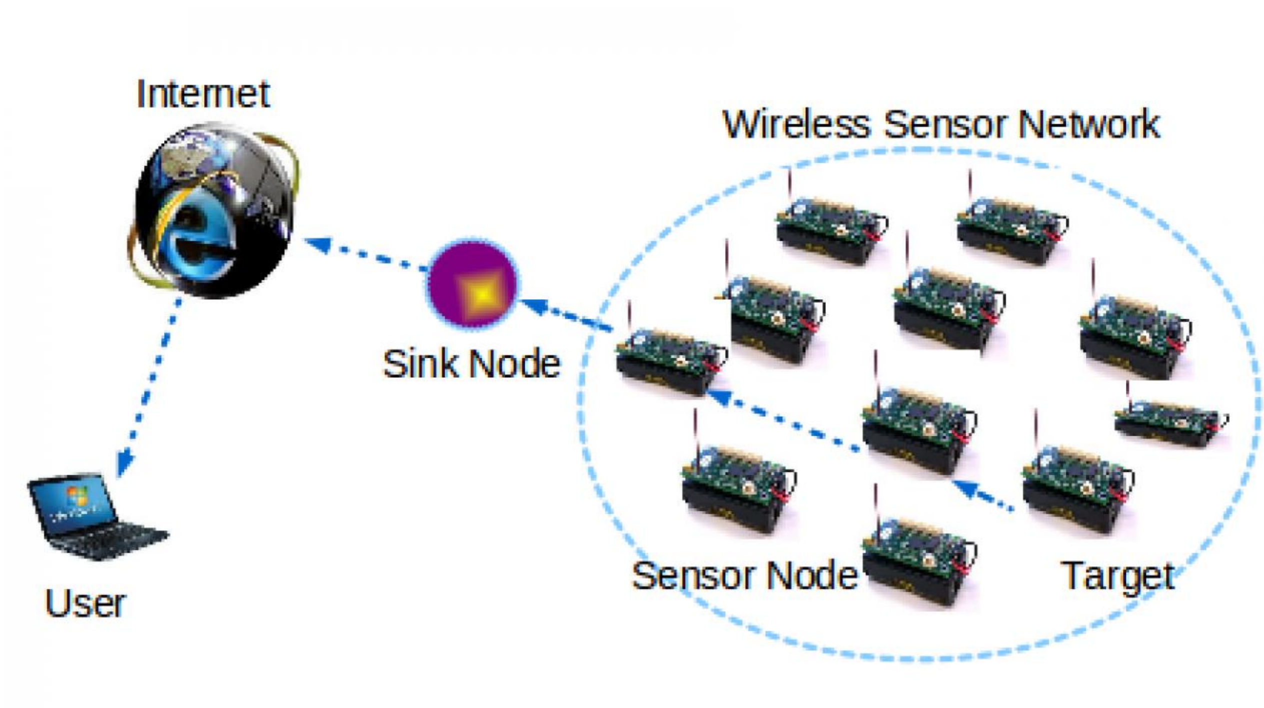

Figure 1:Architecture OF WSN

Due to the severe energy constraints of large numbers of densely deployed sensor nodes, the implementation of different network control and management functions such as synchronization, node localization, and network security requires a network protocol suite. There are several shortcomings in the traditional routing protocols when applied to WSNs, mainly due to such networks' energy-restricted nature [4]. For example, flooding is a technique in which a given node transmits the data and control packets it has received to the rest of the network nodes.

This process is repeated until it reaches the destination node. Note that the energy constraints imposed by WSNs are not taken into account in this technique. Consequently, it leads to implosion and overlap [2] when used for data routing in WSNs. Because flooding is a blind technique, duplicated packets can keep the network in circulation, and sensors will receive those duplicated packets, causing a problem with the implosion. When two sensors sense the same region and simultaneously transmit their sensed data, their neighbors will receive duplicated packets. Another technique known as gossiping can be applied to overcome the shortcomings of flooding [8]. A sensor would randomly select one of its neighbors when gossiping, receiving a packet, and sending it. The same process is repeated until all the sensors receive this packet. Using gossip, only one copy of the packet being sent would be received by a given sensor. There is a significant delay for a packet to reach all sensors in a network, while gossiping addresses the problem of implosion.

2. RELATED STUDIES

The emerging research areas and energy aware routing environment in WSN are explained in this section. In the following subsections, a detailed note on these points is given.

2.1 Emerging Research Areas in Wireless Sensor Networks.

In the late 1990s, the IEEE 802.11 subcommittee invented the word "ad hoc network." Any of the issues that affect wireless communication networks have been handed on to ad hoc networks, such as unreliable time in differing asymmetric channels, poorly defined coverage limits, lossy connections, and so on. Furthermore, in an ad hoc network environment, location recognition, multihop settings, rapidly shifting topologies, node, and channel vulnerability problems all contribute to this convoluted portfolio, lengthening the list of tribulations. As a consequence of the above variations, algorithms built for wireless networks and ad hoc networks are incompatible with WSNs and need customization and enhancement. Because of the above factors, basic wireless protocols cannot be implemented by ad hoc networks without customization.

2.2 Key Challenges in WSN

Since it is not practical to upgrade or recharge the batteries of thousands of SNs deployed in a remote region, optimizing the lifespan of sensors is a major challenge in WSNs. As a result, energy-saving mechanisms must be incorporated in all SN computing and communication protocols. Through reducing data duplication and transmission overheads, data consolidation and routing are two main strategies that can significantly minimize energy usage in WSNs. Routing protocols play a major role in energy usage since data transmission accounts for 70% of overall energy dissipation in a sensor network [5]. One of the reasons for the comprehensive research and development of energy-efficient routing protocols in WSNs is to resolve this problem.

In reality, designing communication protocols for WSNs poses a variety of obstacles and roadblocks. They are as follows:i) Power factors ii) Limited functional capabilities iii) Environmental factorsiv) Topology management complexity v) Transmission channel factors vi) Scalability concerns

Similarly, wireless sensor networks have certain variations from their predecessor, the ANET (ad hoc network), such as densely and randomly deployed nodes, lengthy stretches of unattended service, and other resource constraints. Also in WSN, in addition to most of the above said issues, localization, network partitioning, calibration, network partitioning, network partitioning, aggregationand dissemination, self-organizing and coverage issues, , scalability, load balancing, self-administration, node clustering, end-to-end delay constraint routing, topology management, security and privacy, heterogeneityand other energy, memory, power, and bandwidth constraints are the active challenges. In the closer view, the scheduling of nodes, the issue of gaps, preventing and dealing with void node regions, the loss of nodes, and the associated QoS factors are subject to a high concentration of researchers [59]. The entire network ingredients, their communication, and functionalities are divided into five different layers model, which is a combination of OSI seven layers and four layers of TCP/IP layers models [60]. From sensing to receiving at base station (BS), through communication and processing, the entire network ingredients, their interaction, and functionalities are divided into five different layers model. Each layer has a long list of functionalities and issues to focus on in order to improve their efficiency and produce the best results.

Table 1demonstrates the five working layers of WSN and their related issues. In addition to this five-layer architecture, intermediate or cross-layer problems often play a significant role in successful network performance. Each of the above layers has its main inseparable role in network functionality, ranging from physical environmental sensing to the generation of sufficient binary bit streams, from end-to-end link reliability to error detection and correction, from node addressing to packet routing, from medium access to stable and protected transmission, from signal generation to modulation and multiplexing.

Layer	Issues
Physical layer [6,7]	Frequency selection/carrier frequency generation, modulation anddemodulation, data encryption, channel coding/modeling, , wave propagation, signal detection, spread spectrum communication, antenna sensitivity and transceiver design , packet transmission andsynchronization, multiplexing/demultiplexing, channel coding.
Link/MAC layer [8-10]	Hidden node problem, error control, medium access, congestion control, radio transmission power control, network security, link quality estimation, bandwidth utilization, time synchronization, localization and positioning, scalability, naming and addressing, topology control
Network layer [8, 11-14]	Route discovery, neighbor discovery, reroute discovery, forwarding node selection, void bridging, network security, node operational lifetime, energy efficient cluster designing, energy conservation, throughput improvement
Transport layer [15,16]	End-to-end retransmission based error control, sink-to-sensortransport reliability, event-to-sink transport reliability, congestion control, effect of mobility on routestability, transmission power control
Application layer [17-19]	Physical topology utilization, Generate and execute query in various structures in flat or clustered networks for data aggregation and data generation

Table 1: Layers and its Issues

2.2 Energy Aware Routing Environment in Wireless Sensor Networks

Both conceptual ingredients of these networks are interrelated and necessary for secure, safe, efficient, successful and effective connectivity between the communicating nodes of close or far-reaching networks. Both these logical elements are weighed, finished and used at the node. In addition, the wireless sensor network incorporates wireless connectivity, sensor and networking systems synergistically. In addition to the other legacy issues of the network, the induction of ideas in WSN is constrained by its stringent restriction factors of computing capacity, memory and bandwidth, as stated in the previous section.In addition, node energy in the WSN domain is another constraint. The cause of the overwhelming problem is the unattended deployment of WS nodes with the general battery activity. Battery refill is almost unlikely since the nodes of most systems are unavailable and remotely deployed. As the node energy is the key factor involved in the execution of any task relevant to this problem, any solution proposed in any part of the WSN domain takes this very factor in mind. Sensing, computing, receiving and distributing are all tasks done in / by the WS node. Transmission on the MAC layer only requires protected media access, while transmission is the roundabout of routing and is the heart of the network layer on the network layer. Increased contact distance and greater packet size add higher transmission energy costs. Accordingly, considering the significance of all functionalities of other layers, the position of the network layer among other four layers is highlighted. In view of all of the above, attempts are made and ideas floated to preserve useful constraints energy in this layer by means of minimal transmission, intelligent transmission mechanism for selection of node, stateless trajectory seekingand conservation of path, reroute algorithms etc.

Reducing the transferred size of the packet using data fusion and data aggregation methods constitutes a further effort for the network layer energy conservation. The main factors of the network layer which affect routing and must be taken into account in the design of the routing algorithm are for further consideration are broadcasting, probe messaging, beacon message exchange, route discovery, reroute discovery, forwarding node selection, avoid bridging strategies routing table and frequent updating of neighbor table. Cluster architecture, Cluster heading placement, Cluster head rotation, Cluster overhaul, CH selection forward, Node level calculation/processing, etc. are the main factors for clustered network. For a mobile ad hoc network, it would be more difficult to talk about energy in the above-mentioned routing elements, and to incorporate other complex considerations such as the dynamic topology. In the last study, routing protocols which take into account these factors are important for the lifetimeof the network.

3. ROUTING PROTOCOLS

The following section deals with the various routing protocols, its mechanism, merits and demerits.

3.1 Simple Energy Efficient Routing Protocol (SEER)

This protocol uses hop-count, the residual energy of SNs and the interval between SN and BS to achieve energy efficiency[20]. The source node is used to start a base routing algorithm and to achieve energy savings across a uniform network. The authors note that if the sensors are spread equally and the BS is located in the middle of the network, a reasonable degree of energy efficiency can be obtained. This reveals that the protocol is not appropriate for WSNs arbitrarily used.

3.2 Energy Efficient Dynamic Source Routing (E2DSR):

E2DSR is based on a Dynamic Source Routing protocol which uses the current control packet structure [21]. The Dynamic Source Routing protocol is based on E2DSR. In addition, the protocol alters sensor node routing habits, generates a new 'energy table' and creates a new algorithm for caching paths and selection. E2DSR uses a basic discovery method on demand using tiny routing tables to calculate a path priority. However, the protocol can manage resource consumption between various nodes in the network, but it also requires overheads for storage and connectivity.

3.3 Energy-efficient Asynchronous low Duty-Cycle Routing (E-ADCR):

It is paired with an asynchronous, blind and opportunistic MAC protocol running at a low-duty period [22] and E-ADCR is an important flood-based routing protocol. While the E-ADCR protocol allows the shortest possible use of simplicity and usefulness, it is not ideal for mission-critical applications in WSNs. In comparison, the flood-based process absorbs a large amount of node power and thus contributes to fast network partitions.

3.4 Improved Ad-hoc On-Demand Distance Vector (IAODV):

The IAODV protocol has been proposed to reduce the number of RREQ packets based on an existing location-aided routing (LAR) protocol[23]. Through applying the LAR control routing lookup technique, the protocol restricts the search field. The algorithm also uses a path selection function to maximize energy consumption and extend the length of the network. The benefits of the single-way protocols are their flexibility, scalability, structure-related reliability, capacity efficiency and their sensitivity to large networks. However, due to the flood-based path discovery process it causes delays and requires a large amount of energy to transfer data packets.Therefore, one-way routing on a basis is less energy efficient than location-based routing protocols and hierarchical protocols.

3.5 Linked Cluster Algorithm (LCA):

LCA is an early wireless network routing algorithm [24,25]. This process of clustering is split in five steps. The first stage is topology sensing, with each node using a probe message to discover its neighbors. A sample message is the message broadcast from each node. It is a defect tolerant and offers optimum network access and mobility for nodes that benefit from the LCA protocol. The protocol is not energy efficient, however, and low energy nodes can be chosen as CHs.

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3.6 Threshold sensitive Energy Efficient Sensor Network protocol (TEEN):

TEEN is the first protocol developed for temperature sensing applications for reactive networks[26]. There are two more limits. Next, the node sensing this value needs to turn the transmitter on and record the absolute value of the sensed attribute above a hard threshold (ht). Second, when the sensed attribute value is greater than the soft threshold (ST), the node turns on and record the sensed data. The node is switched on and off. A node can only record data if the sensed value approaches HT, or if it exceeds ST. The key limitations of this arrangement are: I it cannot be implemented in real time, and (ii) realistic execution needs to ensure that no cluster collisions occur. This dilemma can be avoided by using the TDMA schedules, but the reporting of vital data would be delayed[27].

3.7 Low Energy Adaptive Clustering Hierarchy (LEACH):

Low Energy Adaptive Clustering Hierarchy (LEACH) is a clustering protocol that constructs clusters based on signal intensity and utilizes cluster heads to communicate with stations in the base[28]. LEACH is a complementary clustering mechanism. LEACH's key constraint is the probabilistic option of cluster head. Therefore, the option of a low-energy node as a CH is more possible. The entire cluster becoming inefficient until this node runs out of control.

3.8 Power-Efficient Gathering in Sensor Information Systems (PEGASIS):

PEGASIS is an energy dissipation chain protocol that expands the network's existence by allowing nodes that only connect with nearer neighbors[29]. Each node is presumed to know all other nodes' location information.

3.9 Hybrid Energy-efficient Distributed (HEED) Algorithm:

HEED is an algorithm spread that takes energy and coordination costs into account when choosing CHs [30]. HEED is a balanced clustering system that is energy efficient. It also offers a stable and flexible environment. The protocol has one drawback: several iterations will lead to additional charges. In comparison, the HEED Protocol does not fix the fault-tolerance dilemma either.

3.10 Maximum Energy Cluster Head (MECH):

As TEEN and PEGASIS do, it is proposed to boost the efficiency of LEACH's Maximum Energy Cluster Head (MECH) routing protocol [31] MECH builds clusters based on the number and propagation spectrum of clusters. In a given transmission range, MECH guarantees that there is not more than one cluster head. This protocol is limited mainly by allowing the initial CH selection process to choose a low energy node.

3.11.Power Efficient and Adaptive Clustering Hierarchy (PEACH):

By utilizing the over heading functionality of wireless networking, the PEACH protocol forms cluster without any extra overhead [32]. With adaptive multi-level clustering and lowered overhead transmission costs, PEACH increases the network life and energy usage greatly. However, all network SNs are considered to be similarly appropriate by the protocol. PEACH cannot however be matched to heterogeneous WSNs.

3.12 Broadcasting

Radiocasting is the serious rivalry of energy-aware routing; this is a crucial component of most of the routing features such as the formation of the clusters, the cluster head preference, the cluster head rotation and route setting. Given its central value, proposals are floated and strategies suggested for minimizing the broadcasting of messages[33] and for the sharing of light messages[34]. The research community appreciates a routing algorithm with minimal diffusion in the strict energy factor setting. The broadcast's straightforward solution is blind flooding[35] where each node is forced to retransmit the packet after the packet has first been sent. Blind floods produce several transmissions that are redundant. These redundant sending may create the problem of a broadcast storm[36], a problem in which the congestion and contention created by redundant packets.

3.13 Forwarding Node Selection

The node which makes it possible for a node to exchange its packet with other nodes in a network or the base station shall be called the forwarding node, which is called the forwarding node selection process. The required resources and special concentration resulting in increased energy consumption and, hence, a lower energy utilization of the routing protocol are provided for an accurate, precise forwarding node collection. The selection parameters for transmitting nodes are variable for the intended use, however, as energy is the stringent restriction factor in the wireless sensor network, energy conservation should be considered. In comparison, the competing selection parameters often need better tradeoff[38]. For eg, time and distance to destination (BS) are competing factors in the sense of real-time application energy[39]. His literary rich article was submitted by Wu and Lou [37]. This article reflects on the joint effects of the node radio transmittal and propagation in the creation of protocols for narrow networks.

3.14 Route Discovery

The ultimate aim of a wireless network sensor routing protocol is to relay the sensed/generated data to the sink node from the source node. These transient nodes are best chosen to collect on a better path to the base station. The typical characteristics of a desirable and efficient path are less energy consumption, less end-to- end delays, less length of path (hop number or distance), less transient nodes, increased benefit for output assessment or the combination of these [40-42].

3.15 Reroute Discovery.

Reroute Discovery is an expansion of the method of path searching. Death or node defect may cause the defined route to be breached which can result in network partitioning. Therefore, the new direction must be found. This path setting up process is called the exploration of the road, which was started by breaking the existing path. This method is essentially the same as that of path exploration, which was addressed with a variation in the original cause in the previous paragraph. In addition, choosing the forwarding node is an indistinguishable feature of route finding. If a node is death, it is a phase of redirect exploration that restores the disconnected path. In contrast to a static ad hoc network [43] this routine failure solution is more frequently required in the mobile ad hoc network (MANET)[44].

3.16 Network Clustering

Clustering is the unified feature of clustering nodes. The nodes can be independent if one node is known to be the head and other nodes are regarded as members. The category is referred to as a grouping. The appointed head is referred to as the cluster head (CH) and other members are referred to as cluster members (CM). The node not yet included in either cluster is referred to as the undecided node. The clustered architectural network is supported by energy efficiency. A well located Cluster head, a gateway and a high energy supply, plays an important part in solving the target [45] in this sort of network. The distributed network architecture is known as the most energy-efficient because of its fast route exploration, data aggregate, defect tolerance and final latency. The clustered grid architecture has proven energy conscious routing, but in particular in the phase of cluster construction it needs to be strengthened in the energy usage. The selection of CH and its members is based on two approaches. One is the decision taken centrally at the base station, called the central cluster design[46]. The other alternative is distributed, after knowledge transfers between neighboring nodes, before the distributed cluster designing [47] has been chosen for CH with its members.

4. CONCLUSION AND FUTURE WORK:

Since limited battery power is the main source of energy in WSNs, it is highly recommended that WSN protocols should function in an efficient way in order to extend the lifetime as much as possible. Energy is highly affected when both security mechanism and multi-path routing are combined together. Hence, designing lightweight and robust security protocols is a challenging task. Due to the complexity and variety of security solutions, it is not possible to design a single solution that can achieve all security goals. Rather, depending on the applications, security measures have to be carefully chosen to maintain a balance between the security level and minimal utilization of available resources.

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