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WSN Genetic Algorithm for Energy Dissipation

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ABSTRACT: Wireless sensor networks have been a popular research topic in recent years due to their potential applications in many fields. Throughput, delay, and power efficiency are often mutually exclusive. This study aims to determine the highest achievable throughput and latency for a variety of network topologies and receiver architectures, as well as the ideal network configurations for achieving these metrics. Wireless sensor networks are a special subset of the broader class of wireless data communication networks after they have been set up in the right way. The standard components of a WSN node are a sensor, CPU, memory, transmitter, and receiver. These sensor nodes often operate in teams to achieve a common objective, with each node using its own battery. Sensor networks are crucial for the collection of data needed by smart environments such as automated homes, utilities, industries, transit systems, buildings, and more. This explore the basic WSN and Genetic Algorithm for Energy Dissipation.

KEYWORDS: WSN, Genetic Algorithm, Energy Dissipation

I. INTRODUCTION

Because of their potential use in a variety of settings, including the military, the environment, and more, wireless sensor networks have emerged as a vibrant area of study in recent years. In most cases, there will be a compromise between throughput, latency, and energy efficiency. The goal of this research is to identify the optimal network configurations that achieve the desired throughput, latency, and energy consumption, as well as the maximum throughput that is possible under different network configurations and receiver structures. When properly configured, wireless sensor networks create a unique subset of the larger category of wireless data communication networks. Traditional WSN nodes include a sensor, embedded processor, sufficient memory, and transmitter and receiver circuitry. Most of the time, these sensor nodes work together to accomplish a group goal while being powered by individual batteries. In order to collect the data required by smart environments, such as automated buildings, utilities, industries, homes, ships, and transportation systems, sensor networks are indispensable. Fast, simple, and low-maintenance connectivity in a Sensor Network is essential.There has been an uptick in the deployment of wireless sensor networks in the real world [2]. Future prospects for the technology appear bright in two areas [3]. First, in a few years' time, more robust wireless sensor devices will be widely available, and wireless sensor networks will be applicable in an infinite variety of scenarios, thanks to their ability to withstand traffic loads that are currently impossible, to perform more calculations, to store more data, and to remain operational for longer thanks to improved energy sources. Second, the inverse scenario is also conceivable in the future. Forced, nanotechnology-made wireless sensor devices will open up a whole new realm of possibilities for use, as they will be able to function in conditions that are currently unthinkable. Researchers are always on the lookout for new, interesting problems to solve, and these two scenarios present them with exactly that. One of the primary functions of a WSN is to gather environmental data and transmit it to a reporting site where it can be monitored and analysed. Microelectronics and recent improvements in sensor technology have combined to make possible a new kind of communication network consisting of battery-operated integrated wireless sensor devices. Most currently available Wireless Sensor systems are very self-aware in terms of compute, memory, power, and communication capacities [3] owing to economic and technical reasons. Because of this, most studies on WSNs have concentrated on developing low-power algorithms and protocols for monitoring and reporting data, and the range of possible uses for these networks has been severely limited.In order for a network to function, Medium Access Control (MAC) is used. In recent years, research towards Medium Access Control for WSNs has flourished. Due to the nature

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of sensor networks operating on battery power, traditional wireless MAC protocols like IEEE 802.11 are not a good fit. It's not only prohibitively costly, but also usually impossible, to recharge these sensor nodes.

1.1 Energy related Issues

The following are examples of energy-related concerns that must be taken into account by MAC sub-layer protocols for WSNs:

Collisions: Collisions occur when two nodes attempt to communicate at the same moment. It may be necessary to retransmit the data if any of the packets get corrupted. Therefore, a lot of resources are squandered as noise during transmission and reception. Avoiding collisions is preferable since doing so saves resources that would otherwise go into retransmitting frames that were lost due to the collision.

Overhead: The Control Packet Overhead is an additional serious issue. There is no actual data from the programme in these Control Packets, but they are necessary for the transmission to work. There is extra effort for the sensor network caused by sending and receiving these messages. It's important to minimise the use of control messages and lengthy frame headers since they increase the cost of transmission.

Overhearing: Furthermore, a sensor node may pick up packets that were not meant for it due to overhearing. The radio on this node might have been switched off to save power. A node's resources are used up due to overhearing since it is continually listening and decoding frames that are not intended for it. This occurs because the nodes in the network cannot tell beforehand which broadcasts are intended for them while utilising a shared medium.

Idle listening: When there is no traffic on a network, the nodes nevertheless need energy to keep their receivers on and active, a process known as "idle listening." Particularly with WSNs, when nodes only utilise the channel occasionally, this is of paramount importance. Power management strategies for nodes in WSNs are crucial. Putting the radio into sleep mode helps reduce the issue of idle listening in wireless networks.

Complexity: The complexity of a system is measured by the number of resources needed to execute elaborate protocols and algorithms. WSNs aim for simplicity as one of their primary design objectives.

1.2 WSN Medium Access Control Protocols

In recent years, many medium accesses control (MAC) protocols have been proposed for use in wireless sensor networks. The majority of these frameworks aim to secure energy supplies. However, the sensor nodes' energy consumption patterns are context-specific.We may classify the suggested MAC methods for WSNs into two broad categories: Contention-based and Schedule-based. By allocating certain times for transmission and reception, schedule-based protocols reduce the likelihood of collisions, overhearing, and idle listening; nonetheless, they have stringent time synchronisation requirements.In contrast, contention-based protocols ease time synchronisation requirements and may readily adapt to topology changes, such as the addition of new nodes and the loss of others, even years after initial deployment. The costs of message collisions, overhearing, and idle listening are greater in protocols that use the Carrier Sense Multiple Access (CSMA) approach.

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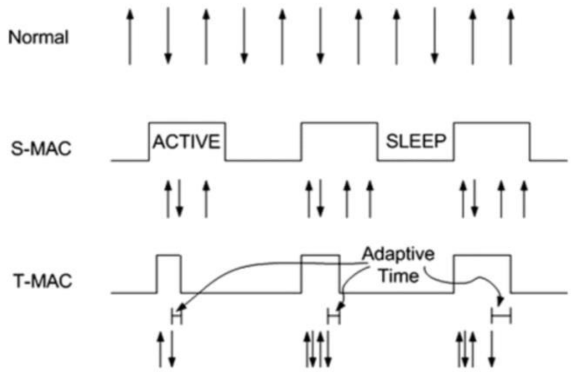

Figure 1. The S-MAC and T-MAC Protocols

Early WSN implementations often made use of IEEE 802.11 DCF (Distributed Coordination Function), a contention-based MAC protocol based on the MACAW.Overhearing, idle listening, control packet head, and collision avoidance are only some of the concerns that are discussed in this part, along with a variety of energy-efficient MAC protocols for WSNs and their respective contributions to these problems. Recently, MAC for WSNs has become a hotbed of academic activity.

1.3 Genetic Algorithm

In engineering, genetic algorithms (GAs) have yielded many useful outcomes as a metaheuristic optimization technique. Selection, crossover, and mutation are the three main genetic operators on which this structured yet random search technique relies [19, 20]. So, let's take a look at some of the genetic algorithm jargon.

Chromosomes. Chromosomes are the name given to the first set of ideas for how to solve the issue. The components of chromosomes are known as genes or alleles, and they should all be the same length.

The Fitness Purpose. Higher-value chromosomes, as measured by the fitness function, will tend to have more successful offspring. In this paper, the fitness value is calculated by adding together a number of different factors according to a specified formula.

Selection. In genetics, it is the fundamental operator responsible for passing on advantageous chromosomes to future generations. Roulette wheel, rank, steady state, and elitism are just some of the selection methods available. Any one of several selection methods may be used, as needed.

Crossover. With the help of crossover, chromosomes from two parents are chosen, causing them to exchange segments of their genetic material and giving rise to the offspring's chromosomes.

$$\begin{array}{l} \text{Chromosome 1 } \ldots 100000 \mid 001000 \ldots \\ \text{Chromosome 2 } \ldots 000100 \mid 000001 \ldots \\ \text{Off-spring 1 } \ldots 100000 \mid 000001 \ldots \\ \text{Off-spring 2 } \ldots 000100 \mid 001000 \ldots . \end{array}$$

Mutation. The chromosomes may be subjected to the mutation operator after the crossover has taken place. It stops the GA method from converging too quickly. Instead of looking for the best solutions already available, it is utilised to find new ones.

$$\begin{array}{l} \ldots 10001000 \ldots \\ \downarrow \text{mutation} \\ \ldots 00010001 \ldots . \end{array}$$

Since mutation may substantially alter the fitness value of a solution, it is utilised less often than selection and the crossover operator [19]. Since include the more sophisticated genetic operators may make the suggested algorithm more difficult to implement, they were left out of the design.

II. RESEARCH BACKGROUND

Singh & Sharma (2018),Improving the stable period and total lifespan of wireless sensor networks requires addressing the energy consumption of sensors through radio transmission, which is a major design challenge. The radio transmission used by sensors drains their limited battery life far faster than the actual sensing itself. Increasing the network's efficiency with less energy consumption is a prominent use of clustering algorithms. However, the networks become energy-heterogeneous over time due to the varying transmission distances for different static sensors in both inter-cluster and intra-cluster communications in clustering algorithms, which can reduce the stable period and lifetime of the network if data transmission is not handled carefully. In order to extend the lifetime of the network as a whole, the authors of this paper propose a novel Genetic-Algorithm-Based Energy-Efficient Clustering (GAEEC) method, which employs the genetic algorithm twice with different parameters and operators to perform static and optimal clustering, and which then enhances the cluster head election by selecting one of the best cluster heads in each cluster while taking into account the current remaining energy and the overall transmission cost. Simulations have been used to evaluate the proposed and implemented protocol's performance in contrast to the state-of-the-art algorithm LEACH in terms of stability period, throughput, energy dissipation, and the number of active nodes. The simulation findings demonstrate that GAEEC outperforms LEACH in terms of stable region length, throughput, and energy conservation.

Sharma et al. (2019),Wireless sensor networks (WSNs) have emerged as a promising new communication technology due to the proliferation of their many uses in recent years. Various environmental risks may be predicted with the use of sensors put in harsh and deserted places, allowing for necessary safety precautions to be implemented in advance of their occurrence. These sensor nodes have little power and few resources to work with. As time goes on, the sensor nodes' batteries will eventually die, bringing down the whole system. Accordingly, WSNs' key priority is their energy efficient performance. As a powerful topology control method, clustering a wireless sensor network appears as a viable solution to these two problems. The network is "clustered" into discrete, non-overlapping subsets. The cluster's head node is responsible for communicating the cluster's findings to the sink, and is hence a highly privileged position. As a result, it facilitates the reduction of energy loss at the remaining nodes. This paper explores the significant role that various metaheuristic approaches, and their hybrids, play in the development of energy-aware clustering algorithms. In addition, this research proposes a clustering strategy that makes little use of energy resources.

Yadav et al. (2022),There are several practical uses for WSNs in areas such as energy management, surveillance, healthcare, military, and environmental tracking. Power constraints with a dedicated battery backup severely constrain WSNs. More energy is used by the sensors because of the great separation between the sensor nodes and the sink. To power a vast network coverage area, the limited energy of sensor nodes is a critical limitation. Therefore, the efficiency and longevity of sensor nodes for WSNs depend heavily on the battery life and position of cluster heads. Convergence-based performance optimization is a popular topic, and this discussion includes a comparison of many techniques, as well as their benefits and drawbacks. High-level security and privacy in WSNs are explained, along with various threats and security objectives. This study provides a comprehensive catalogue of naturalistic WSN evolutionary methods. This study also hopes to provoke thought on the security concerns associated with WSN and to provide practical solutions to these issues.

Dhami et al. (2018),There is a strong emphasis on maximising system lifespan in wireless sensor networks via the use of energy efficiency protocols that reduce the overall energy consumption of the network. In a WSN, rather than relying on a physical media for communication, information is transferred via the placement of nodes. Deployed nodes send information to a "sink" or "destination" node. Clustering is the act of grouping together nodes to facilitate easier communication between them. As part of clustering, nodes in close proximity to one another form compatible clusters, where they share data with the cluster head, who then forwards the aggregated data to the sink. The performance of

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WSN has been improved by the use of a variety of clustering algorithms and methods. In the conventional setup, the node in the middle of the network is chosen as the cluster leader and is the only one allowed to send data. This particular node's excessive energy consumption eventually causes it to fail. Conversely, because it uses a direct path, the route is overloaded, increasing energy use and shortening the network's lifespan. Their proposed method, called Virtual Grid based Dynamic Routes Adjustment (VGDRA), is based on genetic algorithms and is shown to improve the overall performance of wireless sensor networks. The proposed method outperforms LEACH in terms of energy efficiency thanks to its dynamic rather than static nature, its balanced load, and its optimization, which increases the likelihood of a better result with a smaller number of iterations. To test the efficacy of the proposed method, simulations are run in MATLAB.

Mahani et al. (2020),Increased deployment of wireless sensor networks (WSNs) is attracting a lot of interest from a wide variety of fields. With the help of the many sensor nodes that make up WSNs, a single base station (BS) can collect and relay data from all around the network's coverage area.Due to the fact that most sensor nodes have a certain amount of energy to spare while simultaneously transmitting crucial data, it is crucial to improve the lifespan and dependability of WSNs throughout the design phase. As one strategy among several, grouping sensor nodes into clusters has been shown to be useful in lowering WSNs' energy needs and extending their operational lifespan.Using a two-stage Genetic Algorithm, the authors of this work provide a novel procedure for clustering that minimises energy use (GA). Cluster heads (CHs) are first chosen in GA, and then cluster members are picked depending on their proximity to the CHs. When compared to other clustering techniques, the suggested clustering significantly extends the lifespan of WSNs. This improvement is due to the fact that the clustering procedure used here takes into account characteristics that reduce energy consumption.

Ragavan&Ramasamy (2019),Ad-hoc topology in wireless sensor networks makes route optimization, coupled with greater quality of service and minimal energy use, a formidable challenge. In this work, we concentrate on using evolutionary algorithm to create ad hoc topologies. To find the best path, Tabu search is used on top of the current dynamic topology. The use of an elitist mutation operator ensures the best possible routing solution. The goals of the routing protocol proposed in this work are to

(i) improve quality-of-service parameters like reliability and energy constraints by discovering multiple optimised paths, and

(ii) establish a dynamic topology through a metaheuristic search using a genetic algorithm with a mutation operator. Using an optimal route selection approach, the simulation results demonstrate that the proposed protocol improves QoS. It exceeds the standard protocols in terms of data delivery ratio, network longevity, and reliability of transmission and delivery, and it reduces the routing overhead associated with delivering data.

Xiao et al. (2020), Improving the energy efficiency of underwater wireless sensor networks is crucial because of the limited battery energy of underwater wireless sensor nodes and the difficulties of changing or recharging the battery underwater (UWSNs). They propose a new data fusion and GA-based clustering routing system for UWSNs that is energy efficient. The clustering routing protocol involves a CHN collecting data from CMNs, aggregating it using an enhanced back propagation neural network (BPNN), and then sending the combined data to an SN through a multi-hop strategy. By using the improved GA, the most efficient multi-hop transmission path between the CHN and the SN can be determined, which improves transmission efficiency and decreases power consumption. In this study, they introduce the GA that makes use of a tailored encoding scheme, a tailored crossover operation, and a tailored mutation operation. In addition, an optimised momentum method is incorporated into the BPNN used for data fusion, which helps cut down on power consumption by doing away with superfluous data and decreasing the amount of data transferred. They also present a method for selecting CHNs that optimises for both residual energy and node positions. Based on experimental results, they conclude that their proposed protocol offers significant improvements over state-of-the-art solutions in terms of energy efficiency, network lifetime, and packet loss.

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2.1 Literature Review

S. No.	Author/Year	Title	Result
1	Singh, S. P., & Sharma, S. C. (2018).	Genetic-algorithm-based energy-efficient clustering (GAEEC) for homogenous wireless sensor networks	propose a novel Genetic-Algorithm-Based Energy-Efficient Clustering (GAEEC) method, which employs the genetic algorithm twice with different parameters and operators to perform static and optimal clustering, and which then enhances the cluster head election by selecting one of the best cluster heads in each cluster while taking into account the current remaining energy and the overall transmission cost.
2	Sharma, R., Vashisht, V., & Singh, U. (2019)	Nature inspired algorithms for energy efficient clustering in wireless sensor networks.	This paper explores the significant role that various metaheuristic approaches, and their hybrids, play in the development of energy-aware clustering algorithms. In addition, this research proposes a clustering strategy that makes little use of energy resources.
3	Yadav, R., Indu, S., & Gupta, D. (2022).	Review of Evolutionary Algorithms for Energy Efficient and Secure Wireless Sensor Networks.	This study provides a comprehensive catalogue of naturalistic WSN evolutionary methods. This study also hopes to provoke thought on the security concerns associated with WSN and to provide practical solutions to these issues.
4	Dhami, M., Garg, V., & Randhawa, N. S. (2018, November).	Enhanced lifetime with less energy consumption in WSN using genetic algorithm-based approach	The proposed method outperforms LEACH in terms of energy efficiency thanks to its dynamic rather than static nature, its balanced load, and its optimization, which increases the likelihood of a better result with a smaller number of iterations. To test the efficacy of the proposed method, simulations are run in MATLAB.
5	Mahani, A., Farahmand, E., Sheikhpour, S., & Taheri-Chatrudi, N. (2020).	A Novel Energy-Efficient Clustering Protocol Using Two-Stage Genetic Algorithm for Improving the Lifetime of Wireless Sensor Networks	this work provides a novel procedure for clustering that minimises energy use (GA). Cluster heads (CHs) are first chosen in GA, and then cluster members are picked depending on their proximity to the CHs. When compared to other clustering techniques, the suggested clustering significantly extends the lifespan of WSNs. This improvement is due to the fact that the clustering procedure used here takes into account characteristics that reduce energy consumption.

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6	Ragavan, P. S., & Ramasamy, K. (2019).	Optimized routing in wireless sensor networks by establishing dynamic topologies based on genetic algorithm.	The goals of the routing protocol proposed in this work are to (i) improve quality-of-service parameters like reliability and energy constraints by discovering multiple optimised path, and (ii) establish a dynamic topology through a metaheuristic search using a genetic algorithm with a mutation operator.
7	Xiao, X., Huang, H., & Wang, W. (2020).	Underwater wireless sensor networks: An energy-efficient clustering routing protocol based on data fusion and genetic algorithms.	they introduce the GA that makes use of a tailored encoding scheme, a tailored crossover operation, and a tailored mutation operation. In addition, an optimised momentum method is incorporated into the BPNN used for data fusion, which helps cut down on power consumption by doing away with superfluous data and decreasing the amount of data transferred.

III. ENERGY CONSUMPTION IN WSNS

A sensor node's primary function as a microelectronic device is to detect phenomena, process data in real time and locally, and send or receive information. It is common knowledge that a sensor node has four main parts: a power supply, a sensing unit, a computing/processing unit, and a communication unit. There is a fixed amount of power available to the sensor node, and it is not feasible to swap out or replenish the battery. With the exception of the power unit, every other part of the system will need energy to function properly. Research and analysis on WSNs' energy use have been conducted at length.

3.1 Sensing Energy

The sensor and/or actuator built into a node, together with the analogue-to-digital converter, make up the sensing unit. It takes measurements of the environment and translates them into digital signals that may then be analysed by a computer or other processing equipment. The three most power-intensive steps in the sensing process (1) signal sampling from the physical world, (2) signal conditioning, and (3) analogy-to-digital conversionall contribute to the overall energy budget. Depending on the hardware and software being used, the answer will change. For instance, interval sensing uses less power than continuous monitoring does; hence, it may be utilised as a power-saving strategy to decrease unneeded sensing by shutting the nodes off during the idle duty cycles, in addition to developing low-power hardware. Still, switching from a dormant to an active state incurs some additional cost. This causes unnecessary delays and increased energy use. Sensing energy, however, is a negligible component of a WSN's overall power needs. The computer and communication industries account for the bulk of the world's total energy use.

3.2 Computing Energy

The brains of the machine are a microcontroller unit (MCU) or a microprocessor with RAM. It processes data and gives the sensor node insight. The sensing, processing, and communication units are all operated by micro device drivers under the supervision of a real-time micro-operating system running in the computing unit. Both the amount of energy used for switching and the amount of energy lost due to leakage contribute to the total amount of energy used in a computer system. Supply voltage and the total capacitance switched under software control affect the switching energy. The overall cost of computation may be affected by the battery's discharge behaviour. Dynamic voltage scaling (DVS) is one method of reducing computational energy consumption; it dynamically modifies the processor's voltage and frequency to accommodate the ever-changing demands of the application. The term "leakage energy" describes the amount of power used even while no calculations are being made. Because of this, controlling energy loss is essential.

3.3 Computing Energy

A microcontroller unit (MCU) or microprocessor with RAM serves as the central processing unit (CPU). It processes information and offers reasoning power to the sensor node. Micro device drivers in a real-time micro-operating system running in the computing unit manage the on/off states of the sensing/computing/communicating subsystems. Both

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switching and leakage contribute to the total energy consumption of a computer system. The amount of energy required to switch depends on the supply voltage and the total capacitance that is being switched, both of which are calculated by the running programme. How you use the battery's power will change how much it costs to run your computer. Dynamic voltage scaling (DVS), for instance, is a method of reducing computational energy consumption by dynamically adjusting operating voltage and frequency to suit the dynamically changing workload without impairing performance. Leakage energy is the amount of power used even when no calculations are being performed. Reduce the amount of energy lost via leaks.

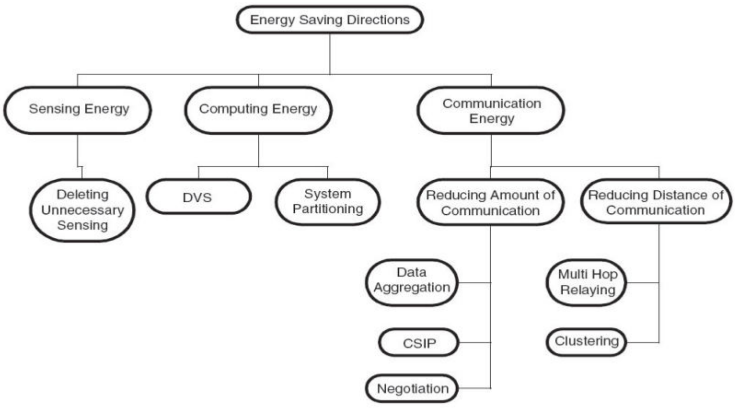

Figure2: Energy-conserving directions in WSNs.

Figure 2 illustrates energy-conserving strategies for improving sensing, computation, and communication power. For example, multi-hop communication and clustering-based hierarchies have been suggested to shorten the distance over which signals must travel. Such methods are very reliant on one another. Eliminating extraneous sensing might minimise data transfer, saving power in the communication process. However, this calls for more complicated control techniques, which in turn may need more energy use for computing. Therefore, trade-offs should be made, and depending on the application case, more weight may be given to one way than another (Dharma et. al., 2011).

3.4 Power Consumption Analysis of 802.11 Basic Mode (ad-hoc)

In this study, we compare the 802.11 protocol's power requirements when operating in ad hoc mode. This protocol was designed with the assumption that all nodes are in radio range of one another. Every device makes an effort to coordinate by broadcasting BEACON packets. During a beacon interval, each node in the neighbourhood will only send out a single BEACON packet. Because we assume no collisions nor collision avoidance, if a node has a packet to transmit and the medium is free for the length of a (DIFS), the node will immediately begin transmitting the packet. Figure 3 illustrates that, with the exception of when they are actively sending data, nodes are always in a receiving state.

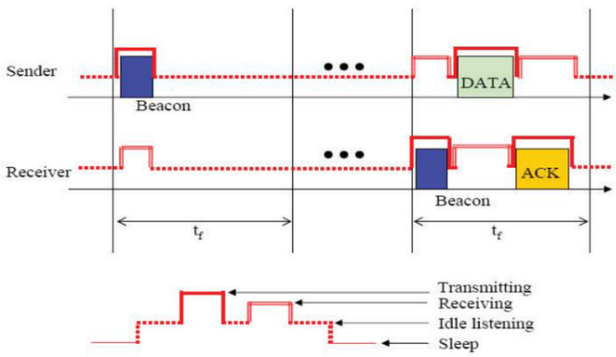

Figure 3: Data exchange in 802.11 in ad-hoc mode

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IV. CONCLUSION AND FUTURE WORK

In recent years, wireless sensor networks have become an increasingly attractive study subject owing to the wide variety of disciplines in which they may find use. It is common for throughput, latency, and power efficiency to be incompatible with one another. This study aims to determine the highest possible throughput and latency for a variety of network topologies and receiver architectures, as well as the ideal network configurations for achieving these metrics. Additionally, the study will determine which topologies and architectures will have the lowest possible latency. After being configured in the appropriate manner, wireless data communication networks fall into a larger category known as wireless data networks, of which wireless sensor networks constitute a unique subset. A sensor, central processing unit (CPU), memory, transmitter, and receiver are the fundamental elements that make up a WSN node. These sensor nodes often work in groups to accomplish a certain goal, and although they all have their own batteries, they all act together. The gathering of data required by smart environments such as automated homes, utilities, industries, transportation systems, buildings, and more is dependent on the use of sensor networks, which are essential to this process. In this, the fundamentals of WSN and the Genetic Algorithm for Energy Dissipation are investigated.

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