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Optimisation of a wireless sensor network using elephant swarms to extend its service life.

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Abstract: Elephant swarm optimisation is used in this study to improve network performance all around by optimising the routeing method, the adaptive radio link, and the balanced TDMA MAC scheduling. In order to include optimisations at the routeing, radio, and MAC levels, the established cross-layer technique has been applied. The routeing and radio link layers have been optimised, and a MAC scheduling programme based on time division multiple access (TDMA) has been established. Experimental studies were conducted to demonstrate the effectiveness of the elephant swarm optimisation technique, and these studies showed improvements in network lifetime, sensor node energy decay rate, throughput active node ratios, and lower communication overhead, among other metrics. The.NET framework was used in the creation of this system, which runs on the SENSORIA wireless simulation platform.

Keywords: Elephant swarm optimisation, time division multiple access (TDMA), sensor node, energy decay rate, throughput active node ratios

Introduction

Effortlessly perform interaction over less coverage with the help of wireless interaction techniques thanks to the efficient and effective solution provided by the rapid and strongly controlled developments in wireless communication system and associated semiconductor technology.These networks and the sensing nodes they use are a significant improvement over the state of the art in terms of both sensing nodes and interaction paradigms. These methods also allow for a more streamlined and productive dialogue. The interaction process with distant or hostile regions is made possible by embedding approaches for interaction in sophisticated nodes or networks. In particular, wireless sensor networks (WSNs) will be built by deploying and assigning a large number of densely deployed nodes in a localised interaction zone. The sensed data from the different nodes must be communicated to the controlling and monitoring base system, which is situated outside of the sensing region, in order to be processed. Using a multi-hop interaction technique, in which the other intermediary nodes operate as a relay node, it may be possible to interact or convey data from the transmitter end to the control or base system. Because of this, data travels via a series of intermediary nodes before reaching the control system. So, it may be said that all intermediary nodes in an interaction system function as transmitters. Each of the sensing nodes in a WSN network is powered either by its own battery or by some other efficient method. However, it is a Herculean operation to replace or fortify the battery sources, since all the interaction nodes have been placed in the remote reaches of the sensing network area.

Therefore, the allotted battery's lifespan should be increased to ensure its continued use and usefulness over a lengthy period of time. When making plans for the longevity of a node, battery life plays a crucial role, and its limitations might lead to changes in the network's structure. Sensing node and, by extension, network lifetime is heavily dependent on battery lifetime. Therefore, the most critical component in providing QoS and an optimised interaction network is the efficient and optimal use of battery. Therefore, optimising and improving a network's lifetime has become a crucial aspect in contemporary and future research scenarios. The suggested study has optimised the interaction system as a whole and increased the longevity of its subjects by mimicking the behaviour of a swarm of elephants. Take into account the different topologies used in WSNs dispersed throughout a certain region, with detector nodes situated near an adequate power supply. Researchers have struggled with how to improve the durability of wireless sensing devices for some time. We were inspired to design wireless sensor networks based on the collective behaviour of elephant swarms. Elephant swarm behaviour, with all its complexity, is integrated using a cross-layer strategy. Improved network performance may be achieved using a combination of the elephant optimisation, adaptive radio link optimisation, and balanced TDMA-MAC scheduling, all of which are covered in this study. We compare the proposed elephant swarm optimisation to two other well-known algorithms, LEACH and PSO. Assuming a WSN interaction topology with nodes spread out over the area's specified interaction coverage, it's safe to assume that all of the nodes involved use the same sort of energy and run on batteries. To achieve greater transmission data rates, a dense distribution of sensing nodes throughout the vast geographical region is prefered. Dense deployments cause a lot of connections to be built and created, which causes interference between the sensing devices. This interference has to be reduced so that the network can function more efficiently. This body of work constitutes:

An "Elephant Based Swarm Optimisation model" has been developed to maximise network performance and reliability. To include the properties and characteristics of elephant swarm optimisation into the system's implementation and optimisation, a cross-layer design method is used. Socio-mammals, like elephants, provide as examples. In a WSN interaction strategy, the power and hence the lifetime of each node plays a crucial role in guaranteeing the service and survival of the network. As a result, the research community must focus on finding ways to improve system design to extend system lifetime. There have been a lot of studies devoted to making WSN nodes last as long as possible. Numerous algorithms, approaches, and protocols based on non-traditional and evolutionary computing schemes have been developed in the present context.

Energy Efficient Routing Protocol

An excess of routing protocols has been designed in WSNs, also might be analyzed, One of the main cause for that kind of an enormous variety of algorithms in WSNs is that those networks are specific to the some application, and a specific routing algorithm will solely fulfill the of WSN application needs. The routing protocols are classified into knowledge centrically-routing, class-conscious-routing, and location-based-routing, and QoS-aware routing

PSO Algorithm

Basically One novel way for determining the most and least important aspects of a computation or technique is known as "optimisation." Which is used in real-time scientific applications like economics, physics, chemistry, social science and engineering, and other fields where optimising efficiency, power, and output is essential. PSO is a well-known method for identifying the parameters and settings that will allow for the most effective optimisation of a given target. First, the concept of swarm intelligence stands apart from the evaluation of swarming characteristics in certain quite natural organisms like ants, birds, honey bees, fish, etc., and second, the specialised study of the evolutionary, biological process computation is usually where this method gets its start. The PSO algorithmic rule computes by continuously preserving a broad range of possible solutions inside the search space. During the computation time of each protocol iteration, the target operation being optimised computes each potential resolution by determining its fitness or threshold. The winner's decision may be quantified as a "particle-flying" from the fitness landscape, revealing the optimal or minimal means to achieve the goal. The PSO algorithm first chose the search space's potential solutions at random. In this case, the objective function is represented by the originating curve, and the search space is a store that contains all potential optimum solutions along the X-axis.

It is also important to note that the PSO algorithm does not have a technique to determine whether or not any of the candidate solutions are near to or distant from a local or global utmost since there is no in-sequence of the basic purpose function. To roughly estimate its candidate explanation, the PSO algorithm uses the purpose function, and then operates on the resulting strength values. Each particle in PSO is responsible for maintaining its own position, which includes its own unique resolution, fitness capability, and speed of movement. In Parallel, this is a recognition of the greatest possible fitness value attained during the whole operation of the mechanism; this value is often referred to as the individual's best fit-ness value and the candidate's outcomes. The fitness value maintained by the PSO mechanism among all particles in a given swarm is known as the global greatest fitness, and the application solution that successfully achieves that exacting fitness or threshold is known as the global greatest candidate solution.

The breakthroughs in WSNs are dependent on hardware innovations, but more on the techniques and processes of wireless networking. Think back to 1997, when the 802.11 standard was being developed as the first of its kind for wireless local area networks. The CSMA/CA methods used to MAC are being optimised for the increased throughput of the 802.11b standard. In addition to the physical and MAC-layers, future WSNs will also need study into wireless network routeing strategies. Some existing routeing algorithms for WSNs square measure the fundamental algorithms of wireless mobile networks and wireless spontaneous networks, respectively. These algorithms, which include DSR and AODV, are not very practical for WSN because of their high energy consumption. As a result, lowering energy consumption is another area with ample room for investigation. WSNs may include revolutionary improvements in the near future. A lot of study has gone into finding ways to extend the life of wireless sensor networks while maintaining high quality of service. In the

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case of a wireless sensor network, the network's expected lifetime plays an especially significant role in guaranteeing the network's quality. Several system designs and protocols have attempted to address the issue of extending the lifetime of individual nodes and networks, but most of these approaches have significant downsides. Very few of these methods have focused on software advancements rather than hardware tweaks. In contrast, real-world evidence suggests that improving software protocols may have a significant impact on raising both the efficiency and quality of the service provided by the system. Although certain methods have shown promise, there is still much room for improvement. Because of the complexity and scale of WSNs, there is an urgent need for a long-term, scalable solution that can keep nodes up and operating at peak performance. Numerous protocols and optimisation strategies are being developed to increase system throughput in spite of the prevalence of traditional procedures. The most cutting-edge practises nowadays are those that factor in natural phenomena and the transmission of characteristics from generation to generation. For optimal system performance, an approach known as evolutionary computing is used. Genetic algorithms (GA), ant colony optimisation (ACO), particle swarm optimisation (PSO), honey bee swarm algorithms, and so on are all examples of bio-inspired evolutionary computer methods. The overall efficiency of the system is improved by using these methods. PSO has shown more success than the other methods. Meanwhile, when compared to other common protocols for improving systems, LEACH has shown greater performance; yet, none of these methods can be guaranteed to provide the end outcome or the optimal design. The author is inspired to consider a further optimal solution by the need for efficient and highly optimised network architecture and the hopeful outlook of evolutionary computing. Based on the distinct and resilient swarm behaviour and characteristic of elephant swarms in nature, the author here opted to use an evolutionary-based computational optimisation approach rather than a more traditional one. The optimal solution for a specified issue may be reached with the use of real-time technology and the elephant species' specific behaviours and traits. The author is inspired to create a system design based on these facts in order to maximise the longevity and, by extension, the throughput of the network under consideration due to the prominence of certain features, such as memory capacity, leadership, interaction style, group isolation, and handling over, etc. Further inspiration for the author to go on with defining and building an elephant swarm based system design for lifetime maximisation and improvement comes from cross-layered system designs that aim to reduce computing complexity while increasing efficiency.

Literature Review

Shreya Mahajan et.al.,(2020) This article details a multi-objective optimisation problem with the objectives of reducing system-wide voltage fluctuation and total real power losses. The objectives are aggregated into a scalar objective optimisation problem using the weighted sum method. Both the particle swarm optimisation and the proposed elephant herd optimisation based method are investigated for the IEEE 14 bus system. In comparison to particle swarm optimisation, elephant herd optimisation has a better voltage profile, lower real power losses, and faster convergence.

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Ivana Strumberger et.al.,(2017) Swarm intelligence algorithms have been successfully applied to complex optimisation tasks, including the optimal deployment of drones. To address the static drone location challenge, this article details how the recently developed elephant herding optimisation technique may be put into practise. The model used in this study seeks to create all-target surveillance using the fewest feasible drones. The 30 targets in the uniform distribution and the 30 targets in the clustered distribution were employed in the empirical testing. Based on the simulation findings, it is clear that the elephant herding optimisation approach is effective in covering goals for both variants of the issue.

Adis Alihodzic et.al.,(2017) Planning a route for an unmanned aerial vehicle is an NP-hard task due to its enormous dimension. It has to do with determining the best possible flying path within the limits of a combat zone. The conventional approaches to this issue failed to provide desirable outcomes due to the high number of control points involved. One of the most recent swarm intelligence algorithms, elephant herding optimisation, has not been studied extensively. We have modified the elephant herding optimisation approach to solve the route planning issue for unmanned aerial vehicles in this study. We put our method to the test using parameters taken directly from published studies of combat conditions, and the results of our comparison study reveal that our modified elephant herding optimisation algorithm provides the best results.

Methodology

The suggested research approach prioritises QoS-oriented network variables such lifetime, least-delay, and interaction overhead by emphasising cross-layer design in accordance with an elephant-based swarm-optimization model. Researchers in this field want to replicate this work by building a LEACH and PSO oriented cross-layer architecture and simulating it with a wide variety of network conditions, variables, and parameters to determine the system's robustness and stability. System behaviours and features model prepared and developed on simulator like SENSORIA, with C# and.NET programming language used to write and implement a code on WSN simulation platform in efficient manner, incorporating the characteristics and futuristic of elephant-basedswarm. The intended study procedure has been developed taking into account for WSNs' inherent homogeneity and the diversity of nodes in the geographic region where sensing nodes are distributed at random. Through the use of TDMA-MAC scheduling and cutting-edge radio-layer control methods, the characteristics of elephant-based-swarm have been modified to build a cross-layered system architecture for optimising process. Elephant-based swarm optimisation with consideration of unconstrained scheduling on communication connections is shown to be applied in the suggested technique of the study effort. In the already calculated scheduling time slot, the TDMA scheme of the sensor data on the interference wireless interaction connections is activated concurrently thanks to the elephant-based swarm optimisation. To extend the useful life of a network, researchers used a regenerative optimisation technique based on elephants to improve routeing, energy consumption and utilisation, and TDMA-MAC scheduling. Numerous QoS-oriented aspects and variables have been simulated the taken into account for plotting in order to give a comparative analysis, study, and research reason.

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Small, wireless, battery-operated devices having processing, interaction, and sensing capabilities are the building blocks of Wireless Sensor Networks (WSN). The problem of packet loss is especially acute in wireless sensor networks.

mobile nodes and continual energy dissipation cause packet loss and retransmission. The introduction of low-power wireless sensing element systems may be attributed in part to recent developments in wireless interaction technologies and thus the development of less cost wireless equipments. Wireless sensing element systems are put to use in a variety of real-time applications, including healthcare for humans, target tracking, environmental monitoring, and weather forecasting, thanks to the versatility of the sensing elements themselves. In every scenario, it is crucial that the sensing element devices monitor and detect the topographic point, then relay that information to the sink sensing device for further processing.

There are many obstacles to developing cost-effective interaction protocols for wireless sensing element networks, including the limited resources of the sensing element nodes, the unreliability of least-power wireless interaction links, and the numerous performance requirements of various real-time uses. Meanwhile, a major challenge in wireless sensing networking systems is the development of appropriate routeing algorithms to meet the varying performance needs and expectations of diverse real-time applications. Existing methods of data transmission and routeing do not account for Energy-Balancing (EB) optimisation. Several algorithms that take power and energy considerations into account claim to be able to make up for the energy that is wasted. Most methods base their operation on routeing data via nodes with the greatest energy consumption, which quickly drains their batteries and shortens the lifetime of the whole network. WSNs are a quickly developing technology that can have a significant impact on research and will get extremely near to our part of life within the next decade, with strong ties between us and sensing technology. WSNssystems have a wide range of potential uses, including in government, law enforcement, the armed forces, the medical area, and even the entertainment industry.

Taking in one's environment, and much, much more besides. We are appreciative of the growing interest in the meaningful, detailed study of WSNs in recent and next years, given the breadth and depth of their potential real-time applications.

A wireless sensing system is a collection of low-power, low-cost sensing element devices that are deployed in close proximity to the target region and communicate with each other over a wireless interface. Sense-hardware, transceivers, computation and storage resources, and batteries together make up sensing element nodes, which are compact devices. Sensors may be placed wherever they're required without any advance preparation or design. It allows for speedy random distribution in difficult-to-reach areas or during emergency relief efforts. Because of the random nature of the sensing node distribution, it is essential that sensing element algorithms have strong self-organizational skills.

Results and Analysis

This part describes the experimental investigation performed to compare the elephant swarm optimisation method provided in this work with well-known and existing systems as the LEACH protocol

Evolutionary methods based on PSO. In this study, the SENSORIA Wireless Sensor Network Simulator was used to test the robust elephant swarm optimisation model, the LEACH protocol, and PSO-based system models The suggested elephant swarm optimisation algorithm's solid system architecture or system model was crafted in C# on the Visual Studio 2010 platform. In order to perform the experiment, simulations were run on a Quad Core CPU with 8GB of RAM.

The region was assumed to span 25 25 metres of terrain while the simulation framework, and hence the wireless sensor network test bed, was being built. There are anywhere from 450 to 700 wireless sensor nodes spread out throughout the landscape. The temperature sensing components installed on sensor nodes with a 3 metre sensing range were taken into account by the test bench. The 5 metre radio range is taken into account. Every 0.1 seconds, a sensing event is triggered. High volumes of traffic may be injected into the test bed by inducing intensive sensing activity and taking dense networks into account. Considered high traffic injection in the test beds leads to more data transactions, which quickly drains the network's resources. The purpose of the simulation research was to track the test bed network's lifetime. For this investigation of the network's lifetime, we used a threshold of 30%; that is, we ran the simulations until 30% of the network's energy was depleted.

Table 1.Parameters and Values for Elephant Swarm Optimization Execution

Parameters	Measuring Value / Event
Network Size (in Nodes)	450 (Min.) -to- 700 (Max.) Nodes
Terrain Measuring	25×25 Meters
Temperature Sensing Range	3 Meter
Radio Propagation range	5 Meter
Induced Sensing Time	0.1 Seconds
Bandwidth	1 Mbps
Nature of Environment	Temperature
Network Type	Homogeneous
Traffic Type	High Traffic Injection
Initial Energy	5 J

The efficacy of the elephant swarm optimisation technique was shown by simulating network test beds with different numbers of nodes (450, 500, 550, 600, 650, and 700).Sensing events were the catalyst for the complete depletion of network energy. Similar Elephant Swarm Optimisation, along with the more well-known LEACH and PSO Algorithms, were all modelled using simulated network topologies. The simulation ended after 30% of the network's energy was gone.Lifespan, interaction overhead, network decay ratio, overhead incurred when optimising the route, processing decay ratio, and node activity are only few of the network metrics that have been the focus of the given study. When taking into account all of the relevant system factors, it is clear that the suggested system places a premium on network longevity and, of course, optimisation.The findings collected are provided below, with their importance and rationale discussed.

LEACH protocol, a PSO-based model, and our own suggested approach, Elephant swarm Optimisation, have all contributed to the overall system design. The created models have undergone simulations in both homogeneous and heterogeneous network conditions using various network topologies. factors such as the number of nodes and the duration of the simulations, to ensure that the proposal's efficacy is tested under realistic conditions.

At first, the evaluation of the results was done separately from the suggested system (Elephant Swarm Optimisation) and the LEACH protocol, which was followed by escalating research, and the findings gained were compared with PSO-based system design. In this study summary report, we have merged the findings obtained via elephant swarm optimisation (the suggested system), LEACH, and PSO to provide the information in the most comprehensive and useful manner possible.

In comparison to LEACH, the current systems are considerably worse, as shown by an independent outcome study showing that the suggested approach gives 72.58% greater life time. The sensor's decay rate has decreased by 81.9% in the same way. In contrast, the identical outcome regarding PSO was deemed intriguing. A 72.58 percent improvement in longevity and a 78.5 percent decrease in node decay rate were seen using elephant swarm optimisation based on a cross-layer architecture.

Results like these prove that the new cross-layer based elephant swarm optimisation approach is superior to preexisting systems like PSO and LEACH protocol. The following diagrams were discovered while researching this topic and are used to display the research's comparative findings analysis.

Lifetime analyses for a variety of network sizes and implementation methods are shown in Figure 2. Lifespan of sensor nodes is displayed against node density in a deployment or test bed environment. Figure 2 shows that the nodes' lifetimes are much longer when the suggested cross-layer based elephant swarm optimisation is used. LEACH is more likely to die than the particle-swarm based model, which has a shorter lifetime overall.

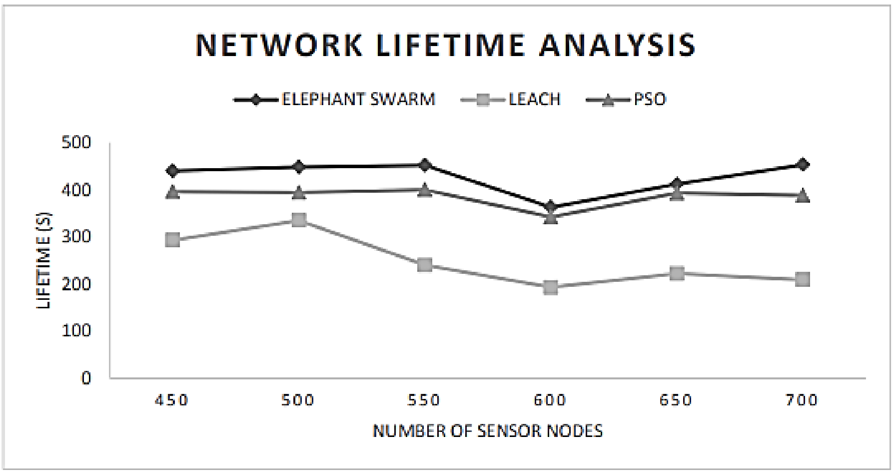

Figure 2. Wireless Sensor Network Lifespan Analysis

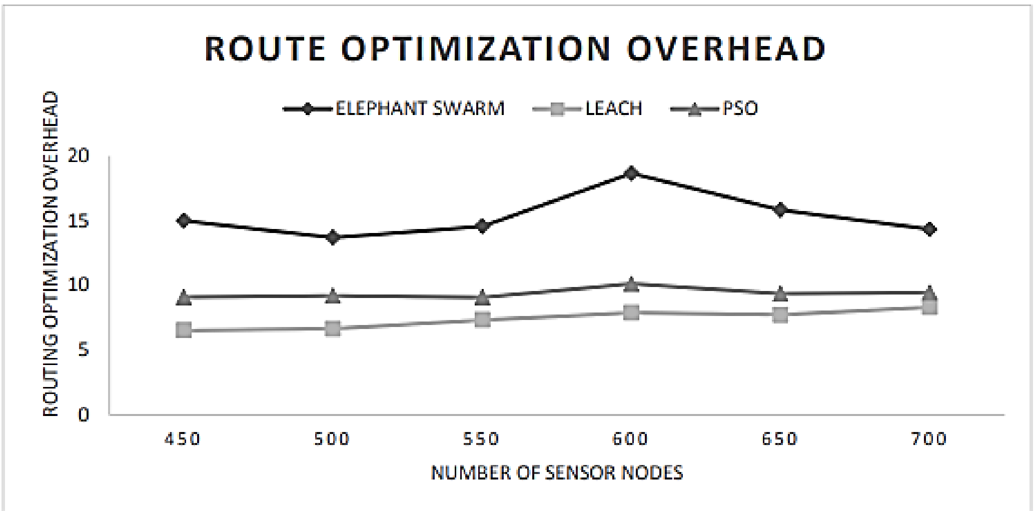

Figure 3. Route Optimization Overhead Analysis

Conclusion

This article compares the proposed elephant swarm optimisation method to existing PSO-based cross-layered designs and finds that the overall network lifetime improves by about 26.8 percent in comparison, proving the method's robustness. The additional outcomes achieved, such as decreased interaction overhead, show a significant improvement of 36.6%. Similarly, the network lifetime is increased by 72.58% using an elephant swarm-based cross-layer optimisation protocol rather than a PSO-based one. Lifespan, interaction overhead, energy decay in sensor nodes, and active node ratio are all measures of network performance that have been shown to improve. One advantage of the suggested system is that it maintains its uniformity over networks of varied sizes, while in other systems, differences or deviations tend to be large.

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