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An Empirical Study of Soft Computing Approaches in Wireless Sensor Networks

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ABSTRACT

The optimal CH selection for finding the shortest path among the CHs is improved by developing the hybrid K-means with particle swarm optimization (PSO)-based hybrid ad-hoc on-demand distance vector (AODV) channeling algorithms. The alive nodes, total packet sending time, throughput, and NL are increased using this hybrid technique, whereas dead nodes and EC are minimized in the network. The proposed algorithm utilizes a rotational method of utilization of cluster head (CH) to ensure that all member nodes are utilized uniformly based on the incoming traffic. The proposed algorithm has been implemented, experimented with, and compared in performance with LEACH, DLBA, and GLBA algorithms. The proposed hybrid approach outperforms the existing techniques regarding average energy consumption and load distribution.

KEYWORDS

Ad-Hoc Network, Network Lifetime, Soft Computing, Wireless Sensor Networks

INTRODUCTION

According to Zakrzewski et al, (2009), and Rani and Gulati (2012) The efficient energy utilization in WSN is a bottleneck problem that affects the network's performance and lifetime. Researchers recently addressed energy consumption attentiveness and power management approaches to tackle this problem. Optimal routing techniques and energy optimization usage significantly affect the WSN performance and guarantee the extension of the network lifetime. Due to WSN constraints and especially the sensors` energy scarcity, a smart routing should be done to balance the energy consumption among nodes. Therefore, prolong the network lifetime and ensuring network coverage. Deploying intelligent and intellectual techniques enhances the effectiveness of wireless sensor networks. Researchers have studied and examined different soft computing paradigms to optimize WSN routing with the consideration of the power consumption, network challenges, and design and deployment aspects. The soft computing paradigms such as RL, SI, EA, FL, NN, and AIS have been applied to different WSN applications and deployment based on their other characteristics (Swami et al, 2013). The section below in this survey work summarizes the recent implementations of soft computing paradigms in routing in WSN with its dynamical and heterogeneous characteristics.

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Background

The two efficient algorithms in a wireless sensor network are AODV and DSR. On-demand routing protocol AODV establishes the route only when there is a requirement. This protocol uses two different broadcast messages such as RREQ and RREP. The advantages of AODV over DSR are that they require less storage. The hello messages will be sent to the network to see whether the nodes are active. If there is no response to the message, then it is considered that the links are broken. Due to which communication overhead is formed in the network (Tuteja et al, 2010). Dynamic source routing will have all the details included in the packet header. It is also a demand-driven protocol. These protocols use route detection and conservation. The network is formed via sending the route request and when the packets remain not sent, a fault message is sent to entire nodes in the network. The main variance between these two algorithms is a direction-finding feature. The novel approach will consider high storage space with less communication overhead. These improve the time of the network activated (Johnson et al, 2001; Mohapatra and Kanungo, 2012).

Table 1 compares AODV and DSR. In AODV the hello message will be sent when there is a demand of creating the network. RREQ will be sent to all the nodes in the network. This request will contain all the details in the network. The sequence number will help us know the destination address of the packet to be sent. RREP is the route reply from the node if the packet reaches the destination node (Lee et al, 2000; Chakeres et al, 2004; Sethuraman and Kannan, 2017). DSR protocol needs an extra storage capacity since it uses caching technology. Here the route detection is initialized when a node needs a route to be established in the network. Flooding technology is used in this protocol. All the packets sent in the network will have all details regarding the routing of data. In case of a link failure, RERR is sent among the source. Here energy is not considered as a factor (Hu and Johnson, 2000).

CASES

Case 1: Wireless Sensor Networks Formation Approaches and Techniques

Despite the open research areas in wireless sensor networks (WSNs), there are already a high number of current problems in which these networks can be applied. Some application fields include tracking, monitoring, surveillance, building automation, military applications, and agriculture, among others. In all cases for the design of any application, one of the main objectives is to keep the WSN alive and functional as long as possible. A key factor in this is the way the network is formed. In fact, the topology is mostly defined based on the application environment and context. The sensor information is usually collected through the available gateways in a given topology. This information is then forwarded to

Table 1. Comparison of AODV and DSR

Scenarios	AODV	DSR
Demand-driven	Yes	Yes
Source routing	Computes and Updates the route	Route detection and maintenance adds a sequence number Multipath.
Routing load	Comparatively high	Less
Route overhead	Find routes in Caches hence reduces	More compared to DSR because there is no caching used
Standardized MAC load	Less when Compared to Lower pause time	Relatively High
Performance	Higher when it is in complex mobility scenarios	Comparatively less.

a leader node or to a base station known as a sink. The design complexity of a WSN depends on the specific application requirements such as the number of nodes, the power consumption, the life span of the sensors, information to be sensed and its timing, geography of where the sensors are placed, the environment, and the context. This survey presents the most recent formation techniques and mechanisms for the WSNs. In this paper, the reviewed research works are classified into distributed and centralized techniques. In the former, nodes are autonomous and the communication is only between neighboring nodes while, for the latter, the network formation is controlled by a single device. The analysis is focused on whether a single or multiple sinks are employed, nodes are static or mobile, the formation is event detection based or not, and the network backbone is formed or not. The survey is dedicated to recent works and presents a discussion of their advantages and drawbacks (Carlos-Mancilla et al, 2016).

Simulation

The comparison of the reactive protocol AODV and DSR are done using the NS2 simulators (Mohapatra and Kanungo, 2012). The performance is compared by using the parameters such as PDR, packet drop, throughput and energy. The simulation is done in 100, 200 and 300 sec. Fig 1 shows the creation of nodes in WSN. All Nodes are homogenous in nature but the deployment of nodes is at different distances. Hence the parameters like energy, functions, quality of the nodes will be the same.

Fig 2 shows the arrangement of nodes and assortment of the source nodes. Source node will gather all the details regarding the route request and route reply. The failure in the link will be informed to the source node selected.

Case 2: Hybrid-K-Means-PSO-AODV Methodology

The objective of energy-efficient routing protocols finds the energy stable way from the source node to the BS for maintaining the NL and functionality for a reasonable duration. In order to extend the functionality and NL, the major aim of the network is to balance the EC by using different techniques and approaches. In this paper, PSO Optimized K-means clustering and ACO optimized AODV (PSO- K-means-ACO-AODV) routing technique is introduced. In this Hybrid-K-means-PSO-AODV

Figure 1. Creation of Nodes

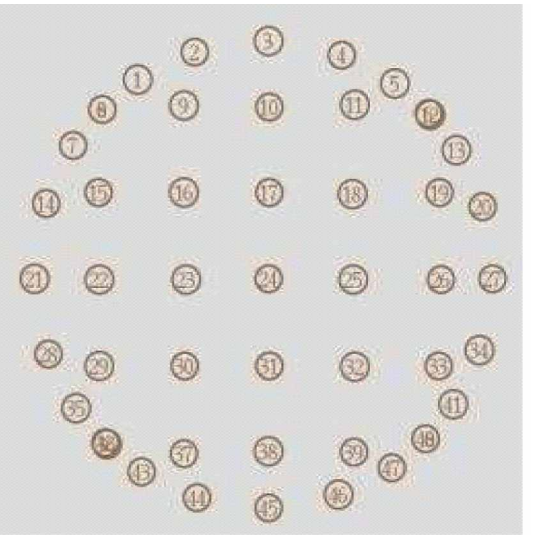
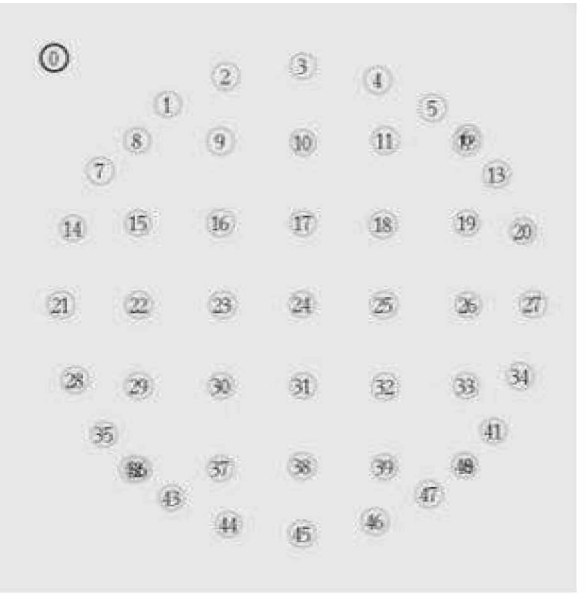


Figure 2. Positioning of Nodes and Selection of Source Node

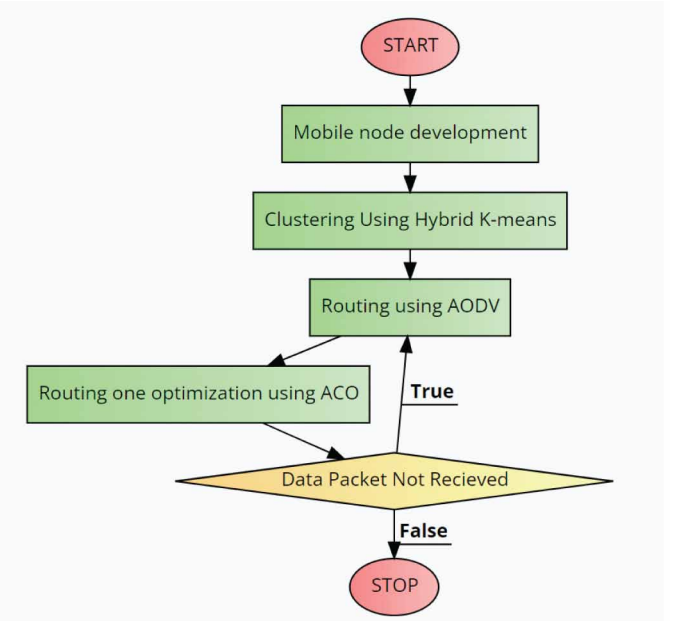


technique, PSO an Algorithm is used to optimize the K-means algorithm, whereas the AODV algorithm is optimized by using ACO (Tamizharasu and Kalpana, 2020).

Ecological situations like sound, temperature and motion are monitored by WSN which consists of an amount of SNs that are interlocked through wireless links. The benefits of sensor technology are improving the consistency and accurateness of data by making low motorized sensing plans which are equipped with designable stemming and small structure with multiple parameter sensing. But the major limitations of the WSN's are imperfect Battery Power (BP), restricted storage and computation abilities, prone to safety occurrences and have limited bandwidth to communicate. To overcome those limitations, the energy efficiency is increased and reduced the network EC by implementing the Cluster-based WSN (CWSN). Clustering in WS Network is performed to minimize the EC and also to decrease the data communication. Over the system that is required to transfer the message to the BS, as the CH becomes accountable for communication, which results in prolonged NL (Wang et al, 2011). In a CWS network, every cluster has a leader sensor node, called CH. LEACH protocol provides advanced security (existing systems do not consist of security systems), high throughput, less EC (while data arranging) and less delay.

The groups are made dynamically and occasionally; security is required for hierarchical (cluster-based) SNs. The sensors are operating autonomously and are expected to deploy remotely in large numbers. The scalability is supported by nodes that are often grouped into non-overlapping clusters. The data aggregation is utilized by using GRASS to reduce the NL in-network processing techniques. The data packets are summarized and combined from several SNs to reduce the EC and Communication bandwidth which is the main aim of data aggregation. The centralized grouping algorithm has been implemented for WSNs to categorize the SNs into groups using the Memetic Algorithm (MA). The results conclude that MA gives the significantly advanced scheme lifetime and shorter procedure performance time, but the packet delivery ratio and packet losses were not discussed. Fig. 3 shows a flow chart of the overall Hybrid-K-means-PSO-AODV Process. Let us describe some optimization techniques in detail.

Figure 3. Flow chart of the overall Hybrid-K-means-PSO-AODV Process



- **Clustering Based on PSO with K-Means:** The particles are initialized; the fitness function is calculated and finally, the velocity and position are updated in PSO based clustering algorithm. PSO is an iteration based optimal procedure, and the structure is initialized with a population of random resolutions and searches for optima by modernizing the generations. According to its own historical and related information of neighboring particles, a particle adjusts its current location and discoveries the best result through reiteration, which combines the local and global information in the search process of PSO. Individually element is updated by using the two finest values in every reiteration. The first most fine rate is obtained by qualification function and the second finest value is gained by using PSO in the population (Niknam and Amiri, 2010).
- **Clustering-Load Balancing Using PSO:** PSO enhances the grouping, which yields inspiration from the attributes of ants in nature and from the associated field of PSO to fathom the issue in conveying systems for picking the briefest directing procedure. PSO is a streamlining calculation that mimics winged creatures' development and running. A molecule swarm is a populace of moving articles that can travel through the pursuit space and be pulled into better positions. Each winged creature is alluded to as a "molecule" that flies with a specific speed and moves to locate the world's best position. PSO is a global pursuit calculation, which has a solid capacity to identify worldwide hopeful outcomes. The gathering is finished utilizing PSO in WSN. Fundamental Clustering techniques for SNs are given in Fig.3. Burden adjusting intends to amplify throughput, limit reaction time and steer overhead in the system. The examination network has broadly sought the gathering in sensor hubs to explain the adaptability, vitality and lifetime issues of SNs (Ebadifard and Babamir, 2018).
- **AODV-Routing Protocol:** The routing protocol is intended for use by mobile nodes in WSN. The control traffic and dissemination of overhead are decreased by designing the AODV which deals with two functions as Route maintenance and Route discovery. The repair of an existing route and finding the links breaks is done by the maintenance function, whereas the fresh route is identified by the discovery function. AODV is used to analyze the network topology changes quickly when the reactive protocol does not maintain the permanent route table (Maurya et al, 2012).

- **Ant Colony Optimization:** The optimal solutions are provided to the hard-combinatorial optimization (CO) problems by using ACO which is a nature-inspired meta-heuristic algorithm. The shortest path is determined by moving a pheromone ant that can act as a base for other ants to follow for getting the probability. To make the pheromone stable and find the best path, a positive feedback loop system is formed through which other ants can follow the path which leads to the emergence of collective behaviour by transferring the food back to the nest (Dorigo et al, 2016).

Case 3: Energy-Aware Routing Protocols for Underwater Sensor Network

Underwater wireless sensor networks consist of a certain number of sensors and vehicles that interact to collect data and perform collaborative tasks. Designing energy-efficient routing protocols for this type of network is essential and challenging because sensor nodes are powered by batteries, which are difficult to replace or recharge, and because underwater communications are severely affected by network dynamics, large propagation delays and high error probability of acoustic channels. In the authors analyze the total energy consumption in underwater acoustic sensor networks considering two different scenarios: shallow water and deep water. Specifically, the direct transmission, the relaying scheme and the clustering structure are compared. They conclude that the worst performance is obtained by direct communications. For shallow water, the clustering scheme is the best option in terms of network overhead, the end-to-end delay and overhead. Additionally, its scalability in terms of the number of nodes and distance is demonstrated (Domingo, 2011).

Case 4: SHRP (Simple Hierarchical Routing Protocol)

In a research project supported by Petróleos de Venezuela, S.A (PDVSA), the state-owned corporation of the Bolivarian Republic of Venezuela responsible for the efficient, profitable, and dependable exploration, production, refining, transport and commerce of hydrocarbons, our group was Sensors interested in considering a routing protocol that could deal with three different aspects: battery availability, number of hops and link quality to guarantee the arrival of messages in the sink node in an energy-saving way. We could not find any WSN routing protocol that used these three parameters together and at the same time was concerned about energy saving and reliability features. For this reason, a new routeing protocol called SHRP was proposed. The SHRP protocol is concerned with topology maintenance that is directed related to the reliability of data delivery. To arrange this, it makes use of metrics like local battery availability and link quality between neighbour nodes in choosing the best route into the sink node. It is also concerned with energy-saving as not all periodic data are sent to the sink, as there is a Concern that transmission is the task that more wastes energy in wireless sensor networks. The SHRP protocol just sends data that has not changed from the last sensing data. The coordinator's nodes can aggregate various data messages and send just one message. In this manner, the SHRP protocol has vino an energy-sa behaviour. SHRP provides a load balance scheme during the creation of best routes groups, so not always will the same best route be chosen (Abbas et al, 2012).

Case 5: SPIN (Sensor Protocols for Information Via Negotiation)

Kulik et al (2002) proposed a family of adaptive protocols called Sensor Protocols for Information via Negotiation (SPIN) that disseminates all the information at each node to every node in the network assuming that all nodes in the network are potential base stations. This enables a user to query any node and get the required information immediately. These protocols make use of the property that nodes in close proximity have similar data, and hence there is a need to only distribute the data that other nodes do not possess. The SPIN family of protocols uses data negotiation and resource-adaptive algorithms. Nodes running SPIN assign a high-level name to completely describe their collected data (called metadata) and perform meta-data negotiations before any data is transmitted. This assures that there is no redundant data sent throughout the network. The semantics of the meta-data format

is application-specific and is not specified in SPIN. For example, sensors might use their unique IDs to report metadata if they cover a certain known region. In addition, SPIN has access to the current energy level of the node and adapts the protocol it is running based on how much energy is remaining. These protocols work in a time-driven fashion and distribute the information all over the network, even when a user does not request any data. The SPIN family is designed to address the deficiencies of classic flooding by negotiation and resource adaptation. The SPIN family of protocols is designed based on two basic ideas:

- Sensor nodes operate more efficiently and conserve energy by sending data that describe the sensor data instead of sending all the data; for example, image and sensor nodes must monitor the changes in their energy resources.
- Conventional protocols like flooding or gossiping based routing protocols waste energy and bandwidth when sending extra and unnecessary copies of data by sensors covering overlapping areas. The drawbacks of flooding include implosion, which is caused by duplicate messages sent to the same node, overlap when two nodes sensing the same region will send similar packets to the same neighbour and resource blindness by consuming large amounts of energy without consideration for the energy constraints. Gossiping avoids the problem of implosion by just selecting a random node to send the packet to rather than broadcasting the packet blindly. However, this causes delays in the propagation of data through the nodes.

Case 6: Hierarchical Routing

Hierarchical or cluster-based routing, originally proposed in wireline networks, are well-known techniques with special advantages related to scalability and efficient communication. As such, the concept of hierarchical routing is also utilized to perform energy-efficient routing in WSNs. In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target. This means that the creation of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other layer is used for routing. However, most techniques in this category are not about routing, rather on" who and when to send or process/ aggregate" the information, channel allocation etc., which can be orthogonal to the multi-hop routing function (Lotf et al,2010).

- **LEACH protocol:** Introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a cluster-based protocol, which includes distributed cluster formation. LEACHES randomly select a few sensor nodes as cluster heads (CHs) and rotate this role to evenly distribute the energy load among the sensors in the network. In LEACH, the cluster head (CH) nodes compress data arriving from nodes that belong to the respective cluster and send an aggregated packet to the base station in order to reduce the amount of information that must be transmitted to the base station. LEACH uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions. However, data collection is centralized and is performed periodically. Therefore, this protocol is most appropriate when there is a need for constant monitoring by the sensor network. A user may not need all the data immediately. Hence, periodic data transmissions are unnecessary which may drain the limited energy of the sensor nodes. After a given interval of time, a randomized rotation of the role of the CH is conducted so that uniform energy dissipation in the sensor network is obtained. The authors found, based on their simulation model that only 5% of the nodes need to act as cluster heads (Xiangning et al, 2007).

CONCLUSION

In this work, we compared AODV and DSR two routing protocols in terms of energy consumption, packet delivery ratio and throughput. This comparison is shown graphically to show their efficiency. We also proposed a new idea of implementing the routing protocol, which will modify AODV but will be more energy-efficient than AODV. We had used NS2 for implementing the routing protocol. In the future, we will use the idea to derive the new protocol and test its energy efficiency. Again, energy is not only a factor; it should also be secure. The authors are also trying to make it more confident in the future. In this paper, relevant works on wireless sensor networks (WSN) have been reviewed. It presents the evolution, design, and implementation of some critical WSN techniques in the last years and the most used protocols and standards to improve the sensor applications. The main characteristics of every method have been discussed. The analysis focused on whether a single or multiple sinks are employed, nodes are static or mobile, the formation is event detection based or not, and the network backbone is formed. We have pointed out advantages and drawbacks for every paper present to improve and give support of the weaknesses and fortress of the used metrics. Centralized and distributed techniques consider conditions for its application, namely, collision over the wireless medium, traffic, failures in the medium access, loss of messages, the size of a network, and so on. We have remarked that distributed solutions are preferred over centralized ones. Distributed techniques support scalability, autonomous nodes, deployment, and elimination of nodes; also, it is possible to use self-organization strategies inspired by the nature in which the information is shared only with neighbor nodes, whilst on centralized techniques, there are no transmission or reception conflicts because the central node coordinates every node. In this research, a new algorithm is introduced with PSO with K-means and AODV with PSO, which enhance the clustering and routing algorithm of the WSNs with limited movement after initial random deployment. The algorithm has analyzed various particle sets to get the best-esteemed grouping and different glowworm sets for routing of the WSNs. From obtained results, we conclude that the PSO-K-means-ACO-AODV method has achieved the best Routing and Clustering of WSN compared to the PSO-GA-WSN algorithms. This GA-GSO-WSN method is used to improve the NL, alive nodes, and throughput, then minimize the EC of the node.

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