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Ant Colony Optimization Based OD-PRRP for Wireless Sensor Networks

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Abstract: - **WSNs are composed of hundreds or thousands of sensor nodes which are deployed either inside the phenomena to be observed or very close to it. These sensor nodes are responsible for collecting & processing and routing data either to other sensor nodes or directly to a base station (BS). In most of the applications, sensor nodes are deployed in a random & uncontrolled manner. These uncontrolled deployment methods cause the random distribution of nodes, i.e., node density is not uniform in the area under consideration. In WSNs, for which designing of protocols is application specific, focus on a single isolated technique cannot lead to optimum levels of energy efficiency, scalability and improved network lifetime. Consequently, exploring several energy efficient and scalable mechanisms that address several different characteristics of the network can help in contributing significant improvements in the various network performance metrics (energy efficiency, scalability, load balancing, network lifetime, overheads, delay, and throughput). The other goal of the paper is to propose an application of computational intelligence-based approaches such as Ant colony optimization which manages WSN characteristics.**

***Keywords*:** **WSN, Delay efficiency, Hierarchical Routing, Ant Colony Optimization Based Orthogonal Directional Proactive-Reactive Routing Protocol.**

I. INTRODUCTION

From the recent studies, it is revealed that WSNs are used for implementing a wide variety of applications and designing systems having varied requirements and characteristics [1-2]. These applications require mainly three types of reporting, i.e. (i) continuous reporting, (ii) event based reporting, and (iii) on demand reporting [11]. For continuous reporting of data, sensor networks are designed to periodically report data of interest. Many environments related applications such as reporting of temperature, pressure, pollution and humidity fall in this category. In event-based reporting, sensor nodes are designed to report the pre-specified type of information. The communication of information by a node takes place only when the sensed information satisfies some predefined attributes. Fire, flood or earthquake detection and alarms based applications fall into this category. In the on-demand reporting, the reporting of information is first requested by sink node and in response to the request; sensor nodes deliver the requisite information. The on-demand reporting of events is mostly used in inventory control systems and requires special attention towards designing of MAC layer and physical layer [13-15]

Node Deployment: Deployment of sensor nodes in WSNs is application specific and affects the performance and methodologies designed for them.

Limited Energy: Sensor nodes in WSN are mostly battery operated and deployed at places where human intervention is rarely feasible

Scalability: In WSNs thousands of sensors are randomly deployed for a given application. These nodes are responsible for collecting data and routing it either to other sensor nodes or to a base station

Network characteristics: Nodes in WSNs have limited energy and computational resources and are mostly randomly deployed with high node density

Capabilities and role of nodes: In WSNs, deployed nodes can be homogeneous (equal capability) or heterogeneous (unequal capability) in nature.

Hot spot mitigation: Due to limited transmission capability and energy efficiency, the sensor nodes in WSNs are required to communicate in a multi-hop mode

Fault Tolerance: In applications like monitoring of harsh and inaccessible environments the nodes are randomly deployed. In such situations, sensor nodes are prone to damage, battery depletion, radio, and processing failure

Delay efficiency: In WSNs minimizing the delay is essential for delay bound applications. For minimizing delay, the originated packet is required to be transmitted as soon as it is received by intermediate nodes. This

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requires the nodes to be always active for receiving and communicating data. However, a significant part of node energy is consumed while it is waiting for the packet to be communicated. To reduce both delay and undue energy consumption, effective sleep-wake schedules are required to be designed for WSNs.

II. METHODS FOR ENERGY EFFICIENT COMMUNICATIONS

In recent past, the research in WSNs has grown enormously. Most of the study is pointing towards scalable and energy-efficient communication protocols in corresponding large-scale environments [6-7]. Following are the main research directions to achieve energy efficient and scalable communication protocols in WSNs.

Hierarchical Routing

Hierarchical routing is a widely accepted method which contributes system scalability, enhanced network lifetime and energy efficiency in large-scale WSN environments. The hierarchical routing protocols entail cluster-based structural organization of the sensor nodes. In the hierarchical structure, each cluster has a leader node, which is named as a cluster head (CH) and rest of the nodes are named as member nodes. The member nodes are required to periodically transmit their data to their corresponding CH nodes. After receiving data, cluster head performs the fusion and aggregation of collected data and transmits the aggregated data to BS. In hierarchical routing, the clustering process is division of sensor network into the two-level hierarchy where the CH nodes and normal nodes of cluster form the two hierarchical levels. In Clustering, short-range communication by member nodes and reduction in number of transmitted messages to the BS leads to energy efficiency and scalability, which in turn increases network lifetime.

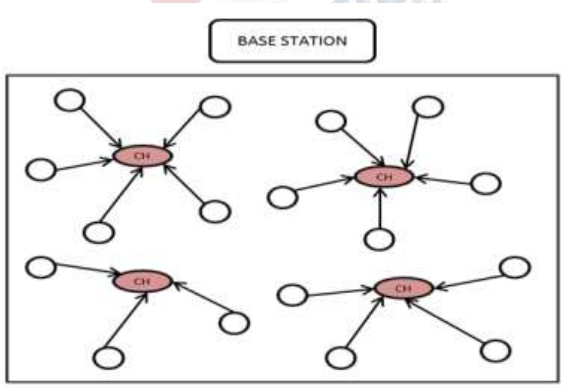

Fig 1.Clustering in Wireless Sensor Networks

Cross-Layer Approach

In WSNs, designing of protocols by using cross-layer approach has resulted in substantial improvement in energy-efficiency. The basic idea behind cross-layer design is to combine and share the resources available at different layers. To optimize the performance of the network, challenges at the physical layer and QoS demands from the application layer are required to be addressed efficiently.

Transmission Range Adjustment

Most of the sensor nodes in WSNs can control their communication range by controlling their transmission power levels. A sensor node has a set of different power levels and depending upon the design requirements; these different power levels can be utilized to adjust their communication range. By choosing a high transmission range of a node for communicating directly with the Base station (BS), numbers of intermediate hops are reduced, which in turn reduces the delay. But high transmission range leads to high collisions, contention and path losses which degrade the network performance

Directional Antennas

Directional antennas have a higher gain than classical isotropic antennas due to limited beam width. Due to this higher gain, the nodes equipped with directional antennas require lower transmission power to communicate at a particular distance.

Multiple Sink Deployment

The overall lifetime of a WSN mainly depends upon the efficiency with which the limited energy resources are utilized. In sensor networks, energy consumed during data transmission and receiving is reasonably higher than that consumed during sensing and computing. Hence, to have a longer life, it is desirable to reduce the number of transmissions and receptions by a node.

III. PROBLEM STATEMENT

In WSNs, for which designing of protocols is application specific, focus on a single isolated technique cannot lead to optimum levels of energy efficiency, scalability and improved network lifetime. Consequently, exploring several energy efficient and scalable mechanisms that address several different characteristics of the network can help in contributing significant improvements in the various network performance metrics (energy efficiency, scalability, load balancing, network lifetime, overheads, delay, and throughput). The other goal of the paper is to propose the application of computational intelligence-based approaches such as Fuzzy Logic, Ant colony optimization, Genetic Algorithm to predict and manage WSN characteristics.

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IV. PROPOSED METHODS

Routing protocols are essential for WSN which leads the various quality-of-service (QoS) concerns about diverse applications. The critical QoS issues while designing routing protocols for WSN are energy responsiveness, scalability and network lifetime time. To address the issues as said above, winning routing protocols regularly portray the system with measurements, for example, lingering vitality, consistency, correspondence cost or deferral [6]. In the majority of the current protocols, it is understood that the area information of the whole system is known to all the sensor nodes. This area information is thought to be gotten either from the introduced GPS beneficiary on nodes or some other restriction technique. Nonetheless, these current arrangements are exorbitant in usage and have availability and versatility related issues. In this examination, another routing strategy that keeps away from intemperate overhead in keeping up entire connection state information is proposed. The proposed strategy does not require global position information and discovers the effective and adjusted utilization of vitality assets. The strategy named OD-PRRP (Orthogonal Directional Proactive Reactive Routing Protocol) ideally uses the qualities of both the proactive and reactive routing model. To unwind information prerequisites, for example, organize space implanting and node limitation, the nodes are made to transmit parcels in orthogonal ways.

In OD-PRRP, routing information is proactively kept up by certain chose "proactive" nodes utilizing Ant colony optimization. These proactive nodes are intermittently chosen by utilizing random back-off plan. Along these lines, the adjust nodes (with no course information) reactively distinguish the course with the assistance of courses officially recognized by these chose proactive nodes. The overheads are controlled as just a couple of chose "proactive" nodes are used for proactive course upkeep. This duty of being proactive nodes is occasionally shared among the nodes in the system to maintain a strategic distance from nonuniform vitality utilizations. For the nodes other than the chose proactive nodes, the postponements related with reactive techniques are tended to at the season of course ID as any node having course information itself sends the course answer to the separate node in the interest of the sink node. Hence the nodes other than the proactive nodes use the technique recommended in AODV strategy. Be that as it may, the deferrals related with AODV strategy are tended to be proactive course support by few chose proactive nodes as talked about above.

Modeling of Network

OD-PRRP ideally uses the qualities of both the proactive and reactive routing model. Fig 2. Demonstrates the Flowchart discourse to the review of the proposed strategy and the points of interest related to every component of OD-PRRP are talked about in the accompanying sub-areas.

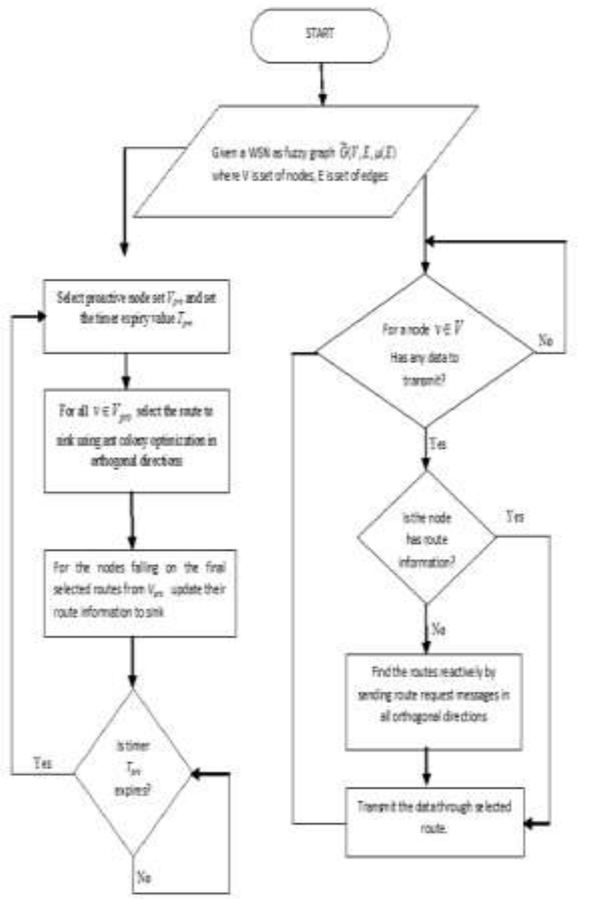

Fig2. OD-PRRP

Both lower estimation of back-off time and which don't get any course ask for till the expiry of their particular clocks chooses themselves as proactive nodes. Along these lines, if any sensor node v does not get any course ask for messages amid its back-off time, at the expiry of its clock, it views itself as a proactive node and sends course ask for the message in every single orthogonal heading. This, like this, guarantees every one of the nodes has availability to a proactive node. At the end of the day, there is no segment of the system which is left with no dynamic node.

This random choice of proactive nodes utilizing this self-assertive back-off plan does not require any information from neighboring nodes and trade of control messages,

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and consequently, it is a financially savvy and direct plan which does not require high calculations at the separate nodes. The determination of proactive nodes utilizing back-off plan works regardless of the extent of the system; arrangement write and number of sensor nodes

Proactive Route Discovery

The primary objective of a routing convention in WSN is to set up a productive course between a source and the sink. The course ought to be found and kept up with at least overhead and bandwidth utilization. In OD-PRRP, choice and usage of some proactive nodes settle both the issues about expanded postponements in reactive routing protocols and blockage misfortunes in proactive routing protocols. The chose proactive nodes to send forward ants in all the orthogonal bearings. The correspondence orthogonal way settle the need for global position information. Be that as it may, the thick organization of sensor nodes may prompt having numerous nodes a specific orthogonal way. In such circumstance, every ant picks its next node through the probabilistic technique according to Equation (1) of segment Though the proactive nodes send the ants in all the orthogonal headings, each neighbor node subsequent to getting the ant discharges the ant at a point of 180-degrees, i.e., ant keeps on moving its unique straight way. In OD-PRRP every node keeps up source and sender's ID alongside jump count as a detriment to finish course information and is in this manner more adaptable because of lower memory and refreshing prerequisites of state information. Likewise, sending of ants in orthogonal ways gives upgraded medium reuse. When ants achieve the sink node no all the more sending is required and relying on the estimation of jump tally sink refreshes the marvel esteem τ(u,v) utilizing Equation (5.25) and sends in reverse and through a similar course. This last course information might be accessible to all the middle of the road nodes in transit the sink answer way and additionally with separate proactive nodes.

Ant colony optimization

Ant Colony Optimization (ACO) is a meta-heuristic which takes a shot at the helpful conduct of ants with each other and is well known among specialists for taking care of combinational optimization issues. The essential thought behind ACO is to demonstrate the given issue as the finding of the best way in a chart which is speaking to various conditions of issue. These manufactured ants speak with each other by laying pheromone trails on the edges of the chart. The measure of pheromone deposition is needy upon the nature of the arrangement found. The choice of the way by any ant concerns the probabilistic esteem which thus is reliant upon the pheromone esteem layered by before ants. In the proposed strategy, counterfeit ants discover the arrangement by proceeding onward the given coordinated fluffy chart G (V E, □ (E)) speaking to the remote sensor organize. For finding the way, at every emphasis, the quantity of manufactured forward ants na, began from a proactive node u and travelling through neighbour nodes v, until the point that ants achieve the last goal, i.e., sink node. What the ID of each went to the node is spared onto a memory Mk , conveyed by ant. At every node u, determination of the following hand-off node v by a forward ant depends on the probabilistic choice run which is given by:

$$P_k(u,v)=\begin{cases}\dfrac{\left[[\tau(u,v)]^{\alpha}[\lambda(u,v)]^{\beta}\right]}{\sum_{v\in N_i}\left[[\tau(u,v)]^{\alpha}[\lambda(u,v)]^{\beta}\right]} & \text{if } v\notin M_k\\ 0 & \text{otherwise}\end{cases}$$

Here Pk(u,v) the likelihood with which an ant k moves from node u to v. Here τ(u,v) speaks to the pheromone esteem which relies on the length of the way. At the point when a forward ant achieves the goal (sink node), it is changed into the regressive ant. The obligation of in reverse ants is to refresh the pheromone trail of the way as indicated by the coveted nature of the way. Ants utilize fortification figuring out how to find the best ways. In support taking in, the savvy framework is simply given an objective to reach. The framework at that point embraces the objective by experimentation cooperation with the earth. For the cooperation that takes the framework near the objective, a positive reward is gotten, and while leaving from the objective, a negative reward is relegated. This is finished by a manufactured framework by presenting the idea called pheromone refresh.

Performance of the OD-PRRP in Dynamic Environment

In this segment, the execution of the OD-PRRP, EARQ, EEABR, and EAODV is dissected in the dynamic condition, i.e., in the wake of consolidating node versatility. For the versatile condition, the execution has been assessed concerning its impact on arranging lifetime, parcel overhead, and end-to-end transmission deferral and bundle conveyance proportion. To assess the execution of the techniques for dynamic WSNs, random waypoint portability demonstrate has been utilized which gives a genuine random node development of course in numerous versatile WSN applications. The Random Waypoint Mobility Model (RWMM) incorporates delays between alters in course and speed. A versatile node starts by remaining in one area for a specific period (i.e., stop). When this time terminates, the versatile node picks a random goal in the reproduction territory and with a speed that is consistently dispersed between [min-speed, max-speed]. The portable node at that point goes toward the recently picked goal at this speed. After achieving the goal, versatile node delays for a predetermined period before it again rehashes this procedure. For the reenactments, course timeout parameter has been presented, and its esteem is set as 5s. The recreation is improved the situation 200 seconds while keeping the other reproduction parameters as considered in the past area. The execution of the protocols is assessed at node thickness 200 and speeds viz. 5m/s, 10m/s and 15m/s are considered for node development. These paces have been picked by some viable portable WSN applications, for example, water quality observing in shut condition (low speed), human services checking (medium speed) or outskirt security reconnaissance observing (higher paces). The outcomes computed depend on the normal of 50 trials of reenactment.

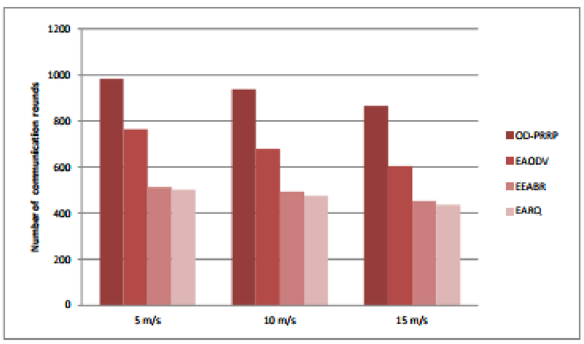

Fig3. Lifetime comparison between EARQ, EAODV, EEABR and proposed OD-PRRP at different node speeds.

V. CONCLUSION:

In this investigation, an ant colony optimization based proactive, the reactive routing convention (ODPRRP), is exhibited, which has utilized the fuzzy graph and orthogonal directional transmission. The reenactment consequences of the proposed convention OD-PRRP demonstrates the diminishment in control overheads without trading off at cost and vitality productivity and without the necessity of global position information. In OD-PRRP, both the proactive routing and reactive routing technique has been utilized to accomplish quick reaction alongside bring down overheads.

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