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Ant Colony Optimization Based Routing in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks consisting of nodes with limited power are deployed to gather useful information from the field. In WSNs it is critical to collect the information in an efficient manner. It is applied in routing and difficult power supply area or area that cannot be reached and some temporary situations, which do not need fixed network supporting and it can fast deploy with strong anti-damage. In order to avoid the problem we proposed a new technique called Bio-Inspired mechanism for routing.ACO is one of the Bio-inspired mechanism. ACO is a dynamic and reliable protocol. It provides energy-aware, data gathering routing structure in wireless sensor network. It can avoid network congestion and fast consumption of energy of individual node. Then it can prolong the life cycle of the whole network. ACO algorithm reduces the energy consumption. It optimizes the routing paths, providing an effective multi-path data transmission to obtain reliable communications in the case of node faults. The main goal is to maintain the maximum lifetime of network, during data transmission in a efficient manner. This paper defines implementation of WSN and comparison of its performance with AODV routing protocol based on ant algorithm is done in terms of packet delivery ratio, throughput and energy level. Performance of our algorithm in comparison of AODV is much better.

Keywords - **Ant Colony Optimization, AODV, Bio-Inspired Routing, Energy efficiency, Wireless sensor networks.**

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I. INTRODUCTION

The Wireless Sensor Networks (WSN) is intended for monitoring an environment. The main task of a wireless sensor node is to sense and collect data from a certain domain, process them and transmit it to the sink where the application lies. The main characteristics of a WSN include power consumption constrains for nodes using batteries or energy harvesting, ability to cope with node failures, mobility of nodes, dynamic network topology, communication failures, heterogeneity of nodes, scalability to large scale of deployment, ability to withstand harsh environmental conditions, ease of use, unattended operation.

However, ensuring the direct communication between a sensor and the sink may force nodes to emit their messages with such a high power that their resources could be quickly depleted. Therefore, the collaboration of nodes to ensure that distant nodes communicate with the sink is a requirement. In this way, messages are propagated by intermediate nodes so that a route with multiple links or hops to the sink is established.

Wireless sensor networks can be used for many mission-critical applications such as target tracking in battlefields and emergency response. In these applications, reliable and timely delivery of sensory data plays a crucial role for the success of the mission. Routing of sensor data has been one of the challenging areas in wireless sensor network research. Current research on routing in wireless sensor networks mostly focused on protocols that are energy aware to maximize the lifetime of the network, scalable for large number of sensor nodes and tolerant to sensor damage and battery exhaustion. This paper focuses on these applications, for which it proposes a localized ACO routing protocol. There are number of reasons that ACO algorithms are a good fit for WSN routing.ACO algorithms are decentralized just as WSNs are similarly decentralized.WSNs are more dynamic that a wired network. Nodes can break, run out of energy, have the radio propagation characteristics change.ACO algorithms have been shown to react quickly to changes in the network.[1]

In this paper we look at ACO routing for wireless sensor networks. We give an overview of several of the currently used routing algorithms in WSNs.We then give an overview of the how AntNet is implemented on he ns2 simulator using 802.15.4. we then compare ACO based routing to AODV and DSR routing, standard WSN algorithms. Finally, we wrap up the paper with a discussion of our results and describe our future work with the project.

II.ROUTING PROTOCOLS FOR SENSOR NETWORK

Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways: There is no infrastructure, wireless links are unreliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements. Routing is a challenging task in WSNs because of their unique characteristics which makes it different from other wired and wireless sensor networks like cellular or mobile adhoc networks. Technically, sensor network nodes are limited in respect to energy supply, computational capability and communication bandwidth. In order to prolong the lifetime of the sensor nodes, designing efficient routing protocol is very critical. There are two important issues should be taken into account while designing a routing protocol for WSN.

- The level of power consumption at each stage of functionalities should be maintained.
- Tolerance of different types of failures should be achieved.

WSNs can be divided into flat-based routing, hierarchical based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality.[1]

III. RELATED WORK AND BACKGROUND

Generally speaking, routing algorithms can be described in two broad classes, reactive (on demand) routing and proactive (table driven) routing. Reactive protocols establish a path between the source and destination only when there are packets to be transmitted. Two commonly found reactive protocols in WSNs are Ad-hoc On-demand Distance Vector (AODV) routing and Dynamic Source Routing (DSR).Proactive protocols always have a route available, so they are more suited for dynamic networks, such as when the nodes are mobile. They are efficient if routes are used often. Reactive protocols create their routes just before data is about to be sent. This ensures the nodes have the most up to date routing information but there is a start up cost as the route is being acquired. Reactive protocols have lower overhead than the proactive protocols and work better for intermittently links. [1]

DSDV is a proactive routing protocol based on the Bellman-Ford algorithm. It expands on Bellman-Ford by having each entry in the routing table contain a sequence number. A route is considered more favourable if it has a higher sequence number. If two routes have the same sequence number, the one with the lower cost metric is chosen. when a node decides a route is broken, it advertises that route with an infinite metric and a sequence number one greater than before. It can be shown that this routing algorithm is loop free.

DSR is a reactive protocol that is similar to AODV, the primary difference from AODV is DSR uses source routing instead of hop-by-hop routing. Each packet routed by DSR contains the complete ordered list of nodes that the packet travels through. The protocol consists of two phases, route discovery and route maintenance. Route discovery is used to obtain a path from a source to a destination. A route request packet is flooded through the network and is answered by a route reply packet. Route maintenance is used to detect if the network topology has changed.

AODV is an reactive protocol that is a combination of DSR and DSDV. Route discovery and maintenance is similar to DSR, and uses the hop-by-hop routing of DSDV. It also uses sequence numbers for loop prevention, with the goals of quick adaptation under rapidly changing link conditions, lower transmission latency that the other protocols and less bandwidth consumption.

IV.PROPOSED FRAMEWORK

1. ANT COLONY OPTIMIZATION (ACO)

Swarm Intelligence (SI) is the local interaction of many simple agents to achieve a global goal. SI is based on social insect metaphor for solving different types of problems. Insects like ants, bees and termites live in colonies. Every single insect in a social insect colony seems to have its own agenda. The integration of all individual activities does not have any supervisor. In a social insect colony, a worker usually does not perform all tasks, but rather specializes in a set of tasks. This division of labour based on specialization is believed to be more efficient than if tasks were performed sequentially by unspecialized individuals. SI is emerged with collective intelligence of groups of simple agents. This approach emphasizes on distributedness, flexibility, robustness and direct or indirect communication among relatively simple agents [2]. The agents are autonomous entities, both proactive and reactive and have capability to adapt, co-operate and move intelligently from one location to the other in the communication network. The basic idea of the ant colony optimization (ACO) meta-heuristic is taken from the food searching behaviour of real ants. Ant agents can be divided into two sections:

- FANT (Forward Ants) and BANT (Backward Ants)

The main purpose of this subdivision of these agents is to allow the BANTs to utilize the useful information gathered by FANTs on their trip time from source to destination. Based on this principle, no node routing information updates are performed by FANT, whose only purpose in life is to report n/w delay conditions to BANT. The various steps how these agents are passing routing information to each other are as follows:

1. Each network node launches FANT to all destinations at regular time intervals.
2. Ants find a path to destination randomly based on current routing tables.
3. The FANT creates a stack, pushing in trip times for every node as that node has reached.
4. When destination is reached, the BANT inherit the stack.
5. The BANT pop the stack entries and follows the path in reverse.
6. The routing table of each visited node are updated based on trip times.

1.1Various fields of FANT

The FANT consist of six field as shown in the Fig. 1

Source address (4 bytes)	Sequence Number (2 bytes)	Destination Address (4 bytes)	Stack	Stack pointer (2 bytes)	Fwd (value =0 or 1)

Fig. 1: Format of Forward Ant

These fields are defined as:

1. Source Address: The 4 bytes field, which contains address of source node discovered by route discovery phase.
2. Sequence Number: The 2 bytes field or local counter maintained by each node and incremented each time when FANT generated by source.
3. Destination Address: The 4 bytes field, which contains address of node where to send the information from source.
4. Stack: The memory area in which data gathered by FANTs is stored.
5. Stack Pointer: It is 2 bytes field, which keep track of number of visited nodes.
6. Fwd: The 1 bit field set to 1 when ant agent is FANT and set to 0 when ant agent is BANT.

When ants are on the way to search for food, they start from their nest and walk toward the food. When an ant reaches an intersection, it has to decide which branch to take next. While walking, ants deposit pheromone, which marks the route taken. The concentration of pheromone on a certain path is an indication of its usage. With time the concentration of pheromone decreases due to diffusion effects. This property is important because it is integrating dynamic into the path Searching process.

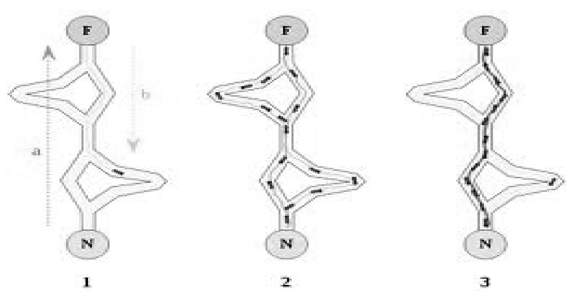

Fig. 2 : All ants take the shortest path after an initial searching time

2. ROUTING IN WSN USING ANT-LIKE AGENTS

2.1 AntNet

AntNet[3] uses ant agents for routing in the network. Using AntNet , nodes in the network frequently send ant agents to randomly selected destinations in the network. After reaching the destination, the ant agent traverses the same path going back to the original source node. On the way back to the Source node, the ant agents update the routing table of the nodes. Launching ant-agents continuously increases the control overhead even more. In a dynamic network such as WSNs, by the time, the ant agent reaches the source node; the routing information may have changed.

2.2 The Three Phases of Ant Based Algorithm

• Route discovery phase
• Route maintenance phase
• Route failure handling

The detailed description of various phases of algorithm is as follows:[4]

2.2.1. Route Discovery Phase

Route discovery phase uses control packet to discover route from source to destination. The control packets are mobile agents which walk through the network to establish routes between nodes. Route discovery uses two ant agents called Forward Ant (FA) and Backward Ant (BA). These two ants are similar in structure but differ in the type of work they perform. A FA is an agent, which establishes the pheromone track to the source node, and BA establishes pheromone track to the destination. A forward ant is broadcast by the sender and relayed by the intermediate nodes till it reaches the destination. A node receiving a FA for the first time creates a record in its routing table. The record includes destination address, next hop and pheromone value. The node interprets the source address of the FA as the destination address, the address of the previous node as the next hop and computes the pheromone value depending on the number of hops the FA needed to reach the node. Then the node forwards the FA to its neighbours. FA packets have unique sequence number. Duplicate FA is detected through sequence number. Once the duplicate ants are detected, the nodes drop them. When the FA reaches the destination, its information is extracted and it is destroyed. BA is created with same sequence number and sent towards the source. BA reserves the resources at along the nodes towards source. BA establishes path to destination node.

2.2.2. Route Maintenance Phase

Route Maintenance plays a very important role in WSN’s as the network keeps dynamically changing and routes found good during discovery may turn to be bad due to congestion, signal strength, etc. Hence when a node starts sending packets to the destination using the Probabilistic Route Finding algorithm explained above, it is essential to find the goodness of a route regularly and update the pheromone counts for the different routes at the source nodes. To accomplish this, when a destination node receives a packet, it probabilistically sends a Congestion Update message to the source which informs the source of the REM value for that route. This Congestion Update message also serves an ACK to the source.

2.2.3. Route Failure Handling Phase

This phase is responsible for generating alternative routes in case the existing route fails. Every packet is associated with acknowledgement; hence if a node does not receive an acknowledgement, it indicates that the link is failed. On detecting a link failure the node sends a route error message to the previous node and deactivates this path by setting the pheromone value to zero. The previous node then tries to find an alternate path to the destination. If the alternate path exists, the packet is forwarded on to that path else the node informs its neighbours to relay the packet towards source. This continues till the source is reached. On reaching the source, the source initiates a new route discovery phase. Hence ant algorithm does not break down on failure of optimal path. This helps in load balancing. That is, if the optimal path is heavily loaded, the data packets can follow the next best paths.

2.3. Applications of ACO algorithms

Since their introduction in the early 1990s, ACO algorithms have been applied to many optimization problems. First, classical problems such as assignment problems, scheduling problems, graph coloring, the maximum clique problem, or vehicle routing problems were tackled. More recent applications include, for example, cell placement problems arising in circuit design, the design of communication networks, bioinformatics problems, or problems arising in continuous optimization. In recent years some researchers have also focused on the application of ACO algorithms to multi-objective problems and to non static problems.

V.EXPERIMENTAL RESULTS

To increase the lifetime for wireless sensor networks, a new ACO routing protocol is used. The data are selected and transferred from the source to the destination via the router. In this result we implemented the simulation of AODV protocol and calculated its performance such as throughput and energy level

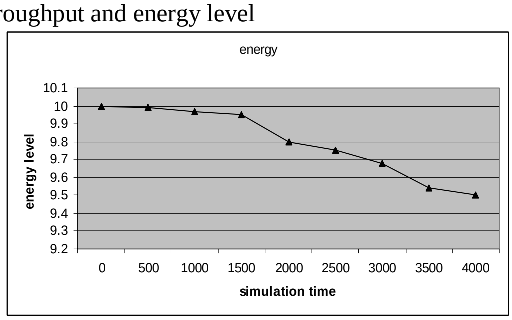

Fig3.AODV Energy Level

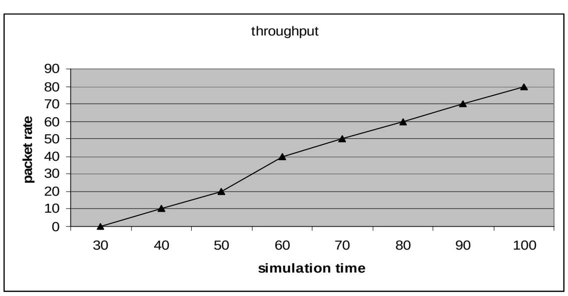

Fig 4.AODV Throughput Level

VI.CONCLUSION AND FUTURE WORK

In this paper, we presented a new protocol for WSN routing Operations. The protocol is achieved by using ACO algorithm to optimize routing paths, providing an effective multi-path data transmission to obtain reliable communications in the case of node faults. We aimed to maintain network life time in maximum, while data transmission is achieved efficiently. Our study was concluded to evaluate the performance of ant based algorithm and AODV routing protocol in terms of Packet Delivery Ratio, Average end-to end delay and Normalized Routing Load. From the comparison it is concluded that overall performance of ant based algorithm is better than AODV in terms of throughput. Our proposed algorithm can control the overhead generated by ants, while achieving faster end-to-end delay and improved packet delivery ratio. The future work could be to investigate different methods to further limit the traffic or load and compare the ant based algorithm for other proactive and reactive routing protocols.

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