MANET and Its Routing Protocols: A Review

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***Abstract*—Wireless Sensor Networks (WSN) that are deployed in applications such as home sentry systems and battlefield monitoring face acute security concerns like forgery of sensor data, eavesdropping, denial of service attacks and the physical compromise of sensor nodes. They consist of tiny devices. These tiny devices have limited energy, computational power, transmission range and memory. Mobile Ad hoc network (MANET) is a kind of WSN which is a self-configurable, restrictive power network of mobile nodes connected by multihop wireless links. MANET often require the use of routing protocols to dynamically discover and assign routes over multiple hops as the network's layout changes. There are many different criteria that can be used by a protocol to predict the loss of a connection, to calculate the quality of the route, and to intelligently decide routing paths. In this paper, different routing protocols have been reviewed to find an appropriate protocol for different applications like requirement of the signal strength between nodes as the criteria for dynamic routing in a MANET, calculation of the cost of each route, comparing BATMAN, OLSR, and BABEL routing protocols, routing enhancement using INTANTSENSE routing protocol based on ant colony optimization etc.**

***Index Terms*—WSN, MANET, aodv, multihop, intantsense, ACO**

I. Introduction

MOBILE Ad-Hoc Network (MANET) is a recent developed part of wireless communication and expected to become an important part of the future generation architecture. One of the major issues that affect the performance of an ad hoc network is the way of routing implemented in a network governed by a dynamic network with high speed. Generally, routing is the process of discovery, selecting, and maintaining paths from a source node to another destination node and using this path to deliver data packets. The goal of every routing algorithm is to direct traffic from sources to destinations, maximizing network performance with minimizing costs; routing overhead and delay.

There are many different criteria used for the determination of routes in Mobile Ad-Hoc Networks (MANET). The decision of which criteria to use is influenced by the available sensors, information, and the deployment environment. Most ad-hoc routing protocols use packet loss, latency, and/or hop count to decide on a route from origin to destination. Some use an even simpler approach and base their routing solely on number of hops between the source and destination. There are many situations where this data does not provide enough information to select the best routes. By using signal strength data, it is possible to improve on many shortcomings of other routing protocols. Important deficiencies are: the non-optimal selection of a route and the large downtime when a route is lost and a new one is discovered. The use of signal strength for routing has been previously discussed in some papers where the approach has normally been simulated. Some simple implementations have also been discussed but provide very little experimental results in real environments.

Swarm intelligence (SI) based, more specially Ant Colony Optimization (ACO) based routing algorithms are novel evolutionary algorithms, which have the characteristics such as positive feedback, negative feedback, distributing computing, stigmergy etc. Swarm Intelligence based techniques like ACO and PSO are inspired from real biological insects like ants, bees, bats, elephants, birds to and is being applied be researchers to solve complex engineering problems.

They possess following characteristics:

- Scalability – The population changes by local and distributed agent interactions.
- Fault tolerance: - There is no centralized control for the agents, so they are able to sustain even in case of small failure in the links.
- Adaptation: - The agents change, reproduce or die as per requirement in the colony.
- Speed: - The agents communicate very fast through pheromone and others follow.
- Modularity: - Agents act independently.
- Autonomy: – No supervision is needed because each agent follows simple rule.
- Parallelism: – Agents perform the operations in parallelism.

II. MANET Routing Protocols: AODV

Ad hoc On-demand Distance Vector (AODV) is a reactive protocol. The nodes use the sequence numbers to avoid loops and take the path information as updated as possible. When a source node wants to transmit information to a destination node, it sends a RREQ (Route Request) packet in broadcast mode to request a route. If a node sees that it is in the destination field of a RREQ, first it checks that this packet has not been received yet by means of a RREQ register. If it was not registered, it sends the message back and increases the

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number of hops and creates the route reverse replying with a RREP (Route Reply) packet to confirm the path. For the maintenance HELLO messages are used for detecting and monitoring links to neighbors. The disadvantages of AODV are; the route request flood all network until reach destination. HELLO Message updating process sends to all network nodes even to nodes they are not associated to the initiated path which leads to adding more overhead on the network. Also AODV not allow multipath routing, new request always must be discovered on route failure situation

III. INTANTSENSE

Intelligent Mobile Ad-hoc routing protocol is a new protocol uses the same mechanisms of pervious AdHoc on demand distance vector (AODV) routing protocol, the same features of reactive routing algorithm route discovery and route maintenance based on Ant Colony Optimization known as an Intelligent Ant Sense, and it depends on pheromone value which is used to control routing process for route discovery, during route maintenance and failure handling. For Intelligent Ant Sense protocol, each route in nodes routing table is assigned a pheromone value to represent the quality of the route, measuring the cost and efficiency of chosen path from source to destination. Ants agent collect the path's information as they travel from node to another, at each node, the initial pheromone value calculated based on the information collected by the ant. This value then assigned to the route entry in the nodes routing table. The pheromone value depending on the number of hops the forward ant needed to reach the node.

This strategy leads to receive low data packets by each node when compared to *AODV*. AODV does not update its route due to mobility of nodes, it kept a higher throughput, but this throughput will be reduced if the speed of the mobile nodes was increased because of low data delivered at each node due to link breaking during high speeds. In case of 15 nodes the throughput remains lower than 25 nodes because increasing in number of nodes with increase the throughput in the network in AODV but has the same value for Intelligent Ant sense.

IV. THE PRINCIPLE OF SELF-ORGANIZING ABILITY

The biological insects follow five basic principle positive and negative feedback, randomness and multiple interactions and stigmergy to self-organize. The self-organizing ability of ants is called *Swarm Intelligence.* We will consider a surface upon which ants and foods are distributed. The ants would like to search the food and carry it to the nest that is; food should be collected in the nest. Each ant acts as individual but follow the basic principles. Ant is bound by the following rules: A biological insect like ant moves around for the search of food source by finding pheromone level on the paths. When no pheromone is found it keeps moving randomly. Once pheromone is found it starts following the path having highest gradient of pheromone. During their random roaming, if an ant finds food and not carrying then picks it up. When an ant is carrying food and find food, the ant will put the food down and start carrying the new food. The ant will also put certain amount of pheromone near the food, so that other ants roaming around can smell the pheromone and hence they also come to know about food source.

The following characteristics describe the principle of *Swarm Intelligence* which is followed by ants for searching a food source:

Positive feedback: When ants find more deposits on a path it is followed by them. A general guideline for particular behavior is formed on the basis of Positive feedback. When an ant finds a food source and returns to its colony, it lays more pheromone on that path. Thereby the pheromone level on that path is increased. Increase in pheromone level in a particular path is a positive feedback for other ants.

Negative feedback: The chemical substance pheromone diffuses in the environment and evaporates over time. This reduces the level of deposit of pheromone in the path. Since the level of pheromone in the path diminishes with time and it does not exist where there is no food, so such paths are not being followed by other ants.

Randomness: A very important characteristic of Swarm Intelligence is randomness. The ants in the colony are not supervised. They do not have central control. They roam around randomly. A small change in pheromone level with lead to a large variation, so it is conveyed at very faster rate.

Multiple interactions: The entire ants keep finding a food source near their colony. They use multiple interactions to find the food source near their colony.

Stigmergy: The ability to communicate indirectly is called stigmergy. The ants in the colony do not communicate directly but they communicate through the deposit level of pheromone level in the path being followed by ants from nest to food source.

V. SIGNAL STRENGTH BASED ROUTING PROTOCOL

Many routing protocols for MANETs have already been developed; however, most are designed for limited use cases and require the user to configure them for each scenario. Many have requirements for specific types and models of sensors to be present, which differ between users. Apart from their difficulty of use, many other shortcomings are present in common routing protocols, such as: loss of communication for many seconds at a time when a connection to a node is lost and low bandwidth when a more optimal route is possible (Zeiger et al. 2008). In the tests run in comparing OLSR, AODV, BATMAN, and DSR, it is found that the re-routing time when a route is lost varied from 2.4 seconds to over 30 seconds which causes a high packet loss between 11.2% and 29.2% for the tested scenario. (Gregor et al. 2012) and (Gaertner et al. 2004), routing protocols for 802.11 MANETS generally use latency, packet loss, hop count, and location information. Using directly measured signal strength information has had limited attention in

simulations and even less in implementations. Additionally, estimations of signal strengths are sometimes derived from other sources. For example, the use of odometry data can be used to calculate relative positions and then to estimate the signal strength based on a signal propagation model. These methods of determining signal strength all have deficiencies and have poor accuracy.

Latency can be unpredictable and can also have very large fluctuations, sometimes with random peaks exceeding the average latency by multiple magnitudes. This can lead to a small number of pings having a very large impact on the average value. The large variations can be due to signals bouncing off obstacles and environmental changes amongst other things. Using latency as a matric requires frequent pinging that adds unnecessary overhead to the channel. It also requires an acknowledgment to be sent which may hinder performance, especially when using UDP or other protocols that do not send acknowledgments.

A. Routing in Wireless Sensor Networks

Routing is a process of determining a path between source and destination upon request of data transmission. In WSNs the network layer is mostly used to implement the routing of the incoming data. It is known that generally in multi-hop networks the source node cannot reach the sink directly. So, intermediate sensor nodes have to relay their packets. The implementation of routing tables gives the solution. These contain the lists of node option for any given packet destination. Routing table is the task of the routing algorithm along with the help of the routing protocol for their construction and maintenance.

B. Routing Challenges and Design Issues

Depending on the application, different architectures and design goals/constraints have been considered for sensor networks. Since the performance of a routing protocol is closely related to the architectural model.

Network dynamics: Most of the network architectures assume that sensor nodes are stationary, because there are very few setups that utilize mobile sensors. It is sometimes necessary to support the mobility of sinks or cluster-heads (gateways). Route stability becomes an important optimization factor, in addition to energy, bandwidth etc. As, routing messages from or to moving nodes is more challenging. So, the sensed event can be either dynamic or static depending on the Application.

Node deployment: It is application dependent and affects the performance of the routing protocol. The deployment is either deterministic or self-organizing. In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. Whereas in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. In later the position of the sink or the cluster-head is also crucial in terms of energy Efficiency and performance. When the distribution of nodes is not uniform, optimal clustering becomes a pressing issue to enable energy efficient network operation.

Energy considerations: During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct Routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi hop routing becomes unavoidable.

Data delivery models: Data delivery model to the sink can be continuous, event driven, query-driven and hybrid, depending on the application of the sensor network. In the continuous delivery model, each sensor sends data periodically. In An event-driven and query-driven model, the transmission of data is triggered when an event occurs or the sink generates a query. Some networks apply a hybrid model using a combination of continuous, event-driven and query-driven data delivery. The routing protocol is highly influenced by the data delivery model, especially with regard to the minimization of energy consumption and route stability.

Node capabilities: In a sensor network, different functionalities can be associated with the sensor nodes. Depending on the application a node can be dedicated to a particular special function such as relaying, sensing and aggregation since engaging the three functionalities at the same time on a node might quickly drain the energy of that node.

Data aggregation/fusion: **S**imilar packets from multiple nodes can be aggregated to reduce the transmission. For this sensor nodes, might generate significant redundant data. Data aggregation is the combination of data from different sources by using functions such as *suppression* (eliminating duplicates), *min*, *max* and *average*.

C. Routing Objectives

Some sensor network applications only require the successful delivery of messages between a source and a destination. However, there are applications that need even more assurance. These are the real-time requirements of the message delivery, and in parallel, the maximization of network lifetime.

Non-real time delivery: The assurance of message delivery is indispensable for all routing protocols. It means that the protocol should always find the route between the communicating nodes, if it really exists. This correctness property can be proven in a formal way, while the average-case performance can be evaluated by measuring the message delivery ratio.

Real-time delivery: Some applications require that a message must be delivered within a specified time, otherwise the message becomes useless or its information content is decreasing after the time bound. Therefore, the main objective of these protocols is to completely control the network delay. The average-case performance of

these protocols can be evaluated by measuring the message delivery ratio with time constraints.

Network lifetime: This protocol objective is crucial for those networks, where the application must run on sensor nodes as long as possible. The protocols aiming this concern try to balance the energy consumption equally among nodes considering their residual energy levels. However, the metric used to determine the network lifetime is also application dependent. Most protocols assume that every node is equally important and they use the time until the first node dies as Metric or the average energy consumption of the nodes as another metric. If nodes are not equally important, then the time until the last or high-priority nodes die can be a reasonable metric.

VI. Conclusion

Wireless Sensor Networks (WSNs) and their quality of services are strongly dependent on the network performance. Ant Colony Optimization (ACO) is a famous meta-heuristic inspired by means of the foraging behavior of real ants. ACO-based approach (ACO-MNCC) can be used for converting the search space of the network lifetime maximization problem in HWSNs into a graph model. The Intelligent Ant Sense has better routing performance compared with conventional routing method AODV at personal area network (WPAN) in case of packet delivered ratio, end to end delay and overhead. Intelligent Ant Sense shows lower overhead, lower end delay with high packet delivered ratio, but it offers low throughput and slightly high packet loss. The signal strength based routing protocol performed best when using the small window size of 16 and a node penalty of 0. The signal strength protocol's performance will vary greatly depending on the environment, MANET size, and the rate of change in the MANET layout. The protocol compared favorably to BATMAN, which is one of the most used routing protocols currently used. It provides significantly better performance than OLSR and BABEL.

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