Comparative analysis of swarm based routing protocols for MANET

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***ABSTRACT*: In the last few decades the attention of the researchers is towards the routing of the data among the sensor nodes in wireless sensor networks. Their main area of concern is based on routing protocols utilizing the concept of SWARM INTELLIGENCE. In this paper we are going to study different routing protocols which are based on swarm intelligence based. After doing a survey their comparison is made based on a number of aspects like route latency, delay, network topology, control traffic, routing information, network mobility, communication overhead and other ones.**

KEYWORDS: Ad-hoc routing protocols, DSDV, WRP, AODV, DSR, ZRP.

I. INTRODUCTION

A Mobile Ad-Hoc Network (MANET) consists of a random collection of wireless mobile devices that cannot rely on centralized approach. The range of MANETs varies from small to large mobile and highly dynamic networks. To establish a data transmission link between two nodes multiple hops are typically required due to the limited transmission range of a single node. Therefore, MANET is A Mobile Ad-Hoc Network (MANET) consists of a random collection of wireless mobile devices (nodes) that cannot rely on centralized approach [1].
All nodes are having routing capabilities and forward data packets for other nodes in multi-hop fashion. Nodes can enter or leave the network at any time, and may be mobile, so that the network topology continuously goes on changing during deployment. The network is required to perform self-configuration by means of the cooperation of mobile nodes: all nodes operate as routers and need to be capable of discovering and maintaining routes, and to propagate data packets accordingly. The movement of mobile nodes requires the employment of quite complex routing algorithms, as paths are not stable and need to be updated continuously [2].

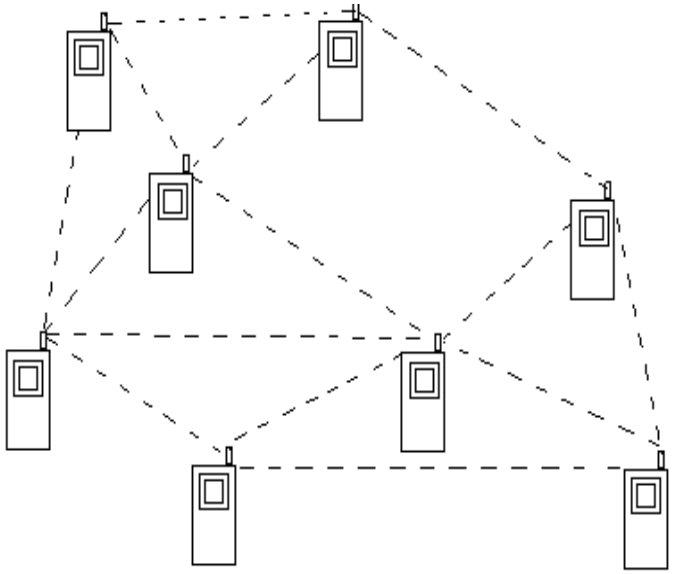

Fig. 1: Example of a Mobile Ad Hoc Network

1. SWARM INTELLIGENCE

Swarm Intelligence (SI) indicates a recent computational and behavioral metaphor for solving distributed problems that originally gets motivated by the biological insects (ants, termites, bees) and by swarming, flocking, herding behavior in vertebrates [3,4]. SWARM INTELLIGENCE is an attempt to design algorithms inspired by the collective behavior of social insects and other animal societies. The common features in all kinds of swarms are [5].

- Control is fully distributed among all individuals.
- Communications among the individuals takes place in a localized way.
- The overall response of the system is quite robust and adaptive with respect to changes in the environment [6].

II. AD-HOC ROUTING PROTOCOLS

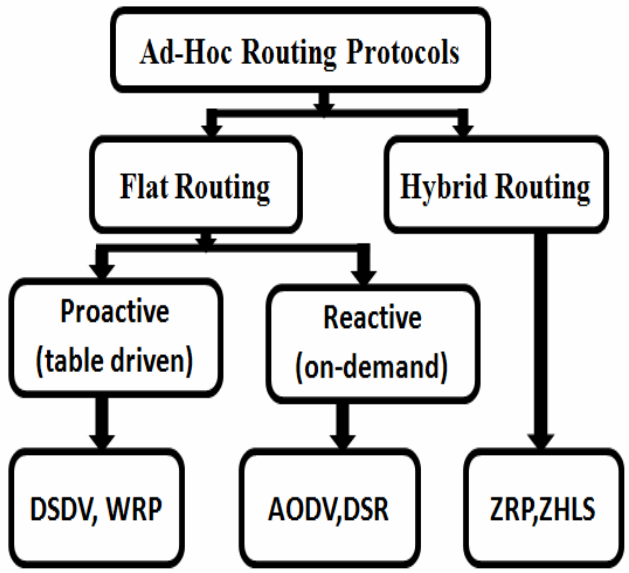

Fig. 2: Classification for routing protocols

The classification for routing protocols for mobile ad-hoc networks are classified as: proactive, reactive and hybrid protocols [7].

The first protocol developed was derived from static networks and require periodic advertisement and global dissemination of connectivity information for proper operation [8]. These so called proactive protocols are table driven, which means that they maintain a routing entry for every possible destination in the sensor network. In Destination-Sequenced Distance Vector Routing (DSDV), for instance, every mobile node in the network holds a routing table where it maintains all possible destinations and their corresponding hop counts [9]. This large amount of network traffic strongly limits the use of this protocol to small ad-hoc networks.

A reactive protocol establishes a route only when needed, that is, if a node wants to transmit some data and is not aware of a route to the destination [10]. Most often, reactive protocols are based on the transmission of route request and route reply messages, which are needed to establish and maintain the routes [11]. Routes are only maintained as long as they are valid and expire after some particular time interval. On-demand route establishment leads to a drastic reduction of control traffic required for routing the data [12].

Finally, hybrid protocols combine proactive and reactive both aspects. Mostly, proactive mechanisms are employed in the local neighborhood of a node to establish routes within a limited amount of radius. Thus, broadcasting over the whole network is avoided.

1. PROACTIVE (TABLE-DRIVEN) ROUTING PROTOCOL

In this all nodes are active and each node discovers path to the other nodes in the network before the actual communication request is made[5]. This leads to less time delay of route discovery during communication request. However, the overhead cost is too high. An example of proactive routing protocol is DSDV [6].

1.1 Destination Sequenced Distance Vector Routing

This routing protocol for MANETs is based on Bellman-Ford Routing Algorithm with few changes. Using DSDV, every mobile node in the MANET network maintains a routing table of its own [13]. This routing table contains the lists of all the destination nodes in the network, the number of hops required to reach those destinations and the sequence number assigned by the destination node. The nodes in the network Based on the DSDV protocol periodically exchange routing tables with their neighboring nodes. A unique sequence number is also used in updating of each route.

2. REACTIVE (ON DEMAND) ROUTING PROTOCOL

On the other hand, this protocol is based on demand basis. All nodes are in sleep mode. The nodes become active only when they need to communicate with other nodes. Therefore, it produces less overhead but possesses more route set up time during communication. DSR, AODV are example of on-demand routing protocol.

2.1 Dynamic Source Routing

The Dynamic Source Routing (DSR) protocol is an on-demand routing protocol based on source routing. In DSR every mobile node in the network has a route cache where it keeps source routes that it has learned. When it wants to send a packet to some other host, the initiating host first checks its route cache for a source route to the destination. In case of a route is found the sender propagates the packet. Otherwise the source node initiates the discovery of route [14].

Route Discovery: For route discovery the source node starts by broadcasting a route request packet to all neighbor nodes within its wireless transmission range. The route request is having the address of the destination host, referred to as the target of the route discovery, the source's address, a route record field and a unique identification number. A simple example is illustrated in the given figure.

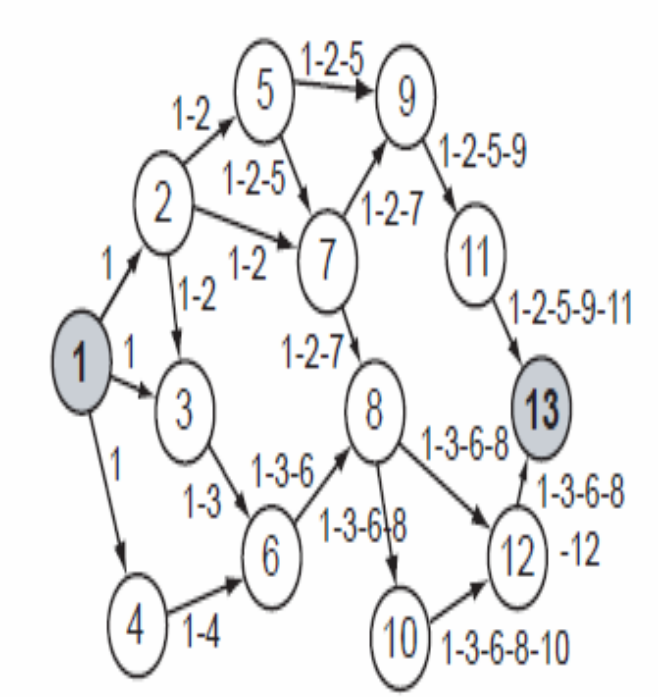

Fig 3: Building of the Route Record

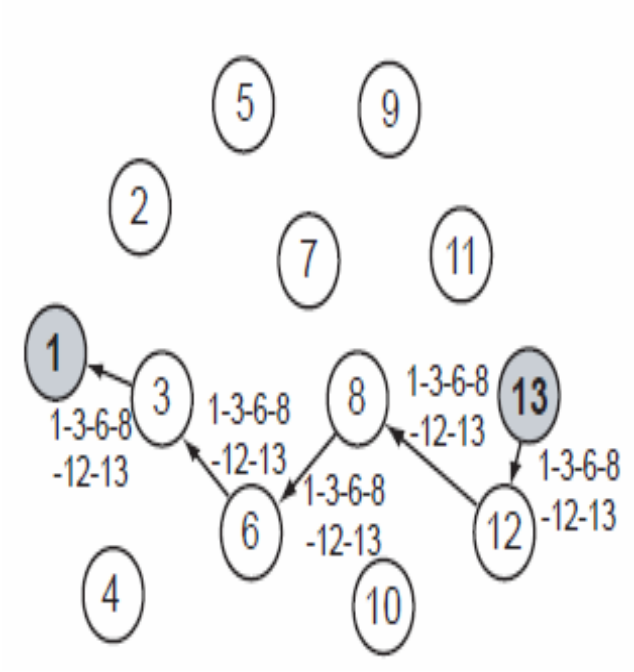

Fig. 4: Propagation of the Route Reply.

During the route discovery the route record field is used to accumulate the sequence of hops which had already taken. First of all, the sender initially fills the route record field as a list with a address of itself only. The next neighboring node appends itself to the list and so on. Each route request packet is also having a unique identification number called request_id. request_id is like a counter, which is incremented whenever a new route request packet is being broadcast by the source node. Thus, every route request packet can be identified uniquely by its initiator's address and request_id. When a host receives a route request packet, it is also important to process the request in a predefined. manner. Using these steps no loops will occur during the broadcasting of the packets.

1. If the pair of source node address, request_id is found in the list of recent route requests, the packet will be discarded.
2. If the host's address is already present in the request's route record, then also the packet will be discarded. This ensures removal of duplicate copies of the same request that may arrive by using any kind of loop.
3. If the destination address in the route request matches the host's address, the route record field will store the list of entire nodes, which have been passed through in order to reach the destination from the source node. A route reply packet is then forwarded to the source node containing a copy of this route.
4. Otherwise, add this host's address to the route record field of the route request packet and broadcast the packet again.

A route reply is sent back if the request packet reaches its destination itself or if the request reaches an intermediate node, which has an active route to the destination in its route cache. The route record field in the request packet stores the sequence of hops taken. If the node which is generating the route reply is the destination node, then it only takes the route record field of the route request and puts it into the route reply packet. If the responding node is an intermediate node, then it appends the cached route to the route record packet and then generates the route reply.

2.2 Ad hoc On-Demand Distance Vector Routing Protocol (AODV)

If a node is using Ad hoc On-demand Distance Vector (AODV) [15] routing protocol and it does not have any information about the route to the destination it wants to communicate with, then that node initiates a route discovery procedure to locate the destination node. During the route discovery process, the source node broadcasts a route request (RREQ) packet to all of its neighboring nodes as shown in figure [16].

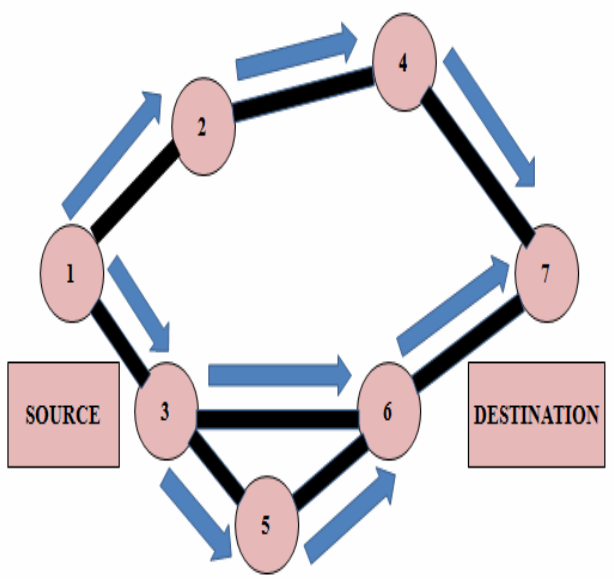

Fig. 5: Propagation of RREQ Packet.

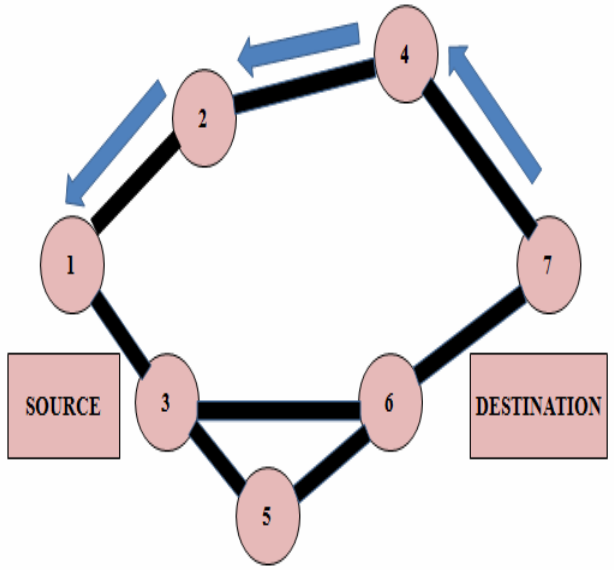

Fig. 6: Propagation of RREP Packet.

When a node receives an RREQ packet, it forwards the same to its neighboring nodes until either the destination node or an intermediate node with a route to the destination is approached.

When the destination node or an intermediate node having a route to the destination receives the RREQ message, it responds back by sending a route reply (RREP) packet to the source node as shown in figure above. Sequence numbers are also used in AODV to ensure that the routes formed are loop free.

3. HYBRID PROTOCOLS

Finally, hybrid protocols combine proactive and reactive. Proactive mechanisms are used in the local neighborhood of a node to establish routes within a given limited radius. Thus, broadcasting through the entire network is avoided. Routing between nodes which are lying farther from each other is still performed by on-demand routing. Hybrid routing is illustrated by means of the ZRP protocol.

3.1 Zone Routing Protocol

In a mobile ad-hoc network it can be assumed that most of the communication takes place between nodes which are closer to each other. The Zone Routing Protocol (ZRP) explained in [17] takes advantage of this fact and divides the entire of the network into a certain number of overlapping zones of variable size. It uses proactive protocols for finding neighboring zones (instantly sending hello messages) as well as reactive protocols for routing purposes between different zones (a route is established if there is a need). Each node may define its own zone size, whereby the zone size is defined as number of multiple hops to the zone perimeter. Sometimes, the zone size may also depend on signal strength, available power, reliability of different nodes etc.

First of all, a node needs to discover its neighboring nodes in order to be able to construct a zone and to determine the perimeter nodes. In figure below, all perimeter nodes are shown in dark gray color – they build the border of A's zone with radius ρ = 2. The detection process is usually accomplished by using the Neighbor Discovery Protocol (NDP). Every node periodically sends some hello messages to its neighboring nodes. If it receives a response, then a point-to-point connection to this node exists. Nodes may be selected based on different criteria like its signal strength, radio frequency, delay etc. The discovery messages are repeated from time to time to keep the map of the neighboring nodes updated.

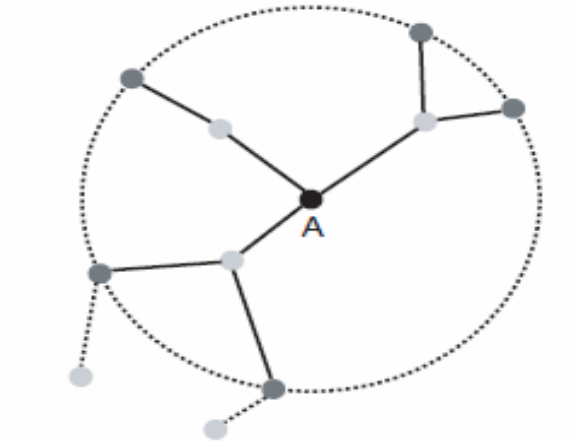

Fig. 7: ZRP - Routing Zone of Node A, ρ = 2

Table 1. Comparison between Swarm Based Protocols

Characteristics	***Table-Driven***	***Demand-Driven***	***Hybrid***
Network Organization	Flat hierarchical	Flat	hierarchical
Examples	DSDV, OLSR, WRP	AODV,DSR,TORA, ARA	ZRP, ZHLS, DDR
Delay	Low	High	Low (in Intrazone) and High (in Interzone)
Route Latency	Always available	Available when needed	Both
Mobility Handling	Periodic updates	Route maintenance	Both
Periodic Message	Required	Not required	Sometimes used inside each zone.
Topology Dissemination	Periodical	On demand	Both
Communication Overhead	High	Low	Medium
Path Information	Stored in routing tables	Doesn't stored	Only available when needed
Control Traffic	High	Low	Lower than other two types
Benefit	Rapid establishment of routes & routing information is updated periodically.	Obtain required route when needed & don't exchange routing table periodically & loop free.	Updated routing information, limited search cost & more scalable.
Drawback	Convergence time is low, resource amount is used heavily, routing information flooded in whole network.	Routes are not up-to-date, large delay, more packet dropping.	Required more resources for larger size zones.

III. CONCLUSION

Wireless sensor networks consist of large sets of battery-constrained nodes. The design of effective, robust, and scalable routing protocols in these sensor networks is a very challenging task [18]. On the other hand, the concept of swarm intelligence offers algorithmic design principles, which are inspired by biological systems, that well match the shortcomings and the challenges of WSNs. Therefore, a large number of routing protocols for WSNs have been developed in the last years based on SI principles, and, more specifically, taking inspiration from foraging behaviors of ant colonies [19]. When the literature was surveyed, it was observed that routing protocols for WSNs were initially implemented for wired networks. The researchers have shown that swarm intelligence based routing protocols can remove at least one or several problems in the area such as Quality of service (QoS), battery life, scalability, maintainability, adaptability and so on. As such, ant based approaches are attracted by much researchers than other approaches in this field.

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