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Survey on Routing Protocols on FANET

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Abstract: Flying Ad-hoc Networks (FANETs) are most popular now a days. They are used in the situations of emergency, in the case of a natural disaster, military battle fields. FANETs are the new family member of the mobile ad-hoc networks (MANETs) class. Group of Unmanned Air Vehicle (UAV) are known as Flying Ad-Hoc Networks. It completed their work without human intervention (i.e Driverless Aircraft). There are many problem arises in this kind of networks. The main problem is the communication between (UAVs). In order to solve this problem several routing protocols have been proposed for flying ad-hoc networks they are static, proactive, reactive routing protocols. This paper provides an overview of the protocols, FANET characteristics and design considerations. The main objective is to make observations about the performance of protocols**.**

Keywords: FANETs, Protocol, proactive, reactive, UAV.

I. INTRODUCTION

MANETs have several application areas such as emergency and disaster scenario, sensor networks, etc., but there are some extreme situations, such as flooding, battlefield and rescue operations, etc., where MANETs cannot be deployed. In those situations, Flying Ad-hoc Networks (FANETs) can play the vital role in established communication. FANET is a subclass of MANETs and made up of a swarm of small flying vehicles enable with camera, sensor and GPS system. Swarms of UAVs arrange themselves to communicate with large operational area using wireless network without any centralized device. UAVs communicate with each other locally, with base station or satellite and also interact with their environment to get information. FANETs use different types of UAVs based on the various application areas. FANETs employ unmanned aerial vehicle (UAVs), UAV is an aircraft which flies without a pilot. The UAV can manage itself and fly based on preprogrammed flight plans or can be operated using complex dynamic automation systems which are versatile and flexible in implementation. FANETs use multi-UAVs to perform operations because of the limitations of a single UAV system such as limited surveillance capability, scalability, and flexibility. There are many routing protocols in the wireless and ad-hoc environment and all of these protocols are not suitable for the FANET. Therefore to adopt the new networking model, some specific protocols have been implemented in literature and some of the previous protocols are modified in the literature.

The paper is organized as follows. In Section 2, we introduce FANET design characteristics. In Section 3, We discuss about FANET design considerations. In Section 4 provide an extensive review of the protocols. In Section 5, We conclude this paper.

II. FANETS CHARACTERISTICS

In FANETs, valid for multi-UAVs systems can create an FANETs network; Some FANETs characteristics are explained below:

A. NODE MOBILITY

Issues of the Node mobility provide the most significant difference between FANET and the other ad-hoc networks. MANET node movement is comparatively slow when it is compared to VANET. In FANET, the nodes mobility degree is much higher than in the VANET and MANET [2]. A UAV has a speed of 30–460 km/h, and this situation results in several challenging communication design problems [3].

2) MOBILITY MODELS

MANET nodes move on the definite territory, VANET nodes move on the highways, and FANET nodes fly in the sky. In many mobility models, the flight plan is predetermined, and each step there is a change, recalculation take place. Other models are using random speed and directions for the UAVs[4].

3) NODE DENSITY

The average number of UAVs in some area is called Node Density. FANET nodes are normally spread in to the sky. The distance between UAVs can be several kilometers for small multi-UAV systems. Thus the FANET node density is much lower than in the MANET and VANET.

4)TOPOLOGY CHANGE

Due to higher mobility degree, FANET topology changes more frequently than MANET and VANET topology. When a UAV fails, the links that the UAV has been involved in also failed and it results in a topology update. The main factor that affects the FANET topology is the link outages. The UAV schedules and variations of FANET node distances, link quality changes very quickly, and it also causes link outages and topology changes [5].

5) RADIO PROPAGATION MODEL

According to the environment in FANETs and the large distances between UAVs. The UAVs uses a line-of- sight between them and with a ground base. In contrast with MANET, it does not use any radio signal between nodes because Radio signals are mostly affected by the geographic structure.

6) POWER CONSUMPTION AND NETWORK LIFETIME

Network lifetime is an important issue in this network, which consists of battery-powered computing devices. Communication hardware used in FANETs is powered by UAV energy source itself. In case of this, FANETs designs may not be power sensitive, in contrast with MANET applications. But it stills a problem in mini UAVs [1].

7) COMPUTATIONAL POWER

MANET nodes are battery powered small computers such as laptops, PDAs and smart phones. Because of the size and energy constraints, the nodes have only limited computational power. On the other hand VANETs and FANETs support devices have high computational power.

8) LOCALIZATION

Localization means determining the location of the UAV. Based on high speed and frequently change, there is a need for highly localization information with small intervals of time. Using GPS, the information about the new locations will be propagated to the network each one second, and this is not sufficient. Therefore, each UAV must be containing a GP and Initial measurement unit to broadcast his location to all UAVs in the network at any time [6].

III. FANET DESIGN CONSIDERATIONS

FANET requires different design considerations than traditional ad-hoc networks. We discuss the following design considerations: adaptability, latency, mobility, and scalability.

• ADAPTABILITY:

FANET nodes are highly mobile in nature. Due to this behavior of nodes, they keep on changing their location. The routes between UAVs keep changes and distance between them is also not constant. Another problem is UAV failure that decreases number of UAVs in networks. Overall performance of a network depends on the adaptability of these path changes and topology changes [4].

• LATENCY:

Latency is the important design issue for all types of Networks. Latency is basically application dependent factor. For real time applications of FANET like search and rescue operations, military applications latency should be low for transferring information. These are time-bound applications. For non-time critical applications such as city architecture planning etc., the latency factor can be little compromised.

• MOBILITY:

Mobility of UAVs plays an important role in the performance of FANETs. There are several moment patterns for an adhoc network node. Moving pattern can be for a group or individual node. It is very difficult to identify that which moving pattern of UAVs will be suitable to complete task effectively and in time bound manner.

• SCALABILITY:

Multi-UAVs can enhance the overall performance of network as compare to single UAV systems. Performance is enhanced by increasing number of UAVs in the network. Higher the number of UAVs, faster will be the task completion and more reliable will be the network. Scalability is an important factor for time-dependent applications in the FANET design consideration.

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IV. TOPOLOGY-BASED ROUTING PROTOCOLS

PROACTIVE PROTOCOLS:

Proactive Routing Protocols (PRP) use tables to store all the routing information in the network. The main advantage of proactive protocols always maintain one or more data-tables to store latest routing information and to propagate that information throughout the network .Such protocols are also known as table-driven. It easily choose a route from the sender to the receiver; as a result transmission delay can be minimized. Some examples of proactive ad hoc routing protocols are DSDV [8], and Wireless Routing Protocol (WRP) [9], optimized Link State Routing Protocol (OLSR) [10].

Destination Sequenced Distance Vector (DSDV)

DSDV is an proactive routing protocol. It uses the concept of the Bellman Ford algorithm. This algorithm was discovered by C. Perkins and P.Bhagwat in 1994. DSDV is modified version of Distance Vector Routing. Distance Vector Routing maintains hop count for each destination node. The routing table consists of destination, distance and next hop. Each node sends its routing table to the neighbor nodes periodically. Nodes re-compute there shortest distance and update their table. Main problems of Distance Vector Routing are count to infinity, slow convergence and looping. DSDV was designed to solve the problems of Distance Vector Routing. DSDV added two parameters Sequence number and Damping. Sequence number was added to avoid looping issues and damping was included to avoid unnecessary updates. DSDV routing updates are done in following two forms.

• **Periodic updates:** Periodic updates are sent after every 15s. Entire routing table of each node is broadcasted.
• **Trigger Updates:** These are the updates that are sent in between periodic updates. These updates are sent when any update is received by any node.

WRP (Wireless Routing Protocol)

This Wireless Routing Protocol (WRP) is based on distributed Bellman- ford algorithm, designed for wireless ad-hoc networks. WRP modifies and enhances the distance vector routing in the following ways. First, when there are no link changes, WRP periodically exchanges a simple HELLO packet rather than exchanging the whole route table. The main advantage of this WRP is reducing the routing loop. The Distance table contains the destination, distance, and the predecessor (second-to-last-hop) node ID. Second, to improve reliability in delivering update messages, every neighbor is required to send acknowledgments for update packets received. Retransmissions are sent if no positive acknowledgements are received within the timeout period. Third, the predecessor node ID information allows the protocol to recursively calculate the entire path from source to destination.

OLSR (Optimized Link State Routing)

OLSR is proactive routing protocol which is designed especially for ad-hoc networks. OLSR provides following features:

- It reduces the size of control packets by declaring a node as a multi-point-relay (MPR) selector to each and every node of its neighbor.
- By using those MPRs which were selected, it reduces to scatter its messages to the whole network.

OLSR use MPR through which it is able to reduce the whole network traffic and also reduces the flooding in the network which is arises when every node transmits data to each other to send the message to the exact destination. Hence, this routing protocol is best fit for large and dense ad-hoc networks.

REACTIVE PROTOCOLS

The Reactive protocols always seek to set up routes. If the node has no route, then the routing protocols establish the route. The reactive protocol is keep routing control packet as minimum as possible throughout the network. To establish a path to destination node send a route request packet to is neighboring node which further forwarded by these nodes to their neighboring node until the destination node is reached. The route followed by the route request packet is recorded and destination node uses this recorded path to send route reply packet back to the source node. Some of the routing strategies are AODV [8], DSR [12] and TORA [12].

AD-hoc On-Demand Distance Vector Routing (AODV)

AODV is important routing class in Reactive protocol and it builds routes via a route request/ route reply query sequence. When a source node wants a route to a target for which it does not already have a path, it transmits a route request (RREQ) packet to the network. Nodes getting this packet bring up to date their information for the source node and set up backward pointers to the initial node in the route tables A node getting the RREQ may launch a route reply (RREP) if it is either the target or if it has a route to the destination with the equivalent series number greater than or equal to that restricted in the RREQ. If this is the case, it unicast an RREP back to the source node, otherwise, it retransmits the RREQ. Nodes keep the path of the RREQ's source node IP address and transmit ID of a better route. If they get an RREQ which they have already progressed, then reject the RREQ.

Dynamic Source Routing (DSR)

DSR is one of the on-demand routing protocol. It is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. Each node maintains a temporary memory which is used to store recently discovered route. Whenever a mobile node needs to establish a connection it checks its temporary memory if there is an entry for required route it uses that path for communication otherwise it broadcast a route request packet to its local topology and wait until the route is obtained. On receiving the route request packet, the intermediate node checks their temporary memory for destination requested if there is an entry for destination then they send a route reply message to the destination otherwise they further forward the route request message in their local topology.

TORA

Temporarily Ordered Routing Algorithm **(**TORA) is another reactive protocol. It overcomes the problem of the loop. TORA uses graph theory, it applies directed acyclic graph to determine the path in the terms of upstream and downstream. With the help of a directed graph, TORA works well in relatively dense network. Unlike other protocol where source reinitiate the path obtaining routine TORA is able to reconstruct broken link locally in which control packet floated around the place of breakage, this quality makes this protocol different from other protocol. This protocol is able to work well in a large network. TORA has following function namely construction, maintenance, deleting, and optimization. In this protocol, every node has a height attribute if a node do not have this attribute considered as a deleted node. Algorithm to optimize height also employed known as optimization of path.

Hybrid Routing Protocols

Hybrid routing protocols make use of the features of Distance Vector Routing protocol and Link State Routing Protocol. Hybrid protocol faces the problem of power consumption and needs large memory because node has to maintain a lot of routing information. ZRP, CEDAR, ZHLS are the example of this category[12].

ZRP

ZRP is a hybrid routing strategy which combines the mobile nodes in to sub group called zone. It combines the advantage of reactive routing protocol and proactive routing protocol. Zone node communicates through table driven mechanism and transmission among the zone utilizes reactive approach leads to reduction in control messages. Node inside a particular zone needs to update their routing table regularly.

CEDAR

Core Extraction Distributed Ad hoc Routing is a distributive protocol which divide the network into group of nodes. Every group has a core node called dominator node. CEDAR also ensures the QOS in routing. It include the concept of dominator set, dominator is a set of a graph defined as group of node such that every mobile node is either Member or should be neighbor of a node. Dominator nodes apply on demand routing for route discovery among the different set from source to destination.

Protocols include three major phase:
1. Creation and maintenance of core for routing.
2. Propagation of link state information in the core.
3. A QoS route construction mechanism is invoked at the dominator node.

CEDAR uses slow moving increase-waves and fast moving decreased waves to achieve QoS which propagates the bandwidth availability information of a stable link.

ZHLS

ZHLS protocol is one of the Hybrid protocol. This protocol partitioned the network in to zones every node in network assigned to a node_id. Zone_id provided by geographical location. Protocol uses two level of topology one is at node level and other on zone level. It has two link state packets namely node LSP and Zone LSP
Node LSP: list of connected neighbor and
Zone LSP: list of connected zone
In this protocol every node share its node LSP to its neighbor node at regular interval thus every node in same zone share common link state information. Whenever a node wants to communicate with node first it checks the intra zone routing information in if destination node present in same zone, it communicates directly through its routing table. Otherwise nodes send a request packet to other zone through gateway node (boundary node) which replies with packet

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having zone id of destination node. In communication data packet contains node_ID and zone_ID of destination node. This Algorithm is adaptable frequent changing topology as zone_id and node_id is needed for communication.

V. CONCLUSION

Flying Ad-hoc Network (FANET) is a wireless ad-hoc network which has many research issues. Due to high mobility and frequent network changes, Communication is one of the major issues in this FANET. There are much work has been done on improving single UAV Communication, it can be improved further for multiple UAV Communication Systems. In this paper, we presented different communication protocols of FANET. We gave a small description about different protocols and how they improve FANET communication.

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