Routing Strategy for Flying ADHOC Network

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Abstract— The usage of UAV(unmanned aerial vehicle) is increasing day by day. In recent years, UAVs are being used in increasing number of military and civil applications such as policing and firefighting. FANET(Flying Ad hoc Networks) is relatively a new technology in network family where requirements vary largely from traditional networking models such as MANET and VANET .During natural disaster like floods, earthquakes and even in military battle field FANET can perform better than other form of Mobile ad-hoc network. In order to overcome obstacles during such operations, we propose to combine omnidirectional and directional transmission scheme. A Flying ad-hoc network is a group of homogeneous flying agents called UAV(unmanned aerial vehicle) and MAV
(micro aerial vehicle)communicates with each other locally. Due to high mobility in FANET, node mobility is a big challenge for researcher to apply routing in it. While designing wireless network there are many issues generated such as UAV mobility and placement, network scalability, QOS(Quality Of Service), reliable data deliver routing. These issues can be overcome by using predictive routing protocols such as RARP(reliable and robust routing protocol), LAR(Link Adaptive Routing).

Keywords- *UAV networks, FANET(Flying ad-hoc network) ,MANET(Mobile ad-hoc network), VANET(Vehicular ad-hoc network), Routing protocols.*

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I. INTRODUCTION

In case of calamitous events, when traditional communication methods are simply not available and out of service, in those situations MANET(mobile ad-hoc network) play an important role to established the communication. Nodes in MANET communicate with each other through wireless communication without using of existing infrastructure. MANET employ ground mobile nodes which are capable to collect information with the help of sensor, cameras and other device. MANET have several applications such as natural disaster, sensor networks etc. But there are some extreme situations(such as flooding, battle field and rescue operations) where MANET cannot deploy. In those situations FANET can play vital role to establish reliable communication. It is similar to MANET and VANET in terms of peer to peer communication. It is a subclass of MANET and made up of small flying vehicles such as UAV(unmanned aerial vehicle) and MAV(micro aerial vehicle) with camera sensor and GPS(global positioning system). UAV is an aircraft which fly without pilot.[1] FANET use multi UAV to perform operations because of limitation of single UAV system such as limited surveillance capability, scalability and flexibility[2]. There are many uses of multiple UAV system:-

Economical: The installation and maintenance cost of small UAVs are much less than that large UAV[3].

Flexibility: Single UAV have limited coverage area, hence coverage rate is low.[4]

Continuity: If the UAV operation fails in a mission, it cannot be proceed. However, if a UAV goes off in multi UAV system , operation can be survived through other UAV

The fast growing global industry of the UAV(unmanned aerial vehicle) commonly known as drone, has already found applications in both civil and military operations such as real time surveillance[5], wildfire monitoring[6], search and rescue operations[7]. A typical UAV may operate with various degree of antimony: either remote control by infrastructure such as ground base and satellite. In order to avoid the restrictions introduced by infrastructure based communication architecture, ad-hoc networking between UAV is preferred [6]. FANET nodes are operating in the sky; line of sight communication is possible most of the time. The speed of typical UAV in it ranges from 30-460 km/h with movement in three dimensional face [9]. It is used for long distance communication. Long distance communications also consume a lot of power which can make a light weight UAV with limited battery power infeasible. Since FANET are deployed for military and civil applications that demand guaranteed data delivery with low latency, reliability and robustness.

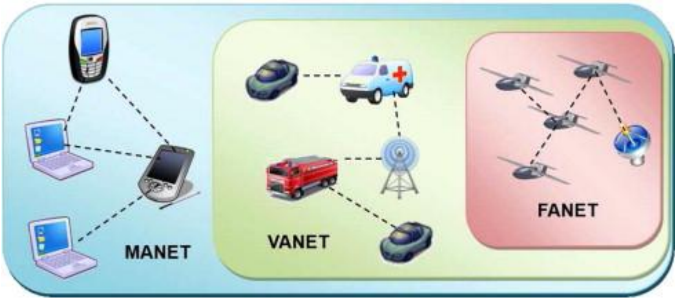

Figure 1 Flying Ad-hoc Network

A. *FANET Challenges*

FANET is the member of MANET family. It faces some additional challenges along with already existing challenges in MANET family due to its high node speed, high topology changes and mobility models. Based on the finding of literature review, following are the areas identified that require significant research to be done:

- *Routing:* Routing in FANETs is different from other ad-hoc networks family. Node movement is relatively very high in it. So the topology changes very frequently. One of the biggest challenges is to develop an efficient routing algorithm that not only able to work with high mobility nodes but should be quick to update its routing table frequently as the topology changes [8].
- *Security:* Ensuring confidentiality, availability and Integrity of information during the communication between UAV to UAV communication and UAV to ground node communication is one of the major issues faced by FANETs [9]. Due to lack of physical security node compromise becomes easy in it. Trust Management among nodes is another challenge due to high topology changes. Nodes join and leave the network very frequently.
- *QOS(Quality of Service):* In FANETs UAVs transmit data includes audio, video, images, text, GPS locations etc.. To transfer such data it should have a good quality of service with less delays and error rates. [10].
- *UAV Mobility and Placement*: The placement of UAVs at appropriate location is one of the major research concerns in FANETs. UAVs of different capacity and capability are used for different purpose. Mini-UAVs are meant for carrying fewer payloads, like a thermal camera, single radar, camera, image sensor, *etc*. So, this is an open challenge to optimize the UAV placement to diminish energy feeding when the retrieved information is taking more time.
- *Reliable data delivery*: FANET applications transfer very important information in different applications, which required to be delivered in time bound manner. So the reliability of the network should be very high. Reliability should be defined with the criticality of data.

Applications of FANET:

Due to various advantages and wide range of application areas FANET are getting attention of research community around the globe.

*Military Services***:** These are very useful in military services. Setting up proper communication system is very difficult in military areas. So they are used for information exchange among soldiers, military headquarters

Security Purpose: They are capable of receiving information quickly. It can be used to collect information for the security purpose of a delegate visiting to a place where no network infrastructure exists.

*Search and Rescue Operations***:** It can be used provide a better way to do search and rescue operations such as rescue operation of hostages [11]. Some times in extreme situations, cellular networks get damaged. FANETs provide better rescue services in such conditions by sending periodic updates to other locations.

In Sensor Networks: Different sensor devices can be used to collect data to do daily functions like weather forecasting, terrestrial movement tracking etc. FANETs can approach to any remote location without difficulties.

Location Aware Services: FANETs can be used in many services [11] like forwarding calls to any location, travel guide for passengers, identify information regarding specific location.

The rest of paper is organized as: Section II provides the information regarding Routing protocol. Section III describes the predictive routing protocols in detail.

II. ROUTING PROTOCOL

Flying nodes have very high mobility and topological changes, so existing solutions of MANETs cannot be directly applied to FANETs. To formulate solutions for FANETs, either existing solutions can be modified or new techniques can be formulated. To establish communication between nodes various routing protocols found in literature. Therefore MANET routing protocols are initial chosen and then tested for the FANET. These protocols are categorized as follows:-

A. Proactive Routing Protocol

In these protocols, each and every node in the network shares its routing information from its routing table at regular time interval which is used by the other nodes to identify the path for destination nodes and make the map of whole network. The big advantage of these protocols is that these protocols take very short time period to get the path to the destination. But, it costs very much bandwidth consumption to update the information within short period of time thorough which it maintain map of whole network. There are several proposed algorithms under this category like WRP, DSDV and OLSR Fisheye [12].

1) DSDV(Destination- Sequenced Distance Vector)

It is a table-driven proactive routing protocol in which each node acts as a router. Each node maintains a routing table which contains sequence number for all other nodes, not only for the neighbor nodes. When the network topology changes the these changes are disseminated by update mechanism of the protocol. Here, sequence number is associated with each route. This protocol is not useful for dynamic networks where topology changes rapidly and does not support for multipath routing. It also requires large updating of routing tables.

2) OLSR(Optimized Link State Routing Protocol)

It is a link-state proactive routing protocol that uses two types of messages (hello and topology control messages) in order to discover neighbors. Hello messages basically used for detecting the neighbor nodes in between the direct communication range. Generally, this message contains the known neighbors list, and it is periodically broadcast to one-hop neighbors. The topology control messages are used to maintain the topological information of the system. These messages are used for periodically refresh the topology information. So, each node can re-calculate the routes to all nodes in the system. Therefore, this periodic flooding nature of protocol results in a large amount of overhead (traffic). In order to reduce this overhead Multi Point Relay (MPR) mechanism must be used.

B. Reactive Routing Protocol:

Reactive routing protocols are on-demand protocols, they build path whenever required by network nodes. The Reactive protocols do not broadcast their routing table information in regular time interval. They broadcast their routing information only when it is needed. Therefore, they minimize the use of network bandwidth. But, due to the reactive nature there is a disadvantage to these types of routing algorithms, End to End delay of packet delivery is increased as compared to proactive protocols. They also take more time to select an immediate node to transfer the data packet because of dynamic network topology. Reactive protocols are less likely to use in applications in dynamic environment. Many algorithms are proposed under this category like AODV, DSR and ABR

1)DSR(Dynamic Source Routing):

Dynamic Source Routing is a reactive protocol designed for wireless mesh networks. Here, route is determined by the sender from source to destination. In DSR, the source node generally sends a route request message to the neighbor nodes. There can be many route request messages in the entire communication route. In order to avoid mixing the source node must add a unique request id. Here, all the nodes must be associated with route caches in which all the routes are present. So, the main problem in this is the maintaining and updating the route caches.

2) AODV(Ad-hoc On-demand Distance Vector)

Ad-hoc On demand Distance Vector (AODV) has similar features with DSR as it is a combination of DSR and DSDV. The only difference maintenance of routing table .In DSR each node stores multiple entries in the routing table for every destination while in AODV; there is only a single record for every destination. Another difference is this that in DSR, all the data packets must transfer the complete route between source and destination nodes. But in AODV, the source node stores only the next-hop information which is consistent to each data communication. AODV routing protocol generally consists of three phases: discovery of route, packet transmission and route maintaining and three message types like route request, route replies and route errors.

C. Hybrid Routing Protocol

Hybrid protocols are combination of both proactive and reactive protocols. These protocols are designed to minimize the overhead which is occurred in both types of protocols [reactive and proactive]. But, the protocols under this category are not suitable for large networks having more than hundred nodes because of large overlapping of zones like ZRP and TORA

1) ZRP(Zone Routing Protocol)

Zone Routing Protocol depends on the idea of zones. In this convention, each hub has an alternate zone. The zone is characterized as the arrangement of hubs whose base separation is predefined range R. Along these lines, the zones of neighboring hubs meet. The directing inside the zone is called as intra-zone directing, and it utilizes proactive strategy. On the off chance that the source and destination hubs are in the same zone, the source hub can begin information correspondence right away. At the point when the information bundles need to send outside the zone the inter zone.

2) TORA(Temporarily Ordered Routing Algorithm)

Temporarily Ordered Routing Algorithm(TORA) is basically a hybrid distributed routing protocol for multi-hop systems, in which routers just keep up data about contiguous routers .Its point is to restrict the proliferation of control message in the very rapid versatile registering environment, by minimizing the responses to topological changes. In spite of the fact that, it essentially utilizes reactive routing protocols, it is additionally upgraded with some proactive methodologies. It constructs and keeps up a Directed Acyclic Graph (DAG) from the source hub to the destination. There are various routes between these hubs in DAG. It is favored for rapidly finding new routes in the event of broken connections and for expanding flexibility. TORA does not utilize a most limited way arrangement, and more courses are regularly utilized to diminish network overhead.

Due to high mobility and unreliable communication, network topology is to be changed and distance between flying nodes will be long, resulting in loss of connections. Long distance communications also consume a lot of power which can make light weight UAV with limited battery power consumption. Since FANET are deployed for sensitive military and civil application that demand guaranteed data delivery with high mobility, low latency, and reliable communication. In this paper we propose a robust and RARP(reliable and robustness routing protocol) and LAR (link adapting routing protocol) to reduce high mobility in the network, reduce overhead(traffic and flooding) and provide robust and reliable communication and hence increase the performance of flying ad-hoc networks.

III. PREDICTIVE ROUTING PROTOCOL

A. LAR (Link Adaptive Routing)

LAR is a mobile ad-hoc routing protocol. LAR uses location information using GPS through which every node know its current physical location. In LAR, node find out route to another node when it wants to send data to another node. LAR utilizes the location information for improving the efficiency of routing by reducing control overhead.

1) Route Discovery Using Flooding

Explore the possibility of using location information to improve performance of routing protocols for MANET.As illustration, we show how a route discovery protocol based on flooding can be improved. The route discovery algorithm using flooding is described next (this algorithm is similar to Dynamic Source Routing [13, 14]). When a node S needs to find a route to node D, node S broadcasts a route request message to all its neighbors hereafter, node S will be referred to as the sender and node D as the destination. A node, says X, on receiving a route request message, compares the desired destination with its own identifier. If there is a match, it means that the request is for a route to itself (i.e., node X). Otherwise, node X broadcasts the request to its neighbors – to avoid redundant transmissions of route requests, a node X only broadcasts a particular route request once (repeated reception of a route request is detected using sequence numbers).Figure 1 illustrates this algorithm. In this figure, node S needs to determine a route to node D. Therefore, node S broadcasts a route request to its neighbors. When nodes B and C receive the route request, they forward it to all their neighbors. When node X receives the route request from B, it forwards the request to its neighbors. However, when node X receives the same route request from C, node X simply discards the route request.

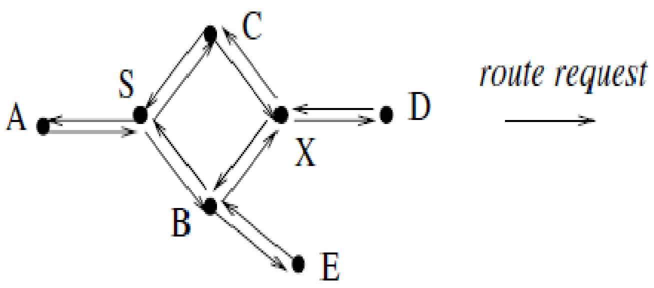

FIG 2:illustration of flooding

Route discovery is initiated either when the sender S detects that a previously determined route to node D is broken, or if S does not know a route to the destination. In our implementation, we assume that node S can know that the route is broken only if it attempts to use the route. When node S sends a data packet along particular route, a node along that path returns a route error message, if the next hop on the route is broken. When node S receives the route error message, it initiates route discovery for destination D. When using the above algorithm, observe that the route request would reach every node that is reachable from node S, Using location information; we attempt to reduce the number of nodes to whom route request is propagate. DSR (Dynamic source routing)[15,16] and (AODV) ad hoc on-demand distance vector routing [14] protocols proposed previously are both based on variations of flooding. DSR and AODV also use some optimizations - several of these optimizations as well as other optimizations suggested in this paper can be used in conjunction with the proposed algorithms. However, for simplicity, we limit tour discussion to the basic flooding algorithm, and location-aided route discovery based on “limited” flooding

B)RARP(Reliable and robust predictive routing protocol)

RARP is based on three-dimensional estimation with a fast update mechanism for the flying path in FANET. We derive closed expression to measure expected connection time between two adjacent intermediate nodes with directional transmission in three dimensions using predictive approach. The performance evaluation of proposed RARP routing protocol is to be presented in terms of route setup success rate, average path life time, successful data transmission rate and provide reliable communication. It is based on geographic locations such as environmental conditions such as wind, rain, humidity ,atmospheric pressure, rains, mountains etc.

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