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Time As A Distance (TAAD) – a new routing protocol for FANETS

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Abstract— **The Unmanned Aerial Vehicles (UAVs) are tremendously used in various applications starting with civil applications, such as policing, fire- fighting to tactical communication and military applications. Using single large UAV is not so efficient hence multiple UAVs are used for larger geographical coverage and for better efficiency. It is requiredtoallowtwoormoreUAVnodestoocommunicatedirectlyon relay node(s). Nowadays ad-hoc network outcomes wired network. Flying Ad-Hoc Network (FANET) is one of the categories of infrastructure-less network which are constituted from UAVs. Routing is a challenging issue in Flying Adhoc Networks. In this paper, routing protocols ofFlyingAd-HocNetworksare criticallyanalyzedandanewprotocolcalledTime asaDistance(TAAD)isproposedwhich is an extension of RGR protocol and is supposedly expected to provide more efficiency thanRGR.**

Keywords— **FANET, routing, protocol, multimedia, UAV.**

I. INTRODUCTION

Earlier, UAVs were simple remotely piloted aircrafts and mostly used for military operations or applications. In recent years, UAVs are being used in increasing number of civil applications, such as policing and fire-fighting, non-military security work, etc. The use of single-UAV system is very common, but using a group of small UAVs has become advantageous. Single UAV system is simple, common but not reliable and is expensive. Multi UAV system is very advantageous, but has several issues. UAVs interoperate using an ad-hocnetwork that is a subclass of MANET and VANET,known as FANET (Flying Ad-hoc Network) and is depicted in the Figure1.

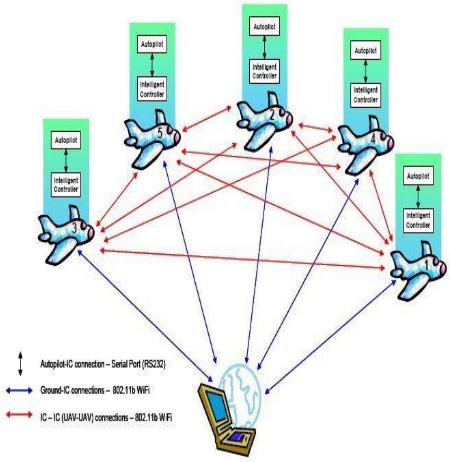

Figure 1. UAVs to UAVs and UAVs to infrastructure communication

II. LITERATURESURVEY

Jean-DanielMedjoMeBiomo.etal[1]:Inthispaperauthorsrelyonsimulation–basedevaluation ofentitymobilitymodalsimpactonroutingperformance.Fortheperformanceevaluationauthorshadtaken network simulators such as Network Simulator-2, Network Simulator-3 and OPNET. The simulation parametersareasfollows:no.ofsimulatednodesis30,arealengthis2000m,areawidthis4000m,wireless transmissionrangeis1000m,packetsizeis1024bits, sendrateoftrafficis5pkts/s,speedis50-6-m/s,pause time at simulation is 0s, simulation time is 1800s are used for the simulation of the routing protocols. After the simulation result authors conclude that that the upper bound for PDR for routing protocols is tend to is about 99.2% based on the result offlooding.

YiLi,MarcSt-Hilaireetal[2]:Inthispaperauthorsreportsenhancing RGRroutingprotocolfor unmannedaeronauticalad-hocnetworksfortheperformanceevaluationauthorshadtakenOPNETmodelerafterthesimulationresultauthorsconcludethattheyreducetheprotocoloverheadbyabout30percent while at the same time increasing PDR by about 3.5 percent and reducing packetlatency.

Stefano Rosati .et al [3]: Here in this paper authors compare two different dynamic routing for flying ad-hoc networks for the performance evaluation authors had taken OPNET for simulation results .In their work they compare two different routing algorithm for ad-hoc networks: OLSR and P-OLSR their emulation and experimental result show that P-OLSR significantly outperforms OLSR in the routing in the presence of frequent network topology changes.

RostamShiraniet.al[4]:Here,inthispaperauthorsoutperformancethedelayperformanceof Reactive-Greedy-Reactive Routing in Unmanned Aeronautical Ad-Hoc Networks. For the performance evaluation authors had taken OPNET Modeler 16.In their work they used such mobility parameters for an UAANETinatrackingmissionaresummarizedas,inatrackingmission,UAVschangingsappedbasedon a uniform distributed in the range of [17, 20] m/s for low speed, [36, 40] m/s for medium size, and [55.60] m/s for high speed respectively. They use 0 pause time and start time and stop time is 1000sec.The results illustrate that when the no. of UAVs is high enough in a searching mission to form a connected UAANET,RGR performs well but not for highly dense tracking mission or verysparse searching missions.

Nanxiang Shi et al [5]: In this paper authors propose a Novel Cluster –Based Location Aided Routing Protocol for UAV Fleet Networks. For the performance evaluation authors had taken OPNET Modelor. In their work they used such simulation parameters are as follows. They used MANET as a network model, MAC protocol IEEE802.11, pause time 0 sec with channel capacity 2Mbps. They carry short transmission range as 500m, long transmission range as 1200m with simulation time 600 sec. After the simulation result authors conclude that the Cluster –Based Location Aided Routing Protocol for UAV Fleet Networks outperforms PSR and GRP significantly in successful delivery ratio and average end toend delay,aswellasinscalabilityanddynamicperformance,whichmakeitmoresuitabletobeappliedinUAV FleetNetworks.

Naveen et al [6]: Here, in this paper authors surveyed the concept of Flying Ad-Hoc Network. One of the most important design problems for multi-UAV system is the communication which is bad for co-operation and collaboration between the Austin this paper, FANET is surveyed; the main design issuesand challenges are also discussed. In this paper that described the most challenging task that is communication between the multi-UAVs. They also discuss the difference between FANET and other Ad- Hoc Network types in terms of mobility, node density, topology change, radio propagation model, power consumption, computational power and localization.

III. FANET ISSUES AND BACKGROUND

The existing protocols used in FANETS are classified into six majorcategories:

- Static protocols, having fixed routing tables (no need to refresh thesetables).
- Proactive protocols have periodically refreshed routing tables.
- Reactive protocols (also called on-demand protocols) discover paths for messages on demand.
- Hybrid protocols that use both proactive and reactive protocols.
- Position/Geographic Based protocols that use position or area coverage.
- Hierarchical protocols that use hierarchy model forrouting.

With the help of all these routing protocols, FANET can actively discover new paths among the communicating nodes. Though FANET is a subclass of MANET and VANET, it differs a lot to implement FANET. There are a lot of challenges that we need to consider.

A. Nodemobility

Nodemobilityissuesarethemostsignificantdifferencebetween FANETandtheotheradhocnetworks. 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. According to [6], a UAV has a speed of 30–460 km/h, and this situation results in several challenging communication designproblems.

B. Mobilitymodel

MANET nodes move on a definite territory, VANET nodes move on the highways, and FANET nodes fly in the sky. In multi-UAV systems, the flight plan is not fixed, if a multi-UAV system uses predefined flight plans it may not be successful, because of the environmental deviations or operation updates, the flight plan may need to berecalculated.

C. Nodedensity

Nodedensityisdefinedastheaveragenumberof nodesinaunitarea.FANETnodesarenormallyspread in the sky, and the distance between UAVs can be several kilometers even for small multi-UAV systems. As a result of this, FANET node density is much lower than in the MANET andVANET.

D. Topology change

Due to higher mobility degree, FANET topology changes more regularly 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. Another factor that affects the FANET topology is the link outages. Because of the UAV schedules and variations of FANET node distances, link quality changes very quickly, and it also causes link outages and topology changes.

E. Radio propagationmodel

FANET and the other ad hoc network operating environments affect the radio propagationcharacteristics. MANET and VANET nodes are very close to the ground, and in many cases, there is no line of-sight between the sender and the receiver. Radio signals are mostly affected by the geographic structure. Again, FANET nodes those are away from the ground can be driven remotely and in maximum case; there is a line-of sight between UAVs [10].

F. Power consumption and networklifetime

Developing energy efficient communication protocols is a major part to increase the network lifetime. Particularly, while the battery-powered computing devices in MANETs; system developers have to pay extra attention to the energy efficient communication protocols. However, FANET communication hardware is powered by the energy source of the UAV. This means FANET communication hardware has no power resource problem as like in MANET.

G. Computationalpower

MANET nodes are battery powered small computers such as laptops, PDAs and smart phones. Becauseofthesizeandenergyconstraints,thenodeshaveonlylimitedcomputationalpower.Onthe other hand VANETs and FANETs support devices with high computationalpower.

H. Localization

In MANET, GPS is generally used to receive the coordinates of a mobile communicationterminal, and maximum time, GPS is enough to regulate the location of the nodes. In VANET, for a navigation-gradeGPSreceiver,thereisabout10–15maccuracy,whichcanbesatisfactoryforroute guidance. Because of the high velocity and dissimilar mobility models of multi- UAV systems, FANET needs highly accurate localization data with smaller time intervals. GPS provides position information at one second interval, and it may not be adequate for certain FANETprotocols.

IV. THE RGRPROTOCOL

TheRGRprotocolisanewroutingprotocol forUAANETbasedonAODVandGGF.RGRissimilar to AODV till a forwarding node faces a broken link. Through forwarding node, we received a data packet and trying to send it to the packet's next hop (these nodes are also called Intermediate Nodes). In AODV, whenthenexthopisoutofreach(brokenlink),wehavetwochoices:first,iflocalrepairisnotenabled,the data packet is dropped. Second, when local repair is enabled, the FN holds the packet and broadcasts an RREQ to "repair" the broken link. Finally, it will send the data packet using the newly repaired or re-established route. In the case of RGR, when the FN faces a broken link (unreachable), it switches to the GGF mode, instead of executing local repair like in AODV. The GGF here works as follows: the FN computesitsowndistancetotheDNbesidethedistancetothesameDNofallitscurrentneighbors.Ifthere is a neighbor that is closer to the DN than the FN, the FN forwards the data packet to that neighbor. Ifthere is no such a neighbor, the data packet is droppedaltogether.

When the neighbor node receives the data packet, it checks for a route to the DN established by means of the reactive part of the protocol. If it does, the data packet is forwarded using that path; and if it does not, thenitshiftstoGGFtooandsoon.Thisstrategygivesthedatapacketasecondopportunitytobetransmitted withoutobtainingadditionaloverheadcosts(duetonewlocalpathdiscoverywithlocalrepairasinAODV).

InRGR,dissimilarinGGFprotocolingeneral,thenodeslocationinformationispiggybackontocontrolmessages from the Reactive mode in order to be propagated to other nodes in the GGF mode for distance calculation purposes. Therefore, no location service is required. A few enhancements for the original RGR were also developed, resulting in protocol variety called mpRGR, sf1mpRGR, and sf2mpRGR.

VI. THE TAADPROTOCOL

TAAD stands for Time as a Distance. It's a Hybrid protocol combining proactive, reactive and Hierarchicalnetworking.ItextendsRGR(Reactive-Greedy-Reactive)Protocol.TAADprotocolisaimedat reducing latency during data transfer between UAVs. Suitable for real-time scenarios like multimedia transmissioninmilitarynetworks.ThemainreasonforTAADprotocolisthattheexistingprotocolsproduce lotoflatencyduringdatatransmission,especiallyduringmultimediatransmission.Videobufferingconcept inFANETSisunexploredandthisprotocoladdsahugeadvantagebyofferingreal-timebufferingabilityto multimedia transmission. Timely delivery is of high importance at emergency situation like wars, natural disasters etc. Since TAAD is primarily dependent on time to solve the routing issue, it's best suitable for timely delivery ofdata.

V. WORKING OF TAADPROTOCOL

TAAD consists of routing table which helps in faster decision making. Unlike many other protocols,TAADnotonlysendsbroadcastmessages toitsneighbornodes.TAADalsoconsidersspeedand motionoftheUAVs.Whenthere'schangeindirectionofUAVs,theroutingtableisupdated.Whenthere's significant change in speed of UAVs, the routing table is updated. TREQ (Time request) packet is broadcasted by an UAV when a change is encountered. Neighboring UAVs responds with a TREP (Time response) packet to the target UAV as well as to all other UAVs in the cluster. This time is converted to distance based on how long it's taking for each UAVs to communicate with the targetUAV.

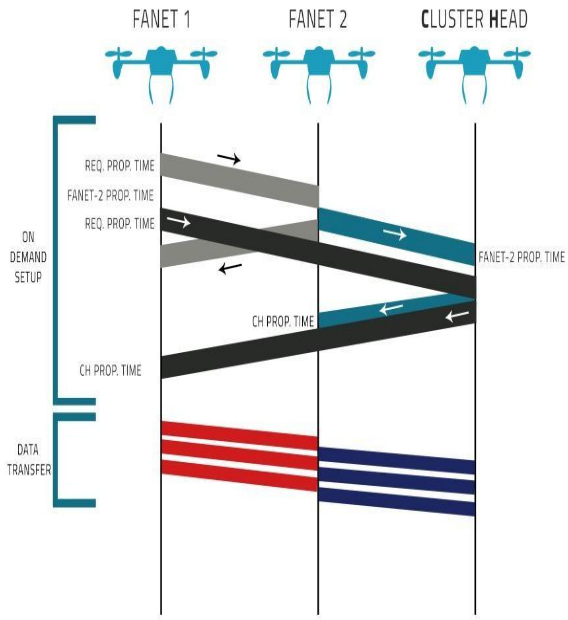

Figure 2.TAAD protocol operation flow.

The advantages of TAAD protocol are that, Congestion is reduced as the routing tables are updated only when needed. Minimum Hops, as the UAV that can receive data faster is selected. Since this protocol works based on time, the more important factor in multimedia transmission, latency, is reduced to greater extent.

TAADperformsmuchbetterthanexistingprotocols.Therawmultimediadataisfragmented andsenttotheclusterheadbythesourceUAV.Fragmentationhelpstokeeptrackofmultimedia buffer sequence. If a link is broken down, new path is established and checked for how many fragments are received by the cluster head. Cluster head sends the received data to the UAV that is connected to infrastructure, which in-turn sends it to the infrastructure. The multimedia data is buffered in real-time at the receiver protocols for multimediatransmission.

VII. EXPECTEDRESULT

An event driven simulator Network Simulator -3 will be used to design, develop, implement, compare and validate the different routing protocols supported for FANETs. There are several areas where TAAD can perform better than other protocols, like, delay, network load, throughput, packet delivery ratio etc. Theoretically, it is assumed to provide more of optimization in performance than RGR, which is, for now, producing best results than any other protocols. Throughput evaluation is yet to be done. End-to-end delay is expected to be the most least, which isthe concern in multimedia buffering. The existing protocols are compared with the TAAD by varying various QoS parameters for the better outcome of theresults.

VII. CONCLUSION

UAVs are the future, which is unexplored yet. UAVs help in emergency situations where human interference is not needed. Existing protocols doesn't help much with Multimedia buffering, which is the best way to interpret data for humans. TAAD is a new protocol that takes time as an important attribute to deliver packets. Minimal latency and congestion control is the target areas of TAADwhichissubclassofRGR.TAADcouldbethefutureprotocolthatisbestsuitableformultimedia transmission and buffering. The tactical communication depends on the correctness rather than timely deliver and it can be achieved with the help of TAADprotocol.

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