

A Comprehensive Survey on Fanet : Challenges and Advancements

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Abstract— The new technological advancements provide alternative solutions to fuelling , coordination , control in multi UAV system .Acting in agroup ,multi UAV system could solve many of the problem of single UAV with fixed architecture .This feature has increased the demand of fanet based system in both military as well as civilian space .The different size of UAV and there flexibility in deployment has make it a efficient mean of surveillance .The new technology also brought the new challenges along with them .The approach is to mention the both challenges as well as advancement related to flying adhoc network.

keywords— unmanned aerial vehicle, multi UAV , FANET

I. INTRODUCTION

The technological advancement in the critical embedded system ,avionics and micro electro mechanical system has paved the path to new fully fledged inter connected multi UAV system , also acronyms as fanet .

UAV system started with single unmanned aerial vehicle mainly for surveillance ,reconnaissance and monitoring , but with increase in miniature technology deployment of coordinated Multi UAV to perform better in group are being developed . Group of networked UAV are now providing a wide range of service from civilian to military . Third of the agricultural aviation in Japan is being governed by UAV[28], surveillance[31],border area patrolling[7], traffic management,[4] monitoring pipeline,seismic activities[4], volcano monitoring [4], environmental surveillance[33][32] are the other area of its application.

Routing in fanet is of major importance , mainly due to large amount of data the bandwidth consideration play critical role in routing decisions. Newer technology of applying optics could handle some of the high data link availability problem in fanet[10].

Fanet are characterized by high mobility rate compared to other infrastructure based network, mobility could lead to collision among the members , one of the major concern in fanet is to avoid the collision . To do that sense and avoid method ,based on receive Signal strength are being applied [5].

Maintaining trade off between the payload and endurance capacity is also seeking attendance of researcher form all over world. As increase in payload capability can increase the count of onboard instruments ,which indirectly enhance the capability of multi UAV system as a whole .

Meanwhile increase in payload effect the flight time of the system [8].

Take off and landing in fanet and multi UAV system is crucial.For fuelling a multi uav system is made to take off and land , which made system more prone to damage. In fanet , an alternative method providing laser based power could be solution of above[29].

The fanet mainly consists of a group of multi devices , in order to coordinate and collaborate ,the different object must respect temporal and as well as spatial space of each other[5] .The temporal aspect consist of monitoring and threat detection area ,while the spatial deals with providing appropriate distance to act safely.

To initiate a fanet structure the multi UAV are attached to ground control station by a star topology ,but to act autonomously the UAV should be adapt anew system where the multi hop routing without a fixed network structure is supported , the advantage of this approach is that group of uav with adhoc network could perform without direct link with ground control system.

Multi-UAV systems can be classified based on the coupling between the UAV's. In [17] state the multi UAV's as

1.Physically coupled

The UAVs are connected by physical links and their motions are constrained .

2 .Formations

The vehicles are not physically coupled, but relative motions constrained to keep the formation .

3.Swarms

They are homogeneous teams of vehicles , by interactions form a collective behaviours.

4.Intentional cooperation

The UAVs of the team move according to trajectories defined by individual tasks that should be allocated to perform a global mission(Parker 1998).

[35] shows the persistence patrolling problem in multi uav architecture which solution could ,make durable and long range fanet system which could work autonomously in military and civilian airspace .

The communication in multi UAV is either a) in vehicle communication(IVC), (b) airplane-to-airplane communication (A2A), and (c) airplane-to-infrastructure communication (A2I) A2A communication is important for decision making and mainly can be applied by providing a mesh network , in such a network difficulty is

that each individual UAV is occupied with heavy communication instrument which in fact effect the payload and endurance capacity . This could be one scenario where the application of fanet is beneficial , as maintaining a fanet architecture the individual communication can be reduced while keeping each connected indirectly .However there are few more scenario where the fanet could be applied :

1 In military scenario a frequent pop up threat may appear towards a group of UAV , the UAV due to environmental effect may not be directly connected with ground control system , a fanet module extending the connectivity may be applied and pop up threat could be avoided .

2 Fanet could act to integrate the heterogeneous system in military scenario, different specialized agent could be coordinated and controlled with fanet. Through routing control information many complex task can be performed such as new route updating and deployment of specialized agent to his allotted work could , while each agent doing other thing but connected by fanet .

some of other aspects where the deployment of fanet : a adhoc network among the flying vehicle could be effective than each unit is swarm [4].`

II . LASER : A RE FUELLING SOLUTION

Fuelling is also a important aspect in fanet architecture , some of the UAV is mainly powered by li ion battery , to get it recharge a multi UAV system has to takeoff many a times . [35]Some of advance UAV could aloft for not more than 80 hr which , in fact act as a limiting effect in range of mission .

A newer technology provides the refuelling by laser beam while keeping the UAV aloft .The advantage is that it would increase the flight time of UAV system , as the UAV doesn't have to land to refuel.

Some of scenario as mentioned in [35] illustrating the application are :

1 Stationary Observing

A stationary monitoring uav deployed in military field for intelligence reconnaissance and providing information at place of military base , the uav could be fuel while being aloft as depicted in fig

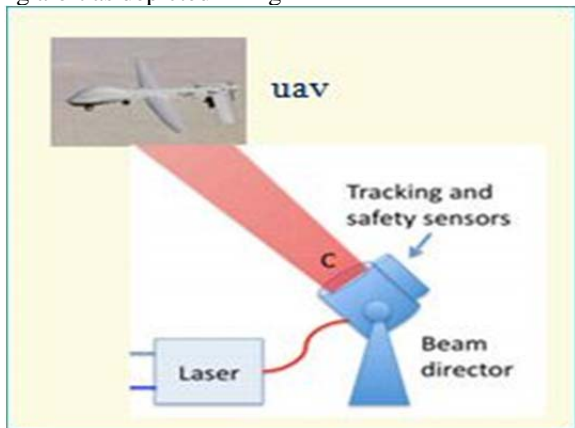


Fig 2.1Showing a fixed laser powered uav 2 Extended Or Multi Mission Application

The UAV could move to deployed battle return at refueling station and return while being aerial

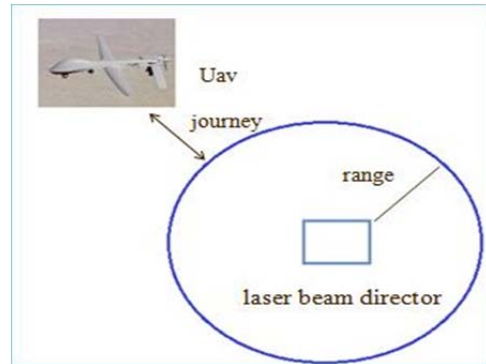


Fig 2.2 Showing the UAV in extended scenario

2 Unlimited Patrolling

The UAV can be coordinated within los range and accomplish the mission by continuously being powered by LASER as depicted in fig 2.2 keeping fanet in range of beaming laser.

NASA DRYPHEN Flight Research Centre (Edward , AFB) is applying optical link in fanet .

III .MIDDLEWARE APPROACH

Another approach to control the system of UAV along with internetworking is by service oriented interface known as SOA (Service Oriented Architecture)[12]. The thing is to provide the coordination , message passing , control and communication management by subscription /service method . The different functionality is provided by different unit as in web service . The publish /subscribe nature lead to high flexibility in fanet system[16] .

[16] Define a middleware layer acting as abstraction as well as providing user demand based UAV service (UAV Service Abstraction Layer)USAL[3] a layer defining the standard services along access point , as in grid have been discussed . However the application of middleware in fanet is difficult due rapid technological changes, interoperability , distributed resource distribution.

IV.NETWORKING

The nature of fanet network layer is mostly based on manet and vanet , the underlying approach being similar .

The network layer mainly consider the hop by hop routing of data considering the shortest route . most of fanet networking deal the same but considering the mobility higher than the other two of network . [16] describes the fanet as a sub class of VANET.

Routing in fanet is mainly based on hierarchical flat geographical /position based , rapid topological change advise the dynamic protocol to be more effective .In [2] Xlingoi isa protocol based on link quality , a modification of Lingo protocol . Xlingo is a cross layer , human interaction parameter based routing . The protocol show efficient performance based on packet delivery ratio, Qos .

The network protocol must be able to cope the high mobility as well as data link level connectivity . According

to [16][14][15] the UAV fanet communication network is based on parameterSuch as

- No of UAVs.
- Degree ofUAV mobility .
- Onboard processing /computational ability.
- Data storage.
- Energy capacity and power consumption capability ofthe UAVs.

Hierarchical protocol could also be one of possible solution of routing in fanet , the different hierarchy of the protocol could reduce the congestion . The hierarchical protocol divide the plan of action into different level and routing isperformed according tothis level. UAVs interconnection form a single hierarchy while the base station forms a another .The CH cluster head of hierarchy is directly connected to satellite or ground base station .Other hierarchical routing are shown in [6] [20][27]Table 4.1 shows the hierarchical and other routing approach and there advantage.

In [24] time slotted based AODV was applied to FANET . in the scheme a slot is dedicated to a unit for sending data packet , the protocol prove to be efficient in packet delivery ratio .In [4] code division multiple access adhoc network have been introduce as a multi channel network . the protocol is based on token system .

Protocol	Feature	Nature	Efficiency
Xlingo[2]	Cross Layer ,Position Based ,Multimedia Data	Position Based	efficient qos reduce, packet delay
TBRF[18]	Reverse Path Forwarding	Proactive	reduce overhead
DSR[21]	Mobility Aware	Reactive	More adaptable to dynamic topology of fanet
GPSR[23]	Position Based, Stateless Protocol	Proactive	Outperform many existing non position based protocol
DOLSR[22]	MTR Node , Direction Antenna	Proactive	Lower end to end delay
TSOR[24]	Based on aodv, dedicated slot to send data	Reactive	Reduced packet collision enhanced packet delivery
GMPOR[19]	Gaussian markov mobility model		Better latency, packet delay ratio position based protocol
Cluster based algo[20]	Highest Weight To Decide Cluster Head	Cluster based	Increase Stability of cluster head

Table 4.1 showing different routing protocol in fanet

V .FREE SPACE OPTICS

Fanet due to nature of deployment creates stream of multimedia data or data with high bandwidth requirement . [1]state employing optical link to meet the challenges of high bandwidth . Free SpaceOptics is beneficial as the link are not that much effected by fading .Meanwhile the safety is enhanced , as less prone to jamming . Doppler effect is also considerable in FSO. Table5.1 shows the advantage of optic in fanet .

But there are few consideration such as proper alignment of receiving unit and maintaining line of sight[10][9].

In [10] depict the optical network with ring , Sa and mesh topology

Feature	Radio link	Optic Link
Data Rate	In mbps	In gbps(1-3)
Line Of Sight	Non essential	Essential
Fading Effect	High	Low
Security/ Jamming	Low (can be detected by enemy) low	High(no jamming)
Licence	Yes	No

Table 5.1Showing difference in radio frequency link and optic link.

VI.STANDARDS

The increase utilization of uav tends to commercial use and addition in civilian space , but due lack of proper standards and rule is a difficult thing . Standard should comply with the safety standard as there must be no interference with the aviation industry . Most of the fanet architecture are deployed in military aspect the civil use may lead to more sophisticated rule defining the range of bandwidth and flight domain[11].

Some of the organization working for standard are EUROCONTROL European Organisation For The Safety Of Air Navigation . JAAJoint Aviation Authority along with there different committee such as Euro Control SRC JAAC (JAAManagement Community)

VII.CONCLUSION

The fanet with multi uav enables the new applications in the field of surveillance , monitoring . Different multi uav size leads to its applicability in different scenario. But new advancement could even further explore the era ofUAV . Flexibility , adaptability , easy deployment is some of the major reason for uav development and integration in commercial and civilian space .

The paper highlight the different functions and requirements that are important to beaddressed to provide robust, energy-aware communication in multi UAV-based systems.Standards , security are some of the section still to be explored much if the integration is to made in civilian space. The new fanet system providing optical link could secure the link of fanet from electronic counter measure . A lot of uav security related area is being discovered but still a lot of area being unfamiliar to most of concern. More effort has to be made in developing application for easy addition of multi uav in civilian space .

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