Datagram Loss Reduction in FANET using Dijkstra Algorithm

Dissertation submitted in partial fulfillment of the requirements for the award of degree of

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Submitted by

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Certificate

I hereby certify that the work, which is being presented in the dissertation, entitled *Datagram Loss Reduction in FANET using Dijkstra Algorithm*, in partial fulfillment of the requirements for the award of the degree of *Masters of Engineering* in *Information Security* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Mr.Sumit Miglani* and refers other researcher's work which are duly listed in the reference section.
The matter presented in the dissertation has not been submitted for award of any other degree of this or any other University.

Alisha Gupta

This is to certify that the above statement made by the candidate is correct to the best of our knowledge.

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Abstract

In recent years lot of research has been done on the mobile adhoc networks so the new research area flying adhoc networks has attracted many researchers. Flying adhoc network is new concept to Mobile adhoc network and Vehicular adhoc network which tackles the situations that Mobile adhoc network and Vehicular adhoc network cannot do. Instead of one large Unmanned aerial vehicle, multi Unmanned aerial vehicles are used which forms an adhoc network which is called Flying adhoc network. Due to the topology change and high mobility of the nodes it is a challenge to apply suitable routing protocol for communication among the Unmanned aerial vehicles. For communication among the Unmanned aerial vehicles routing protocols are used. There are various routing protocols but few can implement the applications of Flying adhoc network in real world scenario. The applications of Flying adhoc network have not been used widely because there is no protocol for connection establishment of Flying adhoc netwrok and there are lot of hurdles in deploying Flying adhoc network. In this dissertation we discussed the feasibility of deploying Flying adhoc network in real world environment.A dynamic network topology is created.The base station and Unmanned aerial vehicles are created dynamically. For communication among the Unmanned aerial vehicles shortest path is calculated using Dijkstra Algorithm. Base Station sends the Internet Protocol of neighbours to all the nodes in the network. Through this the communication among Unmanned aerial vehicles can take place.

Keywords: UAVs, FANETs, MANET, VANET, Mobility models, Routing Protocol,DLR

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Alisha Gupta
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List of Abbreviations

MANET	Mobile Adhoc Network
VANET	Vehicular Adhoc Network
FANET	Flying Adhoc NETwork
UAV	Unmanned Aerial Vehicle
PDA	Personal Digital Asisstant
GPS	Global Positioning System
LCDR	Load Carry and Deliver Routing
OLSR	Optimized Link State Routing
MPR	Multi Point Relay
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic State Routing
AODV	Ad-hoc On Demand Distance Vector Routing
ZRP	Zone Routing Protocol
P-OLSR	Predictive Optimized Link State Routing
MAC	Media Acess Control
JRE	Java Runtime Environment
NS	Network System
SPP	Sequenced Packet Protocol
IDP	Internet Datagram protocol
IDE	Integrated Development Environment
IP	Internet Protocol
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
DLR	Datagram Loss Rate

1. Introduction

1.1 Wired Network

A wired network is a common type of the wired configuration. It involves cables for connection and transfer of data. The wired networks uses Ethernet cables to transfer the data between the connected PCs.In a small network single router is required to connect all the computers. In larger networks more than one router or switch is required to connect all the computers. One of the devices connect to the cable modem or the other type of the internet connection that provides the access to the internet connection to all the devices connected in the network. Users are bound to the location as the devices are connected with wires. It leads to a lot of expense as the wires are to be installed in the walls etc. Wired network cannot handle a large number of users[7]. Considering the problems with the wired networks the wireless networks are introduced. Though the wired connections are faster than the wireless ones which allows the faster data transfer rates but the wireless networks are preferred due to the convenience.

Figure 1.1: Wired Network[1]

1.2 Wireless Network

Wireless Network uses high frequency radio waves to communicate between the nodes for the home and business networking. Unlike the wired networks which use copper wires to connect the devices[8]. Individuals use this to expand their existing wired network or to go completely wireless. Wireless allows devices to share data without networking cable which decreases the range but increases the mobility.

Figure 1.2: Wireless Network[2]

- Convenience: Network resources can be accessed from any location within the wireless network or with the help of WiFi hotspot.
- Mobility: The network resources can be accessed from anywhere as the user is not bound to the desk as with the wired network.
- Productivity: It is the by-product of the increased mobility. It allows the users to work jointly any time. Users are not bound to one place to work example in the office they can work from home too.
- Easy Setup: There is no need of the cables so the installation is very easy and more cost effective[7].
- Expandable: We can easily expand the wireless system with the existing equipments while the wired system may require the additional wiring to do so.
- Security: It is easy to detect and stop the rogue device to connect to the device in the wireless system or to enter the system. The encrypted access can be controlled at the point of connection.

- Cost: Wireless network cost less than the wired network because of the no cost of the wires.
- Coverage: Wireless network covers large spaces than the wired network which are bound to the places which are covered with the wires[8].
- Position: The location and coverage of the wireless devices can be monitored.

1.3 Classification of Wireless Network

Wireless network is classified into infrastructure based network and infrastructure less network on the basis of infrastructure as shown in figure 1.3 [9].

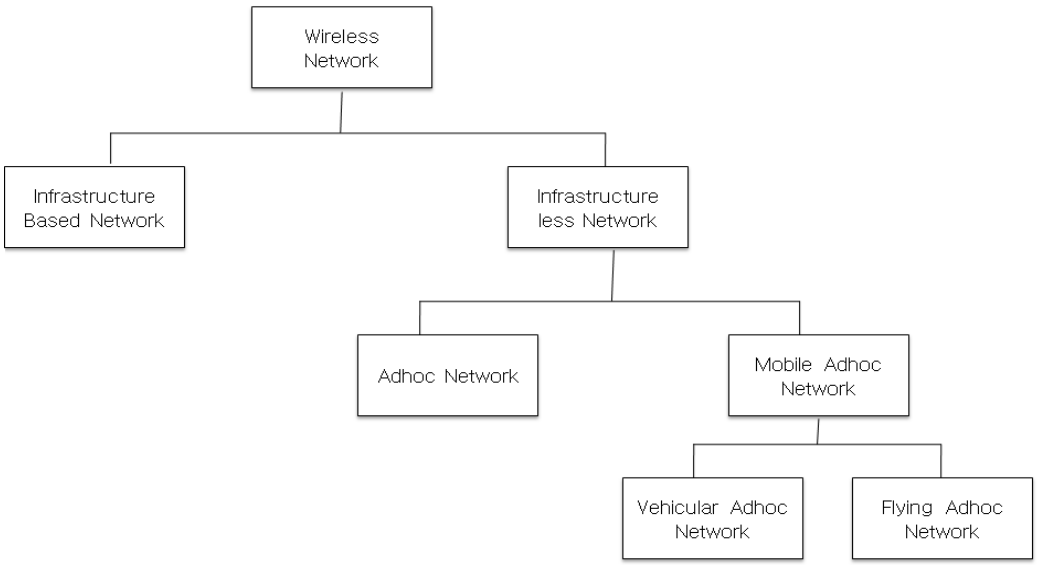

Figure 1.3: Wireless Network Classification

1.3.1 Infrastructure based network

In infrastructure based network there is fixed base station which acts as infrastructure. Communication between the mobile nodes is done with the help of base station as shown in figure 1.4. In infrastructure based network the communication is done between the wireless node and the access point but not between the wireless nodes[9]. The access point or the base station acts as the bridge to

other wireless network. Physical infrastructure is most important in infrastructure based network. It cant be used in critical situations like disaster relief where no infrastructure is left.

1.3.2 Infrastructure less network

Infrastructure less network is the network which does not rely on the physical infrastructure. It does not require any base station to communicate within the nodes. In this the set of mobile nodes are dynamically located in such a manner that they maintain interconnections among themselves.

- Adhoc network: In adhoc network no existing infrastructure is required for maintaining connection between the nodes and transmitting the data packets as shown in figure 1.4. It gets created whenever required[10]. Each node communicates directly with the other node. It does not require any access point to control the communication. Nodes in adhoc mode communicate directly if they are within the range. In this no physical infrastructure is needed.

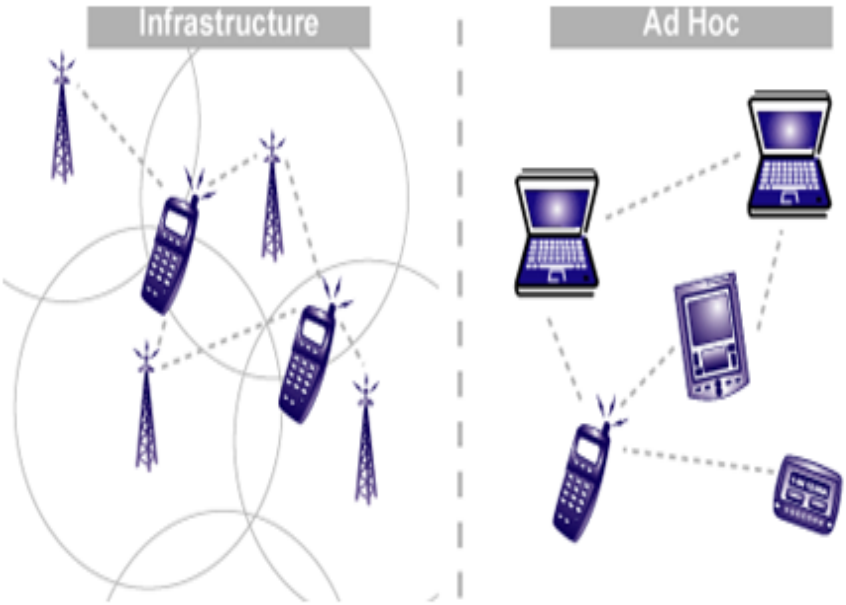

Figure 1.4: Infrastructure Based Network and Adhoc Based Network[3]

- Mobile Adhoc network (MANET): Mobile adhoc network is the mobile devices connected together wirelessly. It is also called wireless adhoc network. It is a self configuring infrastructure less network[11]. The mobile nodes are free to move within the network by changing the topology of the network.

- Vehicular Adhoc network (VANET): It is the subclass of mobile adhoc network. In vehicular adhoc network moving cars acts as mobile nodes which creates the mobile network[12]. In this every moving car is turned into wireless router or node allowing them to create network with wide range. In this the moving vehicles are equipped with wireless communicating devices. The first systems that are equipped with this technology are fire vehicles and police that communicate with each other for safety purposes.
- Flying adhoc network(FANET): Flying adhoc network is also the subclass of mobile adhoc network. It contains the UAVs(Unmanned aerial vehicles). In this UAVs acts as mobile nodes and move freely within the network. The mobility of nodes is much higher than the MANET and VANET which leads to rapid topology change. It is infrastructure less network so it does of require any base station or any access point to communicate between the nodes[13]. The flying nodes communicate with each other locally and also with the environment to get some sort of information.

1.4 Mobile Adhoc Network(MANET)

MANET stands for mobile adhoc networks. This is infrastructure less network. It does not rely upon any physical infrastructure. MANET is a type of adhoc network which change the location and configure itself on the fly. In this the mobile acts as the nodes as shown in figure 1.5. The nodes connect through the wireless network. The moving nodes act as the router for communication among the nodes. The nodes move randomly and thus manage themselves randomly[14]. The network topology changes randomly due to the nodes mobility. The mobile nodes use various wireless connections for communication which can be WiFi or any satellite transmission. The network can be self organized so it is different from the other networks. User can create their own network which can be deployed technically and economically[4]. Adhoc network is becoming the key advancement in the field of wireless technology. Due to this the mobile adhoc network is the trending field which is growing technically day by day in adhoc network. Setting up of MANET structure is easy due to absence of any typical infrastructure for communication. Due to this it is used in military services and emergency rescue operations. MANETs have also entered in the area of gaming, sensing, conferencing. MANET is on the way to be implemented in the areas where it can lead to faster and cheaper data communication and data transfer. In personal area networking also it is applicable where the devices like laptops ,

mobile or PDA create network to share data among themselves which create short range for communication thus could be connected to backbone of network.

Figure 1.5: Mobile Adhoc Network[4]

1.4.1 Characteristics of MANET

- Distributed operation- The control of nodes is distributed among the system. The nodes communicate and cooperate among themselves.
- Autonomous terminal- MANETs are the particular networks in which the nodes work independently so the nodes acts like router and host.
- Multi-hop routing- When one node sends message to other node and the other node is out of range then multi-hop routing is created i.e packet is send through relay of intermediate node.
- Dynamic network topology- The nodes can leave or join the network any time so they are mobile[15].
- Light weight terminal- The nodes are light they have less CPU capability, low power storage and less memory size.
- Fluctuating link bandwidth- The stability, capacity and reliability are less than the wired networks.
- Vulnerabilities accentuated by ad-hoc nature- Physical boundary is not defined for the network. In wired network firewall can be implemented for access control but in wireless firewall cannot be implemented so Dos can attack the wireless.

- Vulnerabilities specific to ad hoc nature- The routing and auto configuration method makes the network susceptible to attack[15].

1.5 Vehicular Adhoc Network(VANET)

Vehicular adhoc network is the sub class of mobile adhoc network. It is infrastructure less network. The structure is made wirelessly. The vehicles act as the nodes in the network. The vehicles contains the wireless transceivers to communicate with the other vehicles to make a wireless network called the Vehicular adhoc network (VANET)[12]. Every participating car within the range of 100m to 300m is turned into router to communicate with each other and thus creating a wireless network. As the car fall out of range of the adhoc network other cars can join in connecting the vehicles to one another. The safety of the drivers needs to be enhanced thus providing them comfortable environment for driving, messages need to be send to the other vehicles through inter vehicular communication. Vehicular networks are composed of mobile nodes; vehicles are equipped with On Board Unit (OBU) and fixed nodes called Road side Units (RSU). RSU are fixed to the infrastructure that is deployed alongside roads[16]. Both OBU and RSU have wired and wireless communication facility as shown in figure 1.6. OBUs communicate with each other and with the RSU in the adhoc manner.

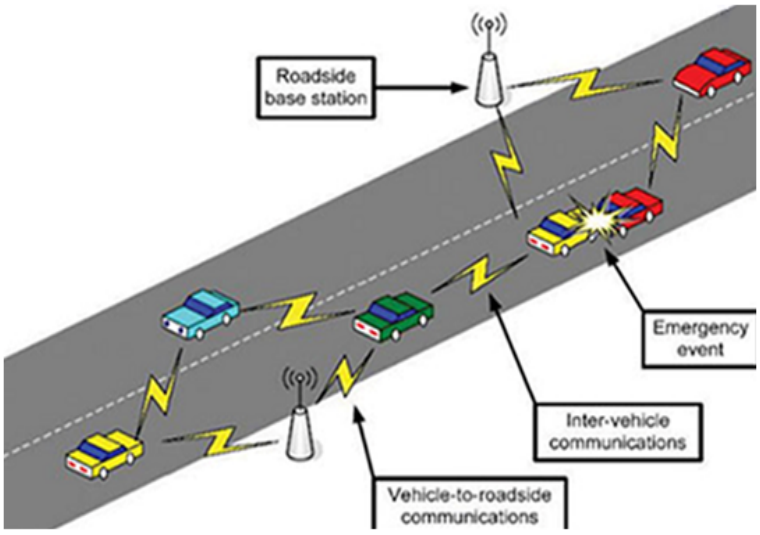

Figure 1.6: Vehicular Adhoc Network[5]

1.5.1 VANET Applications

- Electronic brake lights: driver is allowed to react to the obscured vehicle braking.
- Platooning: road trains are formed by the vehicles which follow the leading vehicle by receiving acceleration and steerig information wirelessly.
- Traffic Information System:obstacle reports are provided by VANET communication to the vehicle's satellite navigation system[17].
- Road Transportation Emergency Services: rescue operations, delays are reduced using the VANET communications, VANET networks , road safety warnings and status information dissemination.
- On-The-Road Services: Drivers are helped by VANETs to discover services on the road. Tickets of cinema can be booked by the driver while driving on the way.

1.6 Flying Adhoc Network(FANET)

Due to rapid change in technology advancement on electronic, sensor and communication technologies, unmanned aerial vehicle system(UAVs) have been proposed which fly autonomously or operate remotely without carrying any human personnel. Single UAV have been in use for decades instead of using one large UAV, using group of small UAVs has many advantages. Using many small UAVs leads to use of multi UAVs. Multi UAV have unique challenges basically in case of communication. FANETS i.e the flying ad hoc networks is the ad hoc network between the UAVs[13] as shown in figure 1.7. Capability of single UAV is much less than the multi UAV .Coordination and collaboration of multiple UAVs can create a system that is beyond the capability of only one UAV[18]. The multi-UAV systems advantages are summarized as follows:

- Cost: The maintenance cost of small UAVs is much lower than the cost of a large UAV[19].
- Scalability: The usage of large UAV enables only limited amount of coverage increases. However, multi- UAV systems can extend the scalability of the operation easily[13].
- Survivability: If the UAV fails in a mission which is operated by one UAV, the mission cannot proceed. However, if a UAV goes off in a multi-UAV

system, the operation can survive with the other UAVs.

- Speed-up: It is shown that with a higher number of UAVs the missions can be completed faster .

In a single- UAV system, a ground base or a satellite is used for communication. It is also possible to establish a communication link between the UAV and an airborne control system.Between the the UAV and the infrastructure the single UAV communication is there[18]. With the increase in no. of UAVs in the unmanned aerial system designing the more efficient architecture is the issue to be solved. In multi UAV system the UAVs can be connected to the ground base or the satellite as in the single UAV system. There may be variants of this star topology based system. While some are connected to the ground base the others can communicate with the satellite, UAV to UAV communication is also realized through the infrastructure. There are several design problems with this infrastructure based approach[19]:

- To communicate with a ground base or a satellite each UAV must be equipped with an expensive and complicated hardware
- Reliability of the communication is the another problem.
- Dynamic environmental conditions also affect the communication links.
- The range between the ground base and the UAV is also a problem. If the UAV is not in the range of the ground base then also the communication hinders.

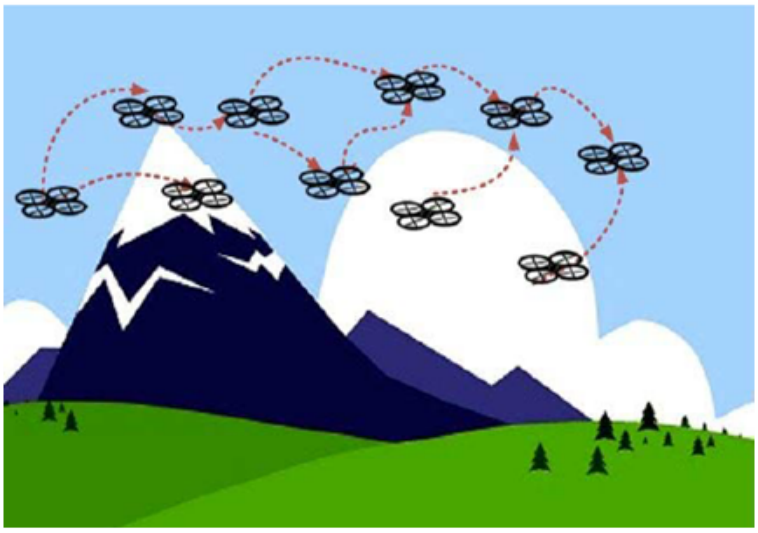

Figure 1.7: Flying Adhoc Network[6]

An alternative communication solution for multi-UAV systems is to establish an ad hoc network between UAVs, which is called FANET. Only one subset could

communicate with the ground base and all the other UAVs communicate with each other. In this way, Communication can be possible within in the UAVs and between the UAV and ground base. There are limitations of vehicular adhoc network which are overcome by flying adhoc network , it is not possible to deploy vehicular adhoc network in flooded areas and also in the situations like battlefield it is not easy to deploy vehicular adhoc network so in these situations flying adhoc network is required because flying mobile agents have the capability to fly through these areas and can cover these search and rescue regions. In FANET the position of the UAVs changes rapidly due to high mobility of the nodes due to which the topology changes frequently.

1.6.1 FANET Application Scenerios

1. Extending the scalability of multi-UAV operations: If the multi UAV communication is related to the ground base and the satellite then the operation area is limited to the area around the infrastructure. If UAV cannot communicate with infrastructure then the FANET cannot operate[20].

2. Reliable multi-UAV communication: Multi UAV system operate in dynamic environment. The conditions which are at the beginning may change during the operation. If the UAVs cannot be connected with each other i.e they cannot form adhoc network then they must be connected with the infrastructure.

3. UAV Swarms: Small UAVs are very light and have limited payload capacity. The UAVs need to be coordinated to form the swarm function. UAV-to-infrastructure communication hardware is heavy so it is not possible to carry it with limited payload. FANETS create network between the small UAVs as it needs lighter and cheaper hardware[18].

4. FANET to decrease payload and cost: The lighter payload means high altitude and longer endurance. If the UAV-to-infrastructure communication link is there then it needs heavier hardware. But if the subset of UAVs use UAV-to-infrastructure hardware and other communicate UAV-to-UAV as in FANET then it needs lighter communication hardware. In this way FANET can extend the endurance of multi-UAV system.

1.6.2 FANET Applications

1. Disaster Management: FANET is useful in case of any disaster and where the existing communication system is also damaged due to disaster.

- Earthquake
- Flooding
- Firing

2. Military Battle Field: FANET is used by military to maintain a information network.

- Among the soldiers
- Military and Soldier Headquarters

3. Search and rescue operation: FANET provides a better way to do search and rescue operations such as the rescue operation of the hostages[21].

4. Location aware services: This type of service is used in the following:

- Call forwarding anywhere
- Advertise location specific services
- Location specific travel guide
- Service availability information

5. Security: FANET can get information quickly. It can get the information quickly and easily of any delegate visiting any location.

1.6.3 FANET Challenges

FANET is somewhat different from MANET and VANET though the basic idea is same they all have mobile nodes and work in adhoc manner. Some challenges in FANET are available in VANET though with some additional challenges. Many researches have been performed to increase the efficiency of flying adhoc network but there are some additional unsolved problems to work upon.

- National Regulations: UAVs are increasingly used in many areas. UAVs have become the part of many countries national airspace but there are some of the areas which do not allow the UAVs to become the part of civil area space. This is the biggest barrier in the growth of the UAVs. There should be rules and regulations to allow the UAVs flights into national airspace[21].
- Routing: In FANET due to fast movement of UAVs the topology rapidly changes. Due to this routing is serious challenge as compared to the low mobility network. Dynamic routing could be used which update the routing table as the topology changes[21].

- Path Planning: Dynamic Path Planning is required to coordinate the path of UAVs. In dynamic conditions there can be change in the topology as the no. of UAVs leave the network and new UAVs enter the network. In such cases UAV have to change previous path and new path have to be calculated[21].
- Quality of Service: FANET is used for many types of applications and transport different types of data like GPS sessions, streaming video/voice messages, simple text messages FANET need to support some service quality.
- Coordination of UAV and manned aircraft: Flight of UAV in comparison to manned vehicle is likely to increase. This coordination leads to destruction of enemy aircraft with minimal loss. Collaboration of manned aircraft and UAV should be in the networked environment[19].
- Standardize FANETs: FANET uses various wireless bands like Very High Frequency, Ultra High Frequency, L-BAND, Ku BAND, The bands use various application areas like Global System for Mobile Communication networks, satellite communication, etc. To reduce the frequency congestion problem, the communications bands, signal modulation and multiplexing models need to standardized[21].
- UAV mobility and Placement: Due to small size of Mini-UAVs they carry limited payloads. To use different sensors hey should be loaded on different UAVs like one is equipped with simple camera and the other with high resolution camera. This allows to take multiple pictures of the same location from different angles.

1.7 Routing in Adhoc Network

In order to send the data from source to destination a specific path is needed and this can be achieved through a mechanism called Routing. Routing Protocol classification has been shown in figure 1.8.

1.7.1 Static Routing Protocol

In this routing table is calculated statistically and uploaded to the UAV nodes. The table cannot be updated during the operation.Topology cannot change in this case. Information is preserved and every node communicate with limited no. of UAVs and the ground station. Wait for the assignment to finish in case of failure of any UAV or ground station[18].

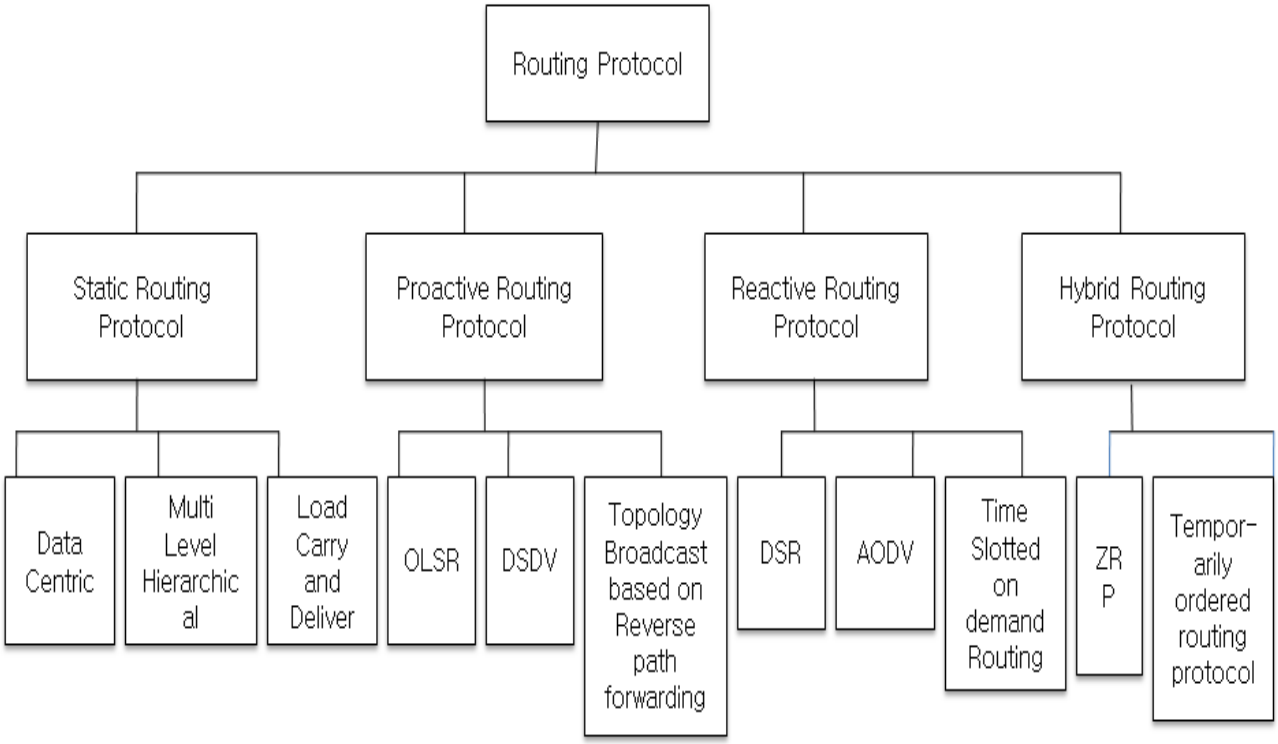

Figure 1.8: Classification of routing protocol

- Data centric Routing: Demand algorithm is used to distribute the data as requested by the number of nodes[21]. Data attributes demand and gather the data instead of sender's and receiver's node ID. Cluster infrastructure is appropriate for this type of model.
- Multi-Level Hierarchical Routing: UAV networks are hierarchically organized at the different mission areas where the clusters are made. Each cluster has cluster Head(CH). Upper/lower are directly or indirectly connected to cluster head. Cluster head of one UAV should be in range with the UAVs in the cluster to control the information or to broadcast the data[6].
- Load Carry and Deliver Routing: In this the data is loaded from the ground node by the UAV and at the end data reaches to the destination ground node[6].

1.7.2 Proactive Routing Protocol

Unlike static routing protocol where the routing table is calculated statistically in this the routing table is created in the network itself. It is easy to choose route from sender to receiver as it stores all the latest information. Disadvantage is that Bandwidth optimization is not possible as the lot of messages are being exchanged

between the nodes. It is not appropriate for larger or highly mobile network. Slow reaction is shown by proactive routing protocol in case of any topology change or connection failure[18].

- Directional Optimized Link state Routing(DOLSR): It is based on OLSR. Multipoint Relay(MPR) is the important factor that affect the OLSR. Set of multipoint relay nodes is selected by the sender node so that the MPR node can cover two hop neighbours.Directional antennas are used to reduce the number of MPRs[21].
- Destination Sequenced Distance Vector: With slight modification for adhoc networks Bellman Ford algorithm is used.In this each node saves the routing table of all the other nodes with the sequence number and not just of the neighbouring node[18]. The changes are circulated by the protocol to update the devices when the topology changes. Sequence number is used to eliminate the loop created by routing and to identify the latest route.
- Topology Broadcast based on Reverse-Path Forwarding: In this dynamic source routing(DSR) is used. If the data is send then the source tries to find the destination[6]. In this the nodes are highly mobile and the topology is unstable.

1.7.3 Reactive Routing Protocol

This routing protocol is the on demand rouitng protocol. If the nodes are not connected then no communication takes place and there is no need to calculate the rote between them. To overcome the overhead problem of Proactive routing protocol for that the reactive routing protocol is used[6]. Route Request message and the Route Reply message are the two messages used in this. Source node sends the Route Request message by flooding the network and then the reply is given by destination with the Route Reply message.

- Dynamic source Routing(DSR): The message is broadcasted by the source node to the neighbouring node. Many route request messages are there in the communication route[21]. To avoid the mix up distinctive request ID is set up. The network topology is changed if the source node is not able to present the route.
- Ad-hoc On-demand Distance Vector routing(AODV): It has the similar features to the DSR. In DSR no table is maintained but in AODV table in maintained. In AODV there can be no multiple eateries stored there can be

single record for each destination but in DSR each node can store multiple eateries in the routing table. The data packet transfer the complete path from source to the destination in DSR. In AODV the information of the next hop is stored in the source node consistent to the data communication[18].

- Time slotted on-demand routing: This is the time slotted version of AODV. Data packets are send by one source node thus time slots are made. This method eliminate the collisions due to the route determination therefore necessary support is ensured for formation movement and enhance the quality of service[22].

1.7.4 Hybrid Routing Protocol

Hybrid Routing protocol is introduced to overcome the problems of the previous routing protocols i.e Proactive routing protocol and the reactive routing protocol. This routing protocol is applicable for the larger networks. Proactive routing protocol has a huge overhead of the control messages and the reactive routing protocol takes much time to discover the route. In this method two zones are created intra zone and inner zone. Intra zone uses proactive method and inter zone uses reactive method[18].

- Zone Routing Protocol: Concept of zones is used in these. Different zone is given to each node. The set of nodes is called zone whose predefined distance is R[6].So, zones of the neighbouring nodes intersect. Routing which is done inside the zone is called the intra zone routing. Communication is started instantly if the source and the destination are in the same zone. Inter zone routing is applied in the case where the data packet is send outside the zone.

- Temporarily ordered routing protocol: The information about the router is saved by the adjacent router. It uses both the reactive and the proactive routing protocol. Directed Acyclic graph is constructed and preserved from source to the destination. Shortest path method is not used in this but sometimes the longer paths are preferred[6].

2. Literature Survey

Ilker Bekmezci et al [13] proposed that communication is the most important design problem in the multi UAV which is the coordination and collaboration between the UAVs. Multi UAV system capabilities are restricted on the infrastructure based architecture. If the UAVs are connected to the satellite or ground base then the communication is only on the basis of infrastructure. Adhoc networking is the way to solve the problem arising with the infrastructure based approach.Flying adhoc network(FANET) is the adhoc network which connects the UAVs. In this paper the difference between the MANET, VANET and FANET is clarified and then the main design issues of FANET are discussed. Along with the existing routing protocols the open research areas are also discussed.

Naveen et al [18]suggested that lot of research has been done in MANET and new research areas have attracted the researchers which is in area of aircraft adhoc network. Flying aircraft construct self organizing network using these networks instead of traditional aircraft-base-aircraft communication.The UAVs capabilities have evolved rapidly and is used in military and civilian areas results in advancement of robotic system like sensors,processor,networking technology and communications. One of the main issue in multi UAVs is the communication between them. Flying adhoc network solve this problem easily. The main design issues and challenges in the flying adhoc network is introduced and open research areas are also discussed.

Ozgur Koray Sahingoz [21] proposed that due to advancement in robotic technologies like sensor, communication, processor leads to use of unmanned Ariel vehicles(UAVs) in military and civilian areas. Development and maintenance cost of UAV is decreasing with the increase in use of this technology. UAVs are evolving rapidly in many fields. Focus is changing from using one large UAV to using multi UAVs which collaborate and work together. New networking models are required to set the high mobile nodes to fleet. The networking model allows two nodes which are in range to communicate with each other or through the UAVs.Setting up of adhoc network is of main issue which is different from traditional networks like MANET and VANET on the basis of topology, routing, node mobility etc.The communication between the UAVs is the main issue. The networking models which are used in MANET and VANET can be used in FANET. These networking mod-

els are discussed and identifying the challenges of using UAVs.

Simarjot Kaur et al [6] came up with that FANET is the latest technology in networking and communication. It is implemented in the areas where MANET cannot be implemented. It is difficult to implement FANET due to high node mobility due to which topology changes rapidly.For communication in nodes routing protocol is required. The nodes can communicate and transfer data on the basis of effective routing protocol.As the nodes position changes frequently so effective routing protocol is required. In this paper the routing protocols like OLSR, DSDV, DCR, LCDR etc are discussed and their routing strategies are overviewed.

Md. Hasan Tareque et al [19] proposed that the use of UAV is increasing day by day so it is used in many applications like civil applications such as policing,fire fighting and in many military applications.For coverage and accuracy multi UAVs are used instead of using one large UAV. For communication between the UAVs networking model is required. Flying adhoc network is the networking model used for communication between UAVs.Requirements of this new networking technology vary from the traditional networking models like mobile adhoc networks(MANET) and Vehicular networking model(VANET). The comparative study of FANET with the tradition networking models like MANET and VANET. The traditional routing protocols are categorised into six methods which are analysed and compared on the basis of performance criteria. The comparative analysis helps in choosing the best routing algorithm where FANET can be deployed.

Karan Palan et al [23] UAVs helped in finding out many new applications and is one of the latest trend of using multi UAV's in place of single UAV. To overcome the problems in infrastructure based approach flying adhoc network is introduced.Communication is the main problem in FANET.The various routing protocols used for communication between the UAVs and the use of these routing protocols on different layers related to FANET. Cross layer approaches are also discussed.

Kuldeep Singh et al [24] proposed that MANET is used in many applications like natural disaster, military battle field UAVs are becoming popular in communication and networking.New network techniques like VANET and FANET are used using the concept of MANET.FANET is used in the situations where traditional MANET cannot work. Due to high mobility of the FANET nodes and the frequent topology change the routing algorithms are used.Adhoc networks performance is greatly enhanced by routing protocols.In this paper the experimental analysis is done on AODV, DSDV. OLSR routing protocol using ns2. The comparative study is done on the basis of three parameters packet delivery ratio,end to end delay and

throughput.

Kuldeep Singh et al [25] proposed that the performance of routing protocol is optimized by mobility models.The research aims in implementing the OLSR routing protocol in FANET and studying the OLSR in different mobility models and to optimize the OLSR in FANET on the basis of three parameters packet delivery ratio, end to end delay and throughput in ns2.

Ganbayar Gankhuyag et al [26] proposed that due to dynamic environmental conditions, terrain structures, high mobility the routing protocols of mobile adhoc network are not suitable for flying adhoc network. Directional and omnidirectional transmissions are combined and used in FANET using a novel directional routing scheme. Location and trajectory information is used for geocasting and unicasting routing with proposed scheme.Route setup success rate and average path lifetime is increased with this method than the traditional AODV method.

Shankar Subramaniyam R et al [20] proposed that retrieval of black box is the main issue in case of airborne accidents. UAV are set in flight. Pilot in the cockpit gets the control of ejection. Between black box and UAV, FANET is formed. In case of any emergency like high jacking, engine failure etc UAV is triggered form its rear wing by pilot. UAV sends the signal to the base station via satellite after tracking the flight black box beacon signal. Setting up the UAV at the rear end is the upcoming idea. In uncertain circumstances like high jack, UAV is configured to send the response.

Vishal Sharma et al [27] proposed that for reliable connectivity among adhoc nodes network is required which is formed by multi networks united together which involves collaborative networking. Aerial nodes form the aerial adhoc network in FANET which is used to identify ground nodes for data transmission between them. Guidance map is formed that forbid the chances of network failure. Continuous connectivity between aerial and ground nodes is provided by opportunistic network formation. Cross layer based network can be used to present data sharing for FANET with efficient use of network resources between ground base and aerial.

lker BEKMEZC et al [28] suggested that with advanced technologies multi-UAVs are proffered in military and civilian areas. Multi-UAVs is beneficial in fulfilling the mission that require communication between the UAVs. FANET is required for data transmission within the infrastructure and to solve the coverage range problem between ground station and UAVs. All the security issues of adhoc networks are held by FANET. Security issues,limitations and challenges are discussed in this paper.

Poonam et al [29] suggested that utilization of FANET in various application and UAVs are used to carry out that applications. The UAVs or the flying nodes should consider multiple factors for information collection for the targeted application. The multiple factors to be considered are path planning, collision avoidance,target coverage and battery power. The path planning for the target coverage is done on the basis of remaining fuel and the location of the target. The pre decided data includes the take off and the landing positions. Information about 3-D coordinates of crafts and height of flight are the required information about path planning. Collision free path should be set for the flying nodes which requires the path length, remaining power is used to compute the current point to target point,points of collisions,etc. In this paper complete control over the crafts during flight is gained through the FANET control system. The proposed model is tested and performs well on the basis of time complexity, no. of bypass decisions etc.

Diksha Goel et al [3] brought forward the idea of collision free path selection in FANET. FANET is composed of multi UAVs which are used in many applications. In cooperative mission with multiple aerial vehicle shield performs a predominant role.Cooperative missions are preserved by FANET, there rises the situation of collisions among the automobiles.It is difficult to resolve the fundamental challenge when flying in small-sized instances with several cars.Ther is requirement to set collision free path and to clear the detected conflict. Method of collision free trajectory planning is enforced to address the defence of cooperative mission with more than one FANET. The proposed approach identifies the conflict among the FANET and resolve them cooperatively using collision free trajectory planning algorithm.

Simarjot Kaur [30] recommended that MANET capability has increased rapidly. With advancement in networking and conversation it is widely used in case of any emergency, army war field. FANET is the new technology and it can tackle the problems which MANET and VANET cannot. Due to rapid change in topology it challengeable to put effective routing protocol. Routing protocol improves the performance of adhoc network. In this DSDV routing protocol is compared on the basis of parameters like packet delivery ratio, throughput and end to end delay.

Farhan Mohammed et al [31] Communication is the important component in FANET. Trusted strategies should be used for communication so that the missions or services are not intentionally or unintentionally attacked. MANET is the group of nodes which are arranged dynamically. MANET is related to group of flying nodes in which the single UAV is treated as one node. In this paper various trust based protocols and management schemes are discussed which are used in

the UAV networks and also identify the applications where such protocols can be adopted.

Dr. Ilker Bekmezci et al [32] proposed the technique for implementing FANET. In this paper the FANET test bed is discussed. To implement a low cost test-bed for FANET is the main task. Ar.Drone 2.0 is used as UAV platform because of its low cost, ease of structural development and easy deployment. 802.11 connection is used to control the Ar.Drone.

Denis Rosario et al [33] proposed as the topology changes rapidly so reliable routing service for FANET must be used. In case of buffer overflow and the packet loss also the user experience on watch live video streaming should be satisfactory. Geographical-aware beaconless opportunistic routing protocol(XLinGO) and Cross Layer Link quality are introduced in this paper. This helps in creating and keeping reliable multi hop routes and by this enhancing the transmission of multiple video flow over FANET.For routing decisions XLinGO considers the human based information as performance metrics and Quality of Experience.

Stefano Rosati et al [34] reported that due to high mobility of the FANET nodes the topology changes very frequently. In this paper the routing protocols are compared for adhoc network i.e optimized link state routing (OLSR) and predictive OLSR (P-OLSR). P OLSR is the designed extension of OLSR for the FANET which uses GPS information. The Linux implementation is available only for P-OLSR. The results of both real world experiment and the Media Access Control(MAC) layer are presented. A test bed is created of two fixed wing UAVs and a node on the ground. The communication range, routing performance and the performance are evaluated through this experiment. P-OLSR is better than the OLSR in frequent topology changes.

Chin E. Lin et al [35] proposed a method to connect the UAV to cloud service like Google Earth. Android based smart phone is used that provide all the data to My SQL Database. Web browser is used to access the information of UAV. Specific flight plan is used to control the UAV which is defines through a waypoint in database. Google Earth Software is used to carry out the mission. The system is designed for single UAV, It is not used for multi UAVs and for the communication among each other.

3. Problem Statement

3.1 Problem Statement

The most recent technology after Mobile Adhoc Networks(MANET) and Vehicular Adhoc Networks(VANET) is now Flying Adhoc Networks (FANET).FANET is considered to be one of the special form of MANET and VANET,although there exist a lot of differences between them. In MANET mobile devices makes up the nodes and in VANET vehicular devices make up the nodes but in FANET Unmanned Aerial Vehicles(UAVs) are used. MANET and VANET nodes are the vehicles or the walking human but the FANET nodes move in the sky. The FANET can send the information quickly and accurately than the other adhoc networks. Unmanned Aerial Vehicles Objects(UAVs) use is increasing day by day in various applications like military and civilian applications[18, 13]. UAVs can move independently, freely and their mobility is much higher in comparison to the nodes in MANET and VANET as a result of which their topology changes frequently. The major problem that arises due to the mobility is that the communication set up between the UAVs is difficult. It always remains a challenging task to find an appropriate route for the communication between the UAVs and to overcome this problem of rapid topology change[31, 18].

3.2 Motivation

The previous work demonstrates the routing between the UAVs by the use of the basic routing protocols that includes AODV,DSDV,OLSR etc[21, 6, 23] and comparing their performances on the basis of packet delivery ratio, throughput, end to end delay[30, 24] in order to determine which routing protocol is better as compared to other. In addition to it ,one of the research paper make use of the mobility models to determine the pattern of moving nodes by considering the changes in node position, node velocity and node acceleration with respect to the time and evaluate the routing protocol like OLSR with the mobility model on the basis of performance parameters like packet delivery ratio, end to end delay and throughput[25].As we know that FANET is created on demand as it

is infrastructure less network depending on the nearby nodes availability which can help in creating the network that is always considered to be dynamic .The motivation behind the work is to create a FANET network which make use of a dynamic routing protocol that helps the UAVs to establish the connection and to find the shortest and the optimal path for the exchange of the data in terms of packets between them in order to reduce the packet losses defined in terms of a parameter called as Datagram Loss Rate(DLR) that happens mainly due to the rapid change in the topology.

3.3 Objectives

The objectives of the dissertation are :

- Creating a Flying Adhoc Network that consists of the nodes categories as server node and few client nodes.
- Applying the Shortest Path Routing Algorithm for the exchange of the data in terms of datagrams or packets that will improves the Datagram Loss Rate(DLR).
- Comparing the results based on the parameters.

3.4 Methodology

In our Methodology a FANET network is created comprising of a Single Server node and few client nodes. A Single Server node acts as the base station to the network that will keep the track of all the client nodes that act as the UAVs in the network and in addition to it will send the IP address of each client to its neighboring client nodes that act as routers for the communication purpose. Out of it, one of the UAV is selected as the source node and other UAV can be selected as the destination node. Source node will send the packet and the destination node will receive the packet. The UAV which acts as the sender will select the message that it wants to send to the receiver. The message selected could be anything audio, video, text, image etc and after it the Dijkstra algorithm will run to find the shortest possible path to the destination node. The message start to traverse in the shortest path reaching to all the client nodes which fall in the shortest path. After the message is received the parameters are compared to the previous method based on dynamic routing using P-OLSR[34]. The parameters

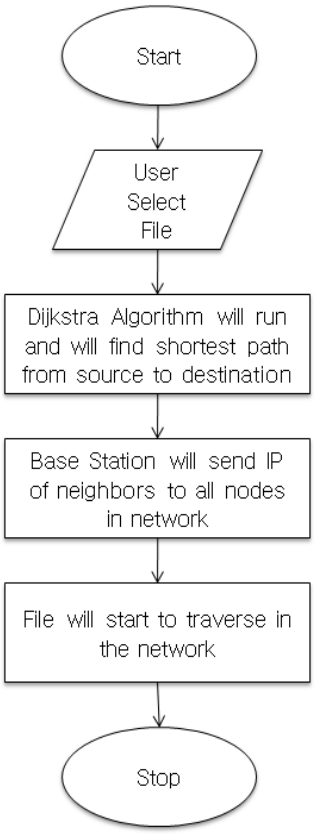

Figure 3.1: Flow Chart

which are compared are time, distance and DLR. The flowchart showing all the steps of the implementation is shown in figure 3.1.

4. Implementation Tools

4.1 Implementation

Practically implementing FANET is very costly devices like mobile and laptops are used to show the simulation.First step for implementing FANET is dynamicaly creating network.We are using netbeans to show the fast movement of data as mobility of nodes is very high. Most important parameter is node mobility and to easily detect node it is easy if every node works as router.Using real world mobility model will make the simulation correct and to reflect the real world performance of FANET. In this to show the real world mobility model java is used in which every node will act as router and will keep the track of all the other nodes through base station.The shortest path will be calculated within the UAVs. If one UAV want to communicate to other UAV one UAV will act as source node and one as destination node. Thus for communication the shortest path within them is selected.

4.2 System Environment

Implementation can be carried out in the system environment as shown in table 4.1:

Table 4.1: System Environment

System	Del Inspiron
System Type	32 Bit
Ram	6gb
Hard Disk	500gb
Operating System	Windows 7
Processor	Intel Core I3

4.3 Java

JAVA is a programming language which is concurrent, object oriented and class based and has few implementation dependencies. Java code can be compiled and run on all platforms that support java without the need of recompilation which intend the application developers to "write once, run anywhere"(WORA)[36].

4.3.1 Features of Java

- Simple: It is simple because the syntax is based on C++ and there is no need to remove the objects which are un referred because there is automatic garbage collection.
- Object Oriented:The software is organized as a combination of different types of objects in which both the data and behaviour are incorporated.
- Secure: Java is secured because it donot have any explicit pointer,programs run inside virtual machine sandbox.
- Platform Independent: Java code can run on many platforms like windows, Linux, Sun Solaris, Mac/OS etc.
- Portable:The java bytecode can be carried to any platform.

4.3.2 Uses of Java

There are many applications where java is used:

- It is used in various desktop applications like in acrobat reader, media player, antivirus.
- Robotics and Games use java as programming language. These games are further used in mobiles which also use java.
- to add new features to web browser Web page uses another type of java program.

4.3.3 Java Editors

Text editors and many IDE's are available for writing Java Program. Following are the well know text editors or IDE's:

- Notepad: Any simple text editor for writing Java Program[37].
- Netbeans: It is the free open source integrated development environment for developing the programs in java, php,C++ and any other programming languages. It is also the platform of modular components used for developing java desktop applications[37].
- Eclipse: Developed by eclipse open source community it is a java IDE. Eclipse provides the development environment like Eclipse java development tools (JDT)for java.[37].

4.4 Swings

Swing is the GUI widget tootlkit for java..Graphical User Interface components like button, scroll bars that are independent of the windowing System for specific operating system are created by the set of program components for the java programmers called the Swings. Swing components are used with the Java Foundation Class(JFC)[38].

4.5 Netbeans

It is the free open source integrated development environment for developing the programs in java, php,C++ and any other programming languages. It is also the platform of modular components used for developing java desktop applications. IDE of netbeans is written in java and run everywhere where a JVM is installed including Windows, Mac OS, Linux, Solaris[39]. Current version of netbeans used in the implementation is 7.3.1

4.6 Socket Programming

A Socket is the endpoint to the two way communication link between the two programs running on the network. It is bound to the port number so that the application can be identified by the TCP to which the data is destined. Most Popular Operating Systems provide a mechanism to give program access to the network. Different networked machines can communicate by sending and receiving messages. To be independent of any type of network this socket mechanism has been created for that[40]. The most dominant network is IP and is the most

popular use of the sockets. Sockets are used in client-server application framework. When client requests for some functions server is the process that performs them. Sockets are used for connection between the client and server for exchanging the data like in the application-level protocols[40].

4.6.1 Socket Types

Four types of sockets are available for the user. Two of them are used commonly and the rest two are rarely used:

- Stream Sockets: In this TCP is used for data transmission. networked environment delivery is surely done. If the data is send through stream socket independently three times "A,B,C", they will arrive in the same order- "A,B,C"[40]. Error indicator is received by the sender if the delivery is not possible. The records of data do not have any boundaries.
- Datagram Sockets: UDP protocol is used. No guarantee is there for the delivery in networked environment. No open connection is required as in the Stream Socket so they are connectionless, destination information is used to build a packet and then it is send[40].

5. Results and Analysis

5.1 Parameters Used

In this the results are shown with respect to three parameters time, distance and DLR (Datagram Loss Rate). DLR is compared as compared to time and distance. If the distance increases the DLR increases. If the time increases then the DLR increases. More time and distance in sending the packet from the source node to the destination node more is the chances of the packet loss. In this experiment the packet sending is fast and takes much less time. Any number of node can be used it can be 50, 60 etc. The packet is send to the destination using the shortest path.

5.2 GUI of Experiment

A Single Server Node in the figure5.1 that act as the Base station in order to keep the track of all the active client UAVs nodes.

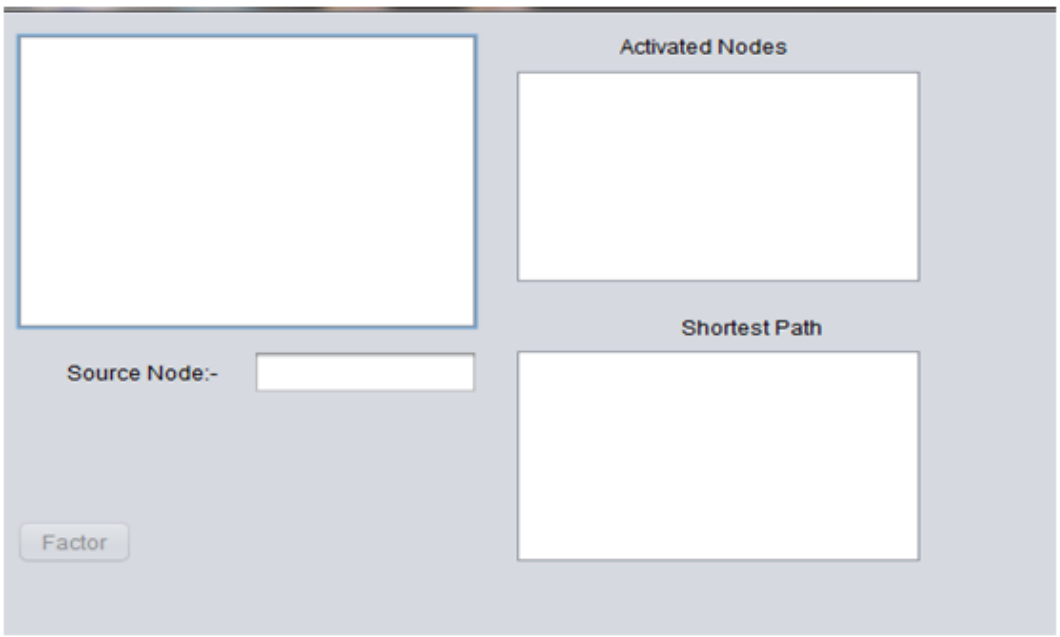

Figure 5.1: Server Node

A Client Node in the figure5.2 that communicates with the other client UAVs nodes. A client node act as the router and checks for the other client nodes.

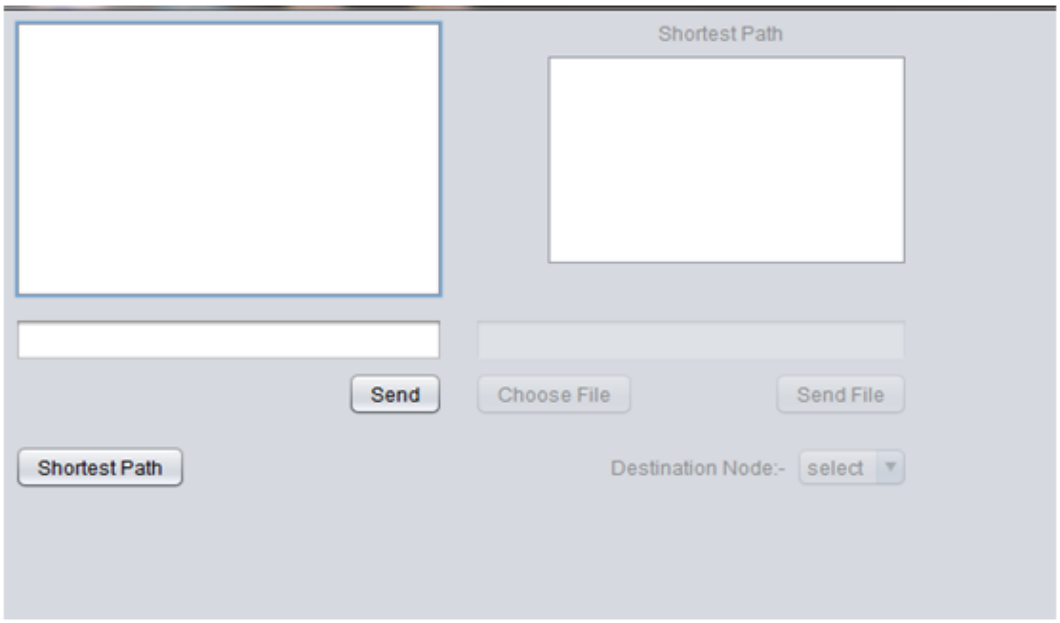

Figure 5.2: Client Node

A Single Server Node and three client UAVs. Figure5.3 displays a single Server Node and three active client nodes ready for the communication. The window of a single server node displays the active client nodes along with their IP addresses.

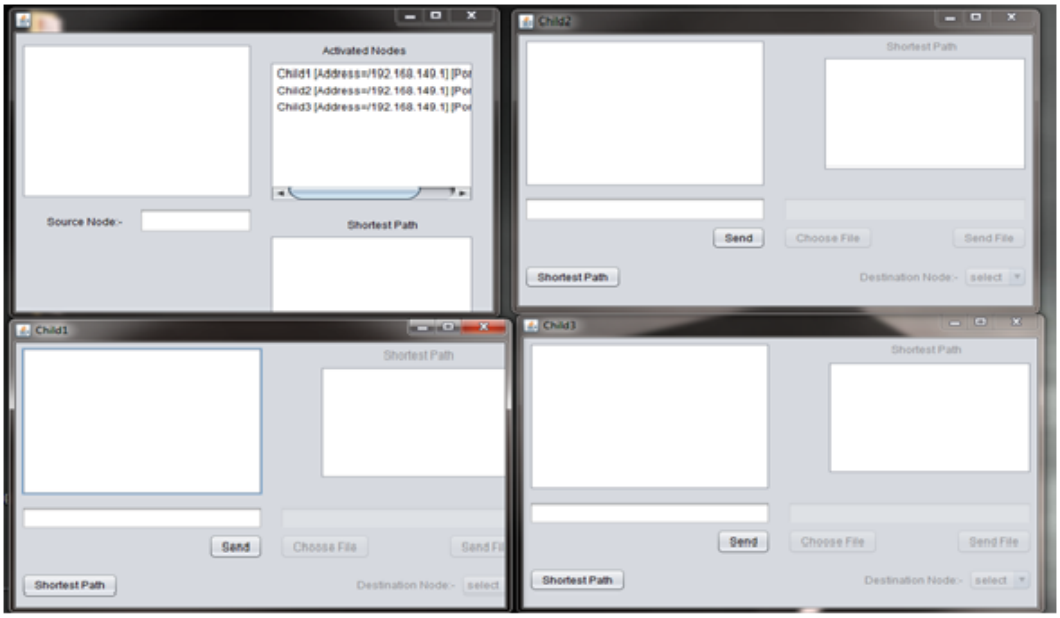

Figure 5.3: A Single Server Node and three client nodes

A Client Node sending the communication request to other Client Nodes.In Figure5.4 from all the activated clients one of them act as the source node and that source node first of all select the shortest path button and initiated a communication by sending Are you ready message by clicking on the send button. The message is received by all the active client nodes. In the window of the server node , the value chid1 appears in the Source Node field.

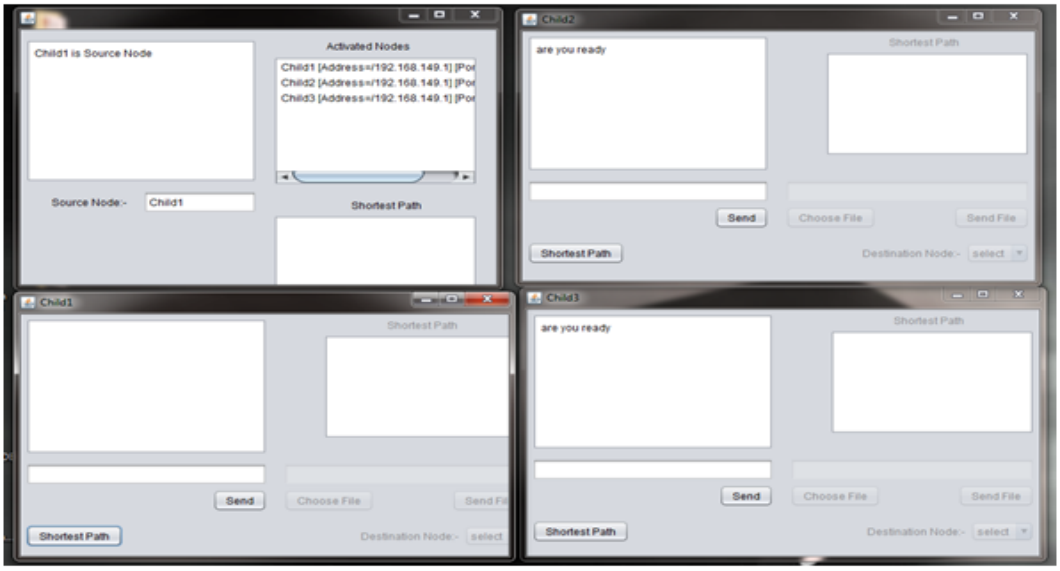

Figure 5.4: Source Node making a communication request to other client Node

Message Reply send by the Client Nodes to the Source Node. In figure5.5 the client willing to take part in the communication with the Source Node replied with Yes message.

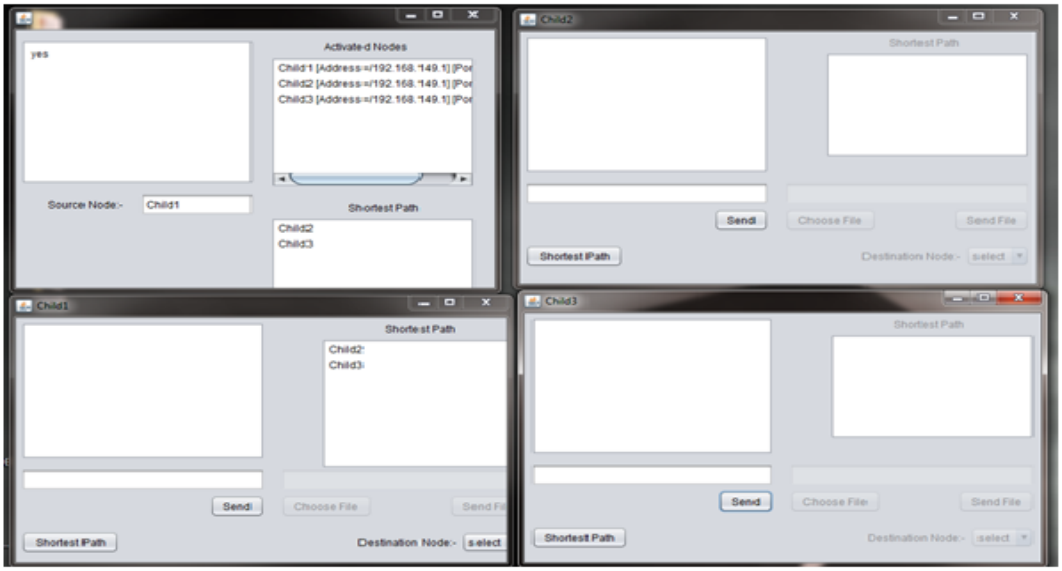

Figure 5.5: A Client Node accepting the communication request from the Source Node

Sender node selects one of the destination nodes.In figure5.6 Sender node select one of the destination node from the list showing activated child nodes with which it want to make the communication or to send the packet The packet will be send according to the shortest path as calculated by the Dijkstra Algorithm

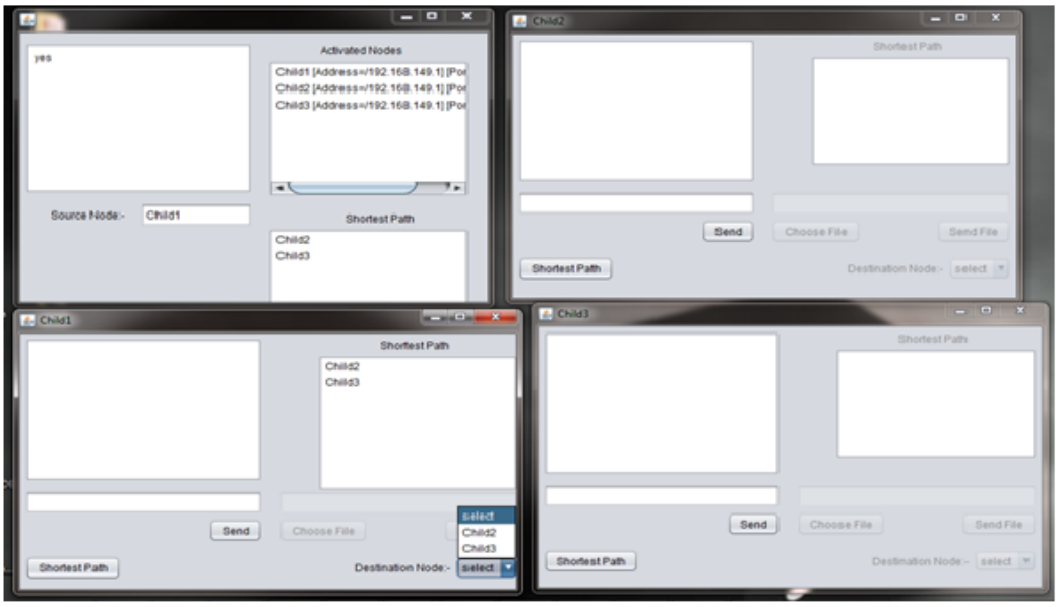

Figure 5.6: Destination Node Selected by Source Node

Source Node selects the message to send to the destination. In Figure5.7 the Source Node selects the Child2 as the destination to exchange the message. The message can be text file, image, audio or video. Here the Source Node selects the file to be exchanged with the Child1 by selecting the button Choose a File.

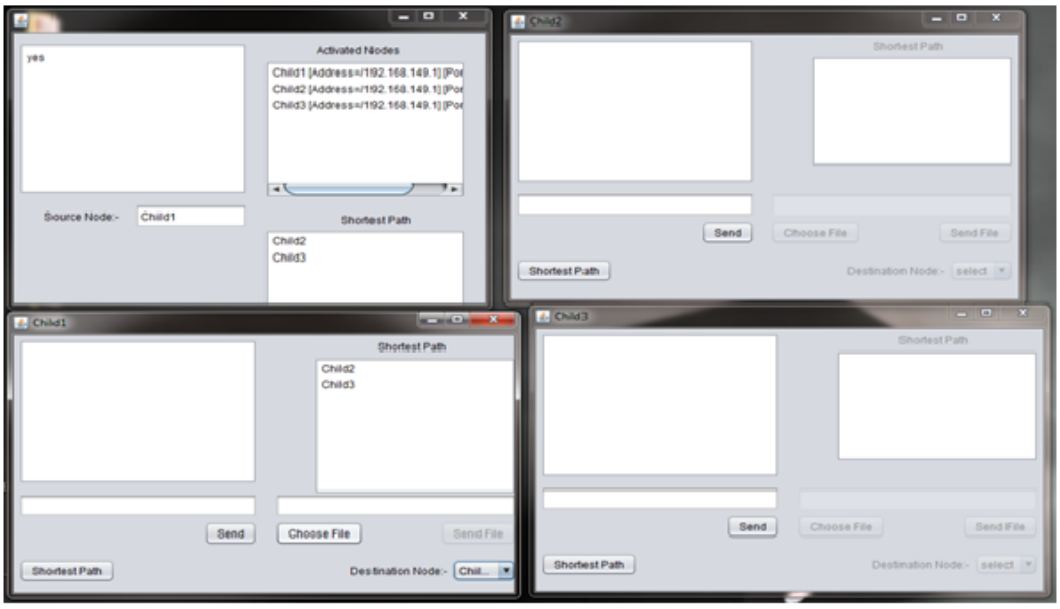

Figure 5.7: Source Nodes Selecting the Destination Node

Choosing the file from the Dialog Box.
In the figure 5.8 a file open dialog box appears to select a file to be exchanged with the destination node.

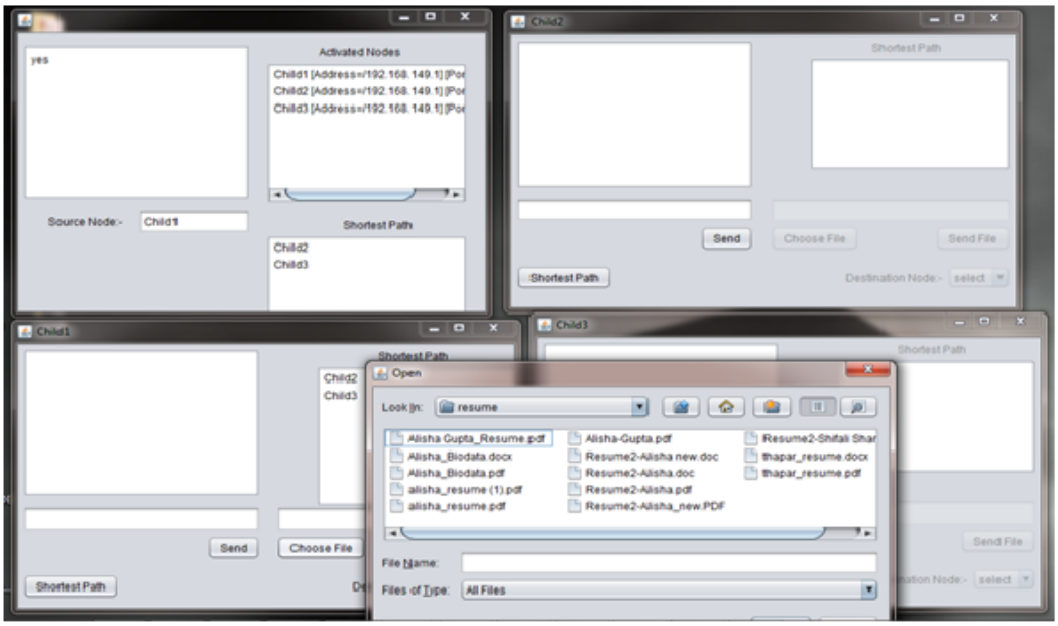

Figure 5.8: A Dialog Box appears to select a File

Sending the file by the Source Node and the file received by the Client Node.
In the figure 5.9 the Source Node selects the file from the dialog box which appears and send to the Child Node2 by clicking on the button Send and it is received successfully by the child2.

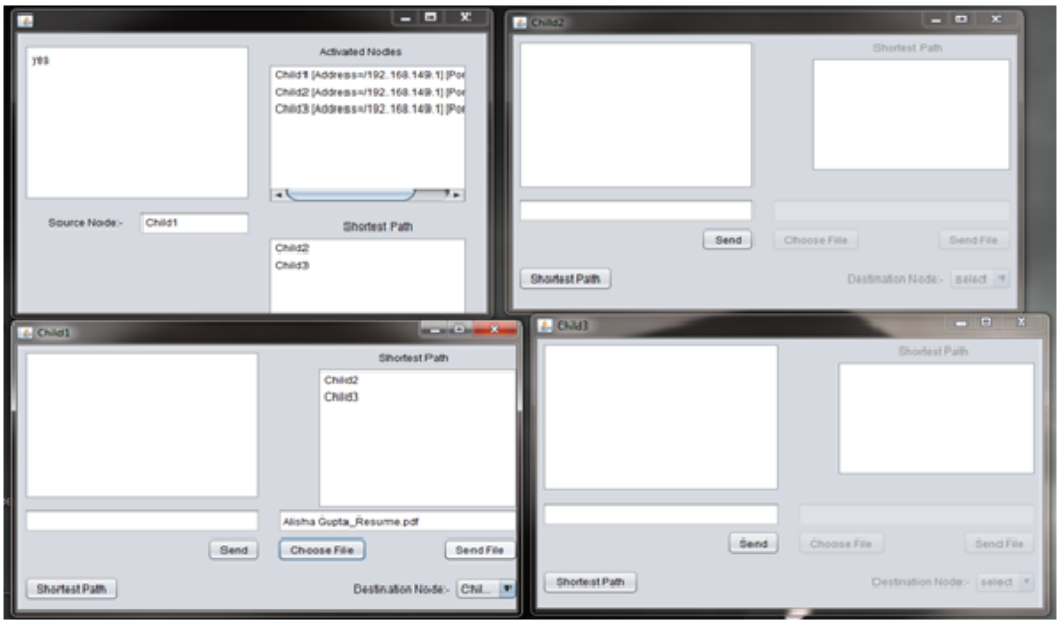

Figure 5.9: File reached to Client node on Shortest Path

After the file is selected which you want to send to the destination node. Dialog Box appears on the client nodes which fall into the path of sending the file to the destination node. The client nodes fall on the shortest path. We have to agree to the file received on the client node so that it moves further to the destination node as shown in figure 5.10.

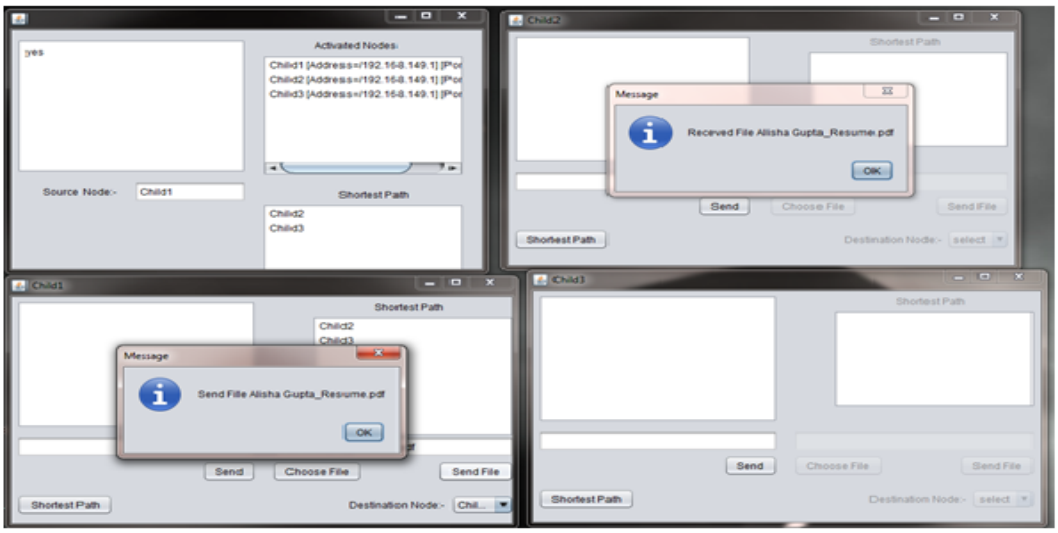

Figure 5.10: File received by node on Shortest Path

After selecting the file to be send from the source node to be send to the destination node. The file is first received on the other child nodes which fall on shortest path which have to approved to be send further to the other node of the shortest path and finally to destination. Dialog box appears on the destination node showing that the file has been received as shown in figure 5.11. Click on OK to the dialog box which appears on the destination node as the file has been received.

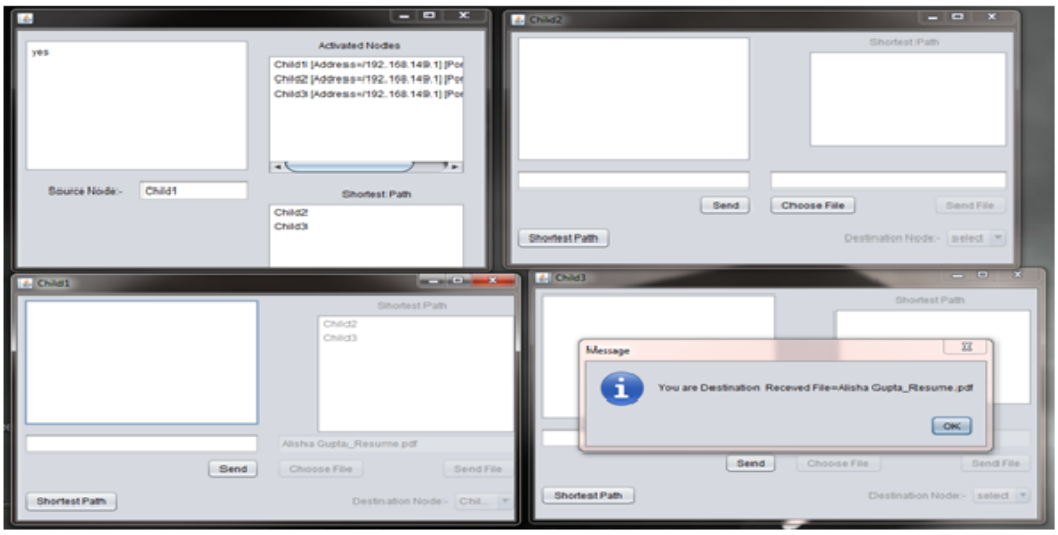

Figure 5.11: File received by Destination

After the file has been received on the destination node. Now we need to check the factors. On the server node which acts as the base station to the FANET network select the Factor as shown in figure 5.12.The factors will show different parameters which the file takes to move from the source node to the destination node. These are the factors which affect the file as it traverse through the shortest path.

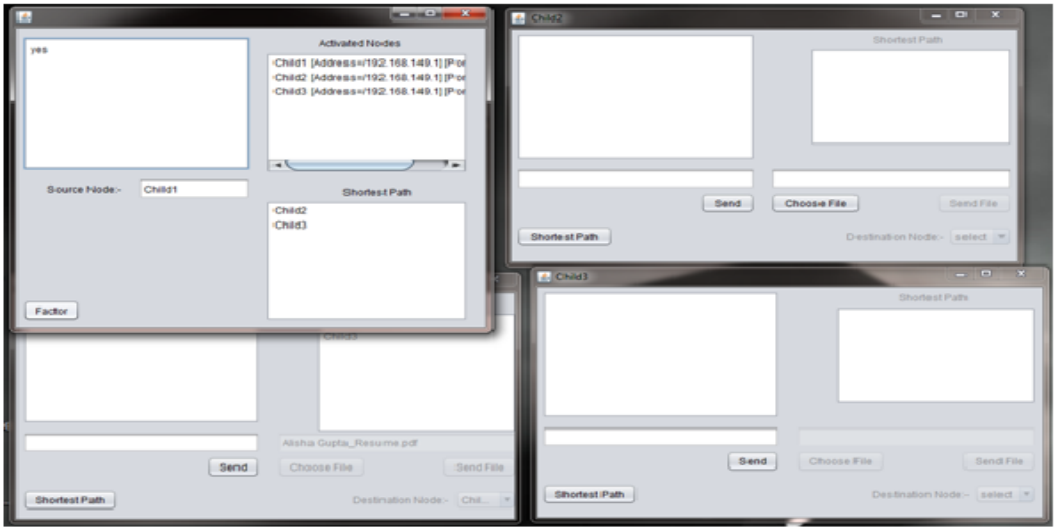

Figure 5.12: Select Factor from Server Node

Factor shows the parameters like time, distance and DLR which shows the different values.With increase in time the DLR decreases. If more time is taken to reach file then more strength is required. If more distance is there then also more strength is required. Time and distance is more but the Datagram Loss Rate is zero which shows that the strength taken is less as shown in figure 5.13.

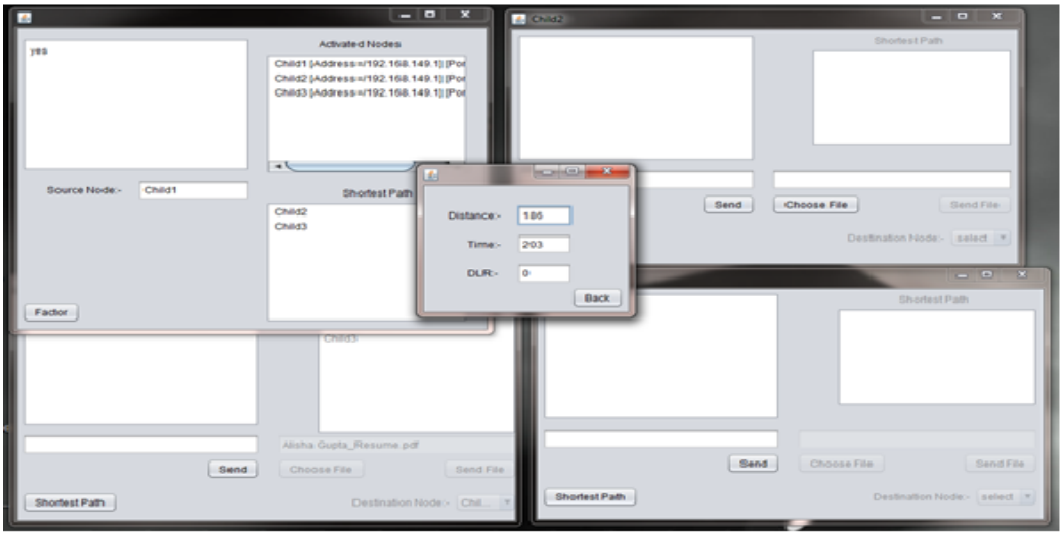

Figure 5.13: Parameters

The folder to all the child nodes which acts as the UAVs are made.The destination child node folder will show if the file has been received or not as shown in figure 5.14.

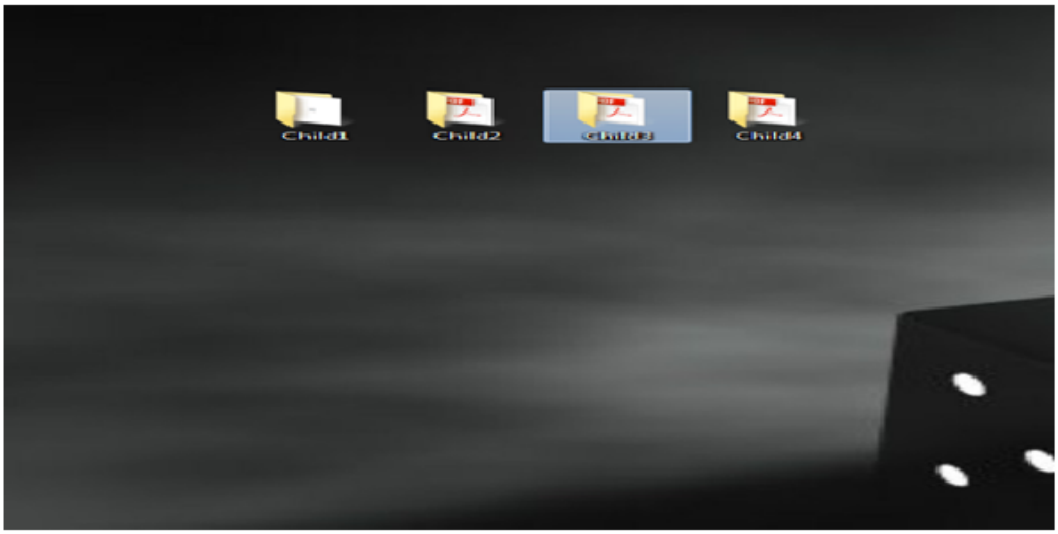

Figure 5.14: Destination node folder

The file which has been send from one UAV to other will be shown. This is the destination folder showing that the file has been received as shown in figure 5.15.

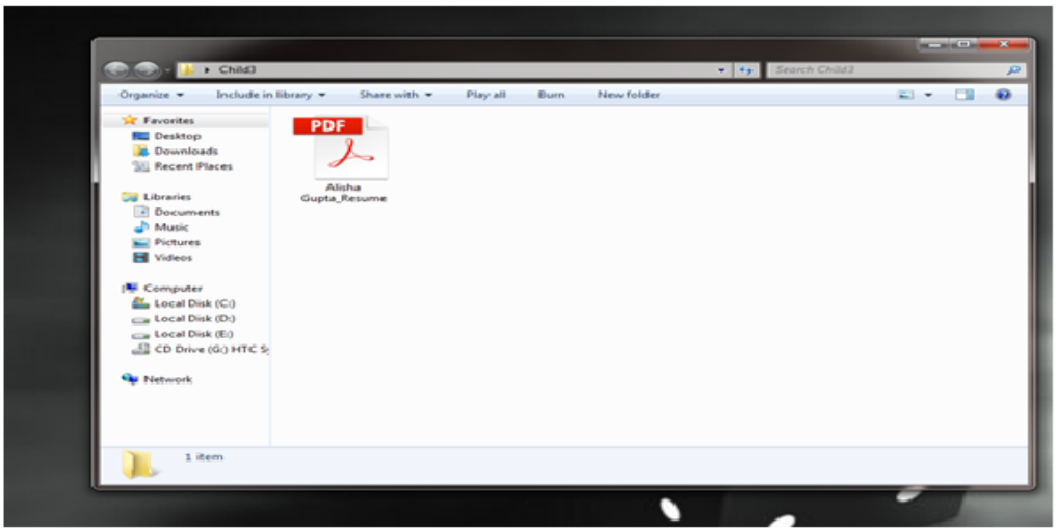

Figure 5.15: File received by Destination node

5.3 Results

5.3.1 Time and DLR

When the communication takes place from the source node to the destination node. The packet is send by using the Dijkastra algorithm from the source node to the destination node. The packet could be anything text file, audio, video, image etc. It is observed that when we send the data over the FANET network the datagram loss rate is higher. So to reduce the datagram loss rate the proposed method is used. The table shows that the time and DLR are compared.
DLR is calculated as:
DLR=(No. of packets lost)/(No. of packets received)
The table shows that the time and DLR are compared.

Table 5.1: Time and DLR based comparison of proposed method with P-OLSR method

P-OLSR Method [34]		proposed method	
Time(s)	DLR	Time(s)	DLR
60	0.1	60	0
192	0.1	192	0
260	0.15	260	0.1
312	0.25	312	0.2

In the above table we compared the DLR of our proposed method with the P-

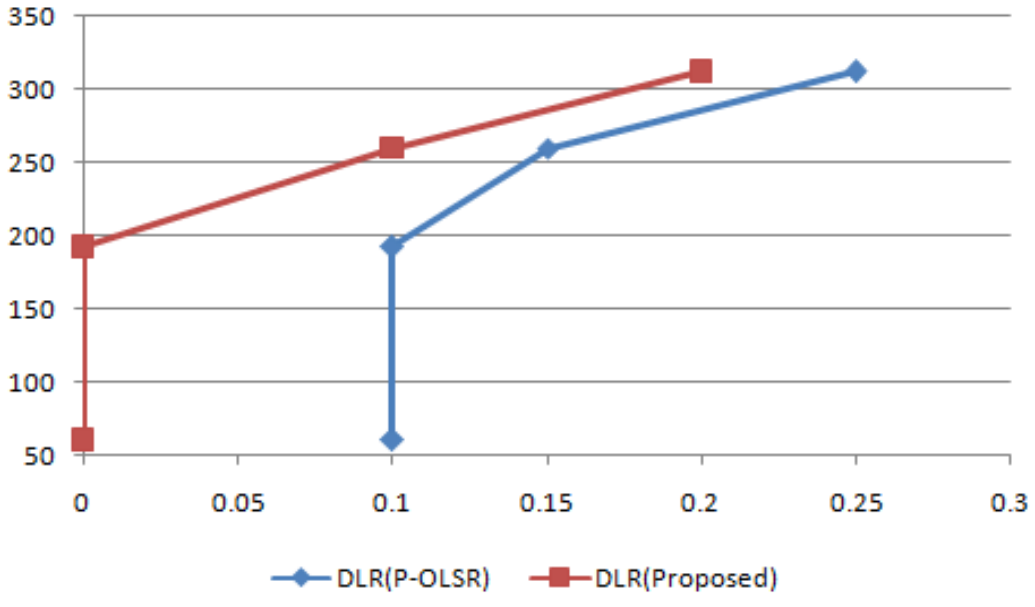

Figure 5.16: Time DLR Graph

OLSR method[34].It is observed that uptil 250 sec the datagram loss rate is 0 but in comparison to it the P-OLSR method the DLR may exceed upto 0.1. If the time increases from 250 sec to 300 sec then the datagram loss rate is 0.1 in the proposed method but it increases upto 0.2 in P-OLSR method[34]. The table is depicted in the form of graph too.

5.3.2 Distance and DLR

The packet is transferred from the source node to the destination node. Distance is calculated by checking delay of response from the access points.In this method the shortest distance is calculated by Dijkstra Algorithm.Any number of client nodes can be used. More the number of client nodes used more is the distance. Datagram Loss rate also varies with respect to distance. Packet loss ratio is checked through this proposed method.Distance is the important factor which need to be considered to check the packet delivery.
DLR is calculated as:
DLR=(No. of packets lost)/(No. of packets received)
The proposed method is compared to the P-OLSR method[34]. It is observed that when the distance is upto 250 m then the DLR is zero in both the cases. If the distance increases upto 300m then the DLR in the proposed method and P-OLSR method changes from 0 to 0.1 . If the distance increases from 300m to 340m then DLR increases upto 0.4 in P-OLSR method and 0.2 in proposed method. If the distance is increased further from 340m then the DLR increases upto 0.2 in proposed method and increases upto 0.5 P-OLSR method[34]. The same is also shown in the graph.

Table 5.2: Distance and DLR based comparison of proposed method with P-OLSR method

P-OLSR Method [34]		proposed method	
Distance(m)	DLR	Distance(m)	DLR
250	0	250	0
262	0.1	262	0.1
310	0.4	310	0.2
350	0.5	350	0.2

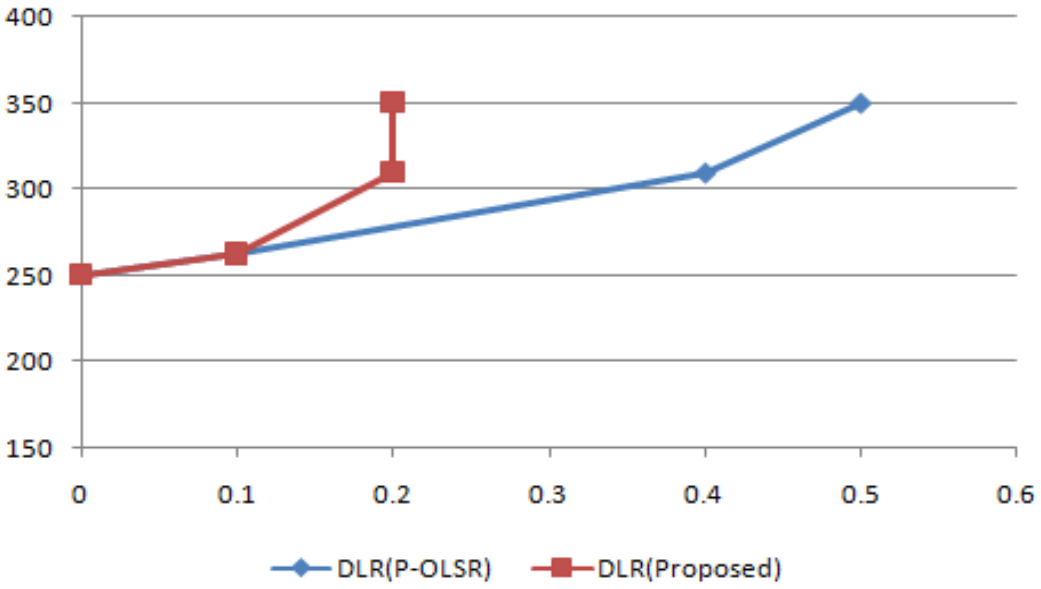

Figure 5.17: Distance DLR Graph

5.4 Summary

In this proposed method the FANET network is created with a single server node and more than two client nodes that act as UAVs. The communication takes place between the UAVs by exchanging the packets. The packet can be anything text file, audio, video, image etc. One of the client node act as the source node, while one of them act as the client node. Then the destination node is selected. The shortest path from the source node to the destination node is calculated using Dijkstra Algorithm. The file is selected from the source node and delivered to the destination node through that shortest path. The parameters like Time , Distance and DLR are calculated and compared to it. It is observed that DLR is less in the proposed method in comparision to P-OLSR method.

6. Conclusion and Future Scope

6.1 Conclusion

In this dissertation the FANET network is made dynamically to show its implementation in real world using the server node which is the base station and 3 client nodes which acts as UAVs. As the mobility of the UAV nodes is very high so the topology changes frequently so FANET implementation in real world application is difficult. The communication between the UAVs is considered as the main problem in FANET. For fast communication this method is proposed. The Source node has to send the data to the destination node so for that shortest path is required. The shortest path is calculated using Dijkstra Algorithm. The Base station will send the IPs of neighbours to all the nodes in the network. Thus for sending any file from source node to destination node that shortest path is followed. The file will start to traverse moving to all the nodes in the shortest path. The Factor is calculated on the Base Station. The Factor shows three parameters Distance, Time and DLR. Results shows that the Distance and Time affect less on the Datagram Loss Rate. Thus ensuring that packet move to destination with no loss. This method is better than the other method with which it is compared. Proposed method is compared to P-OLSR method by comparing the parameters like time,distance and DLR.

6.2 Future Scope

To increase the network lifetime there should be energy efficient communication protocol. In case of FANET when the communication takes place between the UAVs the data has to be transferred. In this case of transmitting the data energy of the UAV goes down very soon due to wireless network. We need to develop some technique so that the energy of the UAV cannot go down soon.

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List of Publications

Alisha Gupta, Sumit Miglani, "Datagram Loss Reduction in FANET using Dijkstra Algorithm", IEEE International Conference on Advanced Networks and Telecommunications Systems IEEE ANTS 2017, Bhubaneswar, Odisha, India, December 2017 (Communicated) .

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Plagiarism Report

Alisha Gupta

ORIGINALITY REPORT

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PRIMARY SOURCES

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2	gdeepak.com Internet Source	%2
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