Dynamic Routing for UAVs through Network Connectivity to Optimize Latency

Bindu S.N[1], Hemanth Kumar A.R[2]

[1]*M.Tech student, Dept. of ECE, Bangalore Institute of Technology, Bengaluru, India-560004*
[2]*Prof, Dept. of ECE, Bangalore Institute of Technology, Bengaluru, India-560004*

Abstract - *In the electronics and communications fields the usage of Unmanned Aerial Vehicles (UAVs) is applicable and it is used in the several fields like civilian, commercial and defense products. The usage of the one aircraft is not enough instead several unmanned aerial vehicles will make application to work regardless to limits of single UAV. The Flying Ad-hoc Networks (FANETS) is a type of system which has set of aircrafts integrated in different strategy which are efficiently used to achieve effective goals. The UAVs are organized to deliver quality of services for network which in turn by using the supportive transmission and reliable. The huge set of UAVs will extend to efficient completion range for internet facilities through reliable nodes. In this paper a layer UAVs set architecture is projected and also optimum number of unmanned aerial vehicles are examined. The Low Latency Routing Algorithm (LLRA) is developed under reference of connectivity, semi data of the location. LLRA guarantees reliability on routing and balancing of load by optimizing the traffic overload on the various node points and also on communication links. Network simulator-2.35 is used to simulate the network performance which are packet delivery ratio, throughput, overhead, delay, consumption of energy is analyzed in the proposed system.*

Key Words: Unmanned Aerial Vehicles (UAVs), Flying Ad hoc Networks (FANETs), Quality of service, Low Latency Routing Algorithm (LLRA)

1. INTRODUCTION

With advancements in technology amelioration, aircrafts significantly impacted the grave products such as border surveillance, ecological monitoring, disaster surveillance and aerial photography. UAV is a type of aircraft that operates without human pilot on board. The aircrafts have distinct characteristics such as informal distribution, reconfigurable aptitude in run time and the self-directed flying capability which provides better Quality of service (QoS), hence it is an integral part of Internet of things (IoT). The ability of using single UAV is insufficient. Several UAVs forms a group, that outperforms limitless of single aircraft (1). Flying Ad-hoc Networks are primitive systems that consist of group of small aerial vehicles interconnected randomly, and unified as group to attain efficient outputs, that could enlarge the communication and outspread transmission level in less infrastructural fields (2). A group of UAVs are allowed to work together to achieve difficult tasks in a wide areas such as military and scientific activities. The drones fly at high altitudes known as upper layer unmanned aerial vehicle. The large size aerial vehicles prolongs the flying time and provides improved transmission ability to bring out a extended periodic activities at high altitude and monitors the larger part (3). However, the small size drones flight is controlled at low altitudes, which acts as lower layer aircrafts. The small size UAV have reliable flying capabilities are deployed to work together at lower heights and transfer the collected data to the users on the ground or base station. Low altitude vehicles are also acts as relay station or node. Upper layer aerial vehicles acts as a bridge for data transmission among the lower layer unmanned aerial vehicles.

In table driven routing protocols each point preserve the data about the subsequent nodes when the communication takes place. All the moving neighborhoods of this protocol have to communicate its entries to the adjacent nodes. Large amount of control messages are generated whenever slight fluctuations occurs in the topology. The nodes change in their devices and transmitters to sense the situation and communicate the information to Base station or sink through appropriate routes. Optimized Link State Routing (OLSR), Destination Sequence Distance Vector (DSDV) and routing information protocol (RIP) are examples of proactive protocols (4).

OLSR is a proactive link state protocol. All nodes of this protocol chooses a neighborhoods as Multipoint Relays (MPRs). The neighborhoods which are selected as MPRs are responsible for transferring the data packets. Multipoint relaying takes place in two ways, by decreasing the magnitude of control packets and by dropping amount of links which are used for promoting the link state packets from source to destination.

Ad hoc on demand distance vector (AODV) algorithm allows all nodes to work separately and do not hold any data of predefined paths over which information can be distributed to the destination or sink. Route will be formed only when a information reaches at a node so as to communicate with destination (5).

1.1 Problem Statement

The nodes are mobile in nature, hence the link stability between two nodes will get faded easily they move apart. The topology keeps on changing, routing becomes difficult. Location based protocols cannot give the exact location of the nodes. So, the quality service of the network will be decreased.

The paper is organized as follows. Section 2 describes the proposed methodology for connecting UAVs using low latency routing algorithm. Section 3 presents the simulation results of performance parameters compared with the existing system and proposed system. Finally in section 4 discussion is concluded

2. PROPOSED METHODOLOGY

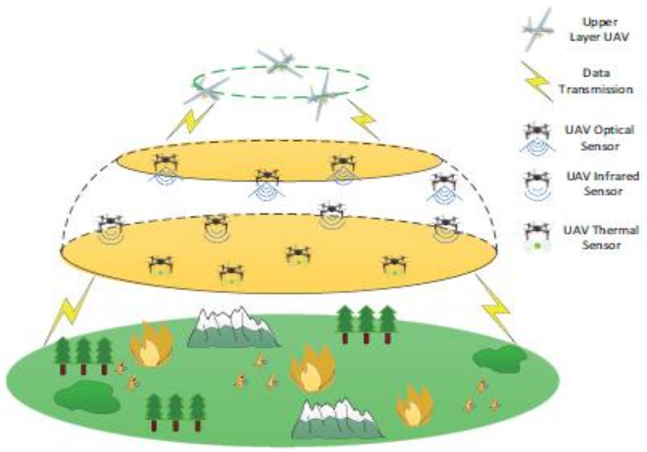

Fig-1: Typical Layered UAV Network

UAVs provides the guaranteed communication in an critical situation such as forest fire and earthquake as illustrated in fig-1. A huge group of UAVs are organized resourcefully for providing increased Quality of service (QoS) to internet devices. UAV based communication is used to gather data from several sensors and conduct real-time video stream.

The various forms of aircrafts are separated into two layers based on the functions performed, which includes upper and lower layer. Based on flying ability of speed and diversity of coverage, the upper layer contains fixed wing aircrafts. These can deliver operative coverage to lower layer aircrafts. The upper layer aircrafts will acts as neighbor nodes to support communication in lower layer by reducing the transmission delay.

The lower layer aircrafts are armed with various types of sensors such as optical, infrared and thermal sensors which are responsible for gathering and transmitting the information. Omnidirectional antenna is used for lower layer aircrafts to improve the communication.

2.1 Dataflow for Connecting UAVs

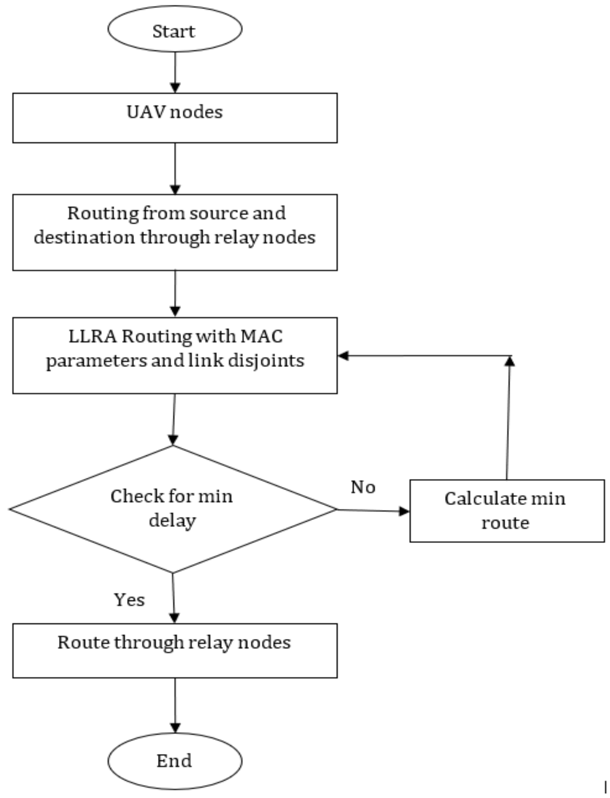

Fig-2: Dataflow for Connecting UAVs

The initialization starts with finding the UAV nodes which are deployed randomly and followed by the route discovery process from source and destination through relay nodes as illustrated in fig-2. The moving topology of the network results in link disjoints or breakage, hence the Low Latency Routing Algorithm (LLRA) is used along with mac parameters which guarantees the quality of service(QoS). LLRA allows to find the relay nodes with minimum distance to communicate from source to destination. If the nodes are found with min delay, the efficient routing is done through relay nodes else the routing information is updated to calculate the minimum route.

2.2 Node Deployment Algorithm

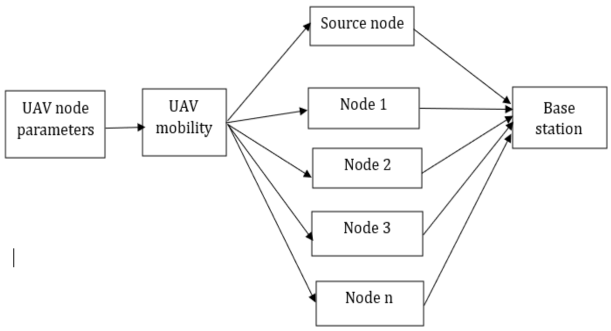

Fig-3: UAV Nodes Deployment

The above fig-3 shows the deployment of UAV nodes using cooperative communication and relay technologies. The topology construction of UAV nodes are dynamic in nature where the link breakage takes place when they move apart.

The node deployment or network module consist of the description and functionality of the scripts used in setting the topology which includes construction of wireless system topology, contains moving nodes and all the nodes are employed with various channels.

- Deploying the nodes randomly by setting the network configuration.
- Setting up of bandwidth, frequency, specifying source and destination.
- Neighborhoods are calculated using Euclidian distance formula.

  $D = \sqrt{(x_2-x_1)^2} + \sqrt{(y_2-y_1)^2}$

- Defining events and specifying the start and stop time.
- Nodes are deployed dynamically.

2.3 Low Latency Routing Algorithm

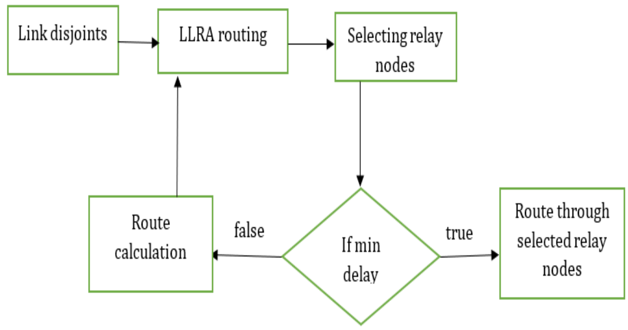

Fig-4: Low Latency Routing Algorithm (LLRA)

Low Latency Routing Algorithm (LLRA) is intended with semi data of the position and network connectivity of aircrafts. This algorithm determines the method of route detection to transfer data packets from source to base station as illustrated in fig-4.

Based on evaluated link stability of aircrafts, the low latency routing algorithm (LLRA) can accomplish best route with minimal delay for load balancing and dynamically allocates different data traffic streams, that can competently increase the packet delivery ratio and enhance the solidity of path.

The congestion in the network is regulated and improves the performance, as all the nodes of the network do not take part in the path detection process for specific source and destination pair. Delay sensitive standards such as 802.11b and 802.11g operates with multiple data rates for QoS controlled communication to employ the partial resources of UAVs more efficiently. The parameters such as Packet reception ratio(PRR), Signal to noise ratio(SNR) and Link Quality Indicator(LQI) are estimated in the process of route discovery.

Once the UAV nodes are deployed, all the UAV nodes intermittently transmits HELLO packets in communication to attain 1-hop relay nodes data and it is kept in Neighbor Table (NT). Signal to noise ratio(SNR) and Link quality indicator (LQI) values are stored and restructured in Neighbor Table (NT) which aims error free breakage of links. Each receiver UAV point calculates the link eminence evaluation for a predefined window period by using

$$LQ_{a \to b} = \sqrt{\overline{SNR}^2 + \overline{LQE}^2}$$

3. SIMULATION RESULTS

For evaluating and analyzing the performance of Low Latency Routing Algorithm (LLRA) Network Simulator-2 is used which is application level simulator. Network Simulator adopts OTcl script as front-end and C++ libraries in backend.

Table-1: Simulation Parameters

Parameter	Value
Operating System	Ubuntu 14.10
Simulator	NS-2.35
Protocol	LLRA
Channel type	Wireless Channel
Simulation duration	100s
MAC layer Protocol	802.11
Number of nodes	30
Radio propagation mode	Two ray ground
Simulation area	800*800

The parameters set up for simulation of 30 nodes is as shown in the above table-1. The QOS constrained parameters are estimated using proposed Low Latency Routing Algorithm (LLRA). The performance constraints such as Throughput, Delay, Packet delivery ratio, Energy and Overhead are compared to existing system and proposed system.

1) Throughput

Throughput is the amount of data or packets delivered successfully over particular time period which is expressed in kbps. The graph plotted w.r.t existing system and proposed system where x-axis gives the node speed and y-axis displays throughput as shown in chart 1. The throughput obtained in existing system is 265.94 Kbps and increased to 336.48 kbps in proposed system.

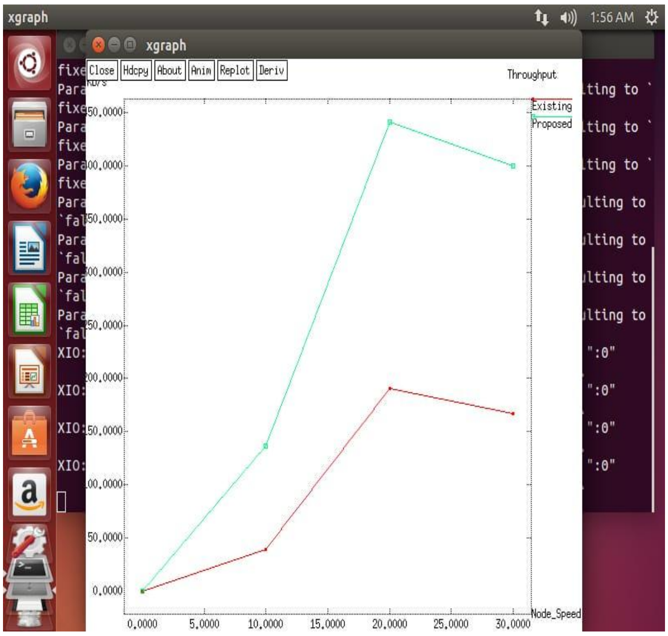

chart-1: Comparison of Throughput with Existing and Proposed System

2) End to end Delay

The amount of time occupied for the packet to communicate in the system from source to base station is referred as delay which is expressed in ms. Types of delay includes Processing, Queuing, Transmission and Propagation delays.

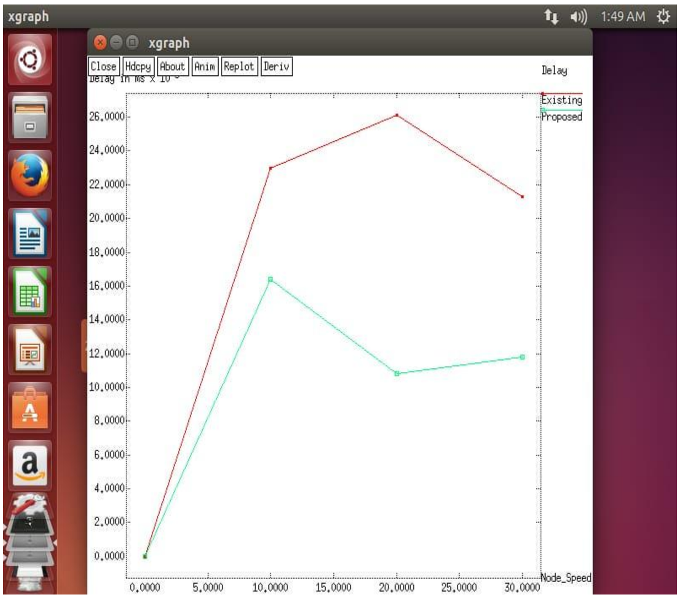

Chart-2: End to end Delay compared with Existing and Proposed System

The chart-2 illustrates the graph of delay compared with existing system and proposed system where the output of existing method delay is 126.598 ms and decreased to 40.6171 ms in proposed system.

3) Packet Delivery Ratio

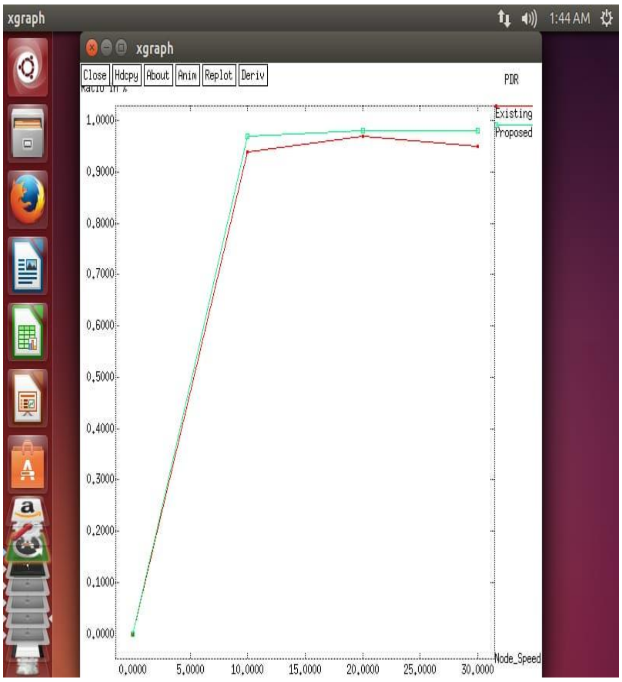

Chart-3: Packet Delivery Ratio Compared with Existing and Proposed System

The proportion of quantity of packets distributed to the destination and amount of packets sent from source is the packet delivery ratio. s:5424, r:5247 and r/s ratio is 0.9674 the loss of packets in existing system is 177, while in the proposed system s:14878, r:14708 and r/s ratio is 0.9886 thus, the loss of packets reduced to 170 as shown in chart-3.

4) Overhead

Overhead is the amount of routing packets processed in a network. Chart-4 shows the output graph of overhead which is decreased from 4.221 to 3.206 when compared with existing and proposed system.

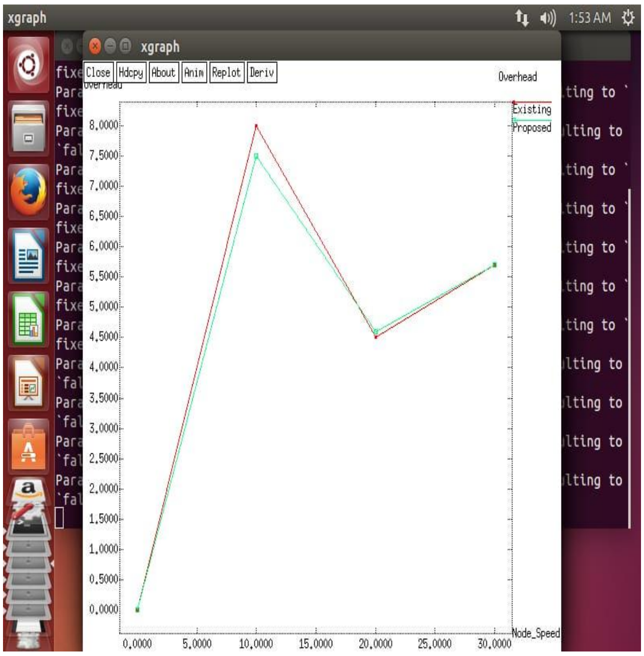

Chart-4: Comparison of Overhead with Existing and Proposed System

5) Energy

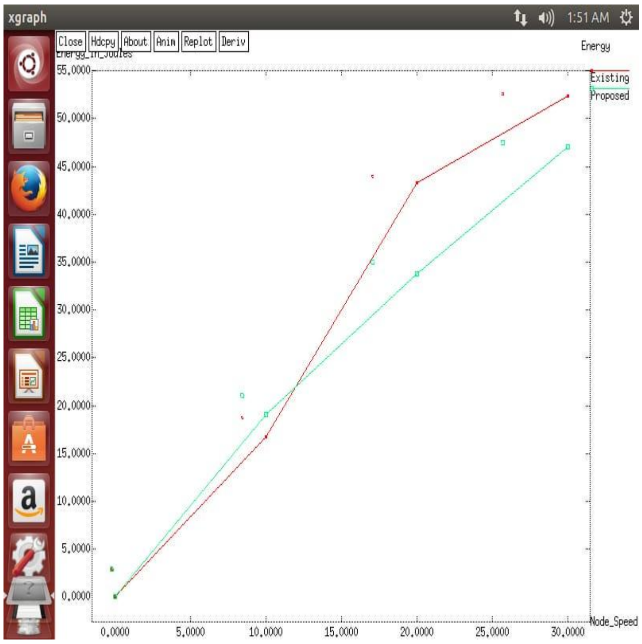

Chart-5: Energy Consumption Compared with Existing and Proposed System

Energy is the key constraint of wireless systems and it is battery operated, hence the nodes requires energy for communication which is expressed in Joules. The chart 5 shows the graph of energy consumption in existing and proposed system.

4. CONCLUSION

The dynamic characteristics of the nodes results in change of network topology. The proposed work intends to state a dynamic method of fetching reliable network performance. Self-organized network constraints are used to accomplish the finest path in the system. The projected system pledges reliability on routing and balancing of load by decreasing the traffic overload between the points and transmission links. If one or more nodes failures, the network overrides the paths repeatedly and ensures data communication by Self-recovering and self-adaptation. The proposed Low Latency Routing Algorithm (LLRA) achieves the best possible route with less delay and vigorously allocate different forms of data traffic streams, which controls congestion in network and enhances the performance. The routing using LLRA gives the better performance compared to the existing system.

The accurate data transmission is one of the major constraint, hence providing security enhances the network reliability. In future, some of the data security protocols can be employed along with existing protocol which provides secure data transmission.

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