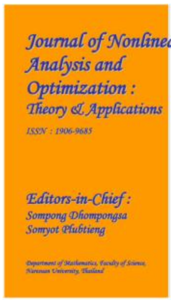
**J**ournal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.15 : 2024
ISSN : **1906-9685**




**Paper ID: ICRTEM24_141** **ICRTEM-2024 Conference Paper**

# CLUSTER BASED PATH OPTIMIZATIONIN UAV USING LORAWAN

**#1Dr. K. KAMALI , Assistant Professor/ programmer,**
**#2Mrs. J. VIJAYABARATHY, Research Scholar (Part-Time),**
**Department of Computer and Information Science,**
**ANNAMALAI UNIVERSITY, TAMILNADU.**

**ABSTRACT:** Owing to the high expense of establishing infrastructures like cellular network base stations and optical fiber connections in large landscapes with sparse populations, unmanned aerial vehicles (UAVs) have demonstrated success in linking rural and isolated locations. But as the network grows, data gathering relying only on unmanned aerial vehicles (UAVs) visiting every IoT sensor node or multi-hop routing between IoT sensor nodes would not be scalable. In order to get around this restriction, a universal multi-UAV-enabled data aggregation and gathering technique that makes use of both multi-hop and UAV routing is suggested. Its goal is to minimize the weighted total of the energy used by UAVs for travel and the transmission of nodes. Instead of all UAV communicate, there choose one as cluster head by for better communication. For this two scenario were to be followed like, find the best cluster head based on distance and direction. Once proper path has been finalized it leads to less energy consumption.

***Keywords:*** *unmanned aerial vehicle (UAV), LoRaWAN, Data forwarding, Routing Path, Cluster.*

## INTRODUCTION:

As more studies examine changes in the global environment, getting environment monitoring data effectively in isolated locations without public internet access has grown in importance. To have data


effectively transfer from source to destination also important, based on the picking the right direction and right angle of travel of UAV. At the same time what type of network used for communication is also important for standard delivery of the data. Choosing right path from source to destination implies improved data transmission efficiently. And also it will manage the energy efficiently.

Fig.1. Unmanned Aerial Vehicles Market Size [10]

The UAV (unmanned aerial vehicle) market is divided into segments based on the following: application (military, civil, and commercial); size (small, medium, and large); type (fixed-wing and VTOL); range (visual range of sight, or VLOS), and geography (North America, Europe, Asia-Pacific, Latin America, and the Middle East and Africa). Figure 1 represent the Unmanned Aerial Vehicles Market Size as of global market.

For the majority of Internet of Things applications, wireless communication must be ultra-reliable, high-throughput, and low-latency. However, conventional terrestrial networks are constrained in their ability to provide sensing services over finite ranges, frequently hindered by impediments that deteriorate sensing efficiency. Nevertheless, these problems can be remedied by incorporating Unmanned Aerial Vehicles (UAV) into the communication network, since they not only increase coverage but also bring processing power closer to Internet of Things devices.

The drones act as the gateway; they visit locations with weak connectivity on a regular basis (e.g., once a day) and gather data while flying over the nodes. This technique seems to be applicable to applications in which collecting data in real-time is not the primary goal.

One of the most exciting LPWAN technologies is LoRa, a patented spread spectrum modulation technology that swaps data rate with distance. Because LoRa operates in unlicensed sub-GHz channels, Internet of Things operators can easily use it. However, a high number of collisions may occur due to the current LoRaWAN MAC layer's ALOHA style transmission policy and the nodes' requirement to convey a sizable amount of data—that is, the total data collected over the course of a day—in a brief period of time.

The key contribution of the paper is as follows.

1.Choosing the cluster head from the different UAVs that are available.

2. Several metrics, including speed, distance, density, and orientation (angle), were taken into account as important factors for the urban environment while choosing the next unmanned aerial vehicle.
3. An analysis was done on the mathematical model for determining the next UAV availability and selecting the optimum forwarding node among nearby UAVs.

4. A realistic environment is used for the suggested system's comparative performance evaluation.

The remaining section of the article is structured as follows: The earlier studies on UAV operation using the clustering concept are listed in Section 2 of the literature. Section 3 presents the suggested system. The simulation and result analysis of our suggested system are displayed in Section 4. The conclusion and suggested next paths are provided in Section 5.

**EXISTING SYSTEM:**

In [1] the author proposed a framework for long-range wide-area networks (LoRaWAN)-based data gathering that permits data acquisition in challenging settings with the assistance of UAVs and/or USVs. In this system, unmanned vehicles serve as a gateway or peer for end devices (EDs) and put end devices in difficult-to-reach regions while doing on-demand data collecting. A detailed process for gathering and analysing data, from parameter configuration to model validation, is also included in the framework. The author conducted extensive real-life measurements for data collecting and establish three situations in a Romanian mountainous location to demonstrate the transmission properties.

In [2] the author examines an orthogonal frequency division multiplexing (OFDM) network enabled by unmanned aerial vehicles (UAVs), in which the UAV serves as an aerial base station and uses OFDM to send discrete data to several users on the ground. They employed a K-means clustering-assisted power control approach to optimize the network's sum-rate while adhering to minimum rate and total transmit power limitations. In order to break down the multi-user power allocation problem, the suggested algorithm divides the Ns subcarriers into K clusters and then uses a power splitting factor to maximize the transmit power for the clustered subcarriers.

In [3] the author stated Complementary non-destructive methods for obtaining three-dimensional forest structural information are unmanned aerial vehicle (ULS) and terrestrial laser scanning (TLS). The full vertical structure of woods can be recreated by registering their point clouds. Since the current registration techniques are mainly intended to register various TLS scans, they are not directly applicable to ULS-TLS registration. The suggested approach in this work used hierarchical clustering to create multi-layer tree maps from ULS and TLS data, and then it retrieved features for each cluster point using Fast Point Feature Histograms (FPFH) based on the spatial correlations in the tree maps.

In [4] the turning radius restriction presents a special difficulty for the author's fixed-wing unmanned aerial vehicles (UAVs) while planning their routes. The goal of this research is to find the best trajectories for fixed-wing UAVs to fully investigate defined areas of interest, with a particular focus on coverage path planning. The approach known as Linear Programming—Fuzzy C-Means with Pigeon-Inspired Optimization (LP-FCMPIO) is suggested as a solution for this problem. A linear programming based model is constructed for fixed-wing UAV coverage path planning, first taking the turning radius constraint into account. Then, a refined fuzzy clustering approach is presented to efficiently divide several regions. Finally, an approximate optimal solution is searched using the pigeon-inspired optimization process. Simulation experiments show that a more balanced clustering effect is achieved by the LP-FCMPIO in comparison to the conventional FCM.

In order to reduce the weighted total of the transmission energy of nodes and the traveling energy of UAVs, the author suggested a general multi-UAV enabled data aggregation and collection method that makes use of both multi-hop and UAV routing [5]. Using data aggregation of IoT packets, an effective joint construction of node clusters, cluster heads, and UAV routing paths is proposed.

In [6] the author presents a brand-new reconfigurable intelligent surface (RIS) assisted multi-UAV system in which many UAVs use a coordinated multi-point method to service ground users organized into multicast groups. By simultaneously optimizing the trajectories, the cooperative beam forming of the clustered UAVs, and the passive beam forming of the RIS, the objective is to maximize the total of the minimum rates for all groups. A suggested hybrid learning scheme integrates an alternating optimization method based on majorization-minimization (MM) with a multi-agent deep reinforcement learning system called RES-QMIX. Initially, the RES-QMIX algorithm is suggested to maximize the paths of every unmanned aerial vehicle. Next, the joint beam forming is decoupled into two sub-problems using the alternating optimization, and each of these is then converted into a convex quadratic cone programming problem using the MM technique.

In [7] the author suggested that in order to gather all data effectively while taking WSN and UAV limitations into account, UAV-assisted data collecting systems must be carefully designed. An energy-efficient multi-UAV data gathering platform for WSNs is presented in this paper. We structure the data collection system as a combined optimization issue of system cost and energy consumption, where the constraints are memory size, UAV mission time, and communication power. Two steps are involved in solving the problem: Initially, a triangulation-based K-means clustering that minimizes the number of aggregators employed and the system cost is used to estimate the position and number of aggregators required.

In [8] the author suggested an energy-constrained unmanned aerial vehicle (UAV) data gathering system for wireless sensor networks focused on the age of information (AoI). In contrast to conventional methods that concentrate on a single UAV, we support the activation of several potential UAVs in order to enhance AoI performances. However, coordinating several UAVs makes each UAV's data collecting strategy more complex, making the minimizing of AoI a difficult task. We suggest a heuristic two-step solution based on greedy search for multiple UAVs to solve the unsolvable stated optimization issue. In particular, we deal with the synchronization of several UAVs using an innovative methodology based on graph theory and kernel K-means techniques.

In [9] the authors study a sensor network system assisted by unmanned aerial vehicles (UAVs), in which data is transmitted from the far-end UAV to the near-end UAV and subsequently to the base station (BS). We study the age of information (AoI) for such a system as a data freshness parameter and suggest an adaptive UAV-aided sensor network cooperative data acquisition technique (AUCDA). To split task areas for UAVs, we first introduce a Gaussian mixture clustering approach based on an ambiguous threshold. Expanding on this, we present a diffusion-based relay pairing technique for forming relay connections between UAVs. In conclusion, we suggest utilizing a multi-layer adaptive large neighborhood search algorithm to produce paths for data relaying amongst UAVs as well as paths for UAVs to return to the base station (BS) in order to be charged.

**PROPOSED SYSTEM:**

Since UAVs don't need human assistance, humans are not at risk in the event of an enemy attack. But in order to supervise, manage, and keep an eye on the numerous operations, many UAVs increasingly require human participation. UAVs cannot carry out a target mission as intended when human operators' decisions are involved. Consequently, it is necessary for UAVs to be able to independently determine the safe route. UAVs need to use path planning techniques in order to make decisions on their own. Here LAR (Location aided algorithm) were used, since this algorithm can cover large geographical area. And this LAR work based on the Location finding and fixing the source and destination for communication. If both are in communicable radius the direction communication was established. But both source, destination point are not in radius then as an alternate method like choose the neighbor UAV for further message passing will be utilized. Here the prosed system work in two phases like, from the group of UAVs form the cluster head. This system is used, if in case the UAV and collection point are different zone.

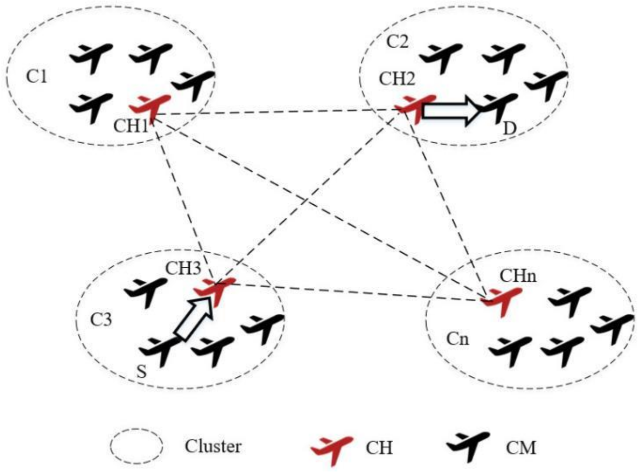



Fig 2 Cluster formation in proposed system

The above figure 2 represent the cluster formation among the group of available UAVs. The dotted circle represent clustered group and named as c1, c2, c3,..cn. And CH represent Cluster Head, CM represent Cluster Manager. Once the cluster was formed then among the group of UAVs once will be choose as Cluster Head (CH). Here once the source, destination were finalized based in the location. The radius parameter will be checked. If it was not in communicable radius, then present source UAV will access neighbor Cluster Head, which exits in some other cluster group will be chosen for further communication. This will be followed until the source was able to communicate the destination.

Figure 3 represent the flow chart for the proposed system. First step started with UAV authentication with available UAV with in the radius. If it is valid then source and destination will be finalized with the UAVs available in different clustered UAV. Manipulate the data which was collected from the Data collection point. Next step will be analyses the received data and convert into the specified format.

If the source and destination are in communication point, then the analyses data will be transmitted to the destination by source UAV. If the source UAV find out that the destination is available in other clustered group. Then the source UAV in different cluster group will check for the new Path by checking with other possible cluster available for communication.

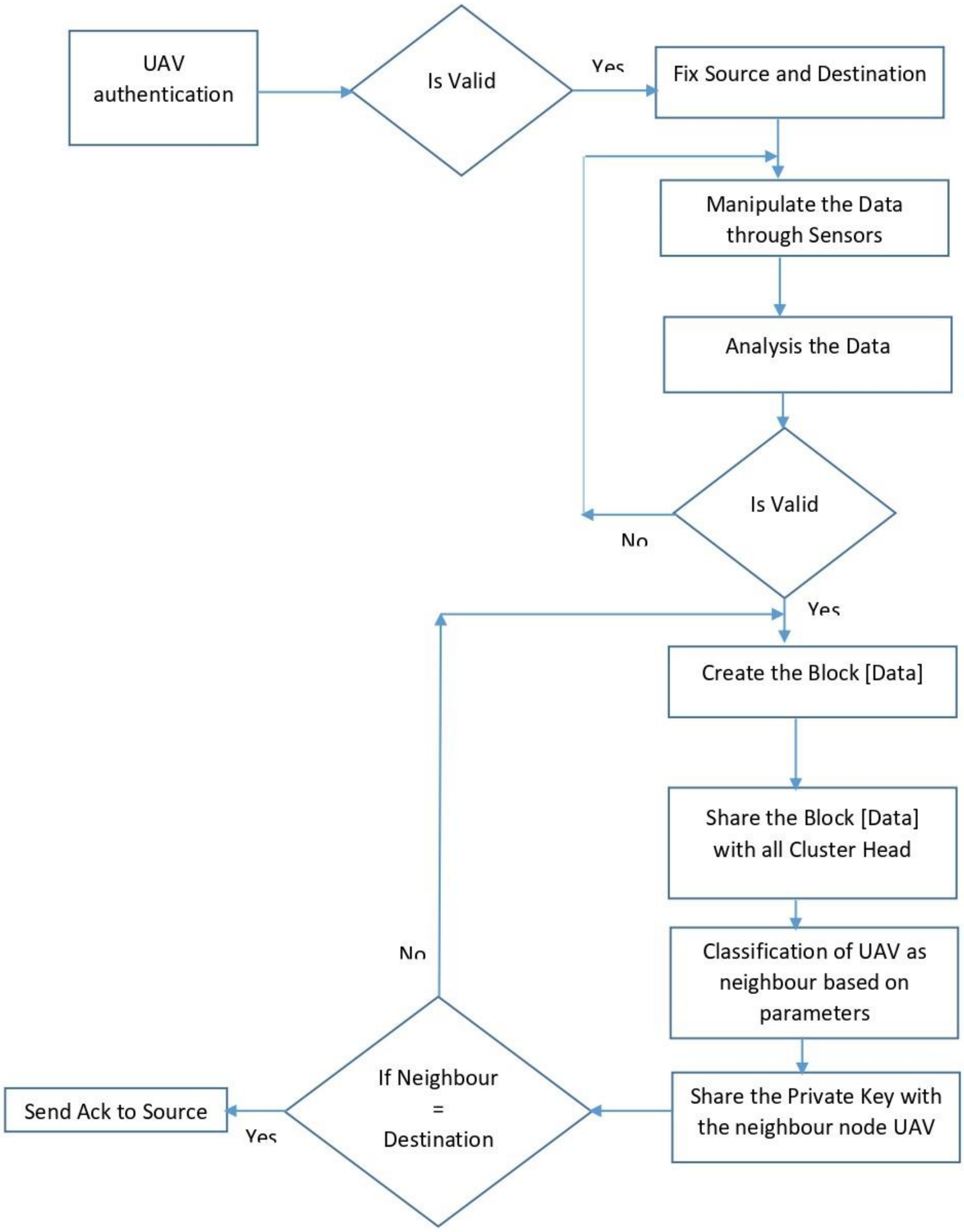



Fig 3 Flow chart for proposed system.

$$P_{CA}(K = t) = \frac{e^{-\lambda\pi r^2}\left(\lambda\pi r^2\right)^t}{t!} \quad \text{-------------------->}\ (1)$$

"r" represents a CH's transmission range in the equation above. In order to continue transmitting, CH1 must locate a CH2 whenever CH is unable to locate a data collection point inside the data collecting range. Assume for the moment that "K" is the total number of Clusters that are accessible within CH1's communication range. The probability of having't' cars that are CH2 with the transmission range given by equation (1) may then be found. Eq. (1) was obtained from the Poisson distribution. In order to determine the CH2, here, "r" stands for the CH1 transmission range.

Equation defines the likelihood that there is at least one cluster in the communication area. (2)

$$P(Z=0)+P(Z=1)+P(Z=2)+\cdots+P(Z=n)=1$$ ------------------------>(2)

Equation (3) defines the chance of selecting at least 'k' clusters within the commutation area.

$$P_k = 1 - \sum_{m=0}^{k-1} \frac{e^{-\left(\lambda \frac{r^2(\pi-2)}{4}\right)} \left(\lambda \frac{r^2(\pi-2)}{4}\right)^m}{m!}$$ ------------------------------> (3)

**Result and discussion:**

The posed system were executed as simulation with NS3. And the following result were obtained and the result were compared as Packet-loss-rate, Delay-comparison with increase in cluster head. Figure 4 represent whenever CH increased, how much of packet loss happens has been compared. In figure 5 represent the delay rate when number of cluster head increases.

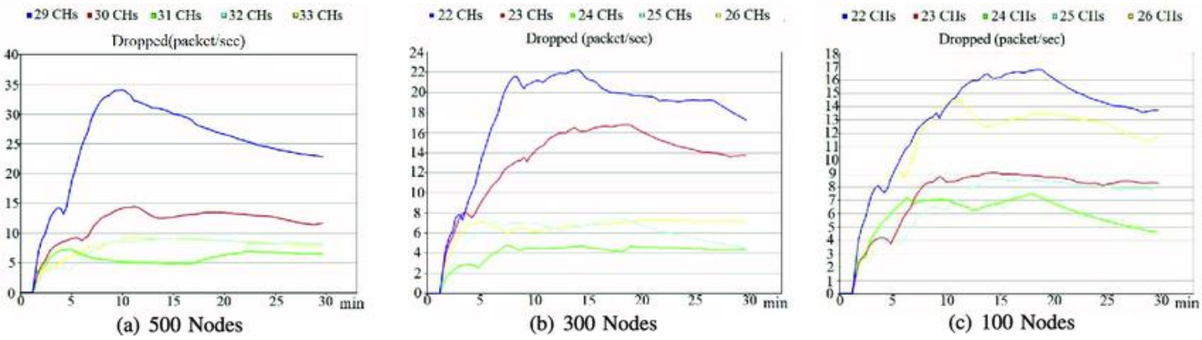



Fig 4 Packet-loss-rate-comparison-with-different-number-of-CHs

If Figure 4 (c) it is clear that for 100 CH the drop rate seems less and a nominal rate of data were obtained. When the number of CH was increased to 300 and 500 is gradual data drop increases was seen through the above graph(referrer figure 4(a) and 4(b).

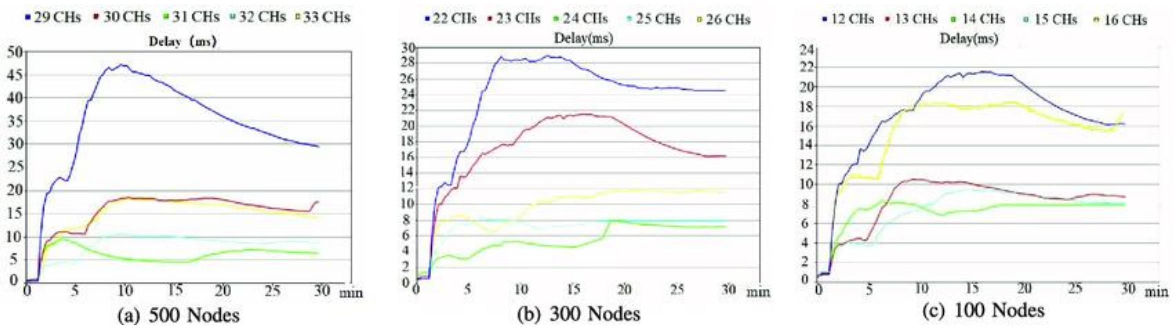



Fig 5 Delay-comparison-with-different-number-of-CHs

If Figure 4 (c) it is clear that for 100 CH the delay shows nominal rate in milliseconds were seen. When the number of CH was increased to 300 and 500 the graph show that delay increases was seen through the above graph (referrer figure 4(a) and 4(b).

**CONCLUSION**:

The main challenges in the UAV are concerned with designing a right routing protocols for dynamic topologies along with mobility of vehicle. In this paper, a novel Cluster based Path Optimization in UAV were applied with the communication schema of LoRaWAN. The proposed system applies path optimization by having clustering among group of UAV that are in the communicable range. After cluster are formed then choosing cluster head is difficult task, due to distance, speed, communication range, etc. In this proposed system LoRAWAN were used for low range rate transmission that must reach maximum area.

To implement the proposed system LAR (Location Aided Routing) algorithm was used to cover long range of area. Once Cluster head are formed, if in case the cluster head is unable to communicate with the data collection point, then the cluster head checks for the nearby or the next cluster group. Once the cluster group is chosen the one group cluster head will interact with the other cluster head. This process continues until the destination (data collection point reached). From the result generated like 'Delay-comparison-with-different-number-of-CHs' and 'Packet-loss-rate-comparison-with-different-number-of-CHs'. The future work will be checking the data consistency in transmission even though the node increases.

**Reference:**


1. Drăgulinescu, A. M., Zamfirescu, C., Halunga, S., Marcu, I., Li, F. Y., & Dobre, O. A. (2024). Understanding LoRaWAN Transmissions in Harsh Environments: A Measurement-based Campaign through Unmanned Aerial/Surface Vehicles. *IEEE Transactions on Instrumentation and Measurement*.
2. Park, J. C., Kang, K. M., & Choi, J. (2024). K-Means Clustering-Aided Power Control for UAV-Enabled OFDM Networks. *IEEE Access*.
3. Chen, J., Zhao, D., Zheng, Z., Xu, C., Pang, Y., & Zeng, Y. (2024). A clustering-based automatic registration of UAV and terrestrial LiDAR forest point clouds. *Computers and Electronics in Agriculture*, *217*, 108648.
4. Jiang, Y., Bai, T., Wang, D., & Wang, Y. (2024). Coverage Path Planning of UAV Based on Linear Programming—Fuzzy C-Means with Pigeon-Inspired Optimization. *Drones*, *8*(2), 50.
5. Kang, M., & Jeon, S. W. (2024). Energy-efficient data aggregation and collection for multi-UAV-enabled IoT networks. *IEEE Wireless Communications Letters*.
6. Chen, J., Zhai, K., Wang, Z., Liu, Y., Jia, J., & Wang, X. (2024). CoMP and RIS-assisted Multicast Transmission in a Multi-UAV Communication System. *IEEE Transactions on Communications*.
7. Amer, A. A., Ahmed, R., Fahim, I. S., & Ismail, T. (2024). Energy Optimization and Trajectory Planning for Constrained Multi-UAV Data Collection in WSNs. *IEEE Access*.
8. Zhou, Z., Liu, J., & Mao, C. (2024). Age of Information Oriented Data Collection via Energy-Constrained UAVs in Wireless Sensor Networks. *IEEE Access*.
9. Fu, X., & Ren, M. (2024). Sustainable and Low-AoI Cooperative Data Acquisition in UAV-aided Sensor Networks. *IEEE Sensors Journal*.
10. https://www.mordorintelligence.com/industry-reports/uav-market