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DESIGN OF HANDOVER MANAGEMENT SCHEME FOR UNMANNED AERIAL VEHICLE (UAV) -ASSISTED NETWORK

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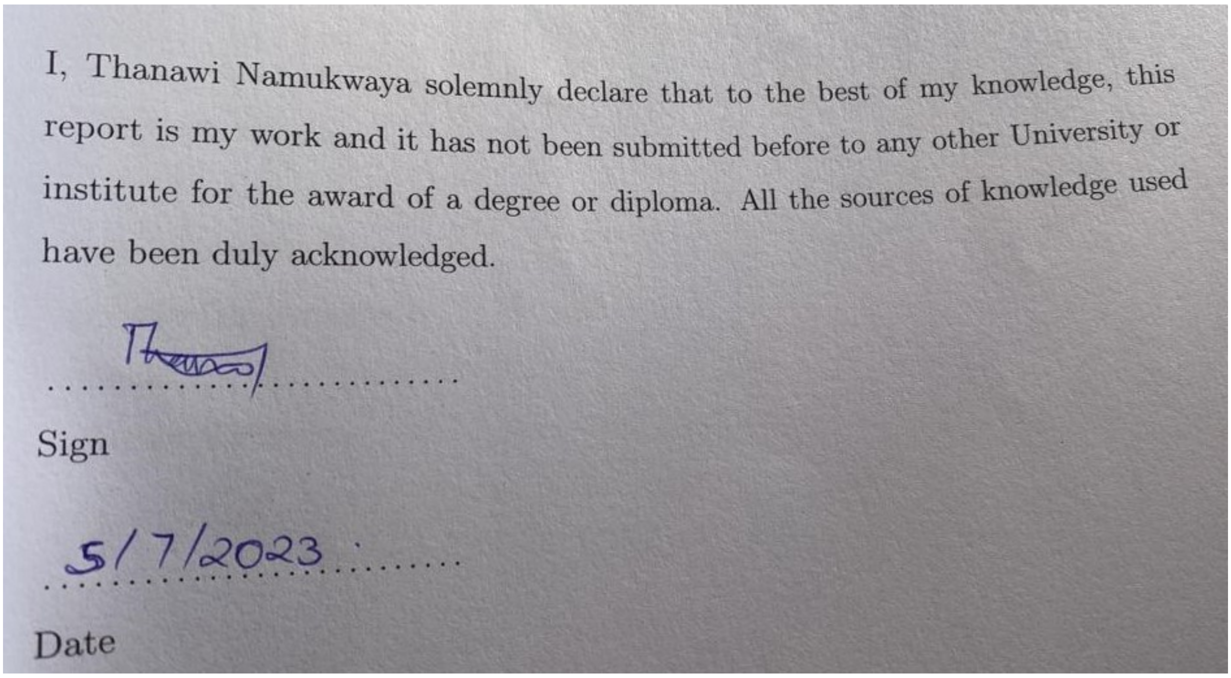
Declaration



I, Thanawi Namukwaya solemnly declare that to the best of my knowledge, this report is my work and it has not been submitted before to any other University or institute for the award of a degree or diploma. All the sources of knowledge used have been duly acknowledged.

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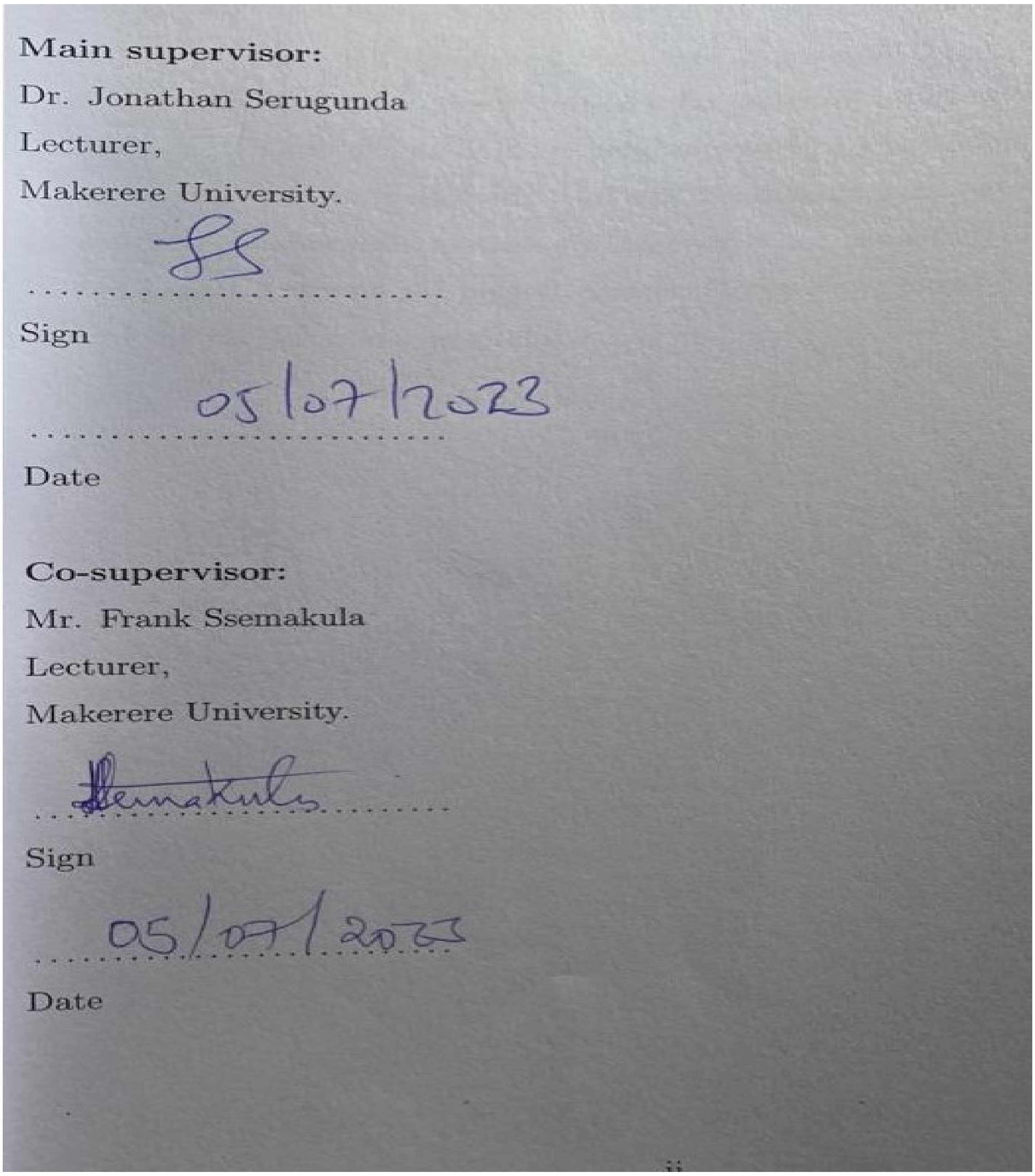
Date

Approval

This project report has been submitted for examination with the approval of the project supervisors.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Abstract

An unmanned Aerial vehicle is an autonomously flying aircraft controlled by an individual. UAVs are currently used as aerial base stations to support the macro and micro-ground base stations. These deployments are usually to provide coverage and capacity. However, there are many implications that come along with the deployment of the UAVs and the key issue is handover.

This project is aimed to design a handover management scheme that enables a seamless handover during the mobility of the users as they move from one cell to another in a communication network. This was achieved through modelling a three-tier network with macro, micro, and UAV base stations, developing an adaptive hysteresis margin algorithm that enables a smooth connection in a UAV-assisted network the comparing the developed algorithm with the already existing algorithm.

The results show that the performance of a network improved the algorithm by 13%. In this project, the handover performance of the networks with and without the algorithm has been studied. the results show that the optimal triggering of the handover depending on the hysteresis margin and signal-to-interference ratio improves the network performance and the performance evaluation was carried out using the number of handover success rate, spectral efficiency, and number of successful handovers.

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List of Acronyms

4G	Fourth Generation
BS	Base station
HFR	Handover Failure Rate
HM	Hysteresis Margin
HSR	Handover Success Rate
Los	Line of Sight
LTE	Long Term Evolution
PDCP	Packet Data Convergence Protocol
RLC	Radio Link Control
RSSs	Received Signal Strength of the serving Bs
RSSt	Received Signal Strength of the target
SDUs	Service Data Units
SINR	Signal to Interference Noise Ratio
SNR	Signal to Noise Ratio
SNs	Subscriber Numbers
TCP	Transmission Control Protocol
UAV	Unmanned Aerial Vehicle
UE	User Equipment

Chapter 1

Introduction

This chapter introduces the project background, problem statement, justification, project objectives, scope, and structure of the report.

1.1 Background

An unmanned Aerial Vehicle(UAV) is an autonomously flying aircraft controlled by an individual. UAVs are commonly known as drones and are a rapidly growing technology that is being used in a variety of industries, including military, agriculture, entertainment, and communication. Some of the potential benefits of UAVs include cost savings where UAVs can be much cheaper to operate than traditional aircraft, improved efficiency, increased safety, enhanced data collection, and flexibility [1]

UAVs can be used as user equipment and aerial base station. In our study, UAVs are operated as aerial base stations to support macro and micro base stations that are on the ground and these deployments are usually used to provide capacity or coverage. However, there are a lot of unknowns when you deployment of these UAVs and some of them are regulatory challenges, technical challenges, security, public perception, integration with the existing systems, and handover [2].

The key challenge is developing an effective handover mechanism that allows UAVs to seamlessly transfer communication links from one ground base station to another as they fly overhead. Handover is a critical component of UAV-assisted networks, as it ensures that communication remains uninterrupted as the UAV moves through the air space. Handover is a process of transferring an ongoing communication as the user moves from one network cell to another. Some factors that trigger handover are reduced signal strength and load balancing [2].

1.2 Problem Statement

A massive increase of mobile users within the network results in an increase in the number of necessary handovers which in some cases could fail and reliable communication is not achieved in the network. Therefore handover management is a primary component so as to achieve success and efficiency of the handover.

1.3 Justification

- To provide a flexible and efficient solution for communication networks in areas with limited network infrastructure or emergency situations where the network infrastructure has been damaged. There is a need for the continuity of the quality of service hence requiring an efficient handover.
- This project provides a handover management scheme for connected UAVs in the network to overcome the problems of dropped connections, slow data transfer rates, and other issues that can reduce the overall quality of service.

1.4 Project Objectives

1.4.1 Main Objective

- To design a handover management algorithm for the UAV-Assisted network that enables a seamless handover during the mobility of the users.

1.4.2 Specific Objectives

- To model a UAV-assisted network with macro and micro base stations and mobile users.
- To develop an algorithm that enables a smooth handover within the network without disruption of service.
- To compare the existing algorithm and the developed algorithm.

1.5 Project Scope

In this project, we considered adaptive HM which uses SINR measured by the user equipment in a UAV- assisted network.

Chapter 2

Literature Review

This chapter gives a theoretical review of the present state of the art based on handover.

2.1 Wireless Networks

Wireless technologies, one of the fastest ever-growing technologies, keep on developing facilities for mobile users. A number of competitive network providers as well as operators are involved in improving the available systems and enhancing user satisfaction. An individual network is incapable of proving expected services to the customers [3].

The term heterogeneous refers to the diversity of the network nodes and their functions designed to provide coverage, capacity, and quality of services in a particular area.HetNets are commonly used in cellular networks to increase network capacity and improve the quality of service for users.By using a combination of low-power and high-power network nodes, NetNets increase network capacity by moving traffic from macro cells to smaller ones while increasing user concentration such as urban areas and stadiums [4]. This explains the origin UAV -assisted net-net concept where drones are used to communicate with mobile base stations. the UAV is a low-power base station that acts as a repeater to improve the signal quality and retransmits the signal. As relay nodes, UAVs play an important role as they receive, demodulate, decode, and apply error correction to improve signal quality. UAVs within this kind of network are used as aerial base stations to improve wireless mobile network coverage, capacity, and energy efficiency, they are equipped with antennas to provide excellent communication to ground users [5].

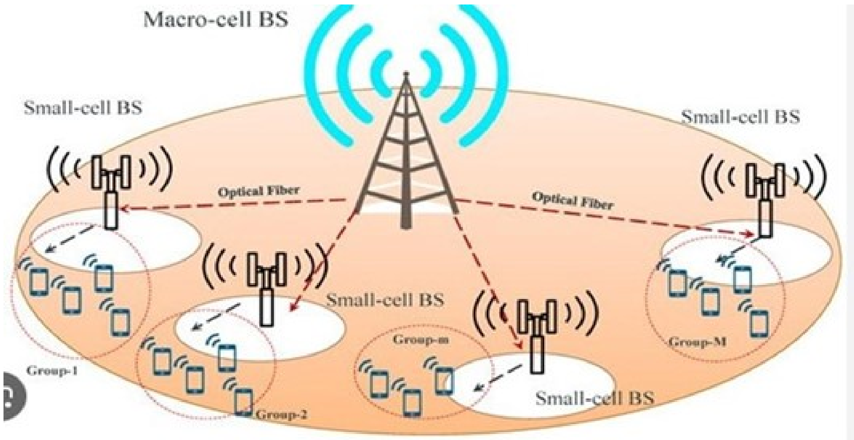

Figure 2.1: A simple network

2.2 Handover

Handover is a process of transferring an ongoing communication as the user moves from one network cell to another cell. This is a process in cellular communication whereby a mobile subscriber communicating with a BS is switched to another BS, which is providing a better link quality during a call. A call in progress could be forced to abort during handoff if sufficient resources cannot be allocated in the new wireless cell. When an MS is traveling from its serving base station to the target adjacent BS, the probability of handoff is generally designed to maximize the cell boundary. In general, handover includes two steps: handoff initiation and execution. In the initiation phase, the RSS is measured according to radio propagation-based methods, and a new candidate BS is chosen. In the execution phase, a new radio channel will be assigned, and a call will be handed over to another BS [3]. For handover to occur, the following condition should be fulfilled;

$$RSS > RSS + H(2.1)_t \tag{2.2.1}$$

where HM is a parameter that governs the HO algorithm between two BS.
The handover is initiated when the link quality of another cell is better than the current link quality. The difference in the link quality is called the hysteresis value. It is used to avoid failed handovers in the network. For the stated handoff condition, the hysteresis margin is fixed and it is quite difficult to choose.
When the hysteresis margin is too large, the failed handovers can be largely reduced,

and allow fewer number of handoff. However, it is likely to cause too large a handover delay and degrade the service quality. While the hysteresis margin is small, the delay in handover can be shortened, yet it will easily lead to failed handovers and increase the number of handovers. Therefore, a fixed hysteresis value is not adequate.

Handover is one of the key procedures for ensuring that the users move freely through the network while still being connected and being offered quality services. Since its success rate is a key indicator of user satisfaction, it is vital that this procedure happens as fast and as seamlessly as possible. Hence, optimizing the handover procedure to get the required performance is considered an important issue in wireless networks [4].

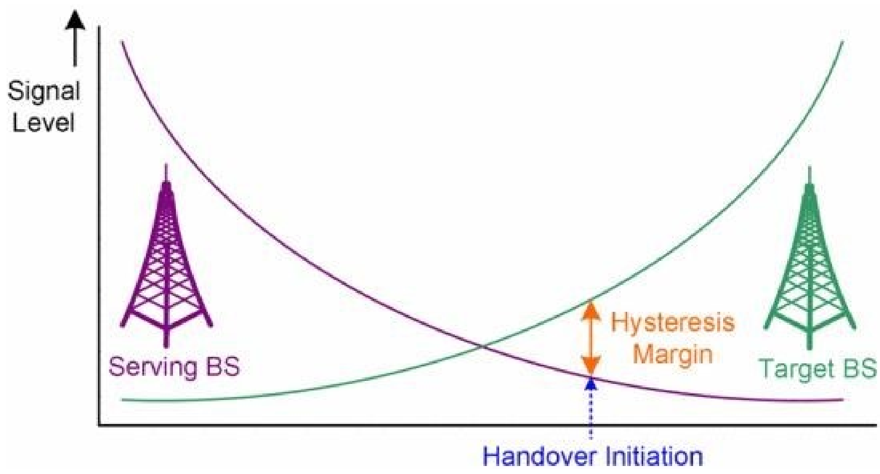

Figure 2.2: Handover Illustration

2.2.1 Handover characteristics

Depending on the required QoS, a seamless handover or a lossless handover is performed as appropriate for each radio bearer. The descriptions of each of them are presented below.

The objective of seamless handover is to provide a given QoS when the UE moves from the coverage of one cell to the coverage of another cell. In seamless handover is applied to all radio bearers carrying control plane data and for user plane radio bearers. These types of data are typically reasonably tolerant of losses but less tolerant of delay, (e.g. voice services). Therefore, seamless handover should minimize the complexity and delay although some SDUs might be lost. In the seamless handover, PDCP entities including the header compression contexts are reset, and the COUNT values are set to zero. As a new key is anyway generated at handover, there is no security reason to keep the COUNT values. On 24 the UE side, all the PDCP SDUs that have not been transmitted yet will be sent to the target cell after handover. PDCP SDUs for which the transmission has not been started can be forwarded via X2 interface towards the target eNB. Unacknowledged PDCP SDUs will be lost. This minimizes the handover complexity because no context (i.e. configuration information) has to be transferred between the source and the target eNodeB [6].

Lossless Handover Lossless handover means that no data should be lost during the handover. This is achieved by performing re-transmission of PDCP PDUs for which reception has not been acknowledged by the UE before the UE detaches from the source cell to make a handover. In lossless handover, in-sequence delivery during handover can be ensured by using PDCP Data PDUs sequence numbers. Lossless handover can be very suitable for delay-tolerant services like file downloads the loss of PDCP SDUs can enormously decrease the data rate because of TCP reaction. Lossless handover is applied for the user plane and for some control plane radio bearers that are mapped on RLC-AM. In lossless handover, on the UE side, the header compression protocol is reset because its context is not forwarded from the source eNB to the target eNB, but the PDCP SDUs' sequence numbers and the COUNT values are not reset [7]. To ensure lossless handover in the uplink, the PDCP PDUs stored in the PDCP re-transmission buffer are re-transmitted by the RLC protocol based on the PDCP SNs which are maintained during the handover and delivered to the gateway in the correct sequence. In order to ensure lossless handover in the downlink, the source eNodeB forwards the uncompressed PDCP SDUs for which reception has not yet been acknowledged by the UE to the target eNodeB for retransmission in the downlink.

2.3 Types of handover

The handover is triggered by the eNodeB, based on the received measurement reports from the UE. Handover is classified into different types based on the origination and destination of the handover. Handover can be classified depending on the following factors [8].

2.3.1 Access Technology

A horizontal handover is a traditional handover. Horizontal handovers are Layer-2 handovers. Here, only the BS is changed, and IP information is maintained. Here, MS uses hard handover (HHO, break-before-make handover) when moving to another BS. All connections are broken at all layers and no context information is shared between BSs. Latency is on the order of around 1000ms. Recent WiMAX standard also supports soft handover (SHO, make-before break) and Fast BS Switching (FBSS) [9].
Vertical Handover, there are also inter-technology handovers where a call's connection is transferred from one access technology to another, e.g., a call is transferred from Group Special Mobile (GSM) to Universal Mobile Telecommunications System (UMTS) or from CodeDivision Multiple Access (CDMA IS95) to cdma2000. This is also called inter-technology handover, and it is a handover that occurs between two networks of different technology, e.g., 3G to 4G. Vertical handover requires both layer 2 (Data Link layer) and layer 3 to complete the handover procedure successfully [10, 11].

2.3.2 Protocol layers involved

- Data link Layer-Based handover
- Network Layer-Based handover
- Cross Layer-Based handover

2.3.3 Type of technology that the network supports

Soft handover, Connect-Before-Break Soft handover

This is a category of handover procedures where the radio links are added and abandoned in such a manner that the UE always keeps at least one radio link to the UTRAN. Soft and softer handovers were introduced in WCDMA architecture. There is a centralized controller called Radio Network Controller (RNC) to perform handover control for each UE in the architecture of WCDMA. It is possible for a UE to simultaneously connect to two or more cells (or cell sectors) during a call. If the cells the UE connected are from the same physical site, it is referred to as a softer handover. In the handover aspect, soft handover is suitable for maintaining an active session, preventing voice calls from dropping and resetting a packet session. However, the soft handover requires much more complicated signaling, procedures, and system architecture such as in the WCDMA network [12].

Hard handover, Break-Before-Connect Hard handover

This is a category of handover procedures where all the old radio links in the UE are abandoned before the new radio links are established. The hard handover is commonly used when dealing with handovers in legacy wireless systems. The hard handover requires a user to break the existing connection with the current cell (source cell) and make a new connection to the target cell [8].In LTE only hard handover is supported, meaning that there is a short interruption in service when the handover is performed [13, 14].

2.3.4 Type of initiating and assisting entities

There are two different things here, i.e., who initiate the handover and who control the handover process?

- Mobile_Initiated_based_Handover MIHO)
- Network_Initiated_based_Handover (NIHO)
- Network_Controlled_based_Handover (NCHO)
- Mobile_Controlled_based_Handover (MCHO)
- Mobile_Assisted_based_Handover (MAHO)
- Network_Assisted_based_Handover (NAHO)

2.3.5 Handover performance metrics

HO performance metrics include specific performance indicators that have a significant impact on network performance.

- **HO rate**: This represents the number of HO per second.
- HOF rate: This can be calculated by the number of HO failures divided by the number of HOs.
- **Number of ping-pong**: Ping-pong event means that the second HO occurrence to serving BS after the first HO from the serving BS to target BS.
- **HO interruption time**: It represents the time duration in which the user cannot receive any packet from both serving and target BS during HO.
- **HO latency**: The time taken during the HO execution phase. Handover failure rate

Handover failure rates can vary depending on various factors such as network conditions, and device compatibility and can be affected by various factors such as network congestion, and signal interference. However, network operators work to keep handover failure rates as low as possible to ensure a smooth user experience and avoid dropped calls or interrupted data sessions. Handover failure rates are typically measured as a percentage of the total number of handovers attempted and can range from less than 1% to several percent depending on the network and the circumstances [14].

2.4 Handover Procedure

The handover procedure in LTE can be divided into three phases: handover preparation, handover execution, and handover completion. The procedure starts with the measurement reporting of a handover event by the User Equipment (UE) to the serving evolved Node B (eNB). The Evolved Packet Core (EPC) is not involved in the handover procedure for the control plane handling, i.e., preparation messages are directly exchanged between the eNBs. That is the case when the X2 interface is deployed, otherwise, MME will be used for HO signaling [7]

During the handover preparation, data flows between UE and the core network as usual. This phase includes messaging such as measurement control, which defines the UE measurement parameters, and then the measurement report is sent accordingly as the triggering criteria are satisfied. A handover decision is then made at the serving eNodeB, which requests a handover to the target cell and performs admission control. Handover request is then acknowledged by the target eNode [15].

2.4.1 1Handover execution

The handover execution phase is started when the source eNodeB sends a handover command to UE. During this phase, data is forwarded from the source to the target eNodeB, which buffers the packets. UE then needs to synchronize to the target cell and perform random access to the target cell to obtain UL allocation and timing advance as well as other necessary parameters. Finally, the UE sends a handover to confirm message to the target eNodeB after which the target eNodeB can start sending the forwarded data to the UE [8].

2.4.2 Handover completion

In the final phase, the target eNodeB informs the MME that the user plane path has changed. SGW is then notified to update the user plane path. At this point, the data starts flowing on the new path to the target eNodeB. Finally, all radio and control plane resources are released in the source eNodeB.

2.5 UAV

An unmanned aerial vehicle (UAV) is an aircraft that carries no human pilot or passengers. UAVs sometimes called drones can be fully or partially autonomous but are often controlled remotely by a human pilot. UAVs are descended from target drones and remotely by a human pilot. UAVs sometimes called drones can be fully or partially autonomous but are more often controlled remotely piloted vehicles (RPVs) employed by the military forces of many countries in the decade immediately after World War 2. UAVs are used in a wide range of civil and military applications, in which they mitigate the risk inherent in traditional manned aircraft surveillance and provide increased performance without the restrictions created by a human pilot .

Air Base stations have a role in both civil and military applications. Because of their inherent characteristics, namely, mobility, higher level of probability for line-of-sight (Los) signal, flexibility, and the easiness of changing the altitude level (adaptive altitude), UAVs constitute an inevitable element for the developments in search and rescue operations, vehicle_to vehicle communication, load balancing in a cellular network, and so on. Air Base stations are battery-powered; however, their performance varies based on the altitude at which UAVs are placed and on the type of UAV. Some of the civil applications of UAVs show in the figure. Unmanned Aerial Vehicle are highly appreciated for their applications in fifth-generation cellular networks (5G).

Over the past few decades, the number of mobile users has increased rapidly, not only the user count but also the user demands changed. As we moved from 1G to 5g, the very purpose of cellular communication networks took a turn from mere calling to a substitute for desktops, laptops, and other processing gadgets. Network operators had to deploy a large number of base stations (BSs) to serve user equipment (UE) with varying demands. To serve each user, a channel has to be allocated and if the user density goes beyond the available channels, the users would not be properly served resulting in low-quality channels, the users would not be properly served resulting in low quality of services (Qos).

Consequently, to improve the service, the operators are forced to install more BSs. For the deployment of terrestrial BSs, the land needs to be acquired so it is a costly affair.UAV BSs are generally termed as aerial base stations (ABs or AirBSs), which are cost-efficient compared to the expense of maintaining a terrestrial base station. Between drones the medium is air, hence, there exist air links for communication among the AirBs .

Between drones the medium is air; hence there exist air links for communication among the AirBS. Communication between the AirBSs can take data from the terrestrial BSs. Upon the data reception from the already deployed terrestrial BS, these drones can pass on the data to the intended users, who were in an outage initially.

As a result, the geographical region without signal coverage gets good signal coverage. In such cases, the users are served by AirBs, although they are out of the coverage radius of the primary terrestrial BS. Deployment of aerial drones not only provides good QoS but also a cost-efficient strategy. QoS but also a cost-efficient strategy.UAVs are broadly classified based on altitude and type. Based on the altitude at which the AirBSs are deployed, they are classified as high-altitude platforms(HAPs) and low-altitude platforms (LAPs). HAPs can provide service to a large geographical area, thereby this results in wider coverage and longer endurance [16].

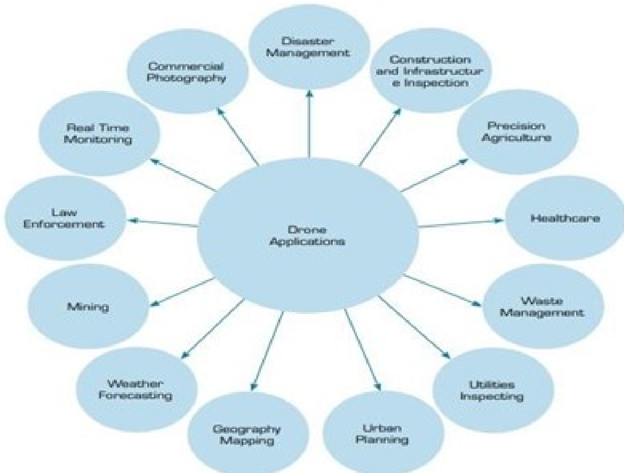

Figure 2.3: Civil application

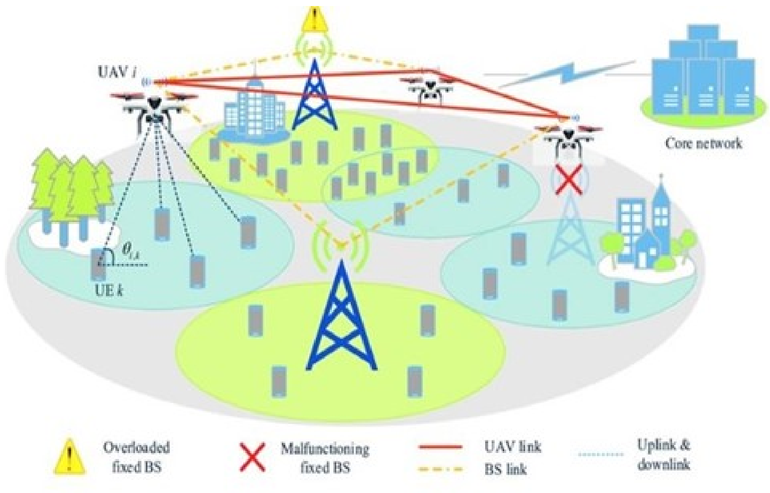

Figure 2.4: UAV- assisted network

2.6 Related Work

Several research works were conducted on handover/mobility management in mobile networks. Several studies concentrating on UAV networks were undertaken to address various issues such as mobility management connectivity, IOT applications, and multi-user access control.

The related work is divided into sections the first section discusses the different solutions for mobility/handover management based on various concepts and techniques and the second section presents the proposed solution for handover/ mobility management based on deep learning technology, machine learning, and different various communication issues based on different proposed solution.

2.6.1 Classical-based techniques for handover management

In 2017, the authors proposed an intelligent handoff algorithm for UAV network. The heart of the algorithm is a fussy inference mechanism whose functionality is based on the comparison of several input parameters. Initially, information collection is established in either the devices or BSs. the device determines whether they prefer to remain connected to a specific BS or switch to another. The parameters that the handover decision relies on are classified into two classes. The first Class consists of the network specification such as RSS, communication coverage, and radius. The second application consists of the device specifications such as altitude and UE speed. The reception signal and coverage have an inverse relationship since the coverage increases and RSS decreases.

Alternatively, the handover rate increases when the drone's motion is rapid. An optimized algorithm was built to correlate handover with the drone speed. The reception signal decreases with the distance between the BS and the drone. After information acquisition, the fuzzification process can then be established. This includes the normalization input parameters and a linguistic variable (i.e., high, average, or low are appointed for the coverage, and high or low are selected for the speed). A predefined table consisting of fussy inference rules is the core of handover decision-making algorithms. A defuzzification mechanism for the parameters was then employed.

The MATLAB fuzzy logic toolbox was used during simulations in a system consisting of three BSs and a single UAV. For the drone's motion, two different models were established: random and straight movements. A hundred simulations were conducted for several drone paths and directions [17]

2.6.2 Machine learning-based techniques

Due to the high mobility of drones, it is difficult to accomplish global information exchange due to unnecessary overheads since the network becomes significantly convoluted. With advancements in machine learning disciplines, the number of applications in various fields has also increased.

Several previous studies were conducted on the application of ML in drones network In 2022, the researchers addressed the optimal location of multiple DBSs in a MIMO wireless network setting. They developed a low-learning machine-based algorithm for optimizing DBS location by minimizing the total wireless RSS occurring by active terminals. When compared to the Euclidean cost benchmark, the proposed algorithm decreases the propagation loss in the system and achieves a lower bit error rate. Nonetheless, energy-related issues have not been fully covered [18].

2.6.3 Deep learning-based techniques

Deep learning is currently becoming g a key solution technology for addressing connection and mobility challenges for connected UAVS. Most current research focuses on deep learning and machine learning-based techniques.

In 2021, research on deep reinforcement learning for user access control in UAV networks was conducted. The authors proposed deep reinforcement learning as a framework solution to address the access control challenges for ground users with the consideration of mobility of UAV-BS. They aimed to enable the user to be able to intelligently perform access decisions, maximize the user's data rate and reduce the handover rate much as possible. Based on the presented simulation results, authors reported that results illustrated the effectiveness of the proposed solution and exposed its gain as compared to the other selected benchmark solutions from the literature [19].

Researchers provided a novel DQL model for optimal deployment of the UAV-BS.

Furthermore, the proposed method presents the optimal UAV-BS trajectory while ground users move without relearning the method or acquiring ground user path information. In particular, the mode optimizes the trajectory of UAV-BS by achieving a maximum Mean Opinion Score (MOS) for ground users who move along various paths [20].

2.6.4 More related studies

In 2019, the researchers conducted a survey study focused on On Demand architecture for an Ultra–Dense Cloud Drone Network (UDCDN)architecture. This architecture can meet the needs of the next generation by addressing interferences issues, energy consumption limitations, front and backhauling challenges, etc. system Optimization for issues such as interference, efficiency, and HO performance can be accomplished by integrating UDCDN with terrestrial networks operating in the sub -6 GHz and mm–wave bands, which are not covered in this study [21].

Chapter 3

Methodology

This chapter describes the system model, tools, simulation procedures, simulation parameters, and the proposed algorithm used to achieve the set objectives.

3.1 Tools

The simulation for the project is done using MATLAB R2018b software which is able to illustrate handover performance using a set of parameters and also to implement the algorithm of adaptive hysteresis margin in order to achieve precise results and performance analysis.

3.2 System Model

A two-dimensional scenario where a mobile phone user is moving is needed.

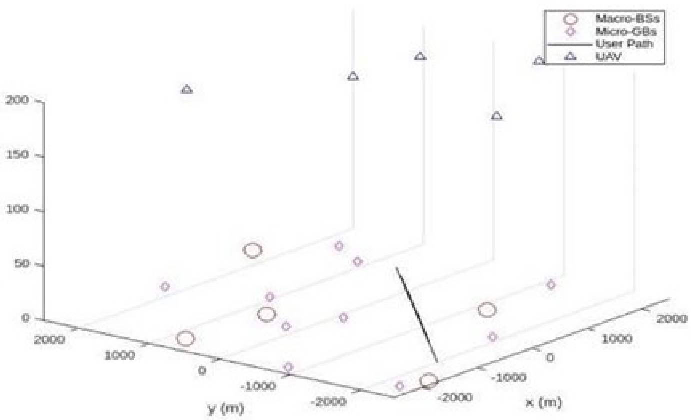

Figure 3.1: System model

The system model provides an analysis of the performance of a two-dimensional network based on the path taken by the user. The network consists of five macro ground base stations,10 micro ground base stations, and five UAVs connected to provide wireless communication services to users. The straight line describes the path taken by the user through the network. A UAV-assisted network with macro and micro base stations and mobile users. The handover is initiated if the signal parameter of the target base station exceeds the signal parameter of the serving base station at least by HM level.

$$RSSt > RSSs + HM \tag{3.2.1}$$

In the conventional HM, the level of hysteresis is constant. The developed scheme is based on the variation in the level of HM.

3.3 Adaptive hysteresis margin implementation

In the conventional HM, the level of the hysteresis is constant. The adaptive HM is based on the modification of the actual HM value according to the position of the user in the cell. The HM is decreasing with UE's moving closer to the cell border. It is presented in the following equation;

$$HM = max\{HMmax * (1 - \frac{d}{R})^4\} \tag{3.3.1}$$

where HMmax is the maximum value of HM that can be set up (in the middle of the cell); d is the distance between the serving BS and UE; R is the radius of the serving BS's cell. As mentioned in the previous section, the parameters d and R cannot be easily obtained or determined either by the network or by the UE. Therefore, this project proposes to replace these parameters with another metric that can be utilized more easily and effectively.

Most path loss models describe the relationship between the distance d of a UE from a BS and a path loss (PL) in the following way:

$$PL(d) = X(f) + Nlog10 \tag{3.3.2}$$

where X(f) represents the dependence of the PL model on the frequency and other terms usually used in models and N is a coefficient related to the type of environment. Function X(f) and N are dependent on the individual path loss model.

The level of the received signal at a specific distance (RSSI (d)) depends on path loss and transmission power of the station of interest (TPst) as defined in the next formula:

$$RSSI(d) = TPst - PL(d) \tag{3.3.3}$$

Furthermore, the distance d can be expressed as an exponential function based on (3.3.2) and (3.3.3) as follows:

$$RSSI = TPst - (X(f) + Nlog10(d)) \tag{3.3.4}$$

Considering (3.3.4), the formula (3.3.1) can be modified in the following manner:

$$HM = max\{HMmax * (1 - 10^{\frac{1}{N}(RSSI - RSSI_{min})})^{EXP}; HM_{min}\} \tag{3.3.5}$$

where EXP represents the exponent (in the former adaptive HM) defined and HMmin is the minimum HM .

Parameters EXP and HMmin can influence the performance of the HM adaptation. However, the investigation of the optimal set of both parameters is out of the project's scope.

In fact, the border of cells are neither regular circles nor hexagons since the system is not distance or signal level limited but it is interference limited. Therefore, the shape of the cells is strongly influenced also by the interference. Hence, this project further proposes to implement SINR instead of RSSI for the calculation of the actual level of HM.

SINR measures the signal quality: the strength of the wanted signal compared to the unwanted interference and noise. Optimizing SINR leads to more base station capacity, hence allowing higher order QAM modulation which is more especially efficient. This results in higher peak data rates, fewer dropped calls and ultimately improved customer satisfaction.

Generally, a signal level influenced by the interference and noise (IN) can be described according to the next equation:

$$SINR = TPst - PL - IN = RSSI - IN \tag{3.3.6}$$

The SINR level is in a different range of values than RSSI. Thereupon, it has to be related to the difference between maximum and minimum SINR in the observed area. Thus, the actual HM level according to SINR is derived as follows:

$$HM = max\{HMmax * (1 - 10^{\frac{SINR_{act} - SINR_{min}}{SINR_{min} - SINR_{max}}})^{EXP}; HM_{min}\} \qquad (3.3.7)$$

where SINRact is the actual SINR measured by a UE; SINRmin and SINRmax are minimum and maximum values in the investigated area respectively.

The actual SINR of UE can be easily measured during UE's operation. It is usually performed with the purpose of handover decision and initiation. However, also the minimum and maximum SINR values have to be known for the utilization of the adaptive HM. The SINRmin corresponds to the cell radius and to the SINR level, at which the UE is able to receive data. Therefore, it is set up as a fixed value for each base station. The SINRmax can be determined by monitoring and reporting of SINR by all UEs connected to the given base station and then selecting the highest SINR from all known values as the SINRmax [11].

3.4 Simulation parameter

Table 3.1: Parameters used in the simulation

Parameter	Value
Frequency	2GHz
Height of the UAVs (H)	200m
Number of Macro BS, Micro BS, UAV-BS	5
Number of Micro BS	10
Number of UAV-BS	5
Transmitter powers of Macro BS, Micro BS, UAV-BS	13dB, -8.86dB, 6.99dB
Default HM	3dB
Path loss exponent	2
Number of mobile users	100
Macro base station path loss	$128.1 + 37.6log10(d)km$
Micro base station path loss	$140.7 + 36.7log10(d)km$
UAV base station path loss	$(44.9–6.55 * log10(H) * log10(dis_UAV) + 26.46 + 5.83 * log10(H) + 20 * log10(f/2)$

Chapter 4

Results

This chapter presents the simulation result for performance comparison between the original scheme and proposed scheme.

4.1 Average number of successful handovers evaluations

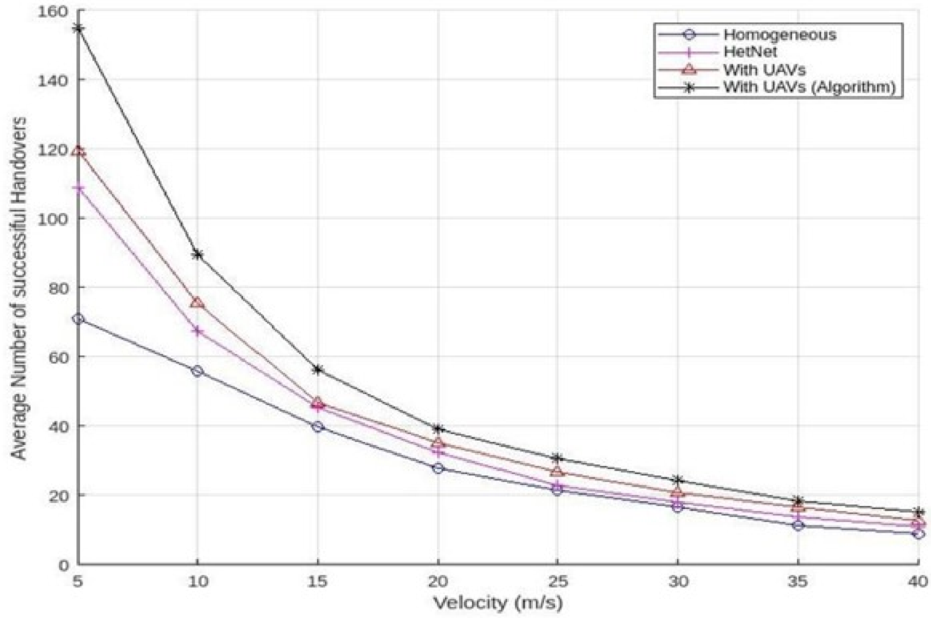

Figure 4.1: Average number of Success handover against velocity

The trend of the graph of the average number of successful handovers against velocity shows how the number of successful handovers changes as the velocity. There could be several reasons why the average number of successful handovers is decreasing and the velocity is increasing. One possibility is that as the velocity, there is less time available for the handover process to occur which can lead to errors or dropped calls. Additionally, higher velocity can make it more difficult for the network to have a constant connection which can also contribute decrease in successful handovers. When a mobile device is moving at a higher velocity, it is more likely to experience interference or signal degradation which can make it more difficult for the network a main a constant connection and this more led to more failed handovers as the network as may fail to transfer the call or data session from one call to another as the velocity increases, there is less time available for the handovers to occur.

As algorithm can improve the network by decreasing the number of successful handovers with increasing velocity by optimizing the handover process. The algorithm can adjust the timing of the handover process to occur more quickly, or it can prioritize certain types of traffic to ensure that they are transferred more reliably by doing the algorithm can help minimize the handover and improve the overall performance of the network.

4.2 Handover Success Rate performance evaluation

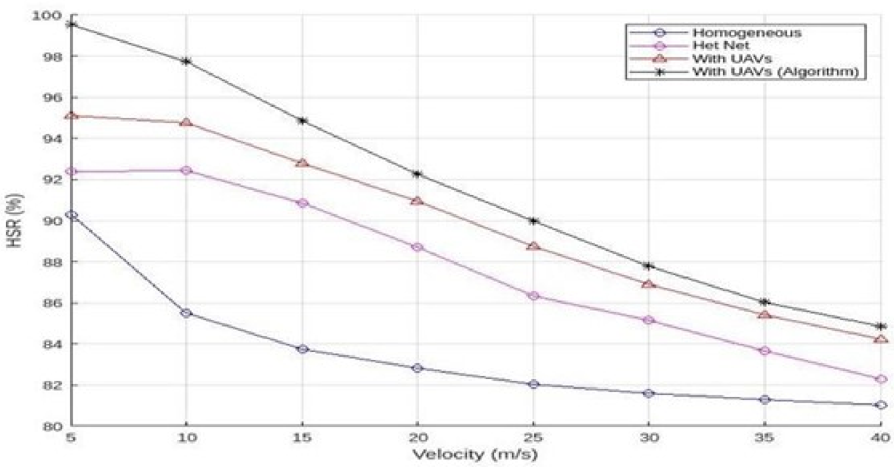

Figure 4.2: Handover success rate against velocity

The trend of all the graphs is the same, there is decreasing handover success rate and increasing velocity. Increasing velocity can lead to a decrease in handover success rate because higher speeds can make it harder for devices to maintain a stable connection to a network. This can result in more frequent handover which can increase the likelihood of error or dropped connections. Additionally, high-speed movement can cause interference or signal attenuation, which can further impact the quality of the connection. All of these factors can contribute to a decrease in the handover success rate when velocity increases.

The handover success rate is affected by a number of factors including the quality of the signal, the distance between cells, and the speed of the user or device. As the velocity of the user increases the time available for the network to perform a handover decrease in the handover success rate. This can result in reduced network performance and degraded user experience.

To address these challenges, an algorithm can be implemented to optimize the handover process and ensure that the user is always connected to the strongest and most reliable signal. The algorithm can use advanced signal processing techniques, adaptive handover management, and dynamic adjustment of the network parameters to optimize the handover process and minimize the success rate.

The effect of velocity on the handover success rate in a handover network can be significant, as the time available for the network to perform a handover decreases as the velocity of the user increases. An algorithm can be implemented to optimize the handover process and ensure that the user is always connected to the strongest and most reliable signal, even as it moves through different areas with different levels of interference or signal quality.

4.3 Spectral efficiency evaluation performance

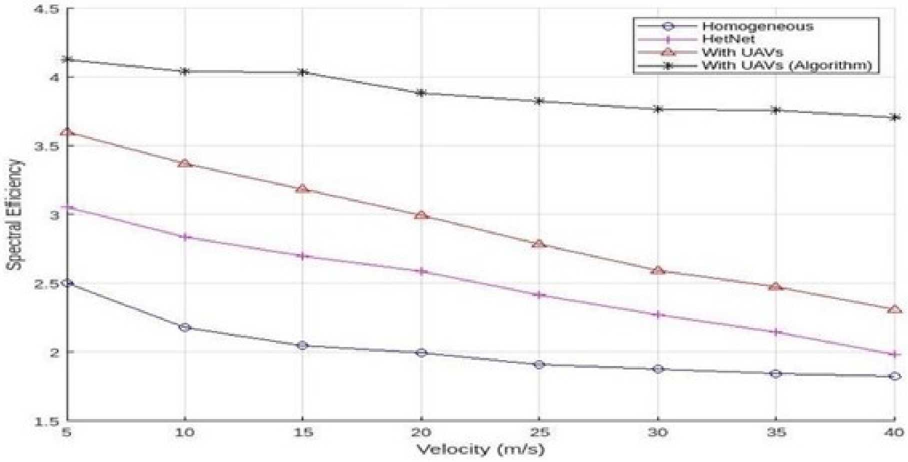

Figure 4.3: Spectral efficiency against velocity

The trend of all the graphs is the same. A graph of decreasing spectral efficiency against the increasing velocity of the user in a UAV - assisted network could indicate that the network is experiencing challenges in maintaining a stable connection as the user moves at higher speeds. This could be due to several factors, such as increased. Doppler shift, fading, and interference. As the user moves at higher speeds. This could be due to several factors such as increased Doppler shift increases, which can cause distortion and reduced signal quality. Fading can also be more severe at higher speeds, as the signal strength fluctuates more rapidly. Interference can also be more significant at higher speeds, as the user moves through different areas with different levels of interference.

All of these factors can contribute to a decrease in spectral efficiency as the velocity of the user increase resulting in a lower data rate and reduced network performance. To address these challenges, UAV- assisted networks may need to implement advanced signal processing techniques, adaptive handover management, and dynamic adjustment of the network parameters to maintain a stable connection and improves spectral efficiency

A graph of decreasing spectral efficiency and increasing velocity of a user can have better performance with an algorithm compared to without an algorithm. This is because the algorithm can monitor the quality of the signal and make adjustments to optimize network performance, even as the user moves at high speed.

Without an algorithm, the network may struggle to maintain a stable connection, resulting in a decrease in spectral efficiency and reduced network performance. The algorithm can help to address the challenges associated with high-velocity networks by implementing advanced signal processing techniques, adaptive handover management, and dynamic adjustment of the network parameters.

By optimizing the handover process and adjusting network parameters in real-time, the algorithm can ensure that the user is always connected to the strongest and most reliable signal even through different areas with different interference or signal quality. This can help to minimize network congestion. In summary, an algorithm can improve the network the performance of the network by optimizing the handover process and adjusting the network parameters in real time to ensure that the user is always connected to the most reliable signal

4.4 Hysteresis Margin evaluation performance

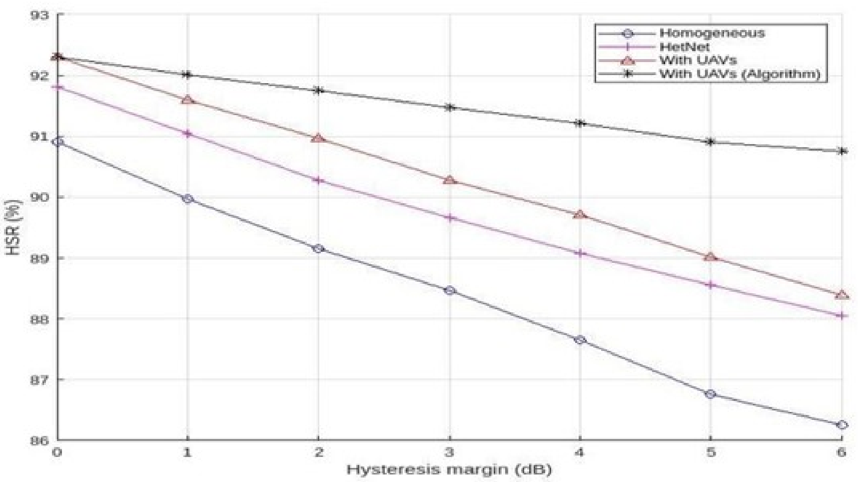

Figure 4.4: Handover success rate against Hysteresis margin

The hysteresis margin is a parameter used in handover algorithms to control the handover decision process. It determines the level of signal strength difference required for a handover to be triggered. The hysteresis margin sets a threshold that must be crossed before a handover is initiated, and it helps prevent unnecessary and frequent handovers between neighboring cells. The hysteresis margin can have an impact on the handover success rate in the following ways: Handover Trigger:

A larger hysteresis margin means that the signal strength of the target cell must be significantly stronger than the serving cell before a handover is initiated. This can help avoid unnecessary handovers caused by momentary fluctuations in signal strength. However, if the hysteresis margin is set too high, it may delay the handover decision, leading to potential service disruption and dropped calls. On the other hand, a smaller hysteresis margin can trigger handovers more frequently, even in cases where the signal strength difference is minimal. Handover Stability: A wider hysteresis margin provides a more stable handover decision, reducing the likelihood of ping-pong effects, where the device continuously switches back and forth between neighboring cells. This stability can enhance the overall quality of the mobile connection and reduce the chances of call drops or interruptions. However, setting the hysteresis margin too wide may also delay the handover process when it is necessary, resulting in degraded service quality. By adopting the hysteresis margin dynamically, the system can adjust the handover criteria based on the current network conditions, which can potentially improve the handover success rate. It is influenced by various factors, including signal strength, interference, network load, and the handover algorithm itself. Adaptive hysteresis margin can impact the handover success rate in the following ways:

- Reduced unnecessary handovers: By adapting the hysteresis margin based on the current network conditions, the system can avoid unnecessary handovers triggered by temporary fluctuations in signal strength or quality. This helps prevent unnecessary disruptions and improves the overall success rate. For example, considering a highly loaded system, the hysteresis margin is increased therefore the network becomes less sensitive to the interference levels.

- Optimized handover decisions: The adaptive hysteresis margin can be tuned based on factors such as network load and signal quality trends. By considering these factors, the system can make more informed handover decisions. For instance, if a particular base station consistently provides better quality than the current serving base station, the hysteresis margin can be adjusted to facilitate faster handovers to that base station, leading to improved success rates.

Chapter 5

Conclusion and Recommendations

This chapter discusses the conclusion and recommendations for further research.

5.1 Conclusion

In this work, we implemented adaptive HM which uses SINR measured by the user equipment in a UAV-assisted network. Our key findings indicate that adjustments in the hysteresis margin depending on the current conditions result in an improved network performance and the performance evaluation has been carried out using number of successful handovers, spectral efficiency, and handover success rate.

5.2 Recommendations

In future work, the variation in hysteresis margin can be analysed in a heterogeneous network where the hysteresis margin is increased for ground base stations that are congested and it is reduced if the base station is not congested.

References

[1] X. Li and A. V. Savkin, "Networked unmanned aerial vehicles for surveillance and monitoring: A survey", *Future Internet*, vol. 13, no. 7, p. 174, Jul. 2021, ISSN: 1999-5903. DOI: 10.3390/fi13070174. [Online]. Available: http://dx.doi.org/10.3390/fi13070174.

[2] R. Bajracharya, R. Shrestha, S. Kim, and H. Jung, "6g nr-u based wireless infrastructure uav: Standardization, opportunities, challenges and future scopes", *IEEE Access*, vol. 10, pp. 30 536–30 555, 2022. DOI: 10.1109/ACCESS.2022.3159698.

[3] M. J. Marcus, "Spectrum policy challenges of uav/drones [spectrum policy and regulatory issues]", *IEEE Wireless Communications*, vol. 21, no. 5, pp. 8–9, 2014. DOI: 10.1109/MWC.2014.6940426.

[4] N. Elmeseiry, N. Alshaer, and T. Ismail, "A detailed survey and future directions of unmanned aerial vehicles (uavs) with potential applications", *Aerospace*, vol. 8, no. 12, p. 363, Nov. 2021, ISSN: 2226-4310. DOI: 10.3390/aerospace8120363. [Online]. Available: http://dx.doi.org/10.3390/aerospace8120363.

[5] M. A. Luna, M. S. Ale Isaac, A. R. Ragab, P. Campoy, P. Flores Peña, and M. Molina, "Fast multi-uav path planning for optimal area coverage in aerial sensing applications", *Sensors*, vol. 22, no. 6, p. 2297, Mar. 2022, ISSN: 1424-8220. DOI: 10.3390/s22062297. [Online]. Available: http://dx.doi.org/10.3390/s22062297.

[6] X. JIANG, M. SHENG, N. ZHAO, C. XING, W. LU, and X. WANG, "Green uav communications for 6g: A survey", *Chinese Journal of Aeronautics*, vol. 35, pp. 19–34, 2022, ISSN: 1000-9361. DOI: https://doi.org/10.1016/j.

cja.2021.04.025. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1000936121001801.

[7] M. Asadpour, B. Van den Bergh, D. Giustiniano, K. A. Hummel, S. Pollin, and B. Plattner, "Micro aerial vehicle networks: An experimental analysis of challenges and opportunities", *IEEE Communications Magazine*, vol. 52, no. 7, pp. 141–149, 2014. DOI: 10.1109/MCOM.2014.6852096.

[8] "Unmanned aerial vehicles". [Accessed 29 June, 2023]. (), [Online]. Available: http://www.rand.org..

[9] "Application ,techniques, and challenges as aerial base station". [Accessed 29 June, 2023]. (), [Online]. Available: https://journals.sageup.com.

[10] "Unmanned aerial vehicle (uav)". [Accessed 29 June, 2023]. (), [Online]. Available: htpp://www.globalspec.com.

[11] R. P. Ray and L. Tang, "Hysteresis margin and load balancing for handover in heterogeneous network", *International Journal of Future Computer and Communication*, vol. 4, no. 4, 2015. DOI: 10.7763/IJFCC.2015.V4.391.

[12] Z. Becvar and P. Mach, "Adaptive hysteresis margin for handover in femtocell networks", in *2010 6th International Conference on Wireless and Mobile Communications*, 2010, pp. 256–261. DOI: 10.1109/ICWMC.2010.17.

[13] M. Emran, V. Thayananthan, M. Umair, I. Kotuliak, M. S. Qureshi, M. B. Qureshi, *et al.*, "The handover and performance analysis of lte network with traditional and sdn approaches", *Wireless Communications and Mobile Computing*, vol. 2022, 2022.

[14] K. F. Hayajneh, K. Bani-Hani, H. Shakhatreh, M. Anan, and A. Sawalmeh, "3d deployment of unmanned aerial vehicle-base station assisting ground-base station", *Wireless Communications and Mobile Computing*, vol. 2021, pp. 1–11, 2021.

[15] J. Chavarria. "Lte handover performance evaluation". [Accessed 29 June, 2023]. (), [Online]. Available: http://epgp.inflibnet%20.ac.in.

[16] A. O. Jeremiah O. Abolade1 Olasebikan A. Fakolujo2, “Handover in mobile wireless communication network - a review”, *International Journal of Advanced Engineering, Management and Science*, vol. 3, pp. 934–940, 2017. DOI: https://dx.doi.org/10.24001/ijaems.3.9.6.

[17] E. Lee, C. Choi, and P. Kim, “Intelligent handover scheme for drone using fuzzy inference systems”, *IEEE Access*, vol. 5, pp. 13 712–13 719, 2017. DOI: 10.1109/ACCESS.2017.2724067.

[18] M. E. Morocho-Cayamcela, W. Lim, and M. Maier, “An optimal location strategy for multiple drone base stations in massive mimo”, *ICT Express*, vol. 8, no. 2, pp. 230–234, 2022.

[19] Y. Cao, S.-Y. Lien, and Y.-C. Liang, “Deep reinforcement learning for multi-user access control in non-terrestrial networks”, *IEEE Transactions on Communications*, vol. 69, no. 3, pp. 1605–1619, 2021. DOI: 10.1109/TCOMM.2020.3041347.

[20] N. Parvaresh and B. Kantarci, “Deep q-learning-enabled deployment of aerial base stations in the presence of mobile users”, in *Proceedings of the 20th ACM International Symposium on Mobility Management and Wireless Access*, 2022, pp. 73–80.

[21] N. Sharma, M. Magarini, D. N. K. Jayakody, V. Sharma, and J. Li, “On-demand ultra-dense cloud drone networks: Opportunities, challenges and benefits”, *IEEE Communications Magazine*, vol. 56, no. 8, pp. 85–91, 2018. DOI: 10.1109/MCOM.2018.1701001.

Appendix

```
clc; clear all; close all;
k=8; %small scale fading value
kuav=8;
Gtx=0;
Grx=0;
BS=5;
radius=5000;
UE=10; Time_Vect=0:60:360;
Ptx= 13; PtxU= 6.99; %Transmit power in dB
UAV=10; H=200;
h_MAX=3; % margin Coeficient
BLK=100;
V_VectU=5:5:40; %Vlecity Vetcor
P_HOU1=[]; %stores the probabilities of
handover
for l=1: length(V_VectU)
    Vu=V_VectU(l);
    Prob_15=[]; i=0;
    while (i < BLK)
        i=i+1;
        P_PERUE=[];
        %BS_location
        x=radius*(rand(BS,1)-0.5);
        y=radius*(rand(BS,1)-0.5);
        BS_location=x + 1i*y;


        %UAV_location
        xU=radius*(rand(UAV,1)-0.5);
        yU=radius*(rand(UAV,1)-0.5);
        UAV_location=xU + 1i*yU;

        x_u0=radius*(rand(UE,1)-0.5);
        y_u0=radius*(rand(UE,1)-0.5);
        for n=1:UE

            Loc_15=[];
            for m=1:length(Time_Vect)
                %UE_location

                x_ue=horzcat(x_u0(n),(x_u0(n)
+ Vu*Time_Vect(m)));
                y_ue=horzcat(y_u0(n),(y_u0(n)
+ Vu*Time_Vect(m)));
                UE_location=x_ue+1i*y_ue;
                Loc_15=unique([Loc_15
UE_location]);
            end
```

```
            for m=1:length(Time_Vect)
                %UE_location

                x_ue=horzcat(x_u0(n),(x_u0(n)
+ Vu*Time_Vect(m)));
                y_ue=horzcat(y_u0(n),(y_u0(n)
+ Vu*Time_Vect(m)));
                UE_location=x_ue+1i*y_ue;
                Loc_15=unique([Loc_15
UE_location]);
            end
            RSS2_V15=[];SIR_VALUES=[];
            for j=1:length(Loc_15)

                %distances to the BS
                dis_UE = abs(BS_location-
Loc_15(j));
                dis_Uav = abs(UAV_location-
Loc_15(j));
                D_uav=sqrt(H^2 +(dis_Uav.^2));

                %FSPL =
128.1+37.6*log10(dis_UE)
                FSPL_T =
128.1+37.6*log10(dis_UE);
                FSPL_U =
128.1+37.6*log10(D_uav);

                %Powers received
                Prx_T = Ptx-FSPL_T-k;
                Prx_U = PtxU-FSPL_U-kuav;
                if max(Prx_T) > max(Prx_U)
                    RSS=max(Prx_T);

P_int=sum(10.^(Prx_T(Prx_T~=RSS)/10));

                else
                    RSS=max(Prx_U);

P_int=sum(10.^(Prx_U(Prx_U~=RSS)/10));

                end
                RSS2_V15= [RSS2_V15 RSS];
                SIR_VALUES=[SIR_VALUES (RSS-
(10*log10(P_int)))];
            end
            rss=RSS2_V15(1);
            P_VECT_15=[];
            f=0;
```

```
P_int=sum(10.^(Prx_T(Prx_T~=RSS)/10));

                else
                    RSS=max(Prx_U);

P_int=sum(10.^(Prx_U(Prx_U~=RSS)/10));

                end
                RSS2_V15= [RSS2_V15 RSS];
                SIR_VALUES=[SIR_VALUES (RSS-
(10*log10(P_int)))];
            end
            rss=RSS2_V15(1);
            P_VECT_15=[];
            f=0;

            while f<length(RSS2_V15)
                f=f+1;

h_M=max(h_MAX*(1-10^((SIR_VALUES(f)-
min(SIR_VALUES))/(min(SIR_VALUES)-
max(SIR_VALUES))))^4,0);

                    p=RSS2_V15(f)> rss+h_M;
                    if p==1
                       rss=RSS2_V15(f);

                    else
                      rss=RSS2_V15(1);

                    end

                P_VECT_15=[P_VECT_15 p];
            end

            P_PERUE=[P_PERUE mean(P_VECT_15)];


        end
        Prob_15=[ Prob_15 mean(P_PERUE)];
    end
    P_HOU1=[P_HOU1 100*sum(Prob_15)/BLK];
end
P_HOU1
```

MAKERERE UNIVERSITY

COLLEGE OF ENGINEERIG DESIGN, ART, AND TECHNOLOGY

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

BSc. TELECOMMUNICATIONS ENGINEERING

Final year project proposal

DESIGN OF A HANDOVER MANAGEMENT SCHEME IN UNMANNED AERIAL VEHICLE (UAV) – ASSISTED NETWORK

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CO – SUPERVISOR	MR. FRANK SSEMAKULA

Submitted in partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Telecommunications Engineering of Makerere University

DECLARATION

I, Thanawi Namukwaya and Nabukenya Grace, hereby declare that the presented full project proposal report is uniquely prepared under the guidance of our project supervisors. The report is prepared for our academic requirement not any other purpose and it has not be submitted to any College, University or Institution for any academic award or otherwise. All the work from other scholars has been clearly referenced.

Thanawi Namukwaya

Signature…………………………………………

Date ……………………………………………...

Grace Nabukenya

Signature …………………………………………

Date……………………………………………….

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LIST OF ACRONYMS

4G:	Fourth Generation
AuC:	Authentication Center
BS:	Base Station
HO:	Handover
HOF:	Handover Failure
PDW:	Packet Data Network
QoS:	Quality of Service
RLF:	Radio Link Failure
RSS:	Received Signal Strength
UAV:	Unmanned Aerial Vehicle
UE:	User Equipment

1 CHAPTER 1: INTRODUCTION

Unmanned Aerial vehicle (UAV) is an autonomously flying aircraft controlled by an individual. UAVs are commonly known as Drones. These UAVs offer benefits such as low cost access, effortless data collection, high efficiency fewer hazards to humans. Based on their potential, UAVs have very wide range of applications for example in the military, search and rescue, telecommunication and other areas. [1]

According to the project we are doing "Design of a handover management Scheme in UAVs assisted network", we Aare interested in telecommunication application of UAVs.

Figure 1: UAV network.

1.1 BACKGROUND

The deployment of UAVs in the cellular networks has significantly contributed to enhanced communication reliability and stability as well as the efficient use of system bandwidths. They also provide good coverage, especially for areas with high density connections and such a scenario may occur during sports events. They can also ensure connection in cases where terrestrial devices fail to do so since in disaster scenarios, it is rather hard to build a network at short notice.

UAVs have been recently included as user equipment in the cellular network architecture. The control link contains two major components that is a point to point connection between the drone and the person maneuvering it, and link that establishes a cellular network connection between the terminal and the Ground Control Station (GCS). UAVs can also be used as the ABS (Aerial Base Station), they can support the connectivity of genuine terrestrial wireless network. [2]

The advantage of using UAVs as ABSs compared to the convectional ground base station is their capability to alter their height, avoid obstacles and improve probability of creating line of sight (LoS) communication links for terrestrial users due to their unique properties such as flexible distribution, mobility in 3D space and adaptive altitude. UAVs can effectively provide wireless communication services by acting as BSs or UEs in the sky and establish multiple connections such as drone to ground mobile users and UAVs to satellite networks.

Despite of the potential prospects of UAVs, a range of practical challenges must be overcome to effectively apply them in each networking application and these challenges can be handling channel modeling, low latency control, interference management and efficient mobility (handover) management.

Among all the challenges efficient mobility (handover) management is a significant factor that must be addressed for UAVs BSs and UAVs scenarios .To ensure smooth and reliable connection services while users are mobile , a secure connection must be established in an addition to an efficient handover process [3]

Handover or handoff is a key technique in mobile networks that allows a UE to switch its connection across BSs while on the move. Handover with drone networks has become a significant matter because the connected drones move in the sky faster with different characterizations.

Depending on the functionality of drones within the network, one or several drones may need to provide network access services to specific terrestrial users. Since a drone's operation is restricted by its poor coverage, mobility characterizations, battery limitations and serving network traffic, handover will be increasingly required. The handover process is crucial for the continuation of a connection, imposing only a short delay. [4]

Handover in cellular networks can be classified into different types, based on technique, network type, network management, operating frequency and scenario. Handover can be classified in two main handover techniques types: soft and hard handover techniques. The soft HO imposes a more gradual connection termination, simultaneous maintaining a connection with two or more BSs for a short period of time. The hard handover requires the UE to terminate the connection from serving BS before it switches to the target BS. The drone's network can apply two different handover techniques depending on the mobile communication technology.

However also can be classified into different types based on the technology of the serving and target networks. The types are horizontal handover and vertical handover. In the horizontal handover, access points use the same technology and the target network interface remains the same. In the vertical the technologies are different from each other and multiple interfaces are employed.

Furthermore, handover in cellular networks can be classified into three methods depending on the network management system. (i) Network controlled handoff (NCHO), (ii) Mobile-Assisted Handoff (MAHO), (iii) Mobile Controlled Handoff (MCHO).

Handover Decision Algorithms are used in cellular networks such as RSRP, Received Signal Strength Indicator of the serving Base station, the Signal-to-Interference plus Noise Ratio (SINR), mobile movement speed, distance between the UE and BS, limited capacity of BSs, weight functions, cost functions, fuzzy logic control, and machine with deep learning technology. The same handover decision making algorithms can be used with drones, but the performance will differ due to different characterization of the drones.

Moreover, the requirements of 6G technology will be ultra-high compared to those of the previous mobile system. This creates the need for robust, efficient dynamic and smart handover decision algorithms for drone networks. [5]

1.2 PROBLEM STATEMENT

The massive growth of mobile users will spread to significant numbers of small cells for the fifth Generation mobile (5G) network which will overlap the fourth-generation network. A tremendous increase in handover (HO) scenarios and HO rates will occur resulting to unstable and unreliable communication, serving signal low reduction in the future mobile networks.

1.3 JUSTIFICATION

There is a need for continuity of the Quality of Services (QoS) hence requiring an efficient handover.

This project provides an overview and brief introduction to UAV networks and connectivity requirements for UAVs and, more specifically handover management in UAVs in networks.

Highlighting and discussing the main challenges facing the implementation of connected UAVs .The main focus is on handover challenges that influence the mobility of connected UAVs in mobile networks.

Summarizing and discussing the previous conducted research that has mostly focused on mobility management, for connected UAVs, including performance, network operation and connectivity issues.

Discussing the key significant future research directions for connected UAVs and this includes mobility management, machine learning and deep learning

This project is to help ensure a continuous and reliable quality of service while users are mobile.

1.4 PROJECT OBJECTIVES

1.4.1 Main objective

- ❖ To design a handover management algorithm that enables a seamless handover during the mobility of the UAVs from one cell to another in the communication network.

1.4.2 Specific objectives

- ❖ To model the basic cellular network
- ❖ Introduce UAVs as aerial base stations in the modeled basic cellular network.
- ❖ To design an algorithm that enables a seamless handover from one cell to another in the network without disruption of service.
- ❖ To compare the performance of our designed algorithm with an already existing algorithm.

2 CHAPTER 2: LITERATURE REVIEW

Handover of UAVs must be professionally and expertly managed in terms of the techniques used to address handover challenges compared to current handover management in terrestrial UEs .Techniques and Algorithms employed in terrestrial UEs may not be suitable for the UAV assisted network due to their distinctive features. They objective for using such methods is to delivery high quality service and reliable communication while maintaining a seamless handover.

Solutions have been investigated in several related works, but challenges still remain .The provided solutions are for both UAVs acting as BSs and UAVs serving as UEs.The UAVs are assessed in two separate movement scenarios: UAV BSs travelling in random directions at the same constant speed and UAV BSs moving at various speeds.

In future mobile networks, node movement prediction is a key recommended technique for enhancing UAV assisted network. Many contemporary methods are based on the distance measurements and projections.

Machine learning assisted studies have been developed to support UAV assisted network in acquiring certain patterns

2.1 RELATED WORKS

Several research works were conducted on handover/ mobility management in mobile networks .Several studies concentrating on UAV networks were undertaken to address various issues such as mobility management connectivity, IOT applications and multi user access control.

The related work is divided into sections and the first sections discusses the different solutions for mobility / handover management based on various concepts and techniques and the second section presents the proposed solution for handover/ mobility management based on deep learning technology , machine learning and different various communication issues based on different proposed solution .

2.2 CLASSICAL BASED TECHNIQUES FOR HANDOVER MANAGEMENT

In 2006, the authors demonstrated the PMIPv6 enables two 802.11p systems to conduct reliable communication between each other .since nodes require extra time to be ready to receive or retransmit packets after handoff is performed, MIPv6 is generally not referred. In UAVs networks, the fundamental procedure will include three nodes: the ground mobile UE, the UAV that will go out of service and the UAV to which the UE will be connected next. [6].

In 2015, the Authors conducted research on optimal coverage control for UAV handover. The authors in this paper proposed a coverage decision making algorithms, which aims to offer seamless handover and complete coverage for connected UAVs network .the Authors presented an Algorithm based on the RSS. The algorithm adjusts the UAVs altitude and separation distance. The proposed coverage decision algorithms evaluated in terms of success and false handover probabilities. The work was conducted by a simulation in order to assess the performance of the proposed algorithm. The presented simulation results illustrated that the proposed algorithm is capable for UAV networks .Regarding the simulations , the algorithm performs admirably .However a more accurate scenario must be considered ,considering the UAV's payload , BS radio range etc. . Furthermore, the coverage algorithms considers each UAVs RSS the same which may not be readily applicable. [7]

In 2017, the authors extensively examined LTE based drone network elements and their functionalities .The MME is crucial in managing handover between the GCSs .Several MMEs are needed to control the handover process. The SGW and Packet Data Network (PGW)elements are used to manage the IP communication between UAV and corresponding control stations .The Home Subscriber Server (HSS) or Authentication center (AuC)has similar functionality as in the LTE cellular system .The control entity in the underlying drone system consists of four fundamental sectors :LTE sector ,Drone –to GCS –LTE link , and Wi-Fi sector . [8]

In 2017, the authors proposed an intelligent handoff algorithm for UAV network .The heart of the algorithm is a fussy inference mechanism whose functionality is based on the comparison of several inputs parameters. Initially, information collection is established in either the devices or BSs .the device determines whether they prefer to remain connected to a specific BS or switch to another. The parameters that the handover decision relies on are classified into two classes .The first Class consists of the network specification such as RSS, communication coverage, and radius. The second application consists of the device specifications such as altitude and UE speed. The reception signal and coverage have an inverse relationship since the coverage increases and RSS decreases. Alternatively, the handover rate increases when the drone's motion is rapid .An optimized algorithm was built to correlate handover with the drone speed. The reception signal decreases with the distance between the BS and drone .After information acquisition , the fuzzification process can then be established .This includes the normalization input parameters and a linguistic variable (i.e. , high , average, or low are appointed for the coverage and high or low are selected for the speed). A predefined table consisting of fussy inference rules is core of handover decision making algorithms .A defuzzification mechanism for the parameters was then employed .The MATLAB fuzzy logic toolbox was used during simulations in a system consisting of three BSc and a single UAV. For the drone's motion, two different models were established: random and straight movements. Hundred simulations were conducted for several drone paths and directions [9]

The table below represents the outcome of the algorithm .As demonstrated in the table, the number of handover decreases in both scenarios (i.e., random and straight motions) when compared to conventional methods

Table 1: The outcome of the algorithm

ALGORITHMS	No.of handovers (random)	No.of handover (straight)
Convectional	13.86	5.03
Work done	0.84	2.37

2.3 MACHINE LEARNING BASED TECHNIQUES

Due to the high mobility of drones, it is difficult to accomplish global information exchange due to unnecessary overheads since the network becomes significantly convoluted. With advancements in machine learning disciplines, the number applications thought various fields has also increased.

Several previous studies were conducted the application of ML in drones network

In 2021, the authors have addressed the optimal location of multiple DBSs in a MIMO wireless network setting. They developed a low learning machine based algorithms for optimizing DBS location by minimizing the total wireless RSS occurring by active terminals .When compared to the Euclidean cost benchmark , the propose algorithm decreases the propagation loss in the system and achieves a lower bit error rate . Nonetheless, energy related issues have not been fully covered. [10]

2.4 DEEP LEARNING BASED TECHNIQUES

Deep learning is currently becoming g a key solution technology for addressing connection and mobility challenges for connected UAVS .Most current research focuses on deep learning and machine learning based techniques.

In 2018, the authors conducted research on deep reinforcement learning for user access control in UAV networks. The authors proposed deep reinforcement learning as framework solution to address the access control challenges for the ground users with the consideration of mobility of UAV-BS. They aimed to enable the user to be able to intelligently perform access decision, and maximize user's data rate and reduce the handover rate such as possible. Based on the presented simulation results, authors reported that results illustrated the effectiveness of the proposed solution and exposed its gain as compared to the other selected benchmark solutions from the literature. [11]

In 2020, the authors provided a novel provided a novel DQL model for optimal deployment of the UAV-BS. Furthermore, the proposed method presents the optimal UAV-BS trajectory while ground users move without relearning the method or acquiring ground user path information. In particular the mode optimizes the trajectory of UAV-BS by achieving a maximum Mean Opinion Score (MOS) for ground users who move along various paths [12]

2.5 OTHER RELATED STUDIES

In 2018, the authors conducted a survey study focused on On Demand architecture for an Ultra – Dense Cloud Drone Network (UDCDN)architecture .This architecture can meet the needs of the next generation by addressing interferences issues, energy consumption limitations , front and backhauling challenges , etc. system Optimization for issues such as interference ,efficiency and HO performance can be accomplished by integrating UDCDN with terrestrial networks operating in the sub -6 GHz and mm –wave bands ,which are not covered in this study . [13]

Table 2: summary list of related works on drone mobility management and connectivity

YEAR	STUDY FOCUS	PROPOSED METHOD	SOLUTION TARGET	ENVIRONMENT	REFERENCE
2015	Coverage and handover	Algorithm based on RSS , regulates the coverage of each drone	Optimal coverage control and efficient handover	Drone networks	[14]
2017	Fuzzy interference system	Fussy inference	Intelligent handover scheme	Drone network	[9]
2021	Location strategy for Drone base stations	Machine learning and performance	Address the optical positioning of multiple DBSs	Heterogeneous networks 2022	[10]
2022	Handover decision	Deep reinforcement learning	Avoid unnecessary handovers upholding reliable and stable communication	UAV network	[13]

3 CHAPTER 3: PROJECT PLAN

3.1 Specific objectives

- To model the basic cellular network
- Introduce UAVs as aerial base stations in the modeled basic cellular network.
- To design an algorithm that enables a seamless handover from one cell to another in the network without disruption of service.
- To compare the performance of our designed algorithm with an already existing algorithm.

3.2 METHODOLOGY

3.2.1 Research

A systematic investigation was carried out and studied various materials and sources and we established facts and new conclusions about the handover management in UAVs.

This will be done through reading textbooks, journals, review, conference papers and other relevant information from reliable sources, interviews with lectures and professionals in MATLAB field. We will use expert consultation and surveys techniques of data collection.

3.2.2 Software

Then implementation of this kind of system requires software programs.

MATLAB software was used to analyze our selected parameters which include hysteresis margin, time to trigger. A MATLAB program was automatically generated and our work was automated and we were able to test and verify our wireless communication system.

To be able to achieve our specific objectives, various activities are carried out which include;

- **To model the basic cellular network.**

  A basic cellular network with 2 ground base stations and having 10 user equipment is designed and attaining a clear understanding of how handover occurs in the network.
- **Introduce UAVs as aerial base stations in the modeled basic cellular network.**

  UAVs acting as aerial base stations are introduced into the basic cellular network when the capacity within the network has increased as they are assisting the ground base stations.

- **To design an algorithm that enables a seamless handover from one cell to another in the network without disruption of service.**

  A mathematical model that relates to handover in UAVs is to be developed.

  A handover algorithm for UAVs is designed and then applied to the UAV- assisted network.

- **To compare the performance of our designed algorithm with an already existing algorithm.**

  Making research about already existing algorithm and clearly understanding its performance and compare it with the performance of the designed algorithm.

3.3 EXPECTED RESULTS

At the end of the project, we expect to have an accurate and fully functional handover algorithm which enables a seamless communication in UAV –assisted networks.

3.4 TIMELINE

A Gantt chart showing the set of time –lines showing the start and end dates of different tasks into which the project has been divided.

The grey color shows that the task has been achieved and the blue color shows what to be achieved.

The project is estimated to run for eight to nine months.

Table 3: the period for which the project will last

HANDOVER MANAGEMENT IN UAVs									
Time / Tasks	2022			2023					
	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUN
Literature Review									
Abbreviated Proposal Report Writing									
Proposal Report Writing & Midterm Presentations									
Algorithm Development & Code writing									
Testing the algorithm									
Final project presentations									
Final report writing									

3.4.1 Limitations and future work

Drones connected to cellular networks will be a vital infrastructure that offers a wide range of services in a various environment .The necessity for stable communication during their movement is a major challenge that must be emphasized. Handover issues would result in high handover rates which would lead to a large ping pong effect or high rate of Radio Link Failures (RLFs) or Handover Failures (HOFs).

3.4.2 Future Directions

UAVs are not yet widely available. It will take time to fully integrate connected drones into the serving communication networks. A number of potentential recommendations and major research directions should be addressed before the wide employment of connected UAVs to mobile network. A number of key research related to mobility management must of UAVs must be addressed efficiently to enable more efficient connected UAV services .These key research directions include ,energy efficiency, mobility Management , security etc.

4 REFERENCES

[1] R. C. D. WT Alshaibaini, "Mobile management of Unmanned Aerial Vehicles in Ultra -Dense," *sensor 22,* p. 16, 2022.

[2] R. J. ,. V. Lav Gupta, *IEEE communication Surveys and Tutorials ,* p. 18, 12015.

[3] T. C. ,. J. J. Thalita Ayass, "UAVs with handover manangement fuzzy system for 5G networks," *intelligence and Robotics ,* no. challenges and perpectives, 20-36.

[4] m. K. Younghoon Jang, "UAVs handover Decision using Deep Reinforcement Learning," *2022 16th international conference on Ubiquitous information Management and communication,* pp. 1-4, 2022.

[5] B. G. K. Erika Fonseca, "Mobility for cellular connected UAVs," *2021 Joint European Conference on Networks and Communication,* pp. 136-141, 2021.

[6] J. Stein, Survey of IEEE802.21 Media Independent handover services, 2006.

[7] K. Park, B. cho, K.J and K. H, Optical coverage controlfor net drone handover, Japan: Piscataway , 2015.

[8] G. Wang and W. Saad, handover key management in an ITE based Unmanned Arieal Vehicle control NETWORKS, USA, 2017.

[9] E. Lee, C. Choi and P. Kim, Intelligent scheme for drone using fussy interenc sysytems, 2007.

[10] Morocho-Cayameela and L. ME, An optical location strategy for multiple drone base station in massiveMIMO, ICTEXPRESS 2021, 2021.

[11] Y. Cao, L. Zhang and C. Y, Deep reinforcement learning for users access control in uav network, USA: Pis -catawayNJ, 2018.

[12] W. Lee, Y. Jeon and Kim, Deep reinforcement learning for UAV trajectory design considering mobile ground users, 8239, 2021.

[13] N. Sharma and M. Magarini, On- demand ultra dense cloud drone networks :Opportunities, challenges and Benefits, IEEE Commun, 2018.

[14] K. Park, B. Cho and K. Park, Optimal coverage control for net drones for future internet platforms, Japan: IEEE Piscataway , 2017.