



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

A.Maheswari¹, Dr. Golda Dilip²

¹Research Scholar, ²Associate Professor

^{1,2} Department of Computer Science and Engineering SRM Institute of Science and Technology, Vadapalani, Chennai, India

¹ma4371@srmist.edu.in, ²goldad@srmist.edu.in

ABSTRACT

Handover is a critical feature of wireless networks that allows mobile devices to seamlessly switch between access points as they move around. In 5G heterogeneous wireless networks (HetNets), handover is even more challenging due to the high density of base stations and the variety of radio access technologies (RATs) that may be used. There are a number of challenges that must be addressed in order to design efficient and reliable handover mechanisms for 5G HetNets. These challenges include: Heterogeneity of the network, Multi-RAT support, Mobility of users. Despite these challenges, there are a number of promising research directions for handover in 5G HetNets. These research directions include: Machine learning, Heterogeneous signaling, Network slicing. The research on handover in 5G HetNets is still in its early stages. However, there is a lot of promising research being done in this area. As 5G networks become more widespread, the need for efficient and reliable handover mechanisms will become even more important.

Keywords: Handover, Heterogeneous Wireless networks, 5G network

1 Introduction

The proliferation of wireless technologies has resulted in compatibility issues between these technologies, which impact handover procedures. Contemporary efforts toward achieving ubiquitous access across heterogeneous technologies necessitate the integration of a variety of existing and emerging networking technologies to create a seamless wireless communication environment. Progress in wireless communication has led to versatile, convenient, and cost-effective network services. The interconnection between heterogeneous networks is an essential component that enables ubiquitous access. Seamless handover remains a challenging issue. The evolution of next-generation networks is anticipated to prioritize handover management as a primary aspect [1]. In a wireless network, handover management is a process that enables a mobile terminal (MT) to maintain ongoing sessions while transitioning from one network access point to another. When the connection moves from one access point to another of similar technology, it is referred to as "horizontal handover." Conversely, a vertical handoff is a handover process between two distinct networks, such as handovers between a wireless local area network (WLAN) and a fifth-



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

generation (5G) mobile network. Handovers may also be categorized as hard and soft handovers. Hard handover is the type of handover that releases the serving station signal before the new resources can be committed. This type of handover results in an interruption to mobile communication during the handover process [2]. Soft handover is the type of handover where the mobile terminal establishes a mobile connection with a new access point before the old link is released. It performs a handover without interruption. The handover process comprises three stages, as depicted in Figure 1. The handover initiation stage detects networks and the primary attributes of the network via the Media Independent Handover Function (MIHF) [3,4]. The handover decision-making process selects the best network based on network information and initiates the handover at the appropriate time. The handover execution stage establishes the connection with the chosen network and terminates the old network. Several handover criteria can be used to facilitate a handover decision, such as received signal strength (RSS), data rate, monetary cost, bit error rate (BER), and signal-to-interference plus noise ratio (SINR). Utilizing multiple criteria in performing handover decisions can enhance handover performance compared to conventional handover algorithms that rely on one or two handover parameters.

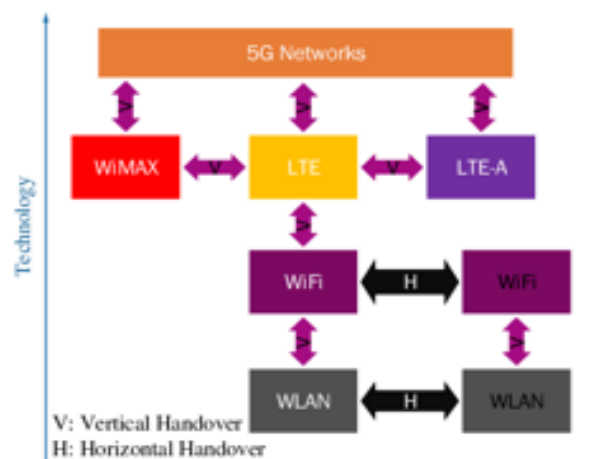


Figure 1: *The Handover types over heterogeneous networks*

The fifth-generation network represents the most advanced mobile wireless technology, boasting a high data transmission rate and low latency [5]. Nevertheless, the 5G network's cell coverage is inferior to that of its predecessor, the 4G network. Mobile terminals (MTs) moving at high speed experience frequent handovers, which can lead to unnecessary handovers and, consequently, data corruption, transmission delays, and a suboptimal user experience [6]. Therefore, achieving seamless handover necessitates an accurate handover decision-making algorithm. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a dependable multi-attribute decision-making (MADM) technique that



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

has found extensive use in handover decision-making in heterogeneous networks. However, most MADM handover algorithms exhibit a bias towards large cell networks, such as 4G networks, in high-speed scenarios. An intelligent-based handover algorithm is more intricate since it necessitates a data training process for algorithm learning [7]. This paper proposes a handover algorithm that fuses a dwell-time prediction technique with the TOPSIS method to reduce the number of unnecessary handovers in 5G heterogeneous networks. The proposed algorithm predicts the connection time to a 5G small cell network using the dwell-time prediction technique, thus avoiding unnecessary handover, while the network evaluation and selection are performed using the TOPSIS method.

2 Literature Survey

Vincent O. Nyangaresi et al [1] discussed technical challenges in 5G networks related to handover authentication, user privacy protection, and resource management. The security requirements for 5G are high compared to previous generations due to interoperability requirements among heterogeneous networks. The current 5G handover protocols have either long latencies or focus on either security or quality of services parameters such as user satisfaction. The paper proposes an ANN-FL protocol that addresses both security and QoS in 5G and B5G networks. The simulation results showed that the developed protocol was robust against attacks such as de-synchronization and tracing attacks and yielded a 27.1% increase in handover success rate, a 27.3% reduction in handover failure rate, and a 24.1% reduction in ping pong handovers. In the literature survey, the paper mentions several other proposed authentication schemes for 5G networks, such as using block chain and SDN to eliminate reauthentication in repeated handovers among heterogeneous cells, an SDHO technique to enhance handover in future ultra-dense 5G networks, and an SDN-based mobility and available resource estimation strategy to address handover latency problems. The paper also mentions a vertical handover framework incorporating IEEE 802.21 Media Independent Handover (MIH) services with OpenFlow protocol (OFP)

The paper discusses the use of fuzzy evolutionary optimization with Nano core elements in mobile healthcare applications to improve handover authentication in fifth-generation communication networks. The authors J. Divakaran et al. [2] propose a model that minimizes delays and complexity while authenticating networks in 5G networks and mitigates attacks using an evolutionary model trained with relevant attack datasets. The simulation results show that the proposed method is effective in improving handling and authentication and mitigating various types of attacks in mobile health applications. In the literature review section, the authors discuss the extension of the 3GPP LTE hierarchical architecture and integration of SDN technology to present a 5G mobile network architecture that leverages intelligence and programmable networking capabilities. They also present an authentication



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

handover based on SDN functions and propose an authentication mechanism for LTE networks using symmetric key cryptography and Elliptic Curve Diffie-Hellman.

The paper discusses the use of fuzzy logic to solve the handover problem in small cell networks for 4G/5G systems. The authors Sandeep Kaur et al [3] propose a WFSO approach with fuzzy logic to lower the rate of Handover Ping-Pong (HOPP), radio connection failure, and Handover Failure (HOF) in comparison to other algorithms. The paper also briefly mentions the use of fuzzy logic to analyze the security of both intra and between system handovers in 5G. However, the paper does not provide a literature survey of previous research in this domain.

The paper provides a comprehensive review of handover management in future mobile Ultra-Dense HetNets. The paper discusses different mobility and handover management techniques to highlight their contribution in providing seamless connection during user mobility. The authors Sajjad Ahmad Khan et al. [4] also examine several key challenges, opportunities, and prospective solutions to pinpoint key issues and determine suitable solutions that may contribute to solving mobility problems in future mobile networks. However, the paper does not provide a literature survey of other papers in the domain.

The paper proposes a new mobility management technique for sliced 5G networks. The authors AzhaguJaisudhanPazhani.A et al. [5] aim to develop an intra-and inter-slice algorithm for determining handover decisions in sliced 5G networks and to assess performance by comparing intra-and inter-slice handovers. The paper discusses the need for such techniques in 5G networks due to the growing need for network services among users and the diverse services that users now expect from the network. The paper also discusses the use of technologies like Software Defined Networks, Network Function Virtualization, and Network Slicing to fulfill the different needs of users in an economical manner while guaranteeing network resources are resourcefully assigned to consumers. The proposed work shows that an inter-slice handover algorithm offers superior quality of service when compared to an intra-slice algorithm. The paper includes a literature survey of related work in the field of mobility management in 5G networks.

The paper discusses the optimization of handover parameters in 5G networks. In the literature review section, the authors WasanKadhimSaad et al [6] mention that there are numerous algorithms suggested in the literature for optimizing HCP settings. Some of the methodologies applied in different environments include machine learning and data mining (MLDM) technique, high-mobility SON function, and others. The MLDM technique was proposed to optimize HO parameters in the LTE system within a building environment. The high-mobility SON function was offered to shorten the multi-layer time that performs the optimization process in the LTE system.

This paper presents a literature survey on the Vertical Handover (VH) algorithms in heterogeneous wireless networks. The investigation is based on the network type and



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

frequency used mechanisms, which are considered as crucially important parameters in the VH handover process. The authors FerasZenalden et al [7] discussed the advantages and drawbacks of recent works and also studies key handover challenges and design issues for the next generation of wireless networks.

The paper provides a literature review of various proposals made for vertical handoff decision algorithms. The traditional approach for vertical handoff decision algorithm is based on RSS (Received Signal Strength). Johann et al [8] evaluate a technology-aware VHDL which considers availability and capacity of the network for decision making process under IEEE 802.21 standard. Some proposals for vertical handoff decision are based on artificial intelligence techniques.

This paper presents a literature survey on vehicular communication systems and handover in 5G networks. The authors Mahmoud M. Elsayeda et al. [9] have reviewed various research papers and studies related to the topic to provide a comprehensive overview of the subject. The survey covers different types of vehicular communication systems, their forms, and handover mechanisms in each category in 5G networks. The paper also discusses the algorithms developed to overcome the problems associated with handover in 5G networks. Overall, the literature survey provides a helpful insight into the current state of research in the field of vehicular communication systems and handover in 5G networks.

The paper discusses the performance analysis of seamless vertical handover in 4G networks. In the literature review section, Izzeldini Mohamed et al [10] mention that numerous proposals and approaches have been made for vertical handoff schemes and decision algorithms. Some of these approaches are based on Received Signal Strength (RSS) combined with other parameters such as network load and network cost. Others use artificial intelligence techniques to combine several parameters such as network conditions and Mobile Terminal's (MT) mobility in the handoff decision. Policy-based approaches combine several metrics such as access cost, power consumption, and bandwidth, velocity of a host, quality of service in VHO mechanism. The paper also references an efficient decision handoff mechanism for heterogeneous networks proposed in a previous work.

The authors Payaswini P et al [11] present a simulation and performance analysis of vertical handoff between Wi-Fi and Wi-MAX networks using the IEEE 802.21 Media Independent Handover (MIH) standard. The paper focuses on the challenge of designing an intelligent vertical handoff algorithm for next-generation networks and proposes the use of the MIH standard to facilitate handover between different wireless networks in a heterogeneous environment. The paper also discusses the development of an add-on module compatible with ns2 version 2.29 to simulate the MIH standard and presents simulation results in terms of throughput, handoff latency, packet drop, and end-to-end delay. The paper provides a literature survey of related work in the field of vertical handoff and MIH standard.



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

The authors Mandeep Kaur Gondara et al [12] of this paper conducted a literature survey to extract the requirements of a vertical handoff mechanism for 4G wireless networks. They used documentary sources such as academic journals, applicable books, and the internet to collect data. Textual analysis was used as a means of data collection, which involved both content analysis and textual interpretations. The requirements were extracted from existing handoff decision models and mechanisms and other surveyed literature on handoff aspects in the wireless network environment. Different authors have indicated different aspects that should be considered while designing a handoff mechanism for the wireless networks. These aspects include many parameters as discussed in section 4 for seamless and secure handoffs in the wireless environment.

The authors Mehek-Moutushy Rahman Mou et al [13] proposed a service-aware fuzzy logic-based handover decision mechanism in heterogeneous wireless networks. The following methods are used in the paper:

- Fuzzy logic is used to make intelligent handover decisions based on several input parameters such as received signal strength indicator (RSSI), data rate, user's velocity, and interference level.
- The proposed system models different cases of handover decisions between macrocell and femtocell networks considering service type (voice, video, and data).
- The performance of different parameters based on service type is analyzed.
- The paper uses a path loss channel propagation model for macrocell and femtocell users to express the received SNIR level in a macrocellular integrated network or femtocellular integrated network.

The paper presents a study on Vertical Handover (VHO) approaches of 3GPP and non-3GPP proposed in the literature and classifies them into two categories for which their characteristics are discussed by the author Dr Omar Khattab [14]. Additionally, the paper provides background information on heterogeneous wireless communication technologies and handover management within heterogeneous wireless communication technologies.

The paper provides a literature review of different methods and studies of vertical handover decision algorithms. Two main approaches are discussed in the literature:

1. RSS-based approach: This method selects the strongest received base station (BS) at all times and has been optimized by adapting the RSS threshold. It has also been combined with other parameters such as user's velocity, location, network cost, and network load.
2. Artificial intelligence-based approach: This approach uses complex techniques such as neural network models to combine several parameters such as network conditions and mobile terminal's mobility in the handoff decision. However, these techniques may be difficult to implement in practical systems.



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

The authors Imad El Fachтали et al. [15] proposed a new approach based on QoS aware ant colony optimization decision algorithm (ACO R) that uses dynamic and static factors such as RSS, the cost of service, bandwidth, the velocity of MT, the power consumption, security, and the module for predicting the traveling distance within an IEEE 802.11 WLAN cell.

The authors Mohammad Arifin et al. [16] discusses the challenges faced by network service providers due to the exponential rise in mobile data traffic and the increasing popularity of portable devices like tablets, smartphones, and laptops. To address this challenge, the paper proposes the use of fifth-generation (5G) wireless communication, which can offer very broad wireless area capacity and potential cut-power consumption. The paper focuses on the use of small cells as the fundamental mechanism for the 5G technology, which can enhance the facility for higher capacity and reuse. However, the deployment of small cells leads to frequent handovers of mobile nodes, which can be problematic. Therefore, the paper proposes a new resource management scheme that can work to minimize the rate of handovers for mobile phones through careful resources allocation in a two-tier network. The paper also discusses the literature review of two-tier networks, which have a combination of macro and small cells, and how this combination results in an increased number of handovers due to the smaller coverage of the small cells. The paper cites a study by Zhang et al. that studied the procedure of decreasing handovers in macrofemto cells.

The paper discusses a fuzzy-based vertical handover network selection scheme for next-generation 5G wireless networks. The authors Meenakshi Subramani et al [17] mention that there are many heterogeneous wireless communication technologies available to satisfy user demands, and the deployment of these networks allows users to access the internet anywhere, anytime through different wireless networks. To obtain seamless service and service continuity, the device should be handed over to the best wireless networks. The paper proposes a half handover scheme for Device-to-Device (D2D) communication for the selection of the best network. The target network selection for vertical handover can be handled using multiple attribute decision making (MADM) methods. The authors analyze the impact of combining fuzzy with the conventional MADM scheme, simple additive weighting (SAW), and compare the hybrid scheme with the conventional MADM schemes like SAW, Techniques for order preference by similarity to ideal solution (TOPSIS), VIKOR in terms of handover decision delay. The paper concludes that the proposed scheme's handover decision delay performance is superior to the considered classical MADM schemes.

This paper provides a literature survey of existing vertical handover decision-making mechanisms in heterogeneous wireless networks. The authors ShidrokhGoudarzi et al [18] categorize these mechanisms based on TCP/IP layers and evaluate them based on their advantages and limitations. The paper also proposes a cross-layer design approach as the best solution for achieving seamless service continuity and facilitating seamless connectivity. The survey can guide interested readers familiar with vertical handover mechanisms through the



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

classification of vertical handover mechanisms based on single layer and cross layer design approaches and helps them integrate these schemes into their own studies.

The authors Pallavi Sapkale et al. [19] discuss the handover decision algorithm for the next generation of wireless communication networks. In the literature review section, the paper mentions various methods for horizontal and vertical handover decision algorithms. Specifically, the paper mentions the following:

- Multiple criteria-based algorithms are used to reduce power consumption.
- An algorithm that minimizes the effect of connection breakdown is implemented.
- An RSS-based algorithm that uses the RSS threshold, user velocity, and location is mentioned.

Overall, the literature review highlights the importance of handover decision algorithms in improving the performance of wireless communication networks.

The authors P. Pramod Kumar et al [20] discuss a vertical handover decision algorithm based on several specifications in heterogeneous wireless networks. The literature survey in the paper discusses various approaches to vertical handover decision algorithms, including RSS-based formulas, context-aware-based formulas, and cost function-based formulas. The RSS-based formula is the least complex but also the least accurate, while the cost function-based formulas are more complex but also more accurate and provide higher network performance. The paper also mentions research regarding 5th generation systems.

The paper provides a literature survey of vertical handover decision algorithms in multi-wireless network systems. The authors Kusay Faisal et al. [21] compares three wireless communication interfaces, which are Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), and Long-Term Evolution (LTE). The study is based on three types of priority algorithms to make a vertical handover decision (VHD), they are: equal, mobile, and network priority. The paper also discusses different methods for triggering handover, such as the method based on RSS and the multi-criteria method. Additionally, the paper mentions the use of fuzzy logic (FL) in decision-making, which is a method inspired by human thinking. Overall, the paper provides a comprehensive literature survey of vertical handover decision algorithms in multi-wireless network systems.

In this paper the authors ShaikMazhar Hussain et al. [22] provides a literature review of previous works related to handover in vehicular networks. One such study by Chang et al. (2019) proposed a cluster-based handoff and dynamic edge-backup node (DEBCK) approach for handover. In this approach, vehicles on the road lane were clustered, and the backup node provided handoff. The cluster head performed the handoff, and the backup mobile edge vehicle was used. The three main parameters that were taken into account for handoff were storage, communication, and energy.

The paper discusses the development of Wireless Body Area Networks (WBANs) in healthcare, where patients are equipped with wearable and implantable body sensor nodes to



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

gather sensory information for remote monitoring. The author Dong Doan Van [23] proposes an effective Multi-Attribute Decision-Making (MADM) handover algorithm that guarantees seamless connectivity and a Content-Centric Networking (CCN) processing module to reduce packet loss, enhance QoS, and avoid unnecessary handovers. The paper also mentions the three tiers of WBAN communication architectures, which are intra-body (tier-1), inter-Body Sensor Network (BSN) communications (tier-2), and extra-body (tier-3) communications. The paper focuses on the tier-3 aspect of WBAN communication and investigates many wireless technologies such as Internet/WiFi/Cellular networks used in CareNet, WiMoCA, and MIMOSA for ubiquitous healthcare.

The paper discusses the challenges faced by mobility management in 5G networks due to the deployment of a high number of small cells and mobile nodes. To address this issue, the author Amina Gharsallah [24] proposes a novel optimized vertical handover approach that uses Media Independent Handover and Software-Defined Networking for seamless vertical handover. The simulation results validate the efficiency of the proposed approach. In the literature review section, the paper mentions a 5G network architecture based on SDN proposed by Bilen et al. that includes mobility management and admission control modules in the SDN controller.

The authors Boh Wen Diong et al [25] proposes a vertical handover algorithm for telemedicine application in 5G heterogeneous wireless networks. The algorithm integrates the Travelling Time Estimation, Fuzzy Analytic Hierarchy Process (FAHP), and Technique for order of preference by similarity to ideal solution (TOPSIS) algorithms to reduce unnecessary handover in high-speed scenarios. The simulation results show that the proposed algorithm has successfully reduced up to 80.3% of handovers compared to FAHP-TOPSIS based handover algorithm in the high-speed scenario. The proposed handover algorithm can improve the quality of telemedicine services in high-speed scenarios. The literature review section of the paper explains the three phases of vertical handover, which are handover initiation, decision, and execution. The handover initiation utilizes the Media Independent Handover Function to discover and retrieve available network information, the handover decision selects the most suitable network based on the network information, and the executive phase establishes the connection with the targeted network and releases the serving network.

The paper proposes a novel vertical handover algorithm based on multi-attribute and neural network for heterogeneous integrated network. The authors Xiaonan Tan et al. [26] have constructed a three-layer BP neural network model for each of the five networks (UMTS, GPRS, WLAN, 4G, and 5G) to evaluate the network download rate and select the right wireless network for vertical handover decision. The algorithm uses maximum transmission rate, minimum delay, SINR, bit error rate, user moving speed, and packet loss rate as reference objects to participate in the setting of BP neural network input layer neurons and



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

the training and learning process of subsequent neural network data. The simulation results on MATLAB platform show that the proposed algorithm has a handover success rate up to 90% and realizes efficient handover and seamless connectivity between multi-heterogeneous networks.

The paper proposes a fast handover algorithm based on location and weight for 5G-railway (5G-R) communications for high-speed railways. The algorithm involves the following steps:

1. Calculating the speed and direction of the train to select a reasonable handover mode and identify the handover chain of neighboring cells.
2. Calculating the location of the train to determine whether the user equipment (UE) enters the defined identification zone of pre-handover.
3. Triggering the command of the handover based on the values collected in the measurement report when the weight of the target cell is greater than that of the source cell.

The author BaofengDuan et al [27] describes the architecture of networks in the 5G-R for HSRs, which involves three parts: access network, bearer network, and core network. The fronthaul network consists of gNodeBs and BBU/DU through a high-capacity optical fiber. The network decouples completely the control plane and the user plane, then reconstructs flexibly the system control.

The paper discusses the concept of vertical handoff in heterogeneous wireless networks, which involves switching connections among different access networks like WiMAX, LTE, Wi-Fi, and WLAN. The paper aims to address the technical challenges of mobility management and integration of emerging wireless access networks. The authors Avinash K S et al [28] have presented an inter-technology handoff scheme between WiMAX and WLAN and evaluated its performance using the Qualnet network simulator platform. The literature review section of the paper discusses the importance of handoff in wireless communication systems and the challenges of poorly designed handoff schemes, which can lead to heavy signaling traffic and a decrease in quality of service.

In this paper the author Mark Irwin Goh et al. [29] proposes a handover decision-making algorithm for 5G heterogeneous networks. In the literature review section, the paper discusses the use of Multiple Attribute Decision Making (MADM) algorithms for handover decision making. The most commonly used MADM algorithms are Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Simple Additive Weighting (SAW). These algorithms select networks by comparing different options based on multiple attributes and choosing the network that best satisfies the conditions. The paper also mentions an adaptive vertical handover algorithm proposed by Li that improves user satisfaction and power consumption using a moving average method to predict future data and reduce the measurement rate in the network discovery phase.



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

The paper discusses the challenges of 5G HetNets, which include frequent handovers, ping-pong effects, and load balancing due to the massive and unplanned deployment of Small cells. To address these challenges, the author Sajjad Ahmad Khan et al [30] proposes an optimized handover decision algorithm that uses a machine learning-based technique to monitor the Reference Signal Received Power (RSRP), available radio resources, active time, and speed of User Equipment (UE) to ensure efficient HO decisions. The proposed algorithm reduces the frequent handovers and ping-pong effects by enhancing the HO procedures. The paper also explains some challenges and research directions for researchers. However, the paper does not provide a literature survey.

The paper proposes a novel handover scheme for ultra-dense networks (UDN) in 5G mobile communications. The authors Qianyu Liu et al [31] highlight the challenges of handover in UDN, such as ping-pong handover, handover failures, and frequent handover. To address these challenges, the proposed scheme integrates fuzzy logic and multiple attributes decision algorithms (MADM) to ensure the handover process is triggered at the right time and the connection is switched to the optimal neighboring base station (BS). The paper also adopts the subtractive clustering technique to define the optimal membership functions within the fuzzy system. The performance of the proposed algorithm is evaluated in a simulation environment and compared with the conventional handover algorithm.

In this paper Jin Cao et al. [32] Proposes secure and efficient group-based handover authentication and re-authentication protocols for mMTC in 5G wireless networks. The proposed protocols are evaluated using the BAN logic and the formal verification tool by using the AVISPA and SPAN to show that they are secure against various malicious attacks. The paper also provides a performance evaluation of the proposed scheme.

In this paper authors Michele Polese et al. [33] implements a novel dual connectivity protocol that enables mobile user equipment devices to maintain physical layer connections to 4G and 5G cells simultaneously. A novel uplink control signaling system combined with a local coordinator enables rapid path switching in the event of failures on any one link. The simulation framework includes detailed measurement-based channel models to realistically capture spatial dynamics of blocking events, as well as the full details of Medium Access Control, Radio Link Control, and transport protocols.

Table 1: Comparison Table

S.No	Name of the paper	Algorithms/ Mechanism	Parameters
1	ANN-FL Secure Handover Protocol for 5G and Beyond Networks	Artificial Neural Network-Fuzzy Logic (ANN-FL) protocol	Increase Handover success rate, reduction in handover failure



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

			rate, reduction in ping pong handovers
2	Improved Handover Authentication in Fifth-Generation Communication Networks Using Fuzzy Evolutionary Optimization with Nano core Elements in Mobile Healthcare Applications	Fuzzy Evolutionary Optimization	optimize handover authentication decisions, network conditions, security requirements
3	5G Networks for Handover Using Fuzzy Logic	WFSO (Weighted Fuzzy System Optimization) approach with Fuzzy Logic.	lower the rate of Handover Ping-Pong (HOPP), radio connection failure, and Handover Failure (HOF)
4	Peer–Peer Communication Using Novel Slice HandoverAlgorithm for 5G Wireless Networks	intra-and inter-slice algorithm	Discussion on the use of technologies like Software Defined Networks (SDN), Network Function Virtualization (NFV), and Network Slicing.
5	Service Aware Fuzzy Logic Based Handover Decision in Heterogeneous Wireless Networks	service-aware fuzzy logic-based handover decision mechanism	RSSI, data rate, user's velocity, and interference level
6	Vertical Handover Study on 4G Category vs. 5G Category for3GPP Generation Mobile Systems and Non-3GPP Wireless Networks	RSS-based approach and Artificial intelligence-based approach	literature review of different methods and studies of vertical handover decision algorithms
7	Vertical Handover Decision Algorithm Using Ants' Colonies for4G Heterogeneous Wireless Networks	QoS aware ant colony optimization decision algorithm" (ACO R)	To optimize the factors like RSS, Cost, Bandwidth, Velocity, power consumption and



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

			security
8	A New Handover Management Model for Two-Tier 5G Mobile Networks	new resource management scheme	minimize the rate of handovers
9	A fuzzy based vertical handover network selection scheme	fuzzy-based vertical handover network selection scheme	to improve the handover decision-making process, reducing decision delay and to improve performance compared to class
10	Vertical Handover Algorithm for WBANs in Ubiquitous Healthcare with Quality of Service Guarantees	Multi-Attribute Decision-Making (MADM) handover algorithm	Reduce packet loss and avoid unnecessary handovers.
11	MIH/SDN-Based Vertical Handover Approach for 5G Mobile Networks	Media Independent Handover (MIH) and Software-Defined Networking (SDN)	to reduce unnecessary handovers
12	Vertical Handover Algorithm for Telemedicine Application in 5G Heterogeneous Wireless Networks	The algorithm integrates the Travelling Time Estimation, Fuzzy Analytic Hierarchy Process (FAHP), and Technique for order of preference by similarity to ideal solution (TOPSIS)	to reduce unnecessary handovers
13	Vertical handover algorithm based on multi-attribute and neural network in heterogeneous integrated network	a novel vertical handover algorithm based on multi-attribute and neural network	Maximum transmission rate, Minimum delay, Signal-to-Interference-plus-Noise Ratio (SINR), Bit Error Rate (BER), User



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

			moving speed, Packet loss rate
14	Fast Handover Algorithm Based on Location and Weight in 5G-R Wireless Communications for High-Speed Railways	a fast handover algorithm based on location and weight for 5G-Railway (5G-R) communications in high-speed railways	The speed and direction of the train are crucial factors in determining the appropriate handover decisions.
15	Vertical Handoff in Heterogeneous Wireless Networks	inter-technology handoff scheme	handoff delay, handoff success rate, signaling overhead
16	Handover Decision-Making Algorithm for 5G Heterogeneous Networks	Discussion on TOPSIS and SAW	improve user satisfaction and power consumption in the network
17	An Improved Handover Decision Algorithm for 5G Heterogeneous Networks	Machine learning-based optimized handover decision algorithm	RSRP, Available radio resources, Active time, Speed of User Equipment,
18	A fuzzy-clustering based approach for MADM handover in 5G ultra-dense networks	A novel handover scheme for ultra-dense networks (UDN) in 5G mobile communications. The proposed scheme integrates fuzzy logic and multiple attributes decision algorithms (MADM)	Ping-pong handover, handover failures, and frequent handover.
19	EGHR: Efficient group-based handover authentication protocols for mMTC in 5G wireless networks	Secure and efficient group-based handover authentication and re-authentication protocols for mMTC (massive Machine	Authentication latency, signaling overhead, computational overhead, and overall system efficiency.



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

		Type Communications) in 5G wireless networks.	
--	--	--	--

3 Conclusion

In conclusion, the papers discussed various aspects of handover management in 5G and heterogeneous wireless networks. They highlighted the technical challenges in handover authentication, user privacy protection, and resource management in 5G networks. The proposed algorithms and protocols aimed to improve handover success rates, reduce handover failures, mitigate attacks, and enhance quality of service parameters. The studies utilized techniques such as artificial neural networks, fuzzy logic, multi-attribute decision making, and machine learning to optimize handover decisions. Simulation results demonstrated the effectiveness of the proposed approaches in improving handover performance and addressing the challenges associated with handover in different network scenarios.

References

1. Vincent O. Nyangaresi; Anthony J. Rodrigues; Silvan O. Abeka, Year: 2021, "ANN-FL Secure Handover Protocol for 5G and Beyond Networks", ICST Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 2021 Published by Springer Nature Switzerland AG 2021.
2. J. Divakaran; S. K. Prashanth; GouseBaig Mohammad; DrShitharth ; Sachi Nandan Mohanty; C. Arvind; K. Srihari; Yasir Abdullah R; Venkatesa Prabhu Sundramurthy, Year: 2022, "Improved Handover Authentication in Fifth-Generation Communication Networks Using Fuzzy Evolutionary Optimisation with Nanocore Elements in Mobile Healthcare Applications".
3. Sandeep Kaur; ErLovepreet Kaur, Year: 2022, "5G Networks for Handover Using Fuzzy Logic", International Journal of Research Publication and Reviews, Vol: 3, no: 9, pp 1588 – 1595, September 2022.
4. Sajjad Ahmad Khan; Ibraheem Shayea; Mustafa Ergen; Hafizal Mohamad, Year: 2022, "Handover management over dual connectivity in 5G technology with future ultra-dense mobile heterogeneous networks: A review", Engineering Science and Technology, an International Journal, Vol: 35.
5. Azhagu Jaisudhan Pazhani; A , P. Gunasekaran; Vimal Shanmuganathan; Sangsoon Lim ,Kaliappan Madasamy , Rajesh Manoharan; Amit Verma, Year: 2022, "Peer–Peer Communication



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

Using Novel Slice Handover Algorithm for 5G Wireless Networks”, Journal of sensor and Actuator Networks, 2022, Vol: 11, pp. 82.

6. Wasan Kadhim Saad; IbraheemShayea; Bashar J. Hamza; Hafizal Mohamad; Yousef Ibrahim Daradkeh; Waheb A. Jabbar, Year: 2021, “Handover Parameters Optimisation Techniques in 5G Networks, Sensors 2021, Vol: 21, pp. 520

7. Feras Zenalden; Suhaidi Hassan; AdibHabbal, Year: 2021, “Vertical Handover in Wireless Heterogeneous Networks, Journal of Telecommunication”, Electronic and Computer Engineering, e-ISSN: 2289-8131, Vol: 9, no: 1 – 2

8. Year: 2015, “Application Based Vertical Handoff Decision in Heterogeneous Network”, 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015), ScienceDirect, Elsevier, Procedia Computer Science, Vol: 57, pp. 782 – 788.

9. Mahmoud M. Elsayeda; Khalid M. Hosnya; Mostafa M. Foudab; Marwa M. Khashaba, Year: 2022, “Vehicles communications handover in 5G: A survey, ScienceDirect, 2022.

10. Izzeldin I. Mohamed; Amran A. Hadi; Md R. Othman; A. Oudah, Year: 2015, “Performance analysis of seamless vertical handover in 4g networks”, Journal of Theoretical and Applied Information Technology, 20th September 2015, Vol: 79, no: 2

11. Payaswini P; Manjaiah D.H, Year: 2014, “Simulation and Performance analysis of Vertical HandoffbetweenWiFi and WiMAX using Media IndependentHandover Services”, International Journal of Computer Applications (0975 – 8887), Vol: 87, no: 4, February 2014, 14.

12. Mandeep Kaur Gondara; Dr. Sanjay Kadam, Year: 2011, “Requirements of vertical hand off mechanism in 4g wireless networks”, International Journal of Wireless & Mobile Networks (IJWMN), Vol: 3, no: 2, April 2011.

13. Mehek-Moutushy Rahman Mou; Mostafa Zaman Chowdhury, “Service Aware Fuzzy Logic Based Handover Decision in Heterogeneous Wireless Networks, 2017 International Conference on Electrical, Computer and Communication Engineering (ECCE).

14. Dr Omar Khattab, Year: 2018, “Vertical Handover Study on 4G Category vs. 5G Category for3GPP Generation Mobile Systems and Non-3GPP WirelessNetworks”, Transactions on Networks and Communications, Vol: 6, no: 2, pp. 1 – 9

15. Imad El Fachтали; RachidSaadane; Mohammed ElKoutbi, Year: 2016, “Vertical Handover Decision Algorithm Using Ants’ Colonies for4G Heterogeneous Wireless Networks”, Journal of Computer Networks and Communications, Vol: 2016, Article ID 6259802, pp. 15.



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

16. Mohammad Arifin Rahman Khan; Mohammed Golam Kaosar; Mohammad Shorfuzzaman; Kire Jakimoski, Year: 2022, “A New Handover Management Model for Two-Tier 5G Mobile Networks”, Computers, Materials & Continua, 2022, Vol: 71, no: 3.
17. Meenakshi Subramani; Vinoth Babu Kumaravelu, Year: 2020, “A fuzzy based vertical handover network selection scheme”, Indonesian Journal of Electrical Engineering and Computer Science, Vol: 17, no: 1, pp. 324 – 330
18. Shidrokh Goudarzi; Wan Haslina Hassan; Mohammad Hossein Anisi; Ahmad Soleymani, Year: 2015, “A Comparative Review of Vertical Handover Decision-Making Mechanisms in Heterogeneous Wireless Networks”, Indian Journal of Science and Technology, Vol: 8, no: 23.
19. Pallavi Sapkale; Dr. Uttam Kolekar, Year: 2021, “Handover Decision Algorithm for next generation”, Easy Chair Preprint.
20. P. Pramod Kumar; K. Sagar, Year: 2019, “Vertical Handover Decision Algorithm Based On Several Specifications in Heterogeneous Wireless Networks”, International Journal of Innovative Technology and Exploring Engineering (IJTEEE) ISSN: 2278-3075, Vol: 8, no: 9.
21. Kusay Faisal Al-tabatabaie, Year: 2019, “Vertical Handover Decision Algorithms in Multi-Wireless Network Systems, International Journal of Engineering Research and Technology. ISSN 0974-3154, Vol: 12, no: 12, pp. 2246 – 2253.
22. Year: 2021, “Performance evaluation of vertical handover in Internet of Vehicles”, International Journal on Smart Sensing and Intelligent Systems, Vol: 14, no: 1.
23. Dong Doan Van; Qingsong Ai; Quan Liu, Year: 2017, “Vertical Handover Algorithm for WBANs in Ubiquitous Healthcare with Quality of Service Guarantees”, Information 2017, Vol: 8, pp. 34
24. Amina Gharsallah; Faouzi Z Arai; M Ahmoud Neji, Year: 2019, “MIH/SDN-Based Vertical Handover Approach for 5G Mobile Networks”, Journal of Information Science and Engineering, Vol: 35, pp. 1161– 1172.
25. Boh Wen Diong; Mark Irwin Goh; Seng Kheau Chung; Ali Chekima; Hoe Tung Yew, Year: 2021, “Vertical Handover Algorithm for Telemedicine Application in 5G Heterogeneous Wireless Networks”, (IJACSA) International Journal of Advanced Computer Science and Applications, Vol: 12, no: 8, pp. 611.
26. Xiaonan Tan; Geng Chen; Hongyu Sun, Year: 2020, “Vertical handover algorithm based on multi-attribute and neural network in heterogeneous integrated network”, EURASIP Journal on Wireless Communications and Networking (2020).



Article Title: Handover in 5G Heterogeneous Wireless Networks: A Comprehensive Review

27. BaofengDuan; Cuiran Li; JianliXie; Wei Wu; Dongmei Zhou, Year: 2021, “Fast Handover Algorithm Based on Location and Weight in 5G-R Wireless Communications for High-Speed Railways”, Sensors 2021, Vol: 21, pp. 3100
28. K. S. Avinash; ArijitUkil; Jaydip Sen, Year: 2010, “Vertical Handoff in Heterogeneous Wireless Networks”, TCS Conference Paper.
29. Mark Irwin Goh; Abbas Ibrahim Mbulwa; Hoe Tung Yew; ArolandKiring; Seng Kheau Chung; Ali Farzamnia; Ali Chekima; Manas Kumar Halder, “Handover Decision-Making Algorithm for 5G Heterogeneous Networks”.
30. Sajjad Ahmad Khan; Mustafa Ergen; braheemShayea; Ayman A. El-Saleh, Year: 2021, “An Improved Handover Decision Algorithm for 5G Heterogeneous Networks”, IEEE Xplore.
31. Qianyu Liu; ChiewFoong Kwong; Sibozhang, Year: 2019, “A fuzzy-clustering based approach for MADM handover in 5G ultra-dense networks”.
32. Jin Cao; Maode Ma; Hui Li, Year: 2018, “EGHR: Efficient group-based handover authentication protocols for mMTC in 5G wireless networks”, 2018.
33. Michele Polese; Marco Giordani; Marco Mezzavilla, Year: 2017, “Improved Handover through Dual Connectivity in 5G mmWave Mobile Networks”, 2017.