Analytical Review and Study on Various Vertical Handover Management Technologies in 5G Heterogeneous Network

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***Abstract*—In recent mobile networks, due to the huge number of subscribers, the traffic may occur rapidly; therefore, it is complex to guarantee the accurate operation of the network. On the other hand, the Fifth generation (5G) network plays a vital role in the handover mechanism. Handover management is a prominent issue in 5G heterogeneous networks. Therefore, the Handover approach relocates the connection between the user equipment and the consequent terminal from one network to another. Furthermore, the handover approaches manage each active connection for the user equipment. This survey offers an extensive analysis of 50 research papers based on existing handover approaches in the 5G heterogeneous network. Finally, existing methods considering conventional vertical handover management strategies are elaborated to improve devising effective vertical handover management strategies. Moreover, the possible future research directions in attaining efficient vertical handover management in a 5G heterogeneous network are elaborated.**

***Index Terms*—Handover, Fifth Generation, Software-defined network, Ping-pong handover, Handover success probability.**

I. Introduction

The next-generation communication structure provides Internet connectivity by several wireless approaches. The usage of various wireless techniques is growing rapidly for the communication system. The 4G Long term evolution (4G-LTE) wireless technologies have several factors, like the accessibility of devices, namely smart phones, notebooks, laptops, and so on, termed Long-term evolution and Wireless Local Area Network (WLAN) various networks simultaneously [1]. 5G is the imminent mobile cellular network technology to enhance the quality of service (QoS), low latency and elevated data rate. However, the 5G network has 10 to 100 times greater base station potential than the current 4G Long-term evolution networks. Generally, 5G network operates on up to the 3 frequency bands such as high, low as well as medium [2]. In the internet mobility management protocols, secure handover of the mobile nodes is an important safety issue. The management of handover reliably and efficiently is a significant challenge for the handover management. The re-authentication process is an important factor for the handover delay, which guarantees a secure network. However, the handover delays affect the cell sizes; therefore, the QoS may be reduced [3, 4].

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DOI: 10.36244/ICJ.2022.2.3

Several handover approaches are recently introduced for various circumstances, but most approaches are unsuitable for inter-domain handover. They failed to concurrently convince the requirements of key agreement, mutual authentication, and several other factors [5]. Thus, soft computing techniques, such as chaos theory [6] [7] [8], neural network [9], genetic programming, and fuzzy controller [8], are extensively used in telecommunication systems [10] [8]. The soft computing methods applied in the 5G systems provide more capacity in traffic controlling and many other systems related to decision making [11]. It is widely used in industry and academia because of advantages, like enhanced energy efficiency throughput, offload cellular traffic, and robustness [12]. Furthermore, the elliptic curve cryptography is also employed for a handover mechanism, enhancing security and reducing latency [13] [14]. The complexity and reduces authentication delay can get reduced by lightweight physical layer authentication approach [15] [14]. Effectual handover management is important in cellular networks extended with small a cell that enables multiple coverage and therefore maximized capacity in certain geographical areas. This work suggests the possible solutions for the handover management issues in 5G heterogeneous network.

The paper is arranged as below: Section 2 describes conventional approaches in the 5G heterogeneous network and the section 3 demonstrates the research gaps and issues of handover mechanisms. Section 4 represents the analysis of handover techniques in terms of utilized software, toolset used, performance metrics, Year of publication, and at last, the conclusion of the paper presents in section 5.

II. Literature Survey

This research considers the various approaches developed for the handover mechanism in 5G heterogeneous networks described in this section. The categorization of handover approaches in 5G heterogeneous networks is shown in Figure 1. Various approaches, such as Radio access-based approaches, self optimization-based approaches, software-defined network-based approaches, authentication-based approaches, eNodeB-based approaches, neural network-based approaches, and blockchain-based approaches, are developed for the handover approaches in 5G heterogeneous networks. The challenges associated with these methods are assessed for motivating the researchers to develop the new handover mechanism for 5G heterogeneous networks.

A. Classification of handover techniques

The homogeneous network is the one in which all the nodes employ the same operation. While in the heterogeneous network, the nodes perform both the function and utility. Besides, the heterogeneous networks based handover offers a better quality of services to the user with high availability of connections. The research works adapted several approaches utilized for handover mechanism in 5G heterogeneous networks are explained below, in Figure 1.

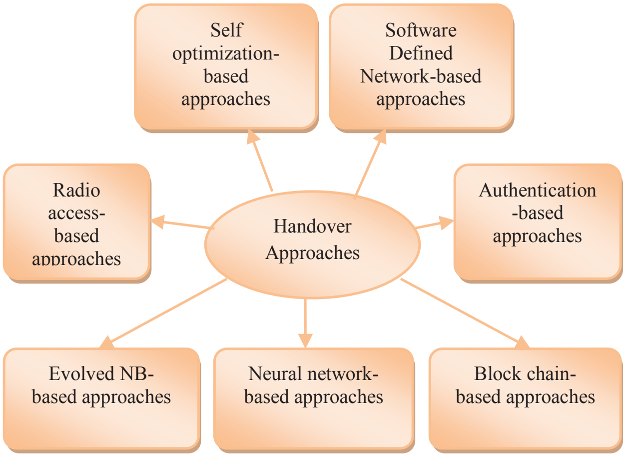

Fig. 1. Classification of Handover approaches

a) Radio access-based techniques

This section describes the Radio access-based approaches applied to manage the handover mechanisms in 5G heterogeneous networks. Zhang et al.[16] developed the cloud radio access network for the handover method in the 5G heterogeneous networks. The coordinated multipoint clustering technique based on affinity propagation was applied to diminish cell edge users' interference. After that, the low complexity handover management method was employed, and the signaling process was analyzed in the heterogeneous network. The coordinated multipoint was employed with the heterogeneous network for enhancing the cell edge user spectral efficiency and system coverage. Combining the handover and clustering methods can rapidly improve the heterogenous network's ability and preserve service quality. However, this method was not developed in the self-organized heterogeneous cloud small cell network for controlling the interference mitigation and handover management.

Stamou et al. [17] presented a context-aware handover approach. This advanced method integrated context-aware theory and multiple attribute decision-making concerning the radio access technique. The preventable handover of user equipment among the radio access technologies was decreased by this introduced method. Here, the developed technique was formed by a context-aware analytical hierarchy process for obtaining weight. Consequently, the Context-aware technique for Order Preference by Similarity to an Ideal Solution (CTOPSIS) method was also employed. The long-term cell association in terms of path loss was included for avoiding computational cost. In addition, the location error method on the global positioning system was also introduced for computing the latency. The developed method was not included the virtualized and programmable design for better efficiency.

Maksymyuk et al. [18] developed the converged access network for handover mechanism in the 5G heterogeneous network. Here, the wireless access segments and the optical backhaul were included with the radio access network. Furthermore, the developed method has a good granularity bandwidth allocation. Moreover, this method permits the channel of cloud radio access network to adapt the radio signals among the remote radio head and baseband processing unit in similar resource blocks. Additionally, the multicast data transmission was also developed to the complicated eNodeB through the mutual task of resource elements for multiple cells. This data transmission was developed in the handover process, which effectively reduces the backhaul traffic. The drawback is that it creates congestion in the network.

Kaloxylos et al. [19] introduced the multi-criteria handover method in the 5G heterogeneous network. This method was used to obtain the essential contextual information and choose the best suitable radio access network. The user equipment gathered the local instance of access network discovery and selection function in this approach. Furthermore, this method involves the fuzzy logic controllers to combine the various inputs, like a load of candidate base station and user mobility. After that, the session launch or per-flow handover was executed based on the third-generation partnership project. Finally, the classification of applications regarding latency and sensitivity was extracted through the user equipment connection manager. They achieved better throughput and delay. The method failed to include a reinforcement learning method for identifying the appropriate thresholds in the fuzzification procedure.

Polese et al. [20] developed the dual connectivity heterogeneous network handover mechanism. The dual connectivity approach allows the mobile user equipment procedure for maintaining the physical layer connections. The uplink control signaling method was joined along with the local coordinator, which allows the path switching in the event of failures. In addition, the utilization of a local coordinator controls the traffic among the cells. The network handover process was utilized for enhancing mobility management in the millimeter-wave network. Finally, the switch decision timing is improved using the busy time to trigger adaptation. The method was failed to use the concurrent millimeter-wave channel measurements for the precise analytical method.

Barmpounakis et al. [21] presented the radio access network method for the handover process in a 5G heterogeneous network. The fuzzy logic method was utilized in the context-aware selection technique for selecting the best suitable radio access technology. Moreover, the network extensions were developed for allowing access to network discovery. After that, the selection function method was employed to provide information about network status. The various groups of parameters, such as mobility, bandwidth, and power consumption, were computed through the network and user equipment. Consequently, the fuzzy logic system was employed for managing the multi-criteria issues. However, the developed method was not included the adaptive sampling rate for optimizing the battery power of user equipment.

Addali et al. [22] developed the Utility-based Mobility Load Balancing (UMLB) technique. This handover method was named the Load Balancing Efficiency Factor (LBEF). The mobility load balancing is employed using the user utility and the operator. Moreover, a centralized controller was also included to balance the small cells. Consequently, for improving the performance of the network, key performance indicators were applied. Finally, an adaptive threshold method was also developed to identify the overload state of small cells. This developed UMLB method decreases the standard deviation by the higher average user equipment data rate. The method failed to observe the impacts of the mobility patterns and user equipment distributions to improve the UMLB method's effectiveness.

A generalized Random-Access Channel Handover (RACH) technique was developed by Choi and Shin [23] for handover in a 5G heterogeneous network. This developed approach obtained the perfect mobility with the absence of a synchronized network. This developed RACH technique combined the Make Before Break (MBB) handover and RACH less handover. The seamless mobility was obtained through the developed RACH technique by relocating from the serving cell to the user equipment. Subsequently, the developed method contains several key features, which correspondingly work along with the long-term evaluation handover, and it also does not influence any other delay factors. Although, this developed method was failed to involve packet duplication for optimizing the path switching.

The rateless properties of the channel conditions are detailed in Mehran et al. [24]. The rateless coding is used for protecting the packets at the physical layer through the noisy channel. The drawback of the rateless channel coding is that it is not applicable for the higher layers because decoding certain information will be lost.

Bogale et al. [25] reviewed the millimeter-wave technologies solve several issues in the 5G heterogeneous networks, enhancing spectral and energy efficiency. It is widely used in high-speed wireless networks and different communication purposes. Besides, large-scale antennas increase the performance of the system. The challenges in the 5G heterogeneous networks are spectral efficiency and energy efficiency to reduce operating costs.

b) Self-optimization-based approaches

The self-optimization approaches employed in the handover mechanism for the 5G heterogeneous networks are detailed in this subsection. Alhammadi et al. [12] introduced the weighted fuzzy optimization technique for handover. It was developed for optimizing the handover control parameters. The developed method used 3 features, namely velocity of user equipment, target and serving base station traffic load, and signal-to-interference-plus-noise ratio. Additionally, the self-optimized handover control parameters and were altered based on these characteristics to enhance handover performance. Although, the developed weighted fuzzy optimization method reduces the handover ping-pong, handover failure, and radio link failure. It also enhances the performance of the system along with various mobile speeds. On the other hand, the developed method was not involved in the cell pair-specific handover offsets for enhancing handover performance. The handover self-optimization technique was introduced for the handover mechanism, but the development was failed to solve the inter-cell interference problem.

Boujelben et al. [26] employed the handover self-optimization technique in the 5G heterogeneous network. This developed approach was utilized for decreasing the consumption of energy. Here, the handover target cell considered the neighbor cell load, user speed, and received signal power for identifying high-loaded cells. However, the developed method has three significant handover decisions: received cell load, user speed, and signal level. Moreover, the universal mobile telecommunication terrestrial radio access network was considered an access layer, and the packet core was considered a control layer. This advanced method was decreased the energy consumption significantly. The inter-cell interference is the major challenge associated with the developed technique.

c) Software-defined network-based approaches

The software-defined network-based handover approaches in the handover mechanism for the 5G heterogeneous network are illustrated in this section. Bilen et al. [27] presented the software-defined network. In this method, the Markov chain formulation was employed for computing the neighbor eNodeB transition probabilities. This method was also applied for selecting optimal eNodeB and also allocated the mobile nodes. Here, the handover failure ratios were also computed based on the user number. Likewise, the observed delays were also estimated by using the densification ratio parameter. Finally, the dual-track estimation approach and allocation strategy were utilized for separating the data channels and control channels. The method was failed to compute the effects of several parameters.

Tartarini et al. [28] developed the combination of software-defined handover decision engine and software-defined wireless networking method for improving the handover in 5G heterogeneous network. Here, the wireless controller was utilized in the baseband pool for receiving the handover information. The controllers published the communication information, and the handover decision was processed for every user optimally. Furthermore, the candidate network selection approach was formulated for solving binary integer linear programming optimization problems. In addition, the adaptive timing approach was also performed to minimize the handover failures, and the unwanted handover was eliminated through user equipment mobility patterns. The developed method has not enhanced the performance by implementing semi-optimal solutions. However, the developed approach failed to improve network performance when higher diversity of network types.

Rizkallah and Akkari [29] introduced a software-defined network for the vertical handover method in 5G heterogeneous networks. By means of exploiting the software-defined network, the data plane, as well as the control plane, were set apart. In addition, the handover signaling message was reduced by using the software-defined network. After that, the software-defined controller was applied for collecting network information. Based on the software-defined controller, the best handover decision was taken, and every network's quality of service was improved.

Alfoudi et al. [3] developed the seamless mobility management method. Initially, a key-value distributed hash table was employed for catching user mobility. It was employed in distributed software-defined controller for addressing the seamlessness and scalability in which the mobile nodes were joined between the correlated software-defined controller. The developed approach was permitted to choose the appropriate access point and the assistance of controllers and mobile nodes. Because of the appropriate access point, the network's performance was enhanced, and the users were satisfied with the required network condition. However, the developed approach was failed to reduce the cell size and enhance security.

In order to conduct the handover procedures in 5G HetNets, multiple-attribute decision-making approaches have also attracted a great deal of interest. More specifically, Liya et al. [30] have shown that eNodeB and many mobile nodes were utilized to maximize the handover count. This advanced method widely reduced the communication time and handover training duration during a handover procedure. Furthermore, for monitoring and performing normal operations, the software-defined controller was applied. On the other hand, the entire operations were managed by a handover controller, and the data plan devices were stated through tables of open flow at the instance of the handover procedure. However, this handover method was not enhanced the execution time.

Hu et al. [31] introduced the intelligent vertical handover process in the 5G heterogeneous network. Here, Media Independent Handover (MIH) and a software-defined network were integrated to ensure a handover, which presents between the two potential networks. After that, the characteristics of the software-defined network were applied to allocate the best networks to obtain the final declaration. This structure correctly chooses an optimal network effectively, decreasing the huge traffic present during the handover procedure. On the other hand, this technique was failed to utilize high-energy transmission approaches for securing backhaul networks. The developed technique was not included the radio resource allocation features for an efficient handover process.

Gharsallah et al. [32] developed the software to define the network-based handover. Here, the network function visualization and the software-defined network were applied for the handover process. Especially, the Software-Defined Handover Management Engine (SDHME) was designed for managing the handover control method. Furthermore, the developed SDHME technique was defined in the application plane of software-defined network structure. In addition, the developed approach was determined the better handover for mobile nodes to increase the quality of service. They achieved a reduced handover failure ratio and delay. The resource allocation is not evaluated for the better optimization of the resources.

Valiveti and Rao [33] presented the exemplary handover method in 5G heterogeneous networks during Device to Device (D2D) communication. The vertical handover process was performed in Content Delivery Network (CDN) using fuzzy logic. Furthermore, the Cramer-Shoup Key Encapsulation Mechanism (CS KEM) was utilized to provide security to users. In addition, the quality of service parameters, such as coverage area, security, and handover mechanisms, was enhanced. Here, the fuzzy rule was employed for handover management, and also L7 switch was utilized for reducing the load. The parameters, like signaling overhead, the number of handovers, signaling cost, end-to-end delay, bandwidth, and throughput, were considered for better D2D communication. However, the developed method failed to improve the network capacity and the energy efficiency.

Sadik et al. [34] introduced the software-defined handover. Here, the software-defined network and the fuzzy logic system were integrated for helping D2D communication. After that, user equipment decides the final handover decision to choose the better network in terms of predicted quality of service. Finally, suitable power control and frequency reuse was employed to increase network capacity and reduce interference. Additionally, the software-defined network was utilized to enhance the handover decision and reduce the decision phase delay and network detection. They achieved delay tolerance in service, whereas single point failure and security is the challenge of the SDN handover approach.

Yaseen and Al-Raweshidy [35] developed a handover mechanism in a 5G heterogeneous network. Here, the tag was generated for identifying the mobile nodes with media access control. Based on the identity of media access control, the mobile node tag was created for controlling the packets inside the mobile network. In the software-defined network, the application layer was performed for managing the interactions of controlling data. Similarly, the control plane was performed for controlling the forwarding decisions and rules of network data. They achieved low packet loss and delay for seamless communication. They failed to consider the registration delay of the network.

The capability-based privacy protection handover authentication method was introduced by Cao et al. [36] in 5G heterogeneous networks. The developed approach was the combination of software-defined network and user capability. Moreover, this technique was employed for obtaining the key agreement and mutual authentication among the base station and user equipment with decreased authentication handover cost. Furthermore, the method effectively protects various mobility scenarios, like intra radio access technology and inter-road access networks. They achieved reduced communication cost and computational cost. Besides, the developed method is efficient and secure handover compared to the existing systems. However, it doesn't withstand unknown attacks.

Kukliński et al. [37] presented the software-defined network for handover management in a 5G heterogeneous network. The centralized or semi-centralized plane was executed to obtain the handover and scalability issues. Subsequently, the centralized technique was employed for reducing the number of messages in the handover process. Finally, handover parameters based on various input parameters and data control were jointly optimized for transmission resources. They evaluated the procedure execution time and the handover execution time. The execution time of handover is higher for the inter-switch handover, which is the drawback of the developed methodology.

Duan and Wang [38] developed the software-defined network for handover mechanism in the heterogeneous network. The developed technique was utilized for enabling privacy protection and authentication handover. The privacy protection was enabled between the correlated access points. Furthermore, the developed software-defined network provides the reconfigurable network management platform and reduces the authentication handover latency. They evaluated the authentication delay and utilization rates. The single point failure and security is the challenge of the SDN handover approach.

d) Authentication-based approaches

This section portrays authentication-based methods employed from the various existing handover mechanism for 5G heterogeneous research. Om and Kumar [1] applied the Universal Subscriber Identity Module (USIM) and Elliptic Curve Cryptography (ECC) for the handover mechanism in the 5G heterogeneous network. A uniform handover authentication approach was also applied along with pairing approaches, and it was used in mobility improvements, like WLAN. The developed method provides secure communication between the visited access point and user equipment in handover authentication. Moreover, the developed method was also offered enhanced computational and communication costs. A handover authentication method was adopted between the access points and mobile users to obtain mutual authentication among the user and target network. Finally, the session key was also computed among the access point and mobile user to attain secure communication. They achieved reduced storage and computation cost. Besides, it provides security against various attacks. While handovering for both the formal and informal security attacks they achieved better communication and storage costs with better authentication. The evaluation is performed on the basis of normal order is the drawback of the developed method.

Cao et al. [39] introduced the secure and efficient reauthentication and the group-based handover authentication procedure for 5G heterogeneous networks. The developed approach includes four stages for efficient handover. Moreover, this approach was used for obtaining robust security protection more effectively. At last, a detached session key was integrated into the network and the machine-type communication devices to attain the subsequent communications. They achieved better security with ideal efficiency. The developed method provides authentication against only some of the unknown attacks.

Ozhelvaci and Ma [4] presented the vertical handover approach for secure communication. The advanced authentication method can obtain strong, mutual, and quick authentication. Here, the certificate from a certification authority was obtained through the authentication server and user equipment. Moreover, a validation was present in the certificate of the user equipment to begin the communication among the server. Finally, the software-defined network was also applied to compact the rising requirements of wireless mobile networks, like mobile fog computing, e-health services, UAV systems, and vehicular communications. They achieved mutual authentication with security and integrity, but the method resists only the passive attacks.

Ma and Hu [14] developed the cross-layer collaborative handover. The method was designed using the upper layer and physical layer of cryptographic approaches for obtaining more reliable and rapid authentication. However, cryptographic approaches can attain high-security objectives, like data integrity, non-reputation, and data confidentiality. Initially, the handover authentication was performed in the physical layer, and then the Kolmogorov-Smirnov theory was applied through developing physical layer behaviors of the wireless channels. After the initial authentication process, the key agreement mechanism and extensible authentication protocol were also developed for obtaining more dependable security. They achieved efficient computational resources with more reliable security and reduced handover delay. The method failed to implement the distribution parameters.

Lee and You [40] employed the security method for the handover approaches. The ticket-based secure handover approach was also employed for the Fast PMIPv6 protocol (F-PMIPv6) protocol. Then, ticket encircling authentication protocol was applied in the mobile nodes for quick handover authentication. Additionally, SPFP has supported the mobile node ambiguity for conserving location privacy. The developed approach was also decreased the quantity of the authentication correlated message connections with the authentication server. The developed SPFP approach was mainly utilized for various security needs. The authentication latency, handover failure probability, handover latency, and buffered packets were also computed for finding the efficiency of the developed SPFP approach. However, the developed method was failed to decrease handover latency.

Fan et al. [41] employed a secure region-based handover technique in the 5G heterogeneous network. The developed region-based fast authentication protocol was applied to reduce communication and computation costs with no core network elements. Furthermore, the protocol assures the uniqueness of anonymity among communication footprints. After that, revocation of user membership was performed through the gathered one-way hash, and it was eliminated the computational cost in the 5G heterogeneous system. This developed approach was decreased the handover latency effectively through region-based secure handover. This advanced method was also satisfied the security conditions of each user. On the other hand, the developed approach did not include performance analytics and key management for providing security.

e) Evolved nodeB-based approaches

The eNodeB-based approaches in the handover mechanism for the 5G heterogeneous networks are detailed in this section. Zhang et al. [42] developed the Control/User Plane Split (CUPS) for executing the handover between the two neighbors. In the overlapping sector, the eNodeB was applied to reduce the failure of handover between two neighbours. In addition, the user equipment was preserved dual connectivity among the two neighbours. Subsequently, the user equipment was managed by the real connection. This method has improved the dependability of communication systems and also attains the better performance of handover. Besides, the handover outage is reduced. The drawback of the method is, the handover decision signaling, and control information is not considered for the analysis.

Huang et al. [43] employed the dynamic Femtocell gNB (F-gNB) on/off system for the handover process in a 5G heterogeneous network. This technique was effectively improved the energy efficiency of the network through calculation of traffic load. The developed optimization technique was detached into two levels. Furthermore, the developed CALB approach was protected the minimum SIR requirements of user equipment and load balancing. In addition, the introduced DFOO method includes the base station operation as per the forecasting time. At last, the dual connectivity-based perfect handover technique was introduced to protect the transmission of quality of service and user equipment. They analyzed the load prediction SINR requirements, and hence improved the QoS of the network. The simulation time increases with the increase in learning time is the drawback of the method.

Bilen et al. [44] developed the optimal eNodeB selection approach. The gain function was computed with dynamic weights for selecting the candidate cells. Here, the Kriging Interpolator and Semivariogram analysis were evaluated by the autoregressive method in spatial estimation to choose the optimal eNodeB. The Kriging Interpolations statistical and stochastic behaviors offer the best modeling performance. The unidentified indicator value of mobile user equipment was also computed through the definite values of neighbor user equipment. Every operation was executed using the developed enodeB estimation entity, which correlates with every network node. In addition, these evaluations were also employed in both control and data channels separately. They reduced the unnecessary, frequent, and ping-pong handover risk, but it doesn't change the throughput.

Islam et al. [45] devised an Integrated Access Backhaul (IAB), allowing to extend coverage by providing wireless backhaul. Besides, the partition between the nodes may change concerning the demand of the network, which is not possible in the fixed access network. Hence, they have a substantial impact on providing seamless connection and avoiding frequent handovers in HetNets. It also reduces the fiber deployment and reduced interference because of narrow beamwidth. The method failed to solve the mixed-integer linear programming (MILP) problem.

f) Neural network-based approaches

The research that used neural network-based techniques is illustrated in this section. Semenova et al. [8] applied a neuro-fuzzy controller for improving the handover mechanism in 5G heterogeneous networks. This controller was developed with three linguistic variable inputs concerning the network's signal strength. In addition, the adaptive fuzzy interface structure was utilized to decrease the handover breakdown rate in the 5G heterogeneous network, and hence the QoS was also enhanced. At last, the adaptive network fuzzy interference systems application was also utilized to enhance the attachment point selection process and avoid useless handovers. On the other hand, the developed method was not considered the other effective parameter for improving the accuracy.

Maksymyuk and Shubyn [9] employed the Recurrent Neural Network (RNN). Here, the neural network was executed using user mobility knowledge to offer maximum efficiency. Consequently, the gated recurrent unit-based neural network was also applied to enhance the performance of the developed system. In addition, the mobility load balance was also executed by locating a cell individual offset parameter. Additionally, the gated recurrent unit-based neural network was adapted for finding the movement of the subscriber. They predicted the traffic in the NN network and achieved an accuracy lower than 90%. Besides, the network parameters are not evaluated to check the efficiency, and benchmark data are also not used.

Morghare and Mishra [46] presented the neural network-based handover approach. Here, the Particle Swarm Optimization (PSO) approach was employed with the neural network scheme. The developed scheme was applied for fast delivery handover route and network selection for increasing the system efficiency. However, a huge amount of secondary users was also considered in a network to enhance the system's efficiency. Additionally, the developed neural network method was adopted for solving an optimization problem and network selection problems. At last, the network selection for the handover route and free route was identified for transferring data. They achieved a better fitness value with a reduced number of iterations while considering the interference and the population size. The method failed to consider the security and the malicious attacks of the network while handovering the mobile terminal.

g) Blockchain-based approaches

This section depicts the blockchain-based techniques gathered from the various existing handover methods in 5G heterogeneous network research works. Ma and Lee [47] developed the blockchain scheme for the 5G heterogeneous network handover process. In this method, Parallel Block-chain Key Derivation Function (PB-KDF) was applied, which controls the principles of Bitcoin blockchain for supporting the key derivation process structurally. Furthermore, the PB-KDF helps to enhance the handover performance. After that, the blockchain outside the crypto-currency realm was utilized to improve the security of the system. In this case, the mining process uses the handover key for supporting full backward and full-forward partition. Therefore, the developed PB-KDF technique enhances the performance of the handover and the security of the handover. They achieved better security in the intracellular handover phase but failed to consider the computation complexity because the key management produces the computation overhead and is not included in the processing phase.

Yazdinejad et al. [48] employed the blockchain-enabled authentication handover method in the 5G heterogeneous network. In addition, heterogeneous network management and the software-defined network were employed for maximizing programmability. In this method, the encryption resources were also utilized for preserving the security privacy of the user. Furthermore, the introduced technique was utilized to reduce the preventable re-authentication in recurrent handover among heterogeneous networks. The software-defined network was also adopted to protect the user's privacy and supply intelligent control among the heterogeneous cells. The optimized energy consumption and scalability are achieved, but the security, data leakage, and delay prevail while handovering, which is considered as the drawback of the system.

Zhang et al. [5] introduced a universal and robust handover approach. This developed approach was used to manage the key agreement. Furthermore, this robust, seamless method was used to obtain a universal handover authentication management. The randomness secrecy, key escrow freeness, and several factors were attained through the developed method. On the other hand, computation efficiency and communication efficiency were also enhanced by this developed scheme. However, the developed method was failed to provide mobile user-friendly and secure design handover authentication methods in 5G heterogeneous networks.

h) Other handover mechanism approaches

In this section, the other handover approaches applied for the 5G heterogeneous networks are explained below. Arshad et al. [2] developed the aware skipping technique for the 5G heterogeneous network handover mechanism. Here, the two-tier network was preoccupied with the poison cluster process, whereas the single-tier cellular network was preoccupied with a poison point process. Moreover, the introduced technique utilizes the cell size and user position to make the handover assessment, and thus the avoidable handovers were evaded easily. In the two network states, handover on user throughput was computed, which portrays the efficiency and gain of the developed approach. The applied method was failed to consider the tractable analysis for finding accurate efficiency.

Mahardhika et al. [49] applied the multi-criteria metrics for the vertical handover decision in a 5G heterogeneous network. This advanced method contains three network interfaces and the metrics, like network occupancy, traffic class, mobile speed, and received signal strength, were considered for vertical handover. The equal priority approach was applied to avoid the unnecessary usage of network resources and balance the traffic load for every complex network, thus enhancing accuracy. After that, the mobile priority approach was employed for balancing the network function. Finally, the network priority approach was utilized for reducing network blocking probability. However, the developed technique failed to integrate other handover methods, like fuzzy logic, for improving the network's performance.

Chandavarkar, and Guddeti [50] introduced the simplified and enhanced multiple attributes alternate ranking approach. This method has effectively reduced the feature normalization and weight estimation dependency, thus enhancing the network selection reliability. After that, the network score and rank were computed to avoid rank reversal issues. Therefore, the developed multiple attributes ranking technique was applied for network selection and solving rank reversal issues. The developed method was not utilized the network simulator for effective performance analysis.

Ouali et al. [51] employed the D2D handover management approach in 5G heterogeneous network. The developed D2D approach permits the mobile terminals to communicate directly with no base station connections as well as, this developed approach has fulfilled the quality of service requirements. Furthermore, it was applied for computing the performance of handover with the practical Reference Point Group Mobility (RPGM) structure. Finally, the spectral expansion technique was employed for attaining the precise solution. Although the developed approach failed to consider D2D relay concerns to enhance the simulation.

Ahmed et al. [52] developed a handover approach for secure communication. This method was mainly applied to offer connectivity to mobile users everywhere. Here, the handover decision approaches were classified into five types based on the parameters. The received signal strength-based handover decision method was applied for providing low cost and high bandwidth. Furthermore, the users handle the different traffics, such as multimedia, data, and voice streams.

He et al. [53] introduced the adaptive handover trigger approach. Initially, the clustering and mobility pattern detection of the mobile node. After that, using the outcome of clustering, the multiple hidden Markov models were trained to determine the grid sizes. At last, the correspondence among every cluster center and test route was identified using the hidden Markov models. Consequently, the Adaptive Received signal strength Prediction (ARP) approach was performed for predicting the strength. The technique was failed to enhance the predication efficiency for the developed adaptive handover

Liu et al. [54] employed a fuzzy-based handover approach. This developed fuzzy clustering approach integrates multiple attributes decision approaches and fuzzy logic to ensure a handover mechanism. At first, the optimal neighboring base station at the handover target was selected. The handover target can compact efficiently with multiple conflicts characteristic. After that, the decision engine closeness coefficient was utilized for determining the triggering timing. Here, the triggering method was permitted the base station for deciding the triggering time. The subtractive approach was executed to detect the membership functions in fuzzy systems. Using this, the maintenance cost and the optimization cost is reduced and the number of handovers is also reduced. The security issues are not considered and network performances are not analyzed.

Danyang et al. [55] presented the effective handover technique and a comprehensive load index in the 5G heterogeneous network. Here, handover parameters were utilized for selecting the network, and it was divided into several modules. Moreover, the triangle module fusion operator was employed for total network load and optimized the switching method. Additionally, this technique was deployed for controlling higher-level user satisfaction as well as for reducing handover frequency. Finally, the block calculation technique was applied in this method to enhance the execution time of the system. The developed handover approach was failed to offer better QoS because of the heavy load.

Fang et al. [56] introduced the Long-term evolution-based handover approach. In this technique, U-plane and C-plane were differentiated to resolve crucial handover problems. Here, the gray system theory was employed to develop handover trigger decisions and predict several values to take the decision. In addition, different signaling was executed through a physical downlink shared channel, and it was planned through the channel. The other signaling element was utilized to generate and control the communication to ensure reliability. This method was failed to include Doppler Effect to manage handover problems.

Chopra et al. [57] developed a technique for handover in a 5G heterogeneous network. The thermal pattern approach was utilized to compute the precise position. Additionally, secrecy capacity analysis was executed on mobile user equipment with the consideration of various channel losses. Here, the thermal pattern-based tracing approach was utilized for effectively identifying low-security regions.

Lahby et al. [58] introduced the k-partite graph-based handover approach in the 5G heterogeneous network. Initially, k-partite graph theory was employed for representing the vertical handover problems. Here, the deployment of access points and user dynamics was considered through a mobile network operator. After that, the robust analytic hierarchy process was performed for calculating the weight of every edge. Finally, Dijkstra's technique was executed for identifying the better paths based on QoS. The packet loss and the delay are reduced with an increase in throughput value is achieved, but the computational cost and complexity are not analyzed. Besides, secure handover is also not analyzed.

III. Analysis and Discussion

This section illustrates the analysis and discussion of vertical handover approaches in 5G heterogeneous networks using various research papers based on the utilized dataset, categorization of techniques, performance evaluation metrics, and publication year.

A. Analysis based on approaches

This section represents the review using several vertical handover approaches in 5G heterogeneous networks. Several approaches devised for the vertical handover are shown in Figure 2. From Figure 2, it is recognized that 24% of the researchers utilized software-defined network-based approaches and 19% of the researchers are created radio access-based approaches. Moreover, an authentication- based approach was used by 13% of researchers, and 21% of the research works are based on other approaches. Likewise, 7% of the researchers utilized the neural network-based, 6% of the research works are based on blockchain-based, and eNodeB-based approaches, and the remaining 4% of the researchers developed self-optimization-based approaches. Hence, from this analysis, software-defined network-based approaches are extensively utilized for vertical handover in 5G heterogeneous networks.

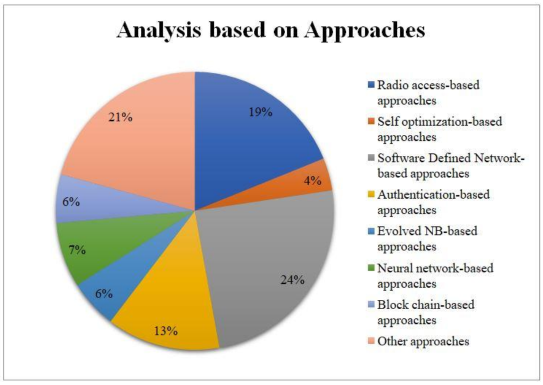

Figure 2. Analysis based on approaches

B. Analysis in terms of toolset

The different tools used by the traditional methods for the evaluation of the developed method are detailed in this section. The analysis in terms of several tools applied is displayed in Figure 3. The software toolsets employed in the research papers are Monte Carlo simulations, MATLAB, Java Pairing Based Cryptography (JPBC), Pro Verif tool, High-Level Protocol Specification Language, AVISPA, BAN logic, OMNeT++ simulator, Scyther, INET 3.6.4 framework, NS-3 simulator, system-level simulation, Java Cryptography Extension (JCE), and Mininet emulator. Based on Figure 3, it is realized that MATLAB is the widely used software toolset for evaluating the vertical handover approaches.

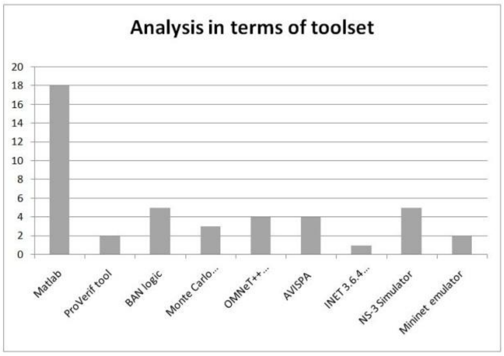

Figure 3. Analysis based on the toolset

C. Analysis based on publication year and the source

This section displays the analysis based on published years. The analysis using the published Year is represented in Table I. Out of the 50 papers surveyed, more number of research papers was published in the Year 2019. The analysis based on the publications is summarized in Table II. In IEEE journal more number of papers was published regarding the handover mechanism.

TABLE I
ANALYSIS USING PUBLISHED YEAR

Year	Journal	Conference
1999	2	-
2012	1	-
2013	1	-
2014	1	3
2015	3	4
2016	3	1
2017	7	4
2018	5	2
2019	15	5
2020	1	1

TABLE II
ANALYSIS BASED ON PUBLICATIONS

Publications	Journal	Conference
IEEE	20	5
Elsevier	7	-
Springer	2	-
KeAi	2	-
Hindawi	1	-
IAENG	1	-
Publons	2	-
Wiley	1	-
TUCS	2	-
Others	1	14

D. Analysis in terms of employed datasets

The analysis concerning the used dataset is detailed in this section. The precision and the legitimacy of the algorithm are validated effectively based on selecting the suitable dataset. Hence the best dataset selection also influences the performance of the system. Figure 4 shows the analysis of various datasets. The commonly utilized datasets in the vertical handover approach in 5G heterogeneous networks are Oracle, multi-dimensional radio-cognitive databases, GitHub, base station parameters, horizontal plane of artificial intelligence, Trajectory set, Fuzzy Logic Inference Systems, linguistic variables. From Figure 4, it is understandable that the most continually utilized dataset is Fuzzy Logic Inference Systems.

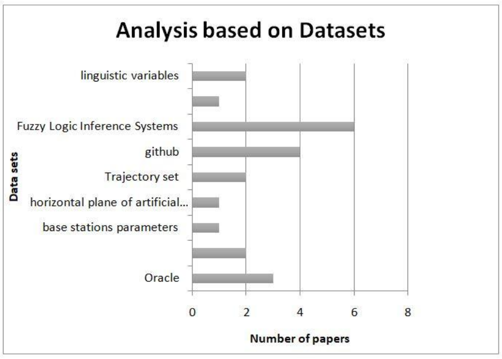

Figure 4. Analysis based on datasets

E. Analysis in terms of evaluation metrics

The performance metrics, such as ping-pong handover, spectrum efficiency, bandwidth, computation cost, communication cost, throughput, number of Handovers, handover failure, traffic overhead, packet loss, accuracy, signaling overhead, and handover success probability are considered for vertical handover approaches in 5G heterogeneous networks. From Table III, it is observed that the number of handovers, handover failure probability, handover success probability, and ping-pong handover are usually chosen performance metrics.

TABLE III
ANALYSIS USING EVALUATION METRICS

Performance metrics	Number of Research papers
Ping-pong handover	[16] [11] [12] [51] [44] [54] [56] [34] [23]
Spectrum efficiency	[16] [57]
Bandwidth	[27] [39] [36] [19] [20] [33]
Computation cost	[1] [36] [47] [5] [41]
Communication cost	[1] [39] [36] [5] [41]
Throughput	[2] [28] [43] [34] [58]
Number of Handovers	[27] [17] [29] [49] [26] [38] [52] [54] [31] [40] [19] [21] [33] [34] [35]
Handover failure probability	[2] [28] [11] [51] [52] [53] [44] [30] [40] [56] [32] [21] [34]
Traffic overhead	[3] [18]
Packet loss	[44] [40] [21] [58]
Accuracy	[9] [46] [40] [57] [58]
Signaling overhead	[29] [48]
Handover Success probability	[42] [29] [51] [52] [53] [30] [48] [40] [56] [20] [34]

F. Analysis based on the handover failure probability

The analysis in terms of handover failure probability is illustrated in this section. Furthermore, Table 4 portrays the review in terms of handover failure probability is specified by five ranges. From the below Table, it is recognized that the research papers [2] [56] obtained better handover failure probability within the range of 90% - 99%, and the research papers [51] [30] had less handover failure probability within the range 50% - 59%. When a handover failure happens the interruption time maximizes considerably to more than hundreds of milliseconds. Hence, to fullfil the requirement in as numerous cases as possible, we need to reduce the rate of handover Failure as close to zero as possible. As the network density increases, the frequency of handover increases that might outcome in higher handover failure rates.

TABLE IV
ANALYSIS USING HANDOVER FAILURE PROBABILITY RANGE

Handover failure probability range	Number of Research papers
50% - 59%	[51] [30]
60% - 69%	[52] [53] [34]
70% - 79%	[28] [44] [32]
80% - 89%	[11] [40] [21]
90% - 99%	[2] [56]

IV. CONCLUSION

In this study, a survey is done on various vertical handover methods in the 5G heterogeneous network. The reviews are collected from several research papers that categorized into Radio access-based approaches, self optimization-based approaches, Software Defined Network-based approaches, Authentication-based approaches, eNodeB-based approaches, Neural Network-based approaches, and Block chain-based approaches. The review of the traditional methods suggests future works for the vertical handover approaches in the 5G heterogeneous network by considering several research gaps and problems. The analysis of the survey is represented in terms of categorization techniques, utilized toolset, datasets used, and evaluation metrics. From this analysis, it is reviewed that a software-defined network-based approach is commonly used in research papers. Similarly, MATLAB is a frequently utilized software tool, and the fuzzy logic interference system database is a generally used toolset in the existing papers. Likewise, the number of handovers, handover failure probability, handover success probability, and ping-pong handover are the most generally used performance metric in most of the research papers.

Besides, the proposed review helps the researchers to identify the research gaps and devise the new technique to overcome the challenges faced by the existing systems. The performance of the heterogeneous network is enhanced by reducing the delay and energy consumption. The context-aware and QOS aware networks are flexible and are the most preferable for the vertical handover.

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