

A Data Driven Automated Handover Mechanism For Iot Networks

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Abstract— With the increase in data traffic in IoT networks, handover in networks has become imminent as a single multiple access technique may not perform satisfactorily under all conditions. Therefore, selecting efficient multiple access mechanisms is essential to optimise the use of available bandwidth. It is important to implement a switching or handover mechanism to ensure excellent service quality, capable of selecting the most efficient multiple access approach according to channel conditions. Given the characteristics of wireless networks, it is essential to continuously assess them and choose the most suitable technique to achieve optimal Quality of Service (QoS). Advancements in machine learning and deep learning have enabled more efficient predictions of channel state information, resulting in improved system performance metrics. This research introduces a machine learning-augmented handover methodology for software-defined networks in next-generation wireless networks. This study proposes the simultaneous sensing of primary and secondary multiple access techniques for wireless networks, with a transition to the one offering superior QoS. Nevertheless, the principal access method must be prioritised to enhance system efficiency. The simulations conducted account for the path loss factor and SINR conditions in a realistic network setting.

Keywords— Internet of Things (IoT), Machine Learning, Handover, SINR, Path Loss, BER

I. INTRODUCTION

A new paradigm in wireless communications has emerged, one that goes beyond 5G and opens up a world of possibilities including the internet of things, digital clones, considerable automation, and the metaverse. [1]. However, the viability of these modern notions is contingent upon the availability of sufficient bandwidth and effective management of the spectrum in wireless networks. Given the restricted availability of bandwidth, it is crucial to efficiently utilize the available bandwidth to fulfill the following requirements [2]:

- 1) Growing user base.
- 2) As more multimedia material must be transferred, the demand for additional bandwidth has grown..
- 3) Requirement for fast data transmission speeds.
- 4) Restricted bandwidth availability.

The need for interconnected devices being diverse in nature makes IoT indispensable from future generation wireless networks. Increasing user count and data congestion makes the challenge more complex to handle with limited bandwidth. In order to meet the demands of future generation wireless networks, it will be necessary to continuously monitor and adhere to quality of service (QoS) requirements. Although there are various multiple access approaches available to support the growing number of users, relying on a single technique may not result in satisfactory quality of service metrics. Consequently, it's important to develop handover procedures that can be used to switch techniques automatically in the event that one of their parameters starts to degrade [4]. There is an additional communication architecture that allows for the connectivity of various devices, alongside cellular and IoT networks, also poses a challenge of handling copious amount of data simultaneously [5]. Traditional wireless networks are undergoing reconfiguration to become software-defined networks (SDNs). Therefore, the most suitable approach for automatic handover mechanisms would be to automate the process through a mechanism typically suited to SDNs. The basic architecture of the network can be viewed below [6]:

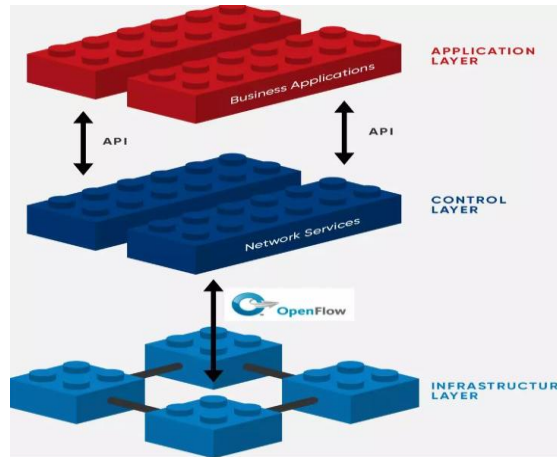


Fig. 1. Conceptual framework for SDNs

The infrastructure is where SDN differs most from traditional networks. While traditional network control is based on hardware, software-defined networking is software-only. Broadband wireless networks that work for everyone. Universal wireless networks require [7]:-

:

1. The coordination and regulation of transportation systems and services.
2. Channel configuration that is capable of adapting and changing in real-time.
3. Swift client re-association.

II. GLOBAL SCENARIO

Ericsson, Huawei, Nokia, and Qualcomm, among others, are pouring resources into research and development to create innovative handover solutions [8]. In order to develop, test, and eventually deploy new technologies, these businesses team up with educational institutions. One example is the use of field trials and pilot projects to test how well handover algorithms work in actual scenarios [9]. The algorithms are improved and fine-tuned through the insights obtained from these collaborations [10].

For wireless networks to progress, research on handover optimization and management at a global level is essential. Research into handoff management will continue to focus on developing smarter, more adaptive systems through increased integration of AI and ML [11]. Academic institutions and industrial organizations in India are driving research in handover management and optimization. Research into cutting-edge handover methods is being spearheaded by prestigious academic institutions. Improving service quality (QoS) and user experience is the primary goal of their study into handoff optimization [12]. A more robust research landscape, with practical applications and innovations, is the result of collaborative efforts between university and telecommunications corporations such as Bharti Airtel, Reliance Jio, and Vodafone Idea [13].

The development of algorithms and protocols for efficient handover management has achieved significant breakthroughs. To reduce latency and find the best handoff places, researchers in India are looking into machine learning and AI [15]. One example is the possibility of proactive and flawless handovers made possible by AI analysis of user movement patterns and network circumstances, as shown in research. Research on enhanced mobile broadband (eMBB) and ultra-reliable low latency communication (URLLC) has also benefited from the advent of 5G and 6G networks in India [16]. Collaboration on research and pilot projects allows for the creation of strong handover solutions that are specifically designed to meet India's needs, whose concepts can be extended worldwide.

Maintaining an appropriate quality of service metric is the main objective of handoff. A measure of the systems' service quality is the frequency with which they experience outages. Poor service quality is more likely to occur as a result of the outage. The system's BER and SINR are the primary factors that determine the frequency of the outage [17]. Many approaches use the CCDF function to represent the system outage, which is typically dependent on SINR, path loss and UE density, given by:

$$\text{Prob}(O) = f(\text{SINR}, \sigma, \lambda) \quad (1)$$

Here,

O denotes outage.

Prob denotes probability.
 σ denotes shadowing.
 λ denotes UE density.

The CCDF would be expresses as:

$$ccdf(O) = 1 - cdf(O) \quad (2)$$

SDNs face a significant obstacle in the form of multipath propagation and fluctuating media conditions, such as fading. The aforementioned issues arise as a consequence of the following factors [18]:

- 1) Decreased strength leading to subpar service quality.
- 2) The increase in bit and packed error rates leads to the outage of the SDN system.
- 3) Significant delays and somewhat limited data transfer rate.

Automatic failover and handoff capabilities are common in most SDNs. A system can initiate a handoff to another system if its performance starts to fall behind that of the other system. [19]. Automated handover mechanisms aim to utilize CSI to determine quality of service (QoS) parameters that regulate the process of handover [20]. The shift from *Access Technique: 1* to *Access Technique: 2* would be purely governed based on channel and QoS metrics sensed iteratively [21].

III. METHODOLOGY

QoS enabled handover would mean iterating the channel sensing mechanism to attain the recent CSI for the multiple access techniques and then deciding which one would be the best suited for the present data transfer mechanism.

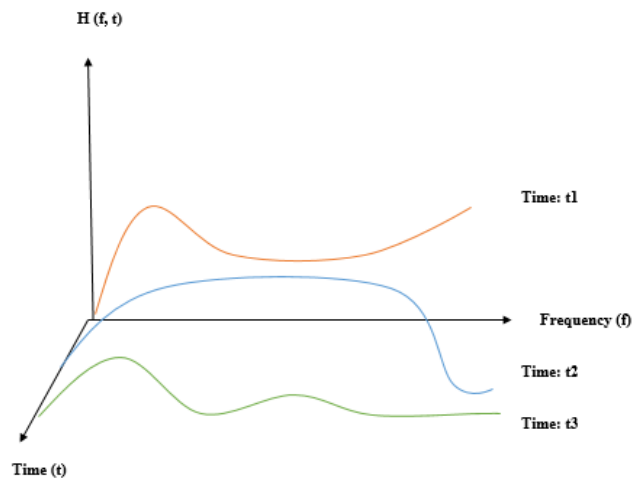


Fig.2 A typical CSI variation

Typically, the CSI needs to be estimated regularly based on the iterative sensing of the channel, would obviously needs a lot of data overhead. Advancements in VLSI technology and advanced machine learning algorithms being implemented on the same have aided analysis of massive amounts of data is now feasible, thanks to advancements in chip fabrication and processing power [22]. It may be nearly impossible to use traditional statistical models to analyze huge and complicated data sets, but machine learning (ML) algorithms can do it extraction, and there are numerous hidden layers.

Handover optimization using machine learning is a method that use artificial intelligence and data-driven models to improve the efficiency and efficacy of the handover process in wireless communication networks, specifically in cellular networks. The objective is to optimize network performance, reduce latency, and enhance the overall user experience by making intelligent handover decisions. Iteratively enhance and optimize the machine learning models using up-to-date network data and performance feedback. This enables the models to adjust to fluctuating network conditions and user behaviors.

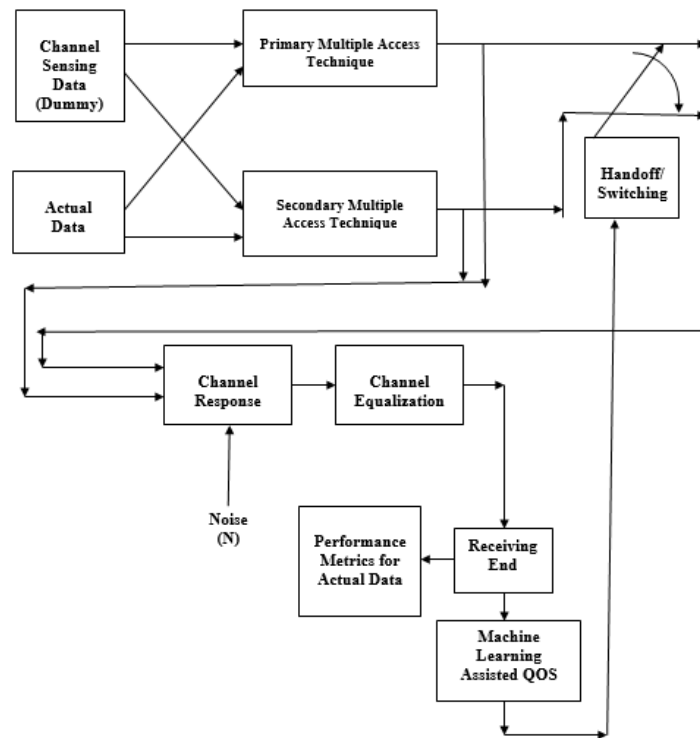


Fig.3 Proposed System

Figure 3 presents a decision-making algorithm in which the machine learning model assesses the present condition of the network and user context to ascertain whether a handover is required. If a handover is deemed necessary, the algorithm will determine the most suitable cell or access point for the handover. Therefore, the utilization of machine learning for handover optimization has the capacity to greatly enhance network efficiency, decrease the occurrence of dropped calls, and improve the overall user experience in wireless communication networks. Nevertheless, it necessitates meticulous planning, constant surveillance, and ongoing refinement to uphold its efficacy as network conditions change. Data packets may be buffered or duplicated to ensure a seamless transition, minimizing data loss during the handover. One of the flip sides of the approach happens to be the system overhead for the method in which the training data is the additional expense which is used to estimate the channel. It can be measured in terms of the number of pilot bits. The iterative process would yield the periodic time frequency data as [23]

$$X_T = \sum_{i=1}^N H(t, f - iT, f), \forall i \in 1:N \quad (3)$$

Here,

X_T denotes the overhead training data.

$H(t, f)$ denotes time frequency dependent channel response.

The sensing of the channel is to be done iteratively for the machine learning algorithm trying to decide the approach to be used based on the following logic

$$\text{for } i = 1:nT_s \quad (4)$$

$$\text{if } (BER_{\text{Technique 1}} < BER_{\text{Technique 2}})$$

Stick to Technique 1.

Else

Invoke Handover

Here,

T_s is the sensing time interval.

This approach is to be continued continuously so as to iterate over the complete time range.

IV. SIMULATION RESULTS

Simulations have been carried out on MATLAB recreating a real life scenario with noisy channel conditions. When it comes to fading, the user who is furthest away from the receiver will typically experience it the worst. Differentiating between close and far users is possible with the use of the path loss factor. Here, AWGN with a frequency-invariant noise psd is the noise condition under consideration. To determine when to hand over control, use the system BER, which is based on the automatic fallback method. We derive the overlapping BER curves for the near-user and far-user scenarios. Whichever technology you choose, make sure it has a lower BER curve. The following designations are made:

NE: Near User

FE: Far User

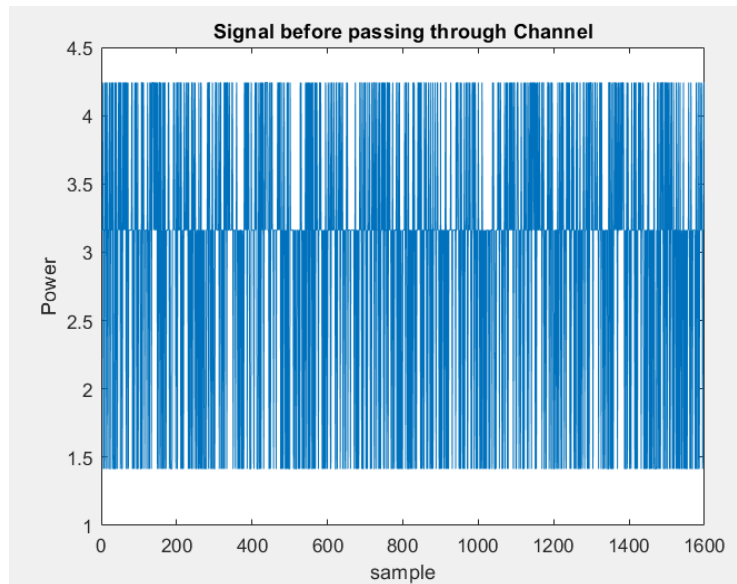


Fig.4 Transmitted binary signal

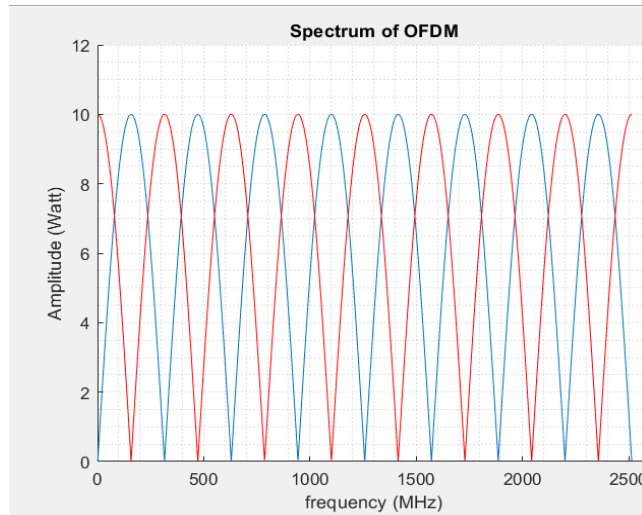


Fig.5 OFDM Transmission

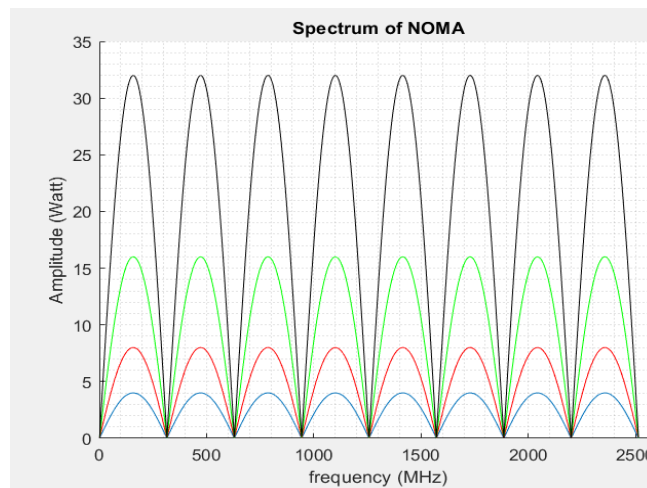


Fig.6 NOMA Transmission

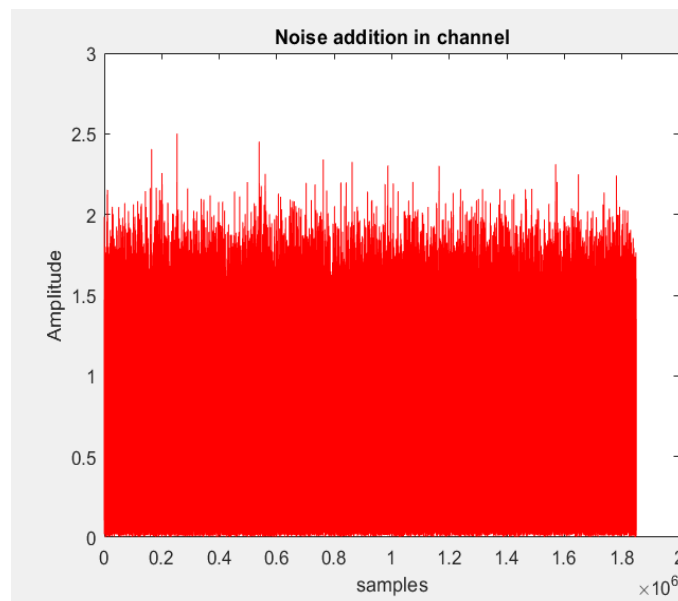


Fig.7 Random Noise Addition

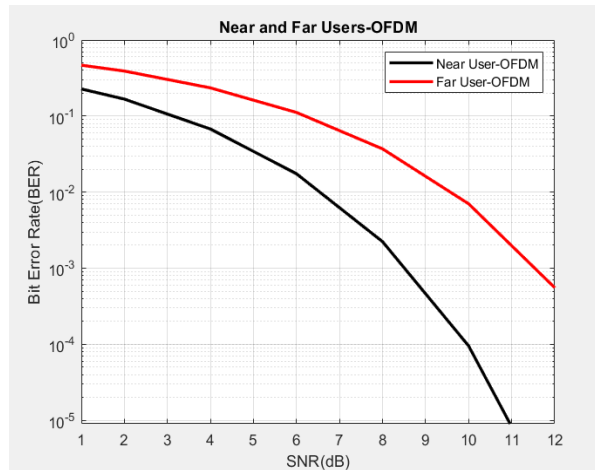


Fig.8 (NE/FE: OFDM)

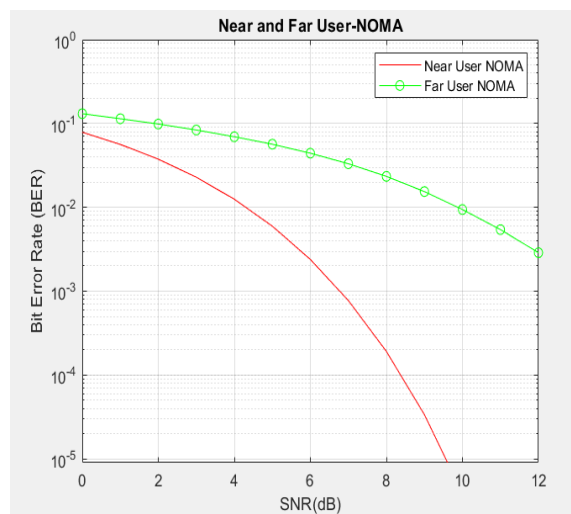


Fig.9 (NE/FE: NOMA)

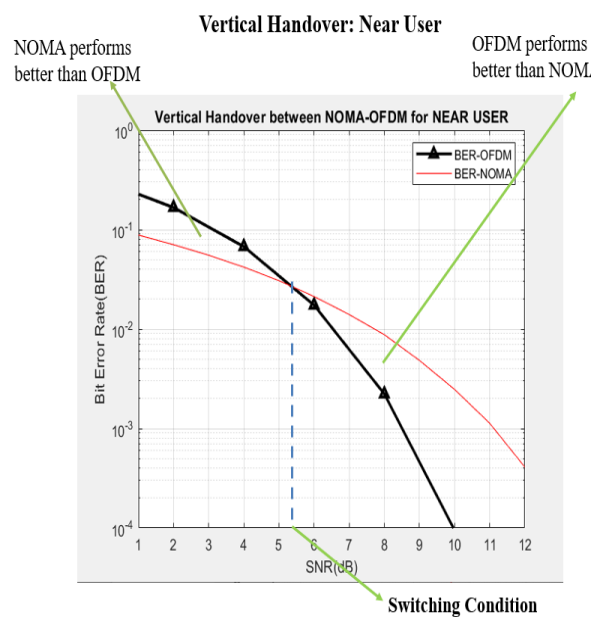


Fig.10 NE handover

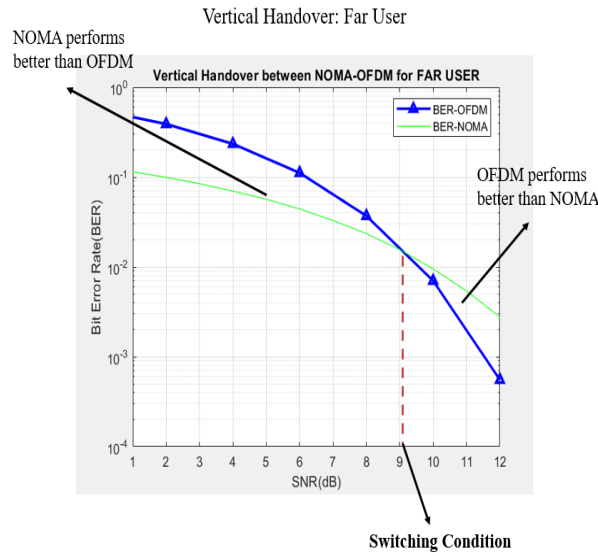


Fig.11 FE Handover

Table I presents the comparative analysis of the results obtained through the implementation of the approach presented in this paper and compares it with existing work in the domain.

Table I Comparative Result Analysis

S.No.	Approach	Metric
1	Lima et al. [21]	Accuracy of 97%
2	Hussain et al. [22]	BER of 10^{-2}
3	Tusha et al. [23]	BER of 10^{-3}
4	Proposed Work	BER of 10^{-4} – 10^{-6} at SNR of 12dB

The performance metrics happen to be the accuracy of initiating and performing successful handovers and the BER of the system. The BER of the proposed system clearly dips lower compared to the earlier works which have been cited. This indicates the fact that the error rate which can be thought of as the QoS metric governing the handover is clearly improved compared to existing work, signifying an improvement in the results.

V. CONCLUSION

This paper identifies the challenges associated with future generation wireless networks as in the terms of the QoS plummeting with increase user counts and traffic congestion, making a QoS enabled decision to implement handovers in wireless networks. The aim would be to evaluate the state of the CSI for multiple access techniques and stick to or switch to the technique which exhibits better QoS. Studies have shown that if the Bit Error Rate (BER) curves do not intersect, the situation remains one where handover does not occur. When looking at the performance metric, Bit Error Rate (BER), one transmission mechanism consistently shows better results. BER curves for NOMA and OFDM meet at a specific point during a handover which are the points of inflexion initiating the necessary handover. The simulations for near and far user scenarios have been simulated based on the path loss and shadowing factors. In addition, when compared to recent studies, the suggested approach has much better performance in terms of accuracy, mistake rate, and SNR needed.

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