ISSN: 2229-6948(ONLINE)
DOI: 10.21917/ijct.2022.0398

HANDOFF IN 5G ULTRA DENSE NETWORKS USING FIXED SPHERE PRECODING

V. Saravanan and A. Jayanthiladevi
College of Computer Science and Information Science, Srinivas University, India

Abstract

It is anticipated that the millimetrewave, often known as mm-wave, technology that will be used in 5G networks will greatly enhance network capacity. The mm-wave signals, on the other hand, are prone to obstructions than the ones at lower bands; this demonstrates the impact that route loss has on the network coverage. Because of the fractal nature of cellular coverage and the different path loss exponents that apply to different directions, it has been suggested that a route loss model in a multi-directional manner for 5G UDN networks. This is due to the fact that different directions have path loss exponents. In addition, the proposed loss model is applied to the 5G ultra-dense network in order to calculate the coverage probability, association probability, and handoff probability (UDN). According to the numerical findings of this research, in 5G UDN, the influence of anisotropic path loss increases the association probability with long link distance. It has also come to light that the performance of the handoff suffers tremendously as a consequence of the anisotropic propagation environment. A new difficulty has arisen for 5G UDN as a consequence of the substantial handoff overhead that has been produced.

Keywords:

Fractal Characteristics, Multi-Directional Path Loss, Cellular Coverage Ultra-Dense Network

1. INTRODUCTION

The greater data rates that are required by applications such as mobile gaming, HDTV, and voice over IP (VoIP), the development of 5G UDN has been driven in large part by these bandwidth-intensive applications [1] [2]. For instance, the 5G UDN is conceptualised as a multi-tier network with large number of BSs with low power and varying degrees of transmission power. These BSs include picocells (33dBM) and femtocells (20 dBM). Long-term evolution (LTE) is often the standard for macrocell base stations [3]. There is not just one kind of radio access technology that pico and femtocells can employ; rather than that, they can use a range of different radio access technologies. WLAN technologies such as WCDMA, OFDM, and IEEE 802.11 are included in this category. It has also been suggested that hotspot locations make use of LTE-U, which is just LTE operating on an unlicensed spectrum [4]. Through the utilisation of LTE-U base stations, unlicensed spectrum will be made available, which will assist in reducing the severity of traffic congestion [5].

A mobile terminal, also known as an MT, is required to switch networks somewhat frequently while travelling throughout a UDN because picocells and femtocells have a relatively small coverage area. Connection quality measures such as RSS and SNR are used to determine which network to connect to during a changeover (SINR). After the destination network has been chosen, it is the responsibility of the MTs to delay the handoff until a present decision criterion has been satisfied [6].

Due to the inherent RF environment, it is important to stress that the circumstances of both licenced and unlicensed channels may drastically change within the time between selecting the target network and carrying out the handoff. This is something that should be emphasised. It is possible for licenced channels to exhibit intermittent characteristics in a UDN environment because of the fluctuating interference intensity. This is because of the large number of access networks that are located nearby [7].

Interference is being caused between neighbouring OFDMA base stations (BSs) as a result of the universal frequency reuse (UFR) approach. Due to the interference that is caused when LTE-U and WLAN operate in the same frequency bands, the link conditions for unlicensed band communication are highly unpredictable. To this day, there is no WLAN and LTE-U cross-domain model that has received widespread approval that would allow for equitable spectrum sharing [8]. There is a possibility that the destination network is selected using immediate dimensions is not an optimal solution while the handoff is taking place. If an error occurs, packets will be dropped, and the throughput will be substantially degraded, which will lead to higher packet losses. Our team refers to this issue as a “handoff anomalous situation” in internal communications [9]. The handoff anomaly problem makes it abundantly evident that a handoff mechanism needs to be developed that is capable of predicting the service guarantees that will be supplied by a number of potential access networks once a handoff has been carried out.

There have been very few studies that have looked at how to create handover processes that take into account the challenges that are presented by a UDN situation. As stated in [10], context-aware multi-attribute model selection is a strategy that has been put forward. The best target network can be determined with the help of the method, which employs a context-aware analytic hierarchy approach. When deciding which network to use, it has been suggested in [2] that the cumulative transmitted power, spectral efficiency and traffic load could be taken into account. [8] suggests a method for selecting target networks that takes into account the context and is driven by the user. The target network selection technique that is provided in [9] for usage in heterogeneous LTE-WLAN networks takes into account the traffic load on the network, the velocity of the users, and their sensitivity to delay. Because they rely on real-time measurements of a wide variety of network indicators, the techniques that are now in use are unable to handle the rapid swings in the circumstances of the link. It is also important to note that the majority of these studies make the assumption that distinct radio access networks will tightly integrate [11], which is not something that is anticipated to occur in the UDN scenario [12].

In addition, all of the currently published publications focus only on the communication of licenced frequency bands. As a direct consequence of this, there has been no research conducted on the challenges presented by the presence of both LTE-U and WLAN in the unlicensed spectrum at the same time.

In this paper, we provide a predictive handoff to solve the issue of handoff anomaly, which is a typical problem in UDN settings. These radio access networks are linked together by means of an integration that is only weakly secured. The findings of our simulations indicate that our strategy is much superior to an existing RBSE-based approach, which we found to be the case.

2. NETWORK MODEL

The study believes that an LTE macrocell base station is able to provide coverage that extends to every nook and cranny. There are a number of base stations (BSs) of LTE-U picocell type and access points (APs) of IEEE 802.11n femtocell type dispersed throughout the coverage area of the macrocell. In this particular illustration, the LTE macrocell base station is connected to the EPC by way of the MME and the serving gateway (SGW).

According to [11], the connection between the picocell LTE-U base stations and the picocell gateway (PGW) is accomplished through the utilisation of S1 interfaces. According to the information presented in [10], PGW is capable of performing the duties of a concentrator, distributor, and security gateway. A WLAN-gateway is required in order to connect the IEEE 802.11n femtocell access points. It is possible to connect the PGW, the WLAN gateway, and the SGW to the internet using methods that are distinct from one another.

Within the context of this example, a DMM architecture based on PMIP6 might be utilised to manage the mobility of terminals [10]. LTE-U base stations and WLAN access points share with the mobile access gateways that are based on the PMIPv6 protocol (MAGs). PGW, WLAN-gateway, and PGW are all viable options for usage as distributed mobility management gateways (DMM-GWs). There is a connection between all of the DMM-GWs and the database that regulates mobility. The CMD keeps an eye on both the existing and prospective access networks.

3. PROPOSED METHOD

The process of predictive handover includes four steps: the initial discovery of prospective networks, the estimation of throughput, the selection of a destination network, and the actual changeover itself. The models in [2] and [14] are utilised during the phases of locating a candidate network and carrying out the handoff, respectively. In the process known as “throughput estimation,” an assessment of the possible throughput offered by the prospective networks is carried out. When modelling the target network selection problem with these estimated throughput values, Stochastic Integer Programming (SIP) is the modelling technique of choice. The possibility that a SIP-handoff device will be can attain the needed data rate in its network at a certain level in order to prevent exceedingly high expectations. The probabilistic constraint that was imposed by the SIP was converted into its deterministic analogue with the assistance of the Hoeffding bound. The following is a rundown of the functions that are distinct to each phase:

3.1 SOURCE NETWORK DISCOVERY

During the candidate network discovery phase, we make use of background inter-frequency measurements (BIM) in conjunction with a measurement gap pattern that is more adaptable. After the candidate networks have been discovered, there will be a p unlicensed LTE-U BSs of band $\{B_1^u, B_2^u, ..., B_p^u\}$ with q licenced BSs of band $\{B_1^l, B_2^l, ..., B_q^l\}$, and r number of access points $\{A_1^w, A_2^w, ..., A_p^w\}$ in the collection of candidate networks for the j^{th} MT. These numbers are based on our best predictions.

3.2 THROUGHPUT ESTIMATION

The interference that occurs within a cell has very little impact on OFDMA systems, but the noise power that is received from interference between cells is far higher.

The SINR $\gamma_{ij}^l(t)$ that was obtained from the i^{th} BS by the j^{th} mobile terminal while using licenced spectrum at time t is represented by the following equation.

$$\gamma_{ij}^l(t) = \frac{\tau_{ij}^x(t)}{P_{col}^l \sum_{k \in N^l(i,j)} I_{kj}^l(t)}$$

where

$\tau_{ij}^x(t)$ - traffic channel power;

$I_{kj}^l(t)$ - received cochannel interference;

$N^l(i,j)$ - set of BSs;

P_{col}^l - probability of sub-carrier collision.

This is the subcarrier collision probability, which can be computed as the ratio of the total number of used subcarriers to the total number of available ones.

3.3 SELECTION OF TARGET NETWORK

In order to begin solving the problem of picking a target network to act as a SIP, we will begin by presenting the following binary variables. If the j^{th} MT is connected with B_α^u, B_β^l and A_γ^w then all three of the binary variables $x_{\alpha j}$, $y_{\beta j}$ and $z_{\gamma j}$ will have a value of 1 in this circumstance. In the event that this is not the case, their value will be 0. Following the execution of the handoff, it is possible to estimate the normalised instantaneous throughput vector $T_j^n(t')$ in the following manner via $T_j(t')$:

$$T_j^n(t') = \{\pi_{\alpha j}^{u,n}(t'), \pi_{\beta j}^{l,n}(t'), \phi_{\gamma j}^n(t')\}$$

where

$\pi_{\alpha j}^{u,n}(t')$ - normalized $\pi_{\alpha j}^u(t')$,

$\pi_{\beta j}^{l,n}(t')$ - normalized $\pi_{\beta j}^l(t')$,

$\phi_{\gamma j}^n(t')$ - normalized $\phi_{\gamma j}(t')$.

Following the handoff, the normalised mean vector $\mu_j^n(t')$ can be calculated using $\mu_j(t')$ as below:

$$\mu_j^n(t') = \{\bar{\pi}_{\alpha j}^{u,n}(t'), \bar{\pi}_{\beta j}^{l,n}(t'), \bar{\phi}_{\gamma j}^n(t')\}$$

where

$\bar{\pi}_{\alpha j}^{u,n}(t')$ - normalized $\bar{\pi}_{\alpha j}^u(t')$,

$\bar{\pi}^{l,n}_{\beta j}(t')$ - normalized $\bar{\pi}^{l}_{\beta j}(t')$,

$\bar{\phi}^{u,n}_{\gamma j}(t')$ - normalized $\bar{\phi}^{u}_{\gamma j}(t')$.

Following the execution of the handoff $T^n_j(t')$, we are able to find the throughput $\chi_j(t')$ of the MT_j as follows:

$$\sum_{\alpha=1}^{p} x_{\alpha j}\pi^{u,n}_{\alpha j}(t') + \sum_{\beta=1}^{q} y_{\beta j}\pi^{l,n}_{\beta j}(t') + \sum_{\gamma=1}^{r} z_{\gamma j}\phi^{n}_{\gamma j}(t')$$

The goal is to achieve the best possible results i.e. maximum of $\chi_j(t')$. When it comes to controlling radio connection management at the cell boundary, the typical strategy of using a hard handover is used. As a result of this, the following regulation must be followed at all times:

$$\sum_{\alpha=1}^{p} x_{\alpha j} + \sum_{\beta=1}^{q} y_{\beta j} + \sum_{\gamma=1}^{r} z_{\gamma j} \leq 1$$

No priority was given to any of the applicant networks even though they all used the same radio access technology. In order to solve the problem with the handoff anomaly, a target overflow probability that is proportional to the desired service assurance was decided upon. The following is a condensed version of these probabilistic constraints:

$$P\left[\chi_j(t') \geq \lambda^{req}_j\right] \geq \Delta \Rightarrow P\left[\chi_j(t') \geq E\left[\chi_j(t')\right] + \Psi_j\right] \geq \Delta$$

$$\Psi_j = \lambda^{req}_j - E\left[\chi_j(t')\right]$$

where

λ^{req}_j - normalized data rate and

r^j_{req} - requested data rate.

The probabilistic constraint can be rewritten by using Hoeffding's bound in the following format:

$$\Delta \leq P\left[\chi_j(t') \geq E\left[\chi_j(t')\right] + \Psi_j\right] \leq e^{-\frac{2\Psi_j^2}{e^{p+q+r}}}$$

The probabilistic constraint can now be transformed into its deterministic counterpart.

$$\Delta \leq e^{-\frac{2\Psi_j^2}{e^{p+q+r}}} \Rightarrow \lambda^{req}_j \leq E\left[\chi_j(t')\right] + \sqrt{(p+q+r)\ln\left(\frac{1}{\sqrt{\Delta}}\right)}$$

The objective of the SIP is to maximise $\chi_j(t')$ within the constraints. The SIP solution is obtained by the CMD component of the network architecture that is being considered. After that, it is communicated to each j^{th} MT via downlink control channels.

4. RESULTS AND DISCUSSIONS

The performance of the 5G UDN handoff is impacted by anisotropic path loss; hence, handoff overhead needs to be taken into consideration. By utilising control protocols that are shared between the two SBSs that are participating in the handoff, it is feasible to hand off control from one SBS to another. Handoff overhead can be partially attributed to control signals transmitted between the user and the SBSs. To put it another way, the length of time necessary to complete a handoff is proportional to the number of handoffs that must be performed.

In order to make it easier to calculate the handoff overhead, we define the handoff rate as the typical number of handoffs that occur during a given amount of time. Information exchange and signal detection between user and SBS are required to be performed during the handoff decision procedures during the periodic execution of the handoff decision procedures as described by the handoff protocols. This interval of time is referred to as the detection interval (t_d). As a result of this, the research being conducted uses Monte Carlo simulations in conjunction with a path loss model in order to conduct an analysis of the handoff rate for 5G UDN.

A user and an infinite number of small cell base stations (SBSs), each of which has a fixed capacity, are required to make up an SBS. SBSs are installed in urban areas. SBSs are placed in a random pattern everywhere around the user, who begins the game located in the middle of a circular territory with a radius of one thousand metres. The user can go in any direction while maintaining a speed of *v*. At each TD interval, the user sends a report to the serving SBS detailing the current state of the channel, after which a decision regarding the handoff is taken. This is why we expect the user to be able to. To get the handoff rate, simply count the number of handoffs that take place in one thousand seconds.

4.1 MODEL SETUP

In a manner analogous to that described in [2] and [5], we have investigated a simulation environment. When we discuss LTE coverage, we are referring to macrocells, which span an area that is 300 metres on each side and are spaced 300 metres apart. There are a total of 1024 subcarriers present in the macrocell BS [4]. There is a presumption that the frequency of the frequency division duplex functioning of the macrocell is 2.12 GHz [2]. Random placement is used to disperse 30 APs and 10 BSs around the coverage area of the macrocell. In each picocell base station (BS), there are three channels that operate in the 7 channels and 2.4 GHz band that function in the 5 GHz band. It is expected that there will be a total of 10 unlicensed channels [5].

It is presumable that all of these channels suffer from Raleigh fading, the form of fading that has been described. On the access points, what is thought to be a proportional and equitable process for accessing the MAC address space is in place. The macrocells have a setting of 35 dBm, whereas the picocells have a setting of 23 dBm, and the femtocells have a setting of 13 dBm [2].

MTs are considered to be roaming at speeds ranging from 3 kmph (pedestrian) to 100 kmph (high mobile), with terminal velocities changing between 0 metres per second and 20m/s. This is done so that smooth random waypoint mobility can be achieved. When the sampling interval is set to 0.01s, the slope estimator window is estimated based on the user's velocity. This occurs when the sample interval is set to 0.01s.

It has been determined that the path loss for macrocells and picocells in an outdoor environment is 15.6+35 log(R), whereas the path loss for femtocells in an indoor environment is 38.46 + 20 log(R). It is claimed that different video standards have a severe requirement for the data rate that MTs must support. Consideration is given to data transfer speeds of 1.5, 0.2, 2.5, and 2.7 Mbps, respectively. There is an equal possibility that a data rate request will be made by an MT in response to any of these video types. For the purpose of this discussion, we will assume that video traffic arriving at constant bit rates follows a Poisson distribution with an arrival rate of 616 and an exponential distribution with a mean that has been normalised to unity. In order to recreate the PMIPv6 protocol, we relied on the standard values for the parameters.

4.2 RESULTS AND DISCUSSION

The path loss model of uniform value is considered as a case with value 0. When a hysteresis parameter is being used, the handoff SINR threshold should be set at 0 dB.

The Fig.1 illustrates the handoff probability in relation to the moving distance v_t for two rare cases in which the path loss exponent varies. In this view, $M = 3$, which indicates that there will be three SBS portions. The greater the distance covered within a certain detection period, the higher the probability of a handoff occurring during that interval. The probability of a handoff rises as the path loss exponent varies in its path. It is possible to ignore the handoff probability in cases 1 and 2 when the moving distance and the variance are equal to one another. According to the data, the direction in which the user is moving does not have an impact on handoff performance.

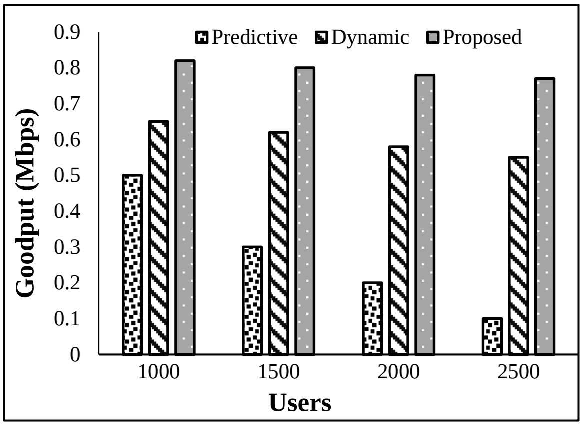

Fig.1. Traffic Load

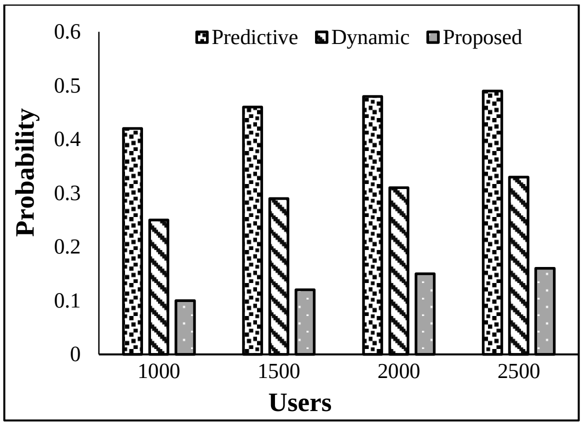

Fig.2. Failure Probability

As can be seen in Fig.2, the rate at which handoffs occur is a function of the variance, which changes depending on the value of M. In order to conduct an examination into the handoff rate, the detection interval has been set to 1s, and the speed v has been set to 5m/s. When M is held constant, the rate of handoffs increases in direct proportion to the variance. To put it another way, the rate at which handoffs occur grows at a faster pace with a larger M than it does with a lower M.

The Fig.3 demonstrates that as the variance grows, so does the maximum handoff rate. This can be seen by looking at the graph. This is due to the fact that M approaches infinity. The path loss exponent is a random variable in this case, so its value will shift depending on the results of each measurement. The value of M does not determine the handoff rate for 5G UDN; rather, the distribution of the path loss exponent does.

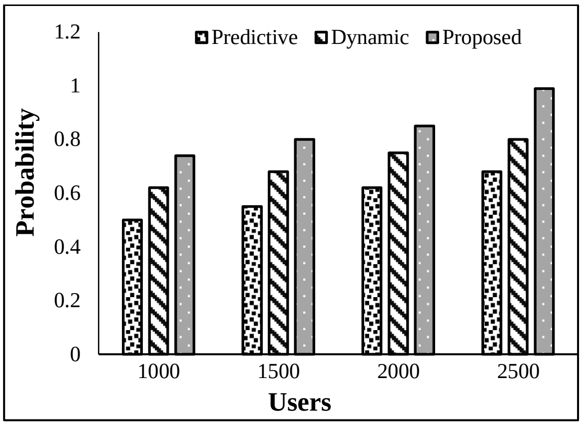

Fig.3. Handoff vs. Load

5. CONCLUSIONS

In this paper, mmWave technology will boost 5G network capacity. mm-wave transmissions are more prone to obstructions than lower-frequency signals, demonstrating the influence of route loss. The path loss model is used in UDN to calculate coverage, association, and handoff probabilities. In 5G UDN, anisotropic path loss increases association likelihood with long link distance, according to this research. The path loss model coverage probability is lower than isotropic. Anisotropic propagation also degrades handoff performance. Handoff overhead has created a new problem for 5G UDN.

REFERENCES

[1] M. Ramalingam, S. Vinothkumar and P. Ramya, "Predictive Handoff Management in Vehicular Networks Using both Weight Value Based and K-Means Algorithm Based Clustering Algorithm to Meet Desired QoS", *Journal of Physics: Conference Series*, Vol. 1969, No. 1, pp. 1-12, 2021.

[2] S.A. Syed, K. Sheela Sobana Rani and V.P. Sundramurthy, "Design of Resources Allocation in 6G Cybertwin Technology using the Fuzzy Neuro Model in Healthcare Systems", *Journal of Healthcare Engineering*, Vol. 2022, pp. 1-13, 2022.

[3] H. Luo, K. Cao and Y. Zhou, "DQN-Based Predictive Spectrum Handoff via Hybrid Priority Queuing Model", *IEEE Communications Letters*, Vol. 26, No. 3, pp. 701-705, 2021.

[4] T. Karthikeyan and K. Praghash, "An Improved Task Allocation Scheme in Serverless Computing using Gray Wolf Optimization (GWO) based Reinforcement Learning

(RIL) Approach", *Wireless Personal Communications*, Vol. 117, No. 3, pp. 2403-2421, 2021.

[5] L. Thomas and J. Paulose, "A Survey on Various Handoff Methods in Mobile Ad Hoc Network Environment", *Proceedings of International Conference on Smart Computing Paradigms: New Progresses and Challenges*, pp. 27-60, 2020.

[6] I. Rabet, S.P. Selvaraju and M. Bjorkman, "Poster: Particle Filter for Handoff Prediction in SDN-based IoT Networks", *Proceedings of International Conference on Wireless Networks*, pp. 172-173, 2020.

[7] A.C. Marino and J.A. Mazer, "Saccades Trigger Predictive Updating of Attentional Topography in Area V4", *Neuron*, Vol. 98, No. 2, pp. 429-438, 2018.

[8] S. Kunarak and R. Suleesathira, "Multi-Criteria Vertical Handoff Decision Algorithm for Overlaid Heterogeneous Mobile IP Networks", *Journal of the Franklin Institute*, Vol. 357, No. 10, pp. 6321-6351, 2020.

[9] S.A. Patil and B.K. Singh, "Prediction of IoT Traffic using the Gated Recurrent Unit Neural Network-(GRU-NN-) based Predictive Model", *Security and Communication Networks*, Vol. 2021, pp. 1-14, 2021.

[10] K.M. Awan and K. Rabie, "Smart Handoff Technique for Internet of Vehicles Communication using Dynamic Edge-Backup Node", *Electronics*, Vol. 9, No. 3, pp. 524-534, 2020.

[11] S. Koley, D. Bepari and D. Mitra, "Predictive Multi-user Dynamic Spectrum Allocation Using Hidden Semi-Markov Model", *Journal of Communications Technology and Electronics*, Vol. 63, No. 12, pp. 1393-1405, 2018.

[12] A.K. Gupta, V. Goel and M. Sain, "A Fuzzy based Handover Decision Scheme for Mobile Devices using Predictive Model", *Electronics*, Vol. 10, No. 16, pp. 1-13, 2021.

[13] P.S. Yawada and M.T. Dong, "Intelligent Process of Spectrum Handoff/Mobility in Cognitive Radio Networks", *Journal of Electrical and Computer Engineering*, Vol. 2019, pp. 1-8, 2019.

[14] S.H. Alsamhi and B. Lee, "Predictive Estimation of Optimal Signal Strength from Drones over IoT Frameworks in Smart Cities", *IEEE Transactions on Mobile Computing*, Vol. 89, pp. 1-8, 2021.