Reliable Cell Selection and Performance Analysis in 5G

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***Abstract* — The requirement for wireless communication devices and fifth generation (5G) cellular network access is rapidly going up. Overlapped cell areas are consisted in 5G cellular networks and it grants dynamic coverage with respect to time. Moreover, 5G users can be covered by number of cells. As the result of that, reliable cell selection is needed in 5G and it is critical decision for 5G users. In this research, two schemes are proposed as the solution. The signal strength is considered as the first scheme while channel availability factor is considered as the second scheme. The result of simulation model is evaluated by considering the fairness index and the blocking probability. For efficient cell selection, scheme 2 is much fairer than scheme 1 because by using scheme 2, channel availability is balanced through cells and radio access technologies (RATs). It can be summarized that the proposed schemes are reliable cell selection schemes which can be used to develop the overall system performance.**

Keywords- cell selection, channels availability, signal strength

I. Introduction

The 5G wireless technology is the most current rendering of cellular technology crafted to increase the efficacious delivery and responsiveness of wireless network services. The advanced 5G technology is not just the next interpretation of mobile communications, evolving from 1G to 2G, 3G, 4G and now 5G. The 5G mobile cellular communications system provides a far higher level of performance than the previous generations of mobile communications systems. It serves data rate higher than 20Gbps. The initial phase of 5G non-standalone deployments focuses on enhanced mobile broadband (eMBB), which provides greater data-bandwidth complemented by moderate latency improvements on 5G. Within enhanced mobile broadband there are three distinct attributes 5G will need to deliver including higher capacity, enhanced connectivity and higher user mobility. The current generation uses Worldwide Wireless Web (WWWW) which is a well-situated combination of broadband and unified IP. Frequency band for this technology ranges from 3GHz-300GHz. Additionally, 5G is prided for its innovative feature of ultra-reliable communication; this has been forecast to be an intrinsic communication pillar which provides services categorized as anywhere and anytime, aimed at the end user in URC [2]. The efficiency and ultimate quality of the services issued to end users will be asserted by the reliability and availability of the network. These are the key benefits that communication service providers expect from 5G. Anytime anywhere communication is a major requirement for critical applications (industrial automation, automotive, eHealth) in 5G networks. Networks such as 5G are designed with the intention to assist in a vast range of services and applications in demand.

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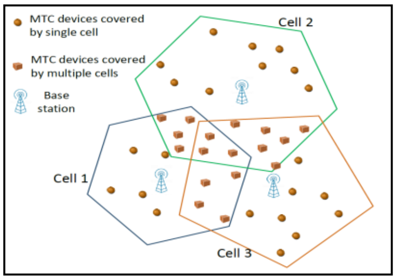

Fig 1: Overlapped cell areas.

Numerous studies and research projects are carried out to develop 5G mobile network technology efficiently. A development of 5G mobile network technology and its architecture are presented in [5]. The study in [5] is concentrated on all foregoing eras of mobile technology, developmental aspect of 5G technology and basic architecture behind this mobile technology. Moreover, the various components including GPRS, EDGE,3G, WLAN, LTE involved in the architecture making it very fast, secure and famous among the customers in all over the world. As the result of that 5G technology is granting specified services with WWWW functionalities in the lowest cost ever, by keeping the users in the top of the priority. The research work performed in [6] focusses on cellular architecture and key technologies for 5G wireless communication networks. According to the work in [6], the performance requirements of 5G wireless communication systems have been specified in terms of capacity, spectral efficiency, energy efficiency, data rate, and cell average throughput. Moreover, the 5G cellular architecture has been proposed with separated indoor and outdoor applications by using distributed antenna system and massive MIMO technology which are consisting of multiple antennas at both the transmitter and receiver. Some short-range communication technologies, such as WiFi, femtocell, and mm-wave communication technologies, be promising candidates to provide high-quality and high-data-rate services to indoor users while at the same time reducing the pressure on outdoor base stations. Additionally, the paper discussed some potential technologies that can be deployed in 5G systems to satisfy the expected performance requirements, such as cognitive radio networks (CRNs) and spatial modulation. Ultra-reliable communication in 5G wireless systems (URC) is presented in [7]. URC is the one of the novel features in 5G which is not exist in today's wireless systems. URC is accorded to provision of some piers of communication services near 99.999% every time. The paper presents a systematic view on URC in 5G wireless systems. It introduces the key concept of reliable service composition, and instance service is designed to assimilate to accommodate the requirement to the level of functional reliability. Furthermore, the problem of URC is analyzed.

Another study in [8] presents a research work on achieving ultra-reliable communication in 5G networks in a dependability perspective considering the space domain. In this investigation, URC which is a part of 5G communication is considered as a critical technology pillar for offering anywhere and anytime uses to end users. The paper highlights the concept of URC from the dependability perspective also in the space domain and defines the cell availability and system availability. Additionally, the availability and the probability of granting a guaranteed level of accessibility in a network are considered as both/either cell-wise and/or system-wise. An automation of 5G network slicing with machine learning is discussed in [9]. Due to appearance of illegitimately vast number of new connected devices and new types of services, the 5G communication networks are getting complex. Moreover, the requisites of creating virtual network slices are appropriate to provide optimal services for different users and applications are posing challenges to the efficient management of network resources, processing information about a huge volume of traffic, staying robust against all potential security threats, and adaptive adjustment of network functionality for time-varying workload.

The above work mostly considered the optimization algorithms or cell association with little attention to RATs. In spite of this, in the proposed algorithm, both signal strength and channel availability factors and balancing of the devices among cell and RATs are thought out. Thus, the outline of the way of solving the problem in this research is to implement an algorithm for devices which are in an overlapping area, considering two schemes, namely, signal strength, and the combination of channel availability and the signal strength.

II. Objetives

The objective of the proposed research is empowering the algorithm for cell selection based on the availability and reliability performance in 5G communication.

III. Methodology

In the both schemes, the mobile network consists of two cells two RATs as illustrated in the figure 2, with two of them overlapping, while 40 devices are distributing among cells.

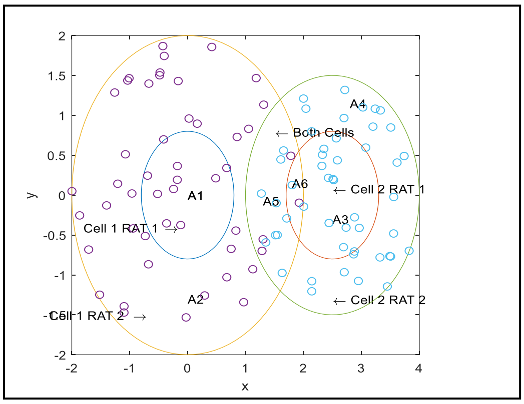

Figure 2: Network Scenario for the simulation

An analysis of many algorithm models created for cell selection is furnished as the solution. Through the elimination of multiple issues in those models, this research proposes an approach for cell selection in heterogeneous 5G comprising of two schemes for different cells. Firstly, as the first scheme, a mobile network of two cells overlapping an area was considered while numerous devices are distributed among the 5G cells. Afterwards, the cell coverage area was determined. From that result, it is possible to compute whether the devices are in cell 1 or cell 2 or an overlapped area. The devices which are in the overlapped area are examined after that. With the help of X and Y coordinates the distance from the base stations for every device could be calculated. Next, the simulation model is used to compare the distance between every device. Secondly, this research paper proposed the second scheme. From the result of the scheme 1 cell coverage area, it could be computed if the devices are in cell 1 or cell 2 or an overlapped area. The devices which are in the overlapped area are dealt with thereafter. Scheme 2 is mainly focused on the channel's availability of each and every cell. Therefore, first, the proposed simulation assigns the channels limit for each cell. Then it is determined whether these cells exceed their channels limit or not. If they do not achieve the channels limit, then the devices can easily select a cell. If the cells achieve their channels limit, then the simulation model checks the distance. The simulation model was implemented according to the above-mentioned schemes by using MATLAB.

IV. Results and Discussion

The simulation results for two schemes are illustrated in this section. The scheme 1 is based on the signal strength. For that purpose, the proposed simulation model considers the distance from the base stations and the locations of the devices. After simulating the above mobile network, the average number of devices for each RAT and the blocking probability were generated as follows:

Average of associated number of nodes in C2R2 : 8.079

Average of associated number of nodes in C2R1 : 3.576

Average of associated number of nodes in C1R2 : 1.248

Average of associated number of nodes in C1R1 : 0.903

Blocked probability is : 0.141

The scheme two is based on the combination of the channel availability and the signal strength. The average number of devices for each cells were as follows in the scheme 2.

Average of associated number of nodes in C2R2 : 9.270
Average of associated number of nodes in C2R1 : 2.262
Average of associated number of nodes in C1R2 : 9.320
Average of associated number of nodes in C1R1 : 1.892
Blocked Probability is : 0.198

The main purpose of scheme 1 and scheme 2 is to model a reliable cell selection model for 5G mobile networks. The evaluation of the performance of scheme 1 and scheme 2 is generated by considering the fairness index and the blocking probability.

Firstly, Fairness measures are utilized in network engineering to find out if users or applications receive a fair share of the system [10]. To calculate the fairness index, Jains Fairness Index is applied. The figure depicts the fairness index of the mobile network based on two schemes as X axis and the ratio of nodes between cell 1 and cell 2 in Y axis. The fairness index in six different scenarios was found out by changing the number of devices in each cell. In Figure 3, the fairness indices of two schemes are compared with the ratio of nodes between cell 1 and cell 2.

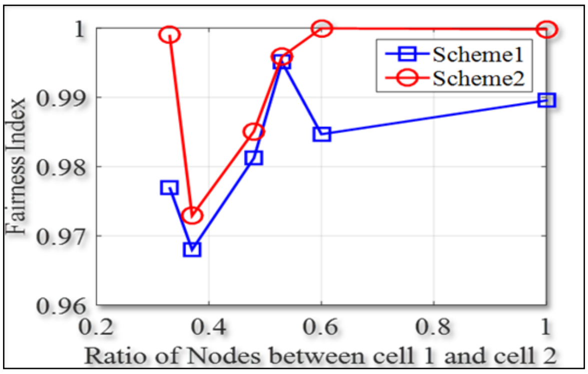

Fig. 3. *Fairness Index of Scheme 1 and Scheme 2.*

When the fairness indices are compared, it is obvious that scheme 2 is fairer than scheme 1 because scheme 2 is always close to 1. This means that its fairness is higher than the fairness of scheme 1. In scheme 2, the simulation model is used mainly by considering the channels availability. By using scheme 2, a channel which is less loaded will be used leading to more balanced channel utilization. As a result of that, scheme 2 always tries to balance the devices in each cell. Therefore, it is proven that for cell selection, scheme 2 is better than scheme 1.

Secondly, the impact of Duty Cycles on the Blocking Probability (BP) was calculated. The BP varies with the duty cycles. A duty cycle or power cycle is the fraction of a period in which a signal or system is active. A period is the time it takes for a signal to complete an on-and-off cycle. On-Off cycles play a major role in 5G devices as there are battery powered devices consist. They stay often in the off mode and, they need to perform cell association again when they in the on mode. Therefore, duty cycles can be considered as an important performance parameter. The duty cycle of this simulation model can be calculated by using following formula.

$$\boxed{Duty\ cycle = \frac{ON\ period}{Total\ period} = \frac{{}^{1}/_{mu\_11}}{\left({}^{1}/_{mu\_11} + {}^{1}/_{mu\_12}\right)}}$$

where:
- 1/mu11=the mean value of on time period
- 1/mu12= the mean value of off time period

The duty cycle changes when mean off period is constant as shown for both schemes in Figure 4. Mean on time period changes from lower to higher and checks the blocking probability. We can see from the image that the probability of blocking rises when the on-time period grows. The number of devices stays active when the on-time period increases. Therefore, new device requesters have to wait until the devices get off. Hence, the blocking probability increases while the on-time period of devices increases in both schemes.

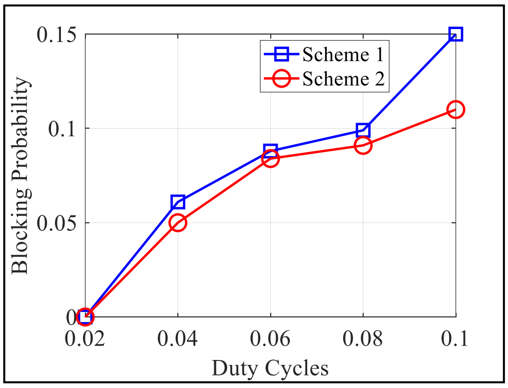

Figure 4: The Graph of Mean Duty Cycle on the BP- Mean Off Time Period Constant.

Thirdly the blocking probability is compared with number of channels by considering both schemes 1 and 2 which is illustrated in figure 5. It can be clearly depicted that the probability of blocking dramatically drops initially when the number of channels grows in both schemes. When there is a limited number of channels, the devices have limited chances to access channels. Therefore, it is proven that when there is a high number of channels, the blocking probability gets low, because there is higher chance to device to access a channel when there are less occupied channels.

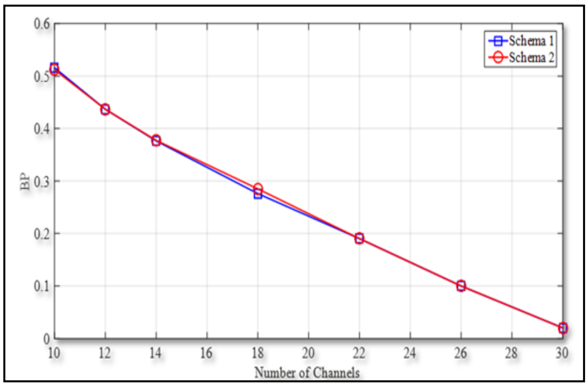

Figure 5: The Graph of Number of Channels on the Blocking Probability

V. CONCLUSION

In this research, the main objective of this study as the constructing of the algorithm for cell selection based on the availability and reliability performance in 5G scenarios, is expressed. The cell selection is executed with the help of two schemes. Scheme 1 is based on the signal strength with the help of the distance of each device and the second scheme consisting of channels availability and the distance.

The accuracy of the model is assessed by simulations. The obtained simulation results are used to evaluate the performance of the simulation model. The numerical results show that the fairness index is high in scheme 2 than the scheme 1. Therefore, the results prove that based on channels availability and the distance, cell selection can be performed.

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