Performance Analysis of QOS Parameters of 5G Wireless Communication Networks

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Abstract

With growing demand in high data speed and increase in number of subscribers which will grow to three times by the year 2021.So, the present technology like 3G, 4G cannot support this hence there is a requirement of developing next generation mobile network which can support high speed internet and large no. of users , that network is 5G network. The main aim of the research work is a comprehensive study about the challenges in 5G and its possible solutions. Here focus is on the performance parameters like better signal coverage, low latency, high data speed greater than 1Gbps, cognitive in 5G, etc. Out of the various parameters our focus will be on some QOS parameter such as low latency, low delay, throughput and ultra reliable communications. The vision of 5G can be achieved by combining various radio access technologies like LTE, HSPA with 5G. Out of the various parameters that can be used to judge the Quality of the network one important parameter is outage probability of the network. We will propose user algorithm and compare their performance based on QOS parameters. Several industries and researchers have addressed and have proposed various ways to improve the quality of the network. Most of the researchers focus on particular protocols and investigate whether their strategy can work at high speed data. Generally, their approaches and strategies can be evaluated through simulations. In our work we will analyze some parameters on different scenarios and on the basis of the analysis will propose improvement measures.

Keywords:- *5G,Throughput,QOS,Communication Networks.*

I. INTRODUCTION

With the increase in requirement of the data speed now there is a tremendous demand of Technology which will support high speed internet with better network efficiency. As of now a days most of our content are video based so need for high data streaming is increasing day by day. Further each user has multiple mobile connections so the network should be such that they can handle billions of devices and the operational network expenditure cost should also be low. Also network operators also need such network which are efficient and require low maintenance. 5G involves all this requirements. Since our key focus is on the key parameter we will consider throughput and data rate as our key parameters to analyze. As in 5G communication our main focus is on high data rate by which the data can be send. Further multiuser diversity will also be one parameter on which we will concentrate. Consequently to get an optimized network power and subcarrier allocation design problem is formulated. The rest of the paper is organized as follows. Section II presents Literature Review about the topic. Section III tells us about proposed model. Section IV gives design and implementation details of wireless networks. Section V gives us simulation results and finally Section VI gives concluding remarks which are then followed by the bibliography.

II. LITERATURE REVIEW

- **Afif Osseiran et al.** (2014) [10] suggested the scenarios that are identified for the purpose of driving the 5G research direction. Further, initial directions for the technology components (e.g., link level components, multimode multiantenna, etc) will allow the fulfillment of the requirements of the identified 5G scenarios. The integration of these new radio concepts, such as massive MIMO, ultra dense networks, moving networks, and device-to-device, ultra reliable, and massive machine communications, will allow 5G to support the expected increase in mobile data volume. The overall approach toward 5G builds on the evolution of existing technologies complemented by new radio concepts that are designed to meet the new and challenging requirements.

- **Xiaofei Wang et al**. (2014) [11] suggests that the demand for rich multimedia services over mobile networks has been soaring at a tremendous pace over recent years. However, due to the centralized architecture of current cellular networks, the wireless link capacity as well as the bandwidth of the radio access networks and the backhaul network cannot practically cope with the explosive growth in mobile traffic. In this article, study techniques related to caching in current mobile networks, and potential techniques for caching in 5G mobile networks are discussed. A novel edge caching scheme based on the concept of content-centric networking or information-centric networking is proposed. Using trace-driven simulations, the performance of the proposed scheme are evaluated.

- **Mohsen Guizani et al**. (2016) [12] discusses how 5G networks tends to achieve gigabit-level throughput in future cellular networks. In this article, the wireless backhaul traffic in two typical network architectures adopting small cell and millimeter wave communication technologies are analyzed. Furthermore, the energy efficiency of wireless backhaul networks is compared for different network architectures and frequency bands. Numerical based results provide some guidelines for deploying future 5G wireless backhaul networks in economical and highly energy-efficient ways.

- **Liang Liu and Chuan Zhang** (2015) [13] discusses an overview to the special session. They presented two technologies namely massive multiple-input multiple-output (MIMO) technique and advanced coding techniques such as polar codes. Massive MIMO is a relatively new wireless communication concept in the paradigm of multi-user multi-antenna system, is capable of providing orders-of-magnitude improvement in both radiated energy efficiency and bandwidth efficiency. Polar codes, can provably achieve the capacity of symmetric binary-input discrete memory less channels(B-DMCs), have become one of the most promising code for 5G due to their improved performance, complexity, and flexibility. MASSIVE MIMO Because of its advantages in enhancing spectrum efficiency, the multiple-input multiple-output (MIMO) technology has been widely adopted in recent high-speed wireless communication standards. While these standards are maturing with successful commercialization, wireless network is evolving at a fast pace to meet the explosive growth in application requirements. The emerging 5G communication is aiming for the connection of tens of billions of devices with some demanding several gigabit-per-second data rates and being served with millisecond-level latency. Massive MIMO [21] [22], a new paradigm of the multi-user MIMO scheme, is one of the strongest candidates to satisfy such high-performance requirements by scaling up the existing MIMO system massively

III. PROPOSED MODEL

In this work, a model is proposed as shown in Figure 3.1 .Here downlink communication scenario with one Base Station and two users are considered. Initially, less number of users are considered and analysis is done. Afterwards the users are increased gradually. In this work, as shown in above figure, there are two users on each subcarrier, it is assumed that user m and user n are paired together. As the numbers of users are increased they are multiplexed on the same subcarrier causing the growth of hardware complexity and processing delay. Therefore, the case of two users per subcarrier is studied in the system model.

As clear from the above figure, there are two users that multiplexed into one subcarrier. User n is closer to the BS compared to User m, which implies User n has a better channel condition as compared to User m. The Base Station optimizes the transmit power for each user on each subcarrier. In particular, instead of allocating all the power to one User, User n with stronger channel condition is allocated less transmitted power and more transmit power is allocated to User m. Thus, User m is allocated with non-zero power which provides certain fairness in resource allocation.

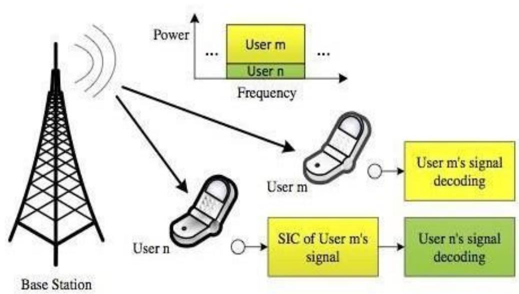

Figure 3.1: Proposed System for 5G Communication

Let the received signals at user m and user n on subcarrier i are given by

$$y_m^i = \sqrt{P_m^i}\,\rho_m\,x_m^i + z_m^i + \sqrt{P_n^i}\,\rho_m\,x_n^i \quad \text{and}$$
$$y_n^i = \sqrt{P_n^i}\,\rho_n\,x_n^i + z_n^i + \sqrt{P_m^i}\,\rho_n\,x_m^i \qquad (1)$$

where x_m^i denotes the symbol transmitted from the BS to user m on subcarrier i; P_m^i denotes the transmitted power of the signal intended for user m on subcarrier i; ρ_m denotes the joint effect of path loss and shadowing between the BS and user m; z_m^i denotes the white Gaussian noise on subcarrier i at user m. Since, user m is further away from BS so it has a poor channel condition as compared to user m.

Now only the strong user is able to receive signals. User n is the strong user in our system model. So, under a certain condition that is

$$\log_2\left(1+\frac{p_m^i\rho_n}{z_n^i+p_n^i\,\rho_n}\right) \geq \log_2\left(1+\frac{p_m^i\rho_m}{z_m^i+p_n^i\,\rho_m}\right) \qquad (2)$$

xm is decoded, which results in User n's achievable rate.
Next, the x_m is obtained from the received signal y_n^i by performing a subtraction,

$$y_n^i - \sqrt{P_m^i}\,\rho_n\,x_m^i = \sqrt{P_n^i}\,\rho_n\,x_n^i + z_n^i \qquad (3)$$

so that the interference caused by user m is removed. Thus, Successive Interference cancellation (SIC) is performed at the receiver end. The achievable rate after employing SIC is

$\log_2\left(1+\frac{p_n^i\rho_n}{z_n^i}\right)$ and SINR at this stage is $\frac{p_n^i\rho_n}{z_n^i}$. It is obvious that SINR is reduced after applying SIC.

While, user m, as a weak user, also has an achievable rate given by

$$\log_2\left(1+\frac{p_m^i\rho_m}{z_m^i+p_n^i\,\rho_m}\right) \qquad (4)$$

which suggests both users in the system can get a certain amount of data rate.

IV. DESIGN AND IMPLEMENTATION DETAILS

4.1 Detailed Design

The problem is designed as a high-dimensional optimization problem, which means the number of possible solutions grows exponentially with respect to the numbers of optimization variables. Thus, the proposed algorithm is defined as a suboptimal solution for solving the optimization problem.

4.1.1 User Pairing Algorithm

The selection scheme is based on channel gain as it tends to focus on pairing minimum two users according to their distinctive user channel gain and underestimate the importance of considering user data rate requirements. So, to optimize the user pairing selection, the proposed user pairing scheme, namely user data rate based selection scheme, is used which takes into account both user channel conditions and user data rate requirements.

For user pairing solution, the designed network basically revolves around finding a suboptimal solution by balancing between user's channel condition and user data rate requirement. One of the possible solutions of user pairing problem at the primary stage is to put two factors, which are user channel condition and user data rate requirement, into one metric through multiplication of them. In that way, both user channel gain and user data requirement weigh equally in the system. It is likely to exist a situation where two users form a paired group that do not have distinctive channel condition, since the strong user and weak user in a system are not distinguished by user channel gain, but by the multiplication of channel gain and data rate requirement. The proposed algorithm is illustrated below in Figure 4. First, of all users are sorted based on their channel gains, the user with the strongest user channel gain is ranked first, the proposed scheme classifies the first half of users that are placed in the front into strong users group in the system and the rest users are treated as weak users. Only weak users are allowed to be paired up with strong users, which ensure that two users in every two-user paired group have distinctive channel gains and thereby enhance the performance gain.

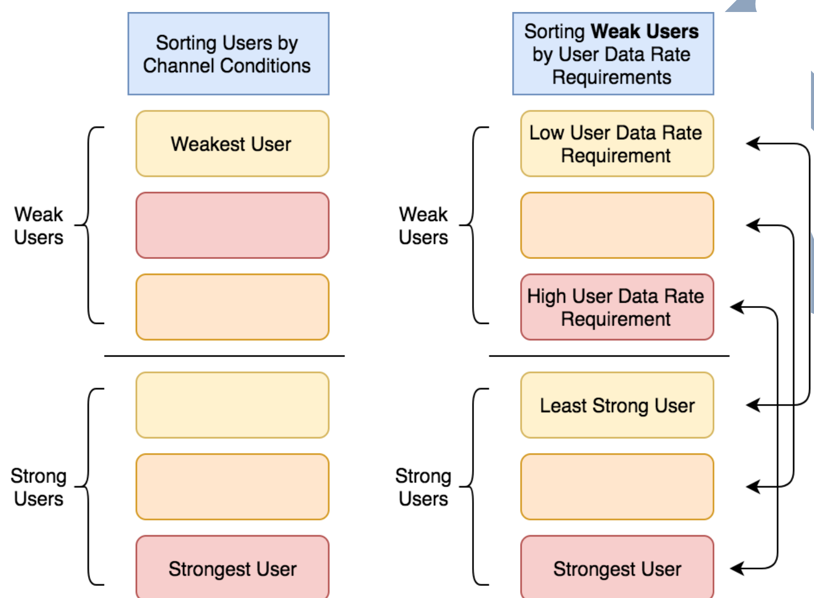

Figure 4.1: The proposed user pairing algorithm.

Secondly, all strong users and weak users are being distinguished, the proposed algorithm considers weak users' data rate requirements by sorting weak users based on their data rate requirements. The strong users' has better channel conditions then weak users, hence, the proposed user pairing scheme favors the weak user with the highest user data rate requirement and pair it up with the strongest user in the system. The weak user that has a low user data rate requirement is treated as the weak user with the least priority in the system, and therefore being selected to group with the least strong user. The algorithm thus clearly shows its rule regarding user pairing selection, which shows that the user with a more stringent requirement has its data rate with higher priority in user selection scheme

4.2 Proposed Algorithm

The proposed algorithm mainly optimizes user pairing scheme. The selection algorithm, except random user pairing algorithm, ensures that two users in every two- user paired group have distinctive channel gains, which maximize the performance gain. The algorithms that are employed in simulations are described and shown below in this section.

Random pairing algorithm is the user pairing scheme that pair two users randomly and without considering both users' channel conditions and users' data rate requirements. This method of user selection has the least complexity. However, it is also the most ineffective algorithm in user pairing since the condition that two users in every two-user paired group have distinctive channels gains that cannot be guaranteed. In addition, there is a possibility that not all the users are being selected and paired up by applying random pairing algorithm, which implies lack of user fairness.

Hence an algorithm is proposed which considers only strongest and weakest users for user pairing in the network, which considers the lack of user fairness that existed in this user selection scheme. Further, two users with the most distinctive channel conditions share the power resource allocated inside a subcarrier, which is expected to have the best outcome on the achieved performance gain, as compared to any other algorithms.

The low-complexity channel gain-based user pairing algorithm that illustrated in Figure 5.1 were established at primary work stage as a proposed user selection scheme.

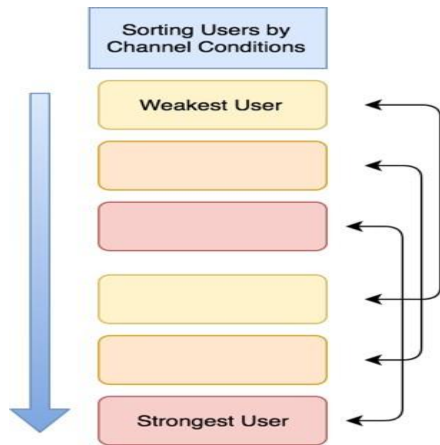

Figure 4.2: The low-complexity user pairing algorithm.

Thus the proposed user pairing algorithm ensures that every two paired users in the system has certain different channel gains. Also, this method of user pairing guarantees that every user in the system is selected at least once as subcarrier so that user fairness is able to be strengthened.

V. SIMULATION RESULTS

The performances on the average system throughput and weak user's achievable data rate have been analyzed and the results are shown below. Additionally, the multiuser diversity of the proposed algorithm has been examined as well.

It is clearly illustrated in Figure 5.1 that the proposed algorithm has the best system performance on weighted system throughput, compared to other simulated algorithms. The proposed algorithm has more efficient performance on average system throughput while increasing the amount of maximum transmit power. As expected, random pairing algorithm has the worst outcome regarding average system throughput due to its ineffectiveness on user selection. The low-complexity channel gain-based user pairing algorithm ensures every user inside system is selected and allocated into each subcarrier, which comes at the expense of low weighted system throughput in contrast to the conventional user pairing algorithm that lack the caring user fairness. The conventional user selection scheme that sacrifices user fairness for improvement on the weighted throughput on each subcarrier, as predicted, has a great result on average system throughput, especially when the maximum transmit power is less than 12 dBm.

However, it tends to lose its leading position with the increment of the maximum transmit power that was used in the system. While the amount of maximum transmit power that is put into the system keeps increasing, the superiority of applying the proposed algorithm for enhancing average system throughput. In other words, the gap of the system throughput performances between the proposed algorithm and the conventional one is enlarged while scaling the transmit power. That is because the proposed algorithm has higher flexibilities for utilizing the degree of freedom among all other compared user pairing schemes.

5.1 Average System Throughput

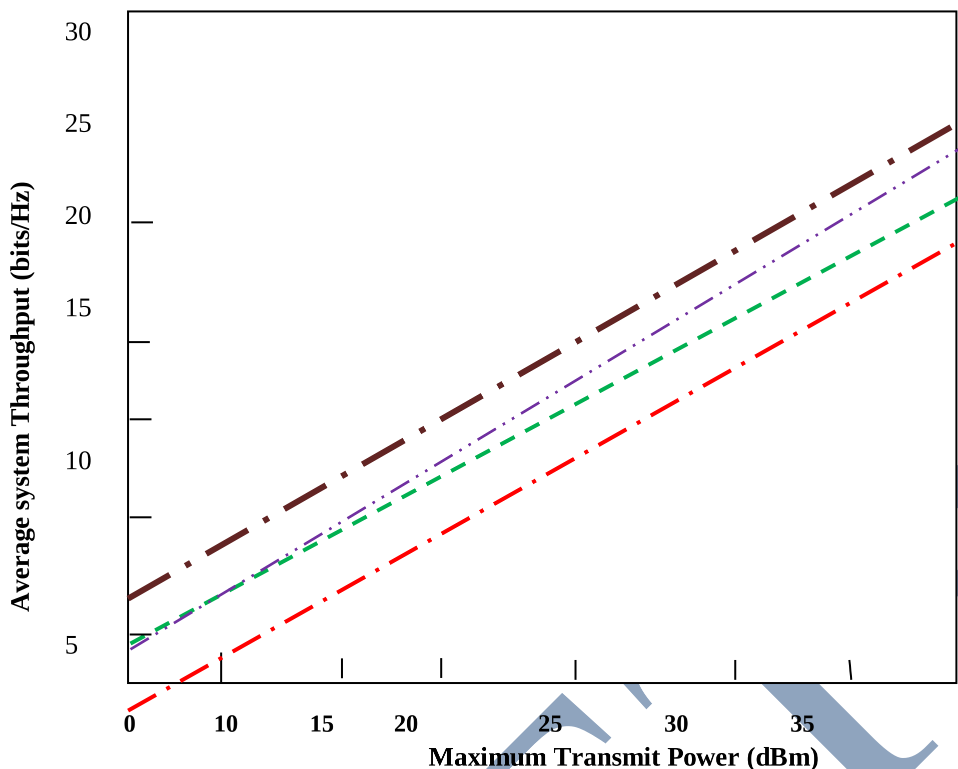

Figure 5.1: Average system throughput VS Maximum transmit power.

Proposed Algorithm
Low complexity channel gain based user pairing algorithm
Conventional user pairing algorithm
Random pairing algorithm

5.2 Weak User Achievable Data Rate

From the above result it is seen that the proposed algorithm performance on the average system throughput is extremely closed to the conventional algorithm system performance and the weak user have a high priority for power allocation in each subcarrier. In Figure 5.2, the weak user's achievable data rate in the simulated system based on the proposed algorithm is improved remarkably. The reason that the proposed scheme has a better outcome on improving the weakest user's achievable data rate is that it has a high level of flexibilities for exploiting the use of the degree of freedom, compared to the conventional user selection scheme.

Since the proposed algorithm devotes its effort to improve the achievable data rate of the weak user with a more stringent requirement for its data rate, its system performance on achievable data rate is inspected as well. The results are showing that the proposed algorithm favorites the weak user with the highest data rate requirement rather than the weak user with the poorest channel gain when the maximum transmit power is limited. However, when the system has sufficient transmit power, all weak users' achievable data rates are significantly increased in spite of data rate requirements and channel gains. In other words, the proposed algorithm has a substantial achievement on user fairness.

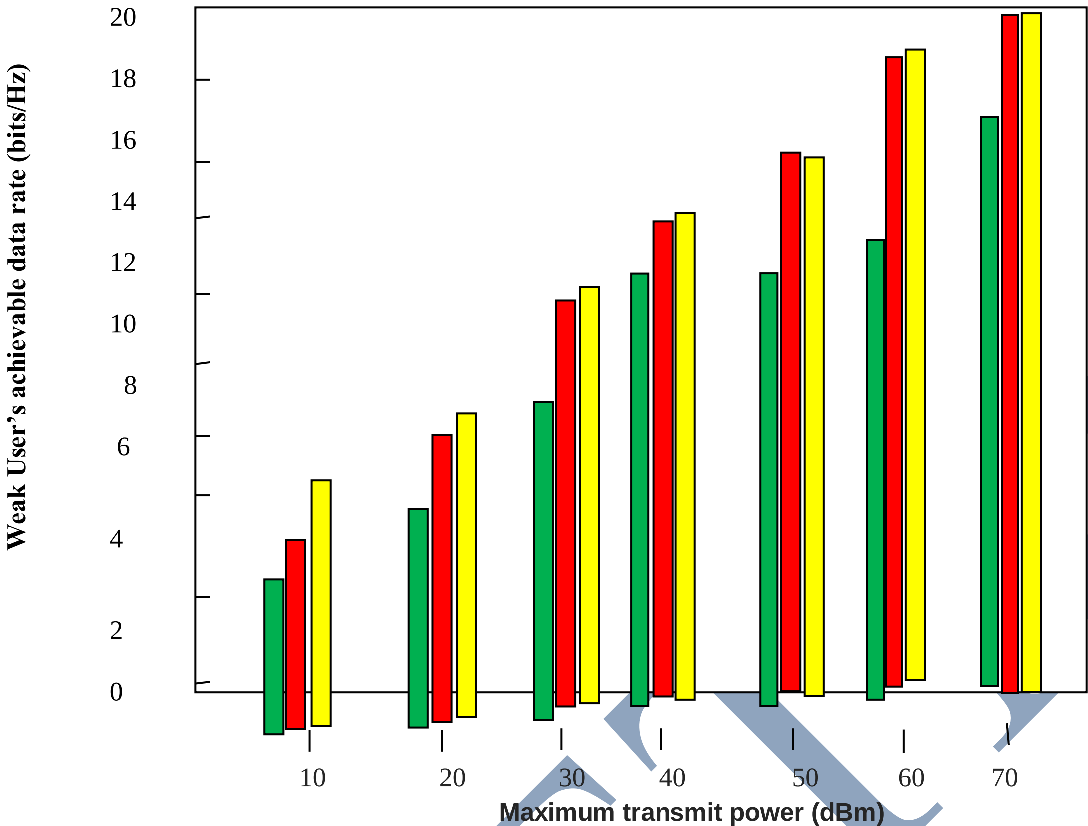

Figure 5.2 Weak User's Achievable Data Rates VS Maximum transmit power.

Weak User with the poorest channel gain in conventional algorithm
Weak User with the highest data rate requirement in proposed algorithm
Weak User with the poorest channel gain in proposed algorithm

5.3 Multiuser Diversity

Due to time limitation, the proposed user selection scheme has been tested in the aspect of multiuser diversity. The number of path loss realization is changed from 10 to 1,000 for accuracy. The test result is illustrated in Figure 5.3.

As indicated, the slop of increment is being decreased and as a result, the average system throughput of the proposed algorithm will reach to its saturation state, which is around 23.50 bit/s/Hz, by increasing the number of downlink users. However, the saturated value of system performance on average throughput by applying the conventional algorithm is being estimated to be around 21.60 bit/s/Hz, which is not impressive in contrast to the proposed algorithm. Thus, the weighed system throughput is heightened with the increasing downlink user, a noticeable decline in its rate of increments also appears as the number of users that are involved is boosted. Since it is challenging to create user fairness among a large number of downlink users, it is an acceptable outcome that the saturated value on average system throughput by using the proposed algorithm is much small than using the conventional algorithm.

To summarize, the proposed user pairing algorithm provides superior improvements in regard of the weighted system throughput and user fairness, as compared to other simulated user pairing algorithms.

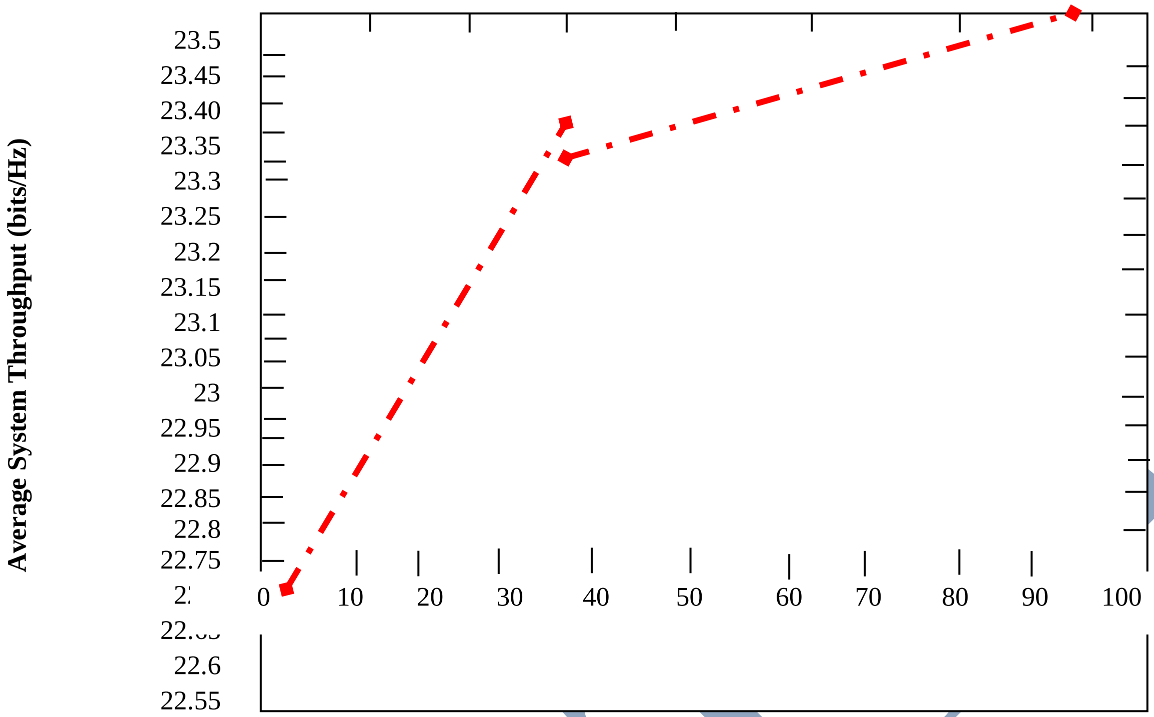

Figure 5.3 Weak User's Achievable Data Rates VS Number of Downlink Users.

VI. CONCLUSIONS

In this work, various problems related to quality of service parameters of 5G communications have been discussed and analyzed. The main aim of the research work is on the performance parameters like better signal coverage, low latency, etc. Networks are designed and an algorithm is proposed and based on the algorithm the design has been formulated by using optimization framework. The proposed algorithm with low computational complexity, namely data rate requirement-based scheme, has considered user channel condition, user data rate requirement and the maximum transmit power constraints. By doing simulation of various user pairing algorithm via SCILAB, the proposed user selection scheme has shown its superior performance on the average system throughput and user fairness in contrast of other conventional algorithms. Thus by our proposed algorithm the performance parameters like average Throughput, user achievable rate and multiuser diversity are improved which in turn will improve the network congestion and will provide high data rates to the users in 5G communication.

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