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SINGLE CARRIER NOMA WITH DYNAMIC POWER ALLOCATION

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ABSTRACT

The rapid increase in the number of subscribers demanding high data rate applications have resulted in the need to shift from the 4G to the 5G networks. The next generation (5G) wireless communication networks (WCN's) are required to fulfill these rising requirements, hence aiming to utilize the available spectrum as efficiently as possible. Also this is leading to a detrimental effect on the ecological balance of the environment as the transmit power levels increase correspondingly in the atmosphere. Hence power optimization has also become a major concern. Various technologies such as massive MIMO, spectrum sharing, device to device communication (D2D), GREEN communication have gained significant attention in aiding spectrum utilization along with power optimization. This proposal intends to optimize power using spectrum sharing for the NGN's to achieve high spectrum and energy efficiency for both the primary and secondary system without introduction of a secondary transmitter. The performance of the proposed model has been compared with the opportunistic spectrum sharing model and other popular resource allocation algorithms. The results obtained confirm the efficiency of the proposed scheme for increased performance of the system. Index Terms— 5G WCN, power optimization, massive MIMO, spectrum sharing, D2D

1. INTRODUCTION

Introduce some basic information about the project in this chapter including research background definition of NOMA multiple carieer and single carieer Dynamic power allocation sum rate We with the massive proliferation in the demand for the mobile wireless communications, smart devices with internet based applications, the expectation from the from the next generation networks has increased manifolds. ▪ Also the next generation networks (NGN) are expected to fulfill the escalating demands of the users with improved quality of service. Since we know that we have a limited radio frequency resource to carry out all the wireless and the mobile communications, the main aim of the NGN is to use the available radio resource most efficiently.

The 5G verbal exchange structures purpose to enhance the fine of verbal exchange in exceptional aspects. For instance, the 5G networks are anticipated to provide severe ability (10 Tbps in step with rectangular kilometer) and statistics rate (multi-Gigabits in step with second), which is called better cellular broadband. 5G ought to additionally permit an ultra-excessive density (1 million nodes in step with rectangular kilometer), ultra-low complexity (10s of bits in step with second) and power consumption, which particularly helps the improvement of the Internet-of-Things (IoT) . Specifically, IoT offers an possibility to understand clever cities, clever homes, long-variety item tracking, etc. Besides, 5G ought to offer ultra-low latency (as low as a millisecond), ultra-excessive reliability (much less than 1 out of a hundred million packets lost) and robust security which enables to obtain mission-important manipulate which includes autonomous vehicles, robotics, business automation, etc. There are numerous disruptive technology for understanding the 5G verbal exchange system, which includes large a couple of-input-a couple of-output (MIMO) , millimeter wave , seen mild verbal exchange [8], and NOMA, etc.

Generation networks (NGN) are expected to fulfill the escalating demands of the users with improved quality of service. Since we know that we have a limited radio frequency resource to carry out all the wireless and the mobile communications, the main aim of the NGN is to use the available radio resource most efficiently.

SYSTEM MODEL

Single carieer NOMA system

Model for single carrier NOMA

2. DOWNLINK NOMA NETWORK

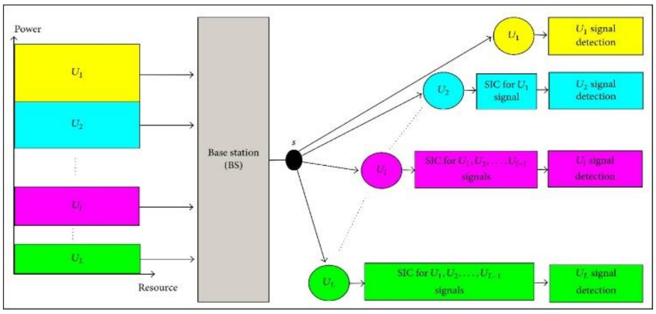
In this section, an outline of NOMA in downlink and uplink networks is delivered via signal-to-interference-and-noise ratio (SINR) and sum charge analyses. Then, excessive signal-to-noise ratio (SNR) evaluation has been carried out so as to examine the performances of OMA and NOMA techniques[3].

At the transmitter side of downlink NOMA network, as shown in Figure 2, the BS transmits the combined signal, which is a superposition of the desired signals of multiple users with different allocated power coefficients, to all mobile users. At the receiver of each user, SIC process is assumed to be performed successively until user's signal is recovered. Power coefficients of users are allocated according to their channel conditions, in an inversely proportional manner. The user with a bad condition is allocated higher transmission power than the one which has a good channel condition. Thus, since the user with the highest transmission power considers the signals of other users as noise, it recovers its signal immediately without performing any SIC process. However, other users need to perform SIC processes. In SIC, each user's receiver first detects the signals that are stronger than its own desired signal. Next, those signals are subtracted from the received signal and this process continues until the related user's own signal is determined. Finally, each user decodes its own signal by treating other users with lower power coefficients as noise..[4] The transmitted signal at the BS can be written as follows

$$s = \sum_{i=1}^{L} \sqrt{a_i P_s x_i}$$

Where x_i is the information of user $i(U_i)$ with unit energy.P is the transmission power at the BS and a1 is the power coefficient allocated for user i is ubjected to $\sum_{i=1}^{L} a_i = 1$ and $a_1 \geq a_2 \geq a_3 \geq ......a_L$ since without loss of generality the channel gains are assumed to be ordered as $|h_1|^2 < |h_2|^2 < ... < |h_L|^2$,where h1 is the channel coefficient of the l th user,based on NOMA concept.The received signal at l th user can be expressed as follows

$$y_1 = h_1 s + n_1 = h_1 \sum_{i=1}^{L} \sqrt{a_i P_s x_i} + n_1$$



Down link NOMA network

a) SNR Analysis

By using(2),the instantaneous SNR of the l th user to detect the j th user, $j \leq l$,with j ≠ L can be written as follows

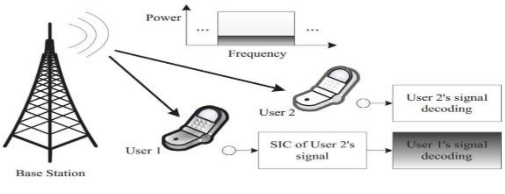


Figure 4 Downlink NOMA Model [45].

$$SNR_{J\rightarrow L}=\frac{a_j\gamma|h_1|^2}{\gamma|h_1|^2\sum_{i=j1}^{L}a_i+1}$$

Where $\gamma=p_s/\sigma^2$ denotes the SNR in order to find the desired information of the l th user,SIC processor will be implemented for the signal of user $j\leq l$ .thus, the SNR of the l th user can be given by

$$SINR_l=\frac{a_l\gamma|h_1|^2}{\gamma|h_1|^2\sum_{i=j1}^{L}a_i+1}$$

Then, the SNR of the Lth user is expressed as

$$SINR_l=a_L\gamma|h_L|^2$$

b) SUM RATE ANALYSIS

After finding the SINR expressions of downlink NOMA the sum rate analysis can easily be done. The downlink NOMA achievable data of lth user can be expressed as [5]

$$R_l^{NOMA-d}=\log_2(1+SINR_L)$$

$$=\log_2\left(1+\frac{a_l\gamma|h_1|^2}{\gamma|h_l|^2\sum_{i=j+1}^{L}a_i+1}\right)$$

Therefore the sum rate of downlink NOMA can be written as

$$R_{sum}^{NOMA-d}=\sum_{i=1}^{L}\log_2(1+SINR_L)$$

$$=\sum_{i=1}^{L-1}\log_2\left(1+\frac{a_l\gamma|h_1|^2}{\gamma|h_l|^2\sum_{i=j+1}^{L}a_i+1}\right)$$

$$+\log_2(1+a_L\gamma|h_L|^2)$$

$$=\sum_{l=1}^{L-1}\log_2(1+\frac{a_1}{\sum_{i=l+1}^{L}a_i+1/\gamma|h_l|^2})+\log_2(1+a_L\gamma|h_L|^2)$$

In order to figure out whether NOMA techniques outperform OMA techniques, we conduct a high SNR analysis thus, at high SNR, that is, $\gamma\rightarrow\infty$,the sum rate of dowenlink NOMA becomes[1]

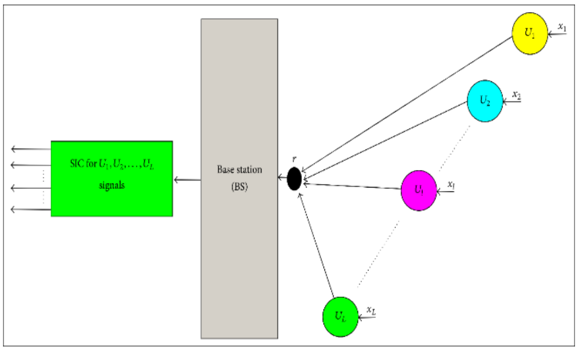
$$R_{sum}^{NOMA-d}\approx\sum_{i=1}^{L-1}\log_2(1+\frac{a_1}{\sum_{i=l+1}^{L}a_i})+\log_2(1+a_L\gamma|h_L|^2)\approx\log_2(\gamma|h_L|^2)$$

3. UPLINK NOMA NETWORK

In uplink NOMA network, as depicted in Figure 3, every cellular person transmits its sign to the BS. At the BS, SIC iterations are performed with the intention to locate the indicators of cellular users. By assuming that downlink and uplink channels are reciprocal and the BS transmits strength allocation coefficients to cellular users, the acquired sign on the BS for synchronous uplink NOMA may be expressed as[2]

$$r = \sum_{i=1}^{L} h_i \sqrt{a_i P_s x_i} + n$$

Where h_i is the channel coefficient of the th user, is the most transmission energy assumed to be not unusual place for all users, and is 0 imply complicated additive Gaussian noise with a variance of σ^2 ; that is, . $n \square CN(0,\sigma^2)$.



Uplink NOMA iNetwork

a) SNR ANALYSIS

The BS decodes the alerts of customers orderly in line iwith strength coefficients of customers, after which the SNR for user $l \neq 1$.

$$SINR_l = \frac{a_l \gamma |h_1|^2}{\gamma \sum_{i=l1}^{l-1} a_i |h_i|^2 + 1}$$

Where $\gamma = p / \sigma^2$ next the SNR for the first user is expressed as

$$SINR_l = a_l \gamma |h_1|^2$$

SUM RATE ANALYSIS

The sum rate of uplink NOMA can be

$$R_l^{NOMA-d} = \sum_{i=1}^{L} \log_2(1 + SINR_L)$$

$$=\log_2(1+a_l\gamma\left|h_1\right|^2)+\sum_{i=2}^{L}\log_2\left(1+\frac{a_l\gamma\left|h_1\right|^2}{\gamma\sum_{i=1}^{l-1}a_i\left|h_i\right|^2+1}\right)$$

$$=\log_2(1+\gamma\sum_{i=1}^{L}a_l\left|h_1\right|^2)$$

When $\gamma\to\infty$,the sum rete of uplink NOMA becomes

$$R_{sum}^{NOMA-d}\approx\log_2\left(\gamma\sum_{i=1}^{L}\left|h_1\right|^2\right)$$

4. SINGLE CARRIER NOMA (SC NOMA) - HOW MANY CUSTOMERS CAN IT SUPPORT

We noticed how non-orthogonal a couple of get entry to (NOMA) can one way or the other magically wreck the capability obstacle confronted via way of means of the opposite conventional orthogonal a couple of get entry to (OMA) schemes. OMA schemes like TDMA, FDMA, CDMA, OFDMA separates the customers in time, frequency, code, subcarrier domain names respectively. No customers are allowed to percentage the identical useful resource concurrently. If this circumstance is violated, interference could arise and each customers could lose their data. For a moment, let's do not forget an OFDMA community with sixty four subcarriers[6]. If we assign one orthogonal subcarrier in line with person, the most variety of customers we will concurrently serve is sixty four. If the sixty fifth person requests a connection, his name should be dropped or he should anticipate one of the different customers to complete transmitting. This is due to the fact we have no greater orthogonal subcarrier to assign to the brand new person. This orthogonality bottleneck imposes a capability obstacle at the variety of customers who can concurrently get entry to the OMA community. NOMA breaks this capability bottleneck via way of means of permitting simultaneous transmission of a couple of customers withinside the identical frequency carrier. Of course, interference could arise. But NOMA employs a way referred to as successive interference cancellation (SIC) to intelligently eliminate the interference. Till now, we noticed approximately person NOMA and 3 person NOMA simulation. After analyzing the ones posts, a number of our readers talked about to me, the subsequent critical query that arises. How many customers can I multiplex withinside the identical carrier? Can I multiplex one hundred customers? Won't this make the receiver facet processing complicated

a) SIC COMPLEXITY AT STRONG USERS

We recognize that, whilst appearing superposition coding on the transmitter side, the customers are ordered in line with their channel situations and the weakest person is allotted the maximum electricity. For example, if we have K customers, and if they're ordered such that, |h1|2<|h2|2<...<|hK|2 , then their corresponding power allocation coefficients will be ordered as α1>α2>...αK . While doing this electricity allocation, we have to make sure that, α1>α2+α3+...αK and α2>α3+α4+...αK , α3>α4+...αK and so on. At the receiver side, the weakest person, i.e., U1 , will carry out direct interpreting. Since, α1>α2+α3+...αK , all different customers' statistics are taken into consideration[7]

interference. So, U1 does now no longer have any complicated processing involved. OK. Let's circulate directly to U2 . In the obtained sign of U2 , U1 's statistics might be dominating because, α1>α2+α3+...αK . So, U2 has to first carry out SIC to estimate and do away with U1 's statistics. Once U1 's statistics is removed, we can have, α2>α3>α4>...αK . So now, U2 's statistics is dominating. Therefore, U2 can carry out direct interpreting, via way of means of treating the statistics of customers U2 , U3 , ... as interference. In a comparable fashion, U3 ought to carry out SIC to do away with U1 and U2 's statistics earlier than interpreting its very own sign. U4 ought to do away with U1 , U2 , and U3 's statistics earlier than interpreting its very own sign. Following the equal educate of thought, how plenty instances have to the most powerful person (UK) carry out SIC earlier than interpreting his very own statistics? K−1 instances. He ought to do away with each unmarried customers' statistics from his obtained sign. Only then αK might be dominating. Thus, if we multiplex a hundred customers withinside the equal carrier, the one hundredth person ought to carry out SIC ninety nine instances earlier than interpreting his very own statistics[8]. This isn't most effective computationally complicated, however additionally consumes plenty time main to processing delay. As if this processing itself isn't complex enough, a brand new trouble known as SIC mistakess propagation may even occur. For example, U5 ought to carry out SIC for U1 , U2 , ... U4 's statistics. If U1 's statistics is decoded in mistakess, then this can cause a incorrect sign being subtracted withinside the SIC process, which could cause interpreting of U2 's statistics erroneously and this mistake propagates on and directly to the interpreting of U5 very own statistics. But this isn't the most effective trouble with multiplexing huge wide variety of customers withinside the equal carrier.

A problem of Interference at weak users

Again, let`s assume we have K users, with U1 as the weakest user and UK as the strongest user. UK already has the problem of complicated and time consuming signal processing requirement. Now, the problem with U1 is this: U1 does direct decoding treating all other users' data as interference. So, the achievable rate equation of U1 will have $K-1$ interference terms

A. THE PROBLEM OF POWER ALLOACTION

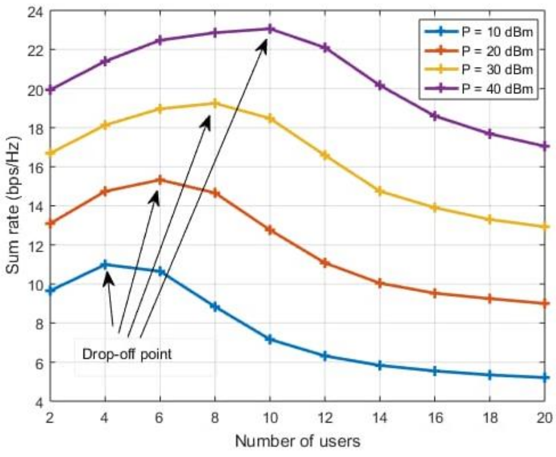
The trouble of strength allocation When we had users, we arbitrarily selected α_1 to be a few value, say 0.75, and $\alpha_2=0.25$. By doing this, we had beencapable of effortlessly fulfill the situations $\alpha_1>\alpha_2$ and $\alpha_1+\alpha_2=1$. When we had 3 users, on this post, we choose, $\alpha_1=0.85$, $\alpha_2=0.15$ and $\alpha_3=0.05$. Thus satisfying,$\alpha_1>\alpha_2>\alpha_3$ $\alpha_1>\alpha_2+\alpha_3$ $\alpha_2>\alpha_3$ and $\alpha_1+\alpha_2+\alpha_3=1$.[9]When we've K users, we've even extra situations to fulfill.$\alpha_1>\alpha_2>\alpha_3>...>\alpha_K$ $\alpha_1>\alpha_2+\alpha_3+...+\alpha_K$ $\alpha_2>\alpha_3+\alpha_4+...+\alpha_K$ $...\alpha_m>\alpha_{m+1}+\alpha_{m+2}+...\alpha_K$ and$\alpha_1+\alpha_2+...+\alpha_K=1$ How can we choose $\alpha_1,\alpha_2,...\alpha_K$ to fulfill a majority of these situations? Obviously, it's far pretty complex to choose them with the aid of using trial and error. So, let`s see a strength allocation approach to address this trouble[15].

A power allocation method for multiple user single carrier NOMA

First, pick fraction less than 1. For example, 34 or 25 etc. Let`s pick 34 . Start with the weakest user. For U1, set $\alpha_1=34$. If $K = 2$, set $\alpha_2 = 1-\alpha_1$. Otherwise, set $\alpha_2 = 34 (1 - \alpha_1)$. If $K = 3$, set $\alpha_3 = 1- (\alpha_1 + \alpha_2)$. Otherwise, set $\alpha_3 = 34 (1-(\alpha_1 + \alpha_2))$. If $K = 4$, set $\alpha_4 = 1- (\alpha_1 + \alpha_2 + \alpha_3)$. Otherwise, set $\alpha_4=34(1-(\alpha_1+\alpha_2+\alpha_4))$ . ... If $K=m$, set $\alpha_m=1-(\alpha_1+\alpha_2+...+\alpha_{m-1})$. Otherwise, set $\alpha_m=34(1-(\alpha_1+\alpha_2+...\alpha_{m-1}))$. By following this heuristic repeatedly to all the users, we will arrive at a power allocation solution which satisfies all the conditions mentioned in the previous section.

This algorithm guarantees proper power allocation in that it meets the required conditions, but new issues are immediately apparent. The more users you push into your network, the less power will be allocated to the strongest users. This reduces the achievable data rate.

Now that we have identified some of the problems faced by so-called single carrier NOMA (or SCNOMA), let's run a MATLAB simulation to see all these problems in action. Let's change the number of multiplexed users to show the achievable cumulative rate of the SC NOMA network. You will get such a graph.



Sum rate (bps/Hz) versus Number of users

1) What can we infer from this graph?

As the number of users of SCNOMA is increased, the sum capacity of the network initially increases and then drops and saturates

- This initial increase is due to the same reasons that NOMA offers better capacity than OMA. The interference levels are manageable and the strongest user, although he is allocated the least power, is given a respectable amount of power.
- We can observe a drop off point beyond which the capacity falls. This drop off point can be regarded as the maximum limit on the number of users who can be admitted into the network without any performance degradation.

- The drop off point moves towards the right as the transmit power is increased. That is, When 10dBm transmit power was used, the sum rate started to decrease beyond 4 users.

- But when 40dBm transmit power was used, the drop off point was beyond 10 users. This behavior is mainly due to the power allocation strategy that we adopted. The weakest user will be assigned the least fraction of power and a small fraction of 40 dBm is greater than a small fraction of 10 dBm.

- Thus, to accommodate more users without performance degradation, we must increase the transmit power

5. CONCLUSION

Simulations have shown that the number of users multiplexed on the same carrier cannot be increased any ifurther. Multiplexing 100 users on the same carrier to answer the first question raises more issues regarding the complexity of SIC calculations, delays, power allocation calculations, and achievable rate reductions. increase. The maximum number of users is determined by the breakpoints in the graph. If yes, what can you do to serve all 100 users of the same carrier? You can choose a hybrid NOMA technology that combines the concepts of OMA and NOMA. We'll talk more about them in future posts

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