A Survey of NOMA with Future Trends and Challenges: 5G

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***Abstract*—NOMA is a fundamental innovation that allows 5-year-old remote (5G) organizations to meet various needs related to short downtime, stable quality, large networks, intelligent enhancement and high performance. The key idea behind NOMA is to provide services to multiple customers with the same asset slice, such as time limit, sub-carrier or spreading code. The latest research and development of NOMA and its applications. Therefore, the article distributed with this extraordinary number falls within the scope of the current letter. In addition, the future challenges of NOMA in 5G and past research will also be discussed.**

Keywords*: *5G, Noma (Non Orthogonal Multiple Access), Orthogonal Multiple Access (Oma), Multiple Input and Multiple Output (Mimo)

I. Introduction

Although academia and industry have proposed several 5G access schemes[1]-[2], including NOMA power domain[3]-[4], cross code access (SCMA)[5]-[6] and hybrid design partition, NOMA has become the fifth remote organization (5G) radio access scheme Main criteria. Access (PDMA)[7],[8], Thin Distribution (LDS) [9], Multi-Grid Segment Access (LPMA)[10] and Nested Variable Partition Access (IDMA)[30]These methods are based on similar key ideas, and each method serves more than one customer. Symmetrical asset access unit, for example, Arrange opening hours, repeat channels, broadcast codes or symmetrical space functional layers. In contrast to NOMA, traditional OMA (Symmetric Large Access) strategies such as TDMA (Time Division Large Access) and OFDMA (Symmetric Multi-Division Repeatable Access) provide services for one customer in each symmetric asset block. The terrible flaws of OMA can be highlighted by the basic model that comes with it. Think about the situation where customers have undefended channels The conditions must be met for reasonable reasons. For example, the customer urgently needs information or is out of service for a long time. In this case, the use of OMA means that despite the lack of defense capabilities of the channel, one of the few bit rate assets will inevitably be used exclusively by the customer. Obviously, this will have a negative impact on area efficiency and overall structural performance. In all cases, the use of NOMA not only guarantees that the client can deliver unhelpful channel conditions, but also that the client with the best channel conditions can use assets similar to the transmission capacity of weak clients at the same time.

NOMA may be much larger than OMA. Although efficiency has been amazingly improved, modern and academic research has also shown that NOMA can fully support huge usability. This is very important to ensure that the upcoming 5G organization can support the corporate Internet (IoT) capabilities. Although academia and industry have proposed several 5G access schemes, including NOMA power domain, cross code Access (SCMA) and hybrid design partition, NOMA has become the fifth remote organization (5G) radio access scheme Main criteria. These methods are based on similar key ideas, and each method serves more than one customer. Symmetrical asset access unit, for example, Arrange opening hours, repeat channels, broadcast codes or symmetrical space functional layers. In contrast to NOMA, traditional OMA (Symmetric Large Access) strategies such as TDMA (Time Division Large Access) and OFDMA (Symmetric Multi-Division Repeatable Access) provide services for one customer in each symmetric asset block. The terrible flaws of OMA can be highlighted by the basic model that comes with it. Think about the situation where customers have undefended channels The conditions must be met for reasonable reasons . For example, the customer urgently needs information or is out of service for a long time. In this case, the use of OMA means that despite the lack of defense capabilities of the channel, one of the few bit rate assets will inevitably be used exclusively by the customer. Obviously, this will have a negative impact on area efficiency and overall structural performance. In all cases, the use of NOMA not only guarantees that the client can deliver unhelpful channel conditions, but also that the client with the best channel conditions can use assets similar to the transmission capacity of weak clients at the same time.

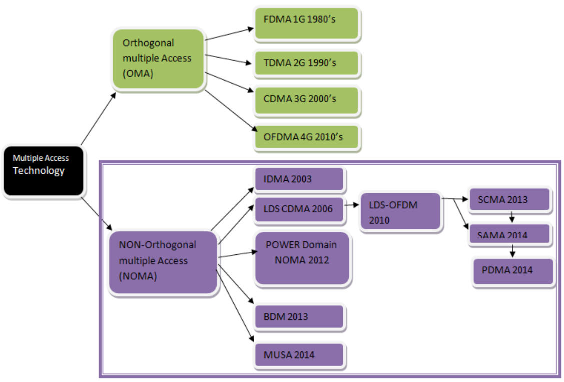

Fig.1: Multiple Access Technology for 5G

NOMA may be much larger than OMA[11]. Although efficiency has been amazingly improved, modern and academic research has also shown that NOMA can fully support huge usability.

This is very important to ensure that the upcoming 5G organization can support the corporate Internet (IoT) capabilities [12]-[13]. Downlink transmission channel CR-NOMA normal power area NOMA provides customers with more power under undefended channel conditions, thus ensuring customer intelligence. Even so, the conventional NOMA energy room cannot strictly guarantee the quality of the customer's research goals. NOMA Cognitive Radio (CR) is an important variant of NOMA Power space, which strictly implements some or all of the customer's QoS requirements. CR-NOMA's critical thinking is to take this into consideration NOMA is an outstanding example of smart proportions, in which a power allocation strategy is planned, the ultimate goal of which is to meet the customer's predefined QoS requirements.

Although the application of NOMA in cellular networks is relatively new, research on the concept of information has been around for a long time. For example, important NOMA components such as overlay coding, sequential interference suppression (SIC) and message transmission algorithm (MPA). Invented for more than 20 years [14] [15] [31]. However, the principle of NOMA that eliminates orthogonality has not been used in previous generations of cellular networks.

We be aware that the philosophy in the back of NOMA is rarther exceptional from that in the back of code department a couple of access (CDMA). In fact, CDMA is more often than not constructed upon the concept that customers are separated via way of means of exploiting the variations amongst their spreading codes, while NOMA encourages a couple of customers to hire exactly the identical code. As a consequence, for CDMA, the chip price must be a whole lot better than the supported records facts price, e.g., assisting a facts price of 10 Gbps may also require a chip price of some hundred Gbps, that's hard to realize with sensible hardware.

II. NOMA MULTI Transmitter

With the special development of OFDMA, this type of OMA may be merged with the 5G organization, so much attention has been paid to the number of OFDMA subcarriers that can be effectively associated with NOMA. It first introduces the general guidelines for multi-operator NOMA, and then introduces some of the existing multi-operator NOMA types provided to 5G organizations.

A. *NOMA MULTI Transmitter*

For half of NOMA, the customers in the organization are divided into several meetings. In particular, according to the NOMA guidelines, customers of each meeting are served in similar symmetric asset blocks, and multiple appointments are arranged for different symmetric asset blocks. The idea of using cross NOMA is to reduce the complexity of the framework. When performing the simulation, assigning each customer in the organization to a separate group to perform NOMA on the symmetric asset block is risky because the customer with the best channel conditions must be disbanded. Before decrypting your own messages, a large number of messages from different clients. This leads to a high degree of complexity and long delays in decryption. The NOMA crossover is an effective way to strike the right balance between shooting performance and complexity. For example, what about multi-carrier NOMA? Customers in the warehouse are divided into multiple appointments that are not fully contacted. In the meeting, the customer was allocated appropriate subcarriers, and NOMA was used to reduce the impedance in the group. Assign multiple customer appointments to multiple sub-operators to avoid crowded crowds. As a result, frames may become overloaded, which is critical to serve more clients than the number of available subcarriers and is required to power large networks Still recognized by this NOMA hybrid conspiracy. It should be noted that at half of NOMA, it is difficult to detect congestion due to the limited number of users in each subcarrier. Especially attractive, especially because OFDMA may be used in the next 5G organization.

1. *MIMO-NOMA and MIMO-OMA:*

NOMA can also be used in the MIMO case where the BS has M radio cables and each client is equipped with N receiving cables. In addition, different customers can meet randomly in M groups, with two customers in each group. In terms of overall channel limitation (not including transmission to a single client in a MIMO frame), MIMO-NOMA is better than MIMO-OMA[35],

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that is, for each rate pair that the MIMO-OMA plan achieves, a small part of the force MIMO-NOMA is designed for higher matching rate.

2. *An Edge Study of NOMA Over OMA*

shows that NOMA can achieve a higher bit rate than OMA. In particular, the advantages of NOMA and the old OMA style in the mainstream contrast can be summarized as follows:

Supernatural capabilities and performance are added at the edge of the cell: recurring assets will not be orthogonally distributed on the client over time, just like in Norma As mentioned above, in the NOMA code domain and in the uplink of the AMAGN channel, although both OMA and NOMA can reach the maximum possible overall limit, NOMA maintains a fairer client decency. One of OMA's downlink AWGN channels. In two-way low-impedance inter-frame (ISI) unsharpened channels, NOMA depends on MUD, although OMA is actually designed to meet the highest overall limit achievable on the downlink Ideally, if the CSI is only known in the downlink collector, OMA is still not perfect.

Huge availability: The asymmetric asset allocation in NOMA shows that the number of qualified clients/devices is not strictly limited by the number of available symmetric assets. In the case of incorrect locations, please significantly increase the number of simultaneous allocations in order to maintain high availability. Existing NOMA schemes based on code domain or power domain multiplexing can use non-orthogonal general tools to improve spectrum performance.

III. Basics and Advantages of NOMA

In this section, we first compare the basic principles of OMA and NOMA, and then compare the advantages and disadvantages of NOMA and OMA in detail. In conventional OMA schemes (such as FDMA, TDMA, CDMA, and OFDMA) used for 1G, 2G, 3G, and 4G, respectively, orthogonal wireless power sources are allocated to multiple users in the time domain, frequency, code, or a combination thereof. In FDMA, a signal is sent out with its unique frequency resource so that the receiver can easily capture all user data in the corresponding frequency band. Similarly, in TDMA, each user is assigned a unique time slot, which makes it easy to distinguish between different signals from the user to the receiver in the time domain. In CDMA, several users can share the same time resource frequency, and orthogonal cover sequences such as Walsh-Hadamard codes can be assigned to symbols sent by different users. Therefore, a de-correlation receiver with low complexity can be used for multi-user identification (MUD).OFDMA can be regarded as the intelligent integration of FDMA and TDMA, in which radio resources are divided orthogonally in a time-frequency grid. Theoretically, due to orthogonal resource allocation, there is no interference between users in the OMA system, so low-complexity and linear-complexity detectors can be used to separate different user signals [29].

When 5G requires large-scale connections, the number of orthogonal resources available in the traditional OMA solution will become a serious limitation. In addition, theoretically, OMA may not always be able to reach the maximum overall speed that can be achieved by wireless multi-user systems, and if necessary, NOMA can provide multi-user bandwidth through time sharing or rate sharing . The following subsections will explain in detail.

In order to bypass the above OMA restriction, Recently, NOMA has been used as a design alternative. The main function of NOMA is to allocate non-orthogonal resources, and the number of users it supports exceeds the number of orthogonal resource time slots. This can be achieved through complex interference cancellation between users. Due to the higher complexity of the receiver, it has a polynomial or exponential computational complexity. If we choose the OMA circuit, the time domain signal will become blurred due to the convolution of the time domain signal and the channel impulse response (CIR) with dispersion. In addition, the historical concept of NOMA consists of a series of CDMA systems that use more non-orthogonal sequences than Nc chips to support more sequences than Nc users through inter-user interference. Only a powerful multi-user detector can effectively eliminate this interference. Therefore, the concept of NOMA is very attractive. The NOMA schematic series can be roughly divided into two categories: NOMA in terms of performance and NOMA in terms of code[20]. Frequency code resources are shared among multiple users. At the receiving end, the NOMA performance domain uses the difference in user performance to distinguish different users Based on sequential interference suppression (SIC). The NOMA code domain is similar to CDMA or CDMA multi-carrier (MC-CDMA), except that it prefers low-density or non-orthogonal sequences with low cross-correlation.

IV. Demanding Situations and Opportunities

In addition, the NOMA strategy can be used within a limited range to maintain good communication. Therefore, NOMA solutions may be regarded as a promising candidate for 5G. However, many problems still need to be solved. Therefore, for many important aspects, it is possible to emphasize the difficult situations related to NOMA design, as well as the possibilities and trends of research directions aimed at solving these problems.

A. *Practical Analysis*

Circuit access potential is one of the most important criteria for improving device performance. In particular, the bandwidth limitation of the NOMA code domain based on the current propagation sequence should be checked. For MC-CDMA, similar technologies and

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tools are also possible. On the other hand, the maximum standardized user load supported is limited. Both because of the possibility of interference cancellation, and because of the low-cost receiver complexity associated with each propagation sequence and the unique design of the receiver.

B. Drafting Broadcast Sequence or Code Book

In the LDS system, the non-orthogonal allocation of resources between users can cause mutual interference. The maximum type of overlapping symbols in each orthogonal payload "index" is determined by certain broadcast sequences or client codeword's, which directly affects the interference suppression capability achieved at the receiver. Therefore, the component diagram of the message passing algorithm needs to be optimized to achieve a convincing compromise between the supported normalized user load and the load. In addition, it has been shown that in the case of an idealized cyclic problem graph, a set of rules traversed by the message can determine the exact marginal distribution, and the "area tree is" can be used to obtain the correct solution. The component diagram implies that the scope loop must be high enough. The schematic can be used to design component diagrams with loops or "area trees" for NOMA without sacrificing spectral efficiency. In some convenient packages, the cycle graph can be decomposed into individual cycle graphs.

C. Receiver Design

However, the complexity of a complete MPA receiver may become overwhelmed by the large 5G link. Therefore, some approximate MPA solutions can be used to reduce the complexity of the receiver, such as the Gaussian interference approximation that simulates interference. More noise in the form of a Gaussian distribution. As predicted by 5G, this approximation becomes more accurate as the diversity of connections increases. In addition, MPA can be used to search and decode symbols received at the same time for each channel. The constructed graph is composed of variable nodes, observation nodes and test nodes corresponding to the LDPC code check equation. The information exchange between the decoder and demodulator used in the receiver can be more correct to improve the overall signal recognition performance. For mainly SIC-based receivers, the propagation of related errors will further affect the overall performance of multiple receivers.

D. Channel Estimation

Therefore, high-performance nonlinear detection algorithms can be used in each stage of ICS to reduce the impact of error propagation. It is meaningful to achieve ideal CSI in an actual system, which will lead to channel estimation errors in NOMA[16]-[17]. The influence of residual interference superimposed by sensitive incomplete channel estimation on the possible performance of the NOMA structure and the return algorithm with low complexity aim to reduce the influence of channel estimation error. Estimates developed for NOMA and some optimization algorithms have been proposed to reduce channel estimation errors[18]-[19]. Therefore, a higher-level channel estimation algorithm is required to obtain Perform channel evaluation correctly in the conclusion of NOMA Systems.

V. Future Research Goals

This section describes many promising areas for NOMA's future research.

A. The Application of Wireless Energy Transmission in NOMA

Uses the cooperative NOMA scenario to illustrate the motivation for using simultaneous wireless transmission of information and energy (SWIPT). It is a new member of the energy storage family in NOMA [22]-[23].For example, cooperative NOMA can effectively support users in a weak channel environment by using strong users as repeaters[24]. In fact, the user may not want to transmit a signal because it consumes its own energy, thereby shortening battery life. Using SWIPT, heavy users can extract energy from the signal sent by the base station and use the collected energy to power the relay transmission. As a result, strong users have more motivation to forward and help weak users. According to the idea the design of cooperative SWIPT-NOMA is being studied[25],[24]. the range of NOMA rates that can be achieved using wireless energy transmission[21].The influence of user selection and antenna selection on the interoperability between SWIPT and NOMA is studied[26]-[27]. SWIPT is not only suitable for cooperative NOMA numbers, but also useful for other NOMA communication schemes. For example, SWIPT To request NOMA uplink transmission[27]-[28], the user receives power from the BS, and then uses the NOMA principle to simultaneously send its information to the BS. In [29], the resource allocation of this form of uplink SWIPT-NOMA transmission was examined, in which energy allocation, energy duration and information transmission were designed together to counter the dual impact of "close range". Note that most existing SWIPT-NOMA schemes are based on different idealized schemes. The assumptions and effects of actual constraints such as hardware defects, nonlinear energy harvesting, and circuit power consumption on SWIPT-NOMA performance are yet to be studied.

B. The Combination of NOMA Network and Cognitive Radio is Described

The application of the cognitive radio concept can significantly reduce the complexity of formulating

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power allocation strategies and strictly enforce user QoS requirements [11],[32]. These two communication concepts are two-way, and NOMA is also important for cognitive radio networks.For example,The principle of NOMA is largely applied to the cognitive radio core network to improve the connectivity of the auxiliary network[21]. Unlike the NOMA application in traditional wireless networks, the performance of overlapping signals from NOMA cognitive radio users should avoid unnecessary interference to the main receiver. the auxiliary transmitter uses NOMA[19], which supports two functions. One is to pass information to its own recipients, that is, secondary recipients, and the other is to act as a repeater to help the primary recipient. Current research results on the combination of NOMA and cognitive radio networks still largely depend on the network topology under consideration. More work is needed to gain a basic understanding of the synergy between these two communication best practices.

C. *Security of NOMA*

The security of NOMA is the same as other multiple access methods, and no security is considered in the design of NOMA. The special security risk of NOMA is that in order to implement SIC, a user must be able to encrypt another user's message. Such security threats exist for other multiple access methods, such as . TDMA users can temporarily open The slot is not allocated and is trying to decode another user's information. In modern telecommunication systems, security is ensured through encryption technology rather than multiple access strategies. However, preliminary studies have shown that the use of NOMA can improve transmission security, especially in the following two situations:

1. For external espionage activities, the principle of NOMA can be combined with the physical layer.Security (PLS) [35]-[33]. In particular, the advantage of NOMA is that the power distribution factor of NOMA is designed according to the channel conditions of legitimate users, which means that SIC may not be implemented in the interceptor, so it can effectively suppress eavesdropping.
2. For certain situations where NOMA users may lose their leaves [34] shows that NOMA is useful in preventing droplets from being discarded.In particular,the principle of NOMA is used for the simultaneous transmission of multicast and unicast messages[34]. The beamforming of the base station is carefully designed to artificially increase the difference between the channel conditions of the two types of users, which is very useful for improving data confidentiality.

PLS and NOMA are a broad and promising research field, and more research is needed to develop practical low-complexity circuits to achieve NOMA security.

III. Conclusion

In this article, we discussed the key concepts and advantages of NOMA technology, which is one of the most promising technologies for future 5G systems. It works, key features, receiver complexity, advantages and disadvantages. NOMA is the resolution era required to meet key 5G performance requirements (including excessive system bandwidth, low latency, and high connection speed). By leveraging heterogeneous user channels and QoS requirements, NOMA can use constrained bandwidth sources more successfully than OMA, and ongoing research convincingly confirms NOMA's potential in improving the performance of network equipment. The requirements for 5G, LTE-A and digital TV show that NOMA can become an important part of the next-generation Wi-Fi network. We hope this review and articles on specific topics are helpful to readers. You can also better understand the advantages and functions of NOMA.

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