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A Survey on Modulation and Multiple Access Techniques For Exploiting Heterogeneous User Mobility Profiles

Kripa M S[1], Luxy Mathews[2]
[1](Department of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Thiruvananthapuram, Kerala, India)
[2](Department of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Thiruvananthapuram, Kerala, India)

Abstract:.*Fifth generation (5G) remote advancements face a few difficulties in order to help huge heterogeneous traffic and users. Novel modulation and multiple access methods are being created to satisfy the needs of 5G networks. Orthogonal frequency division multiplexing (OFDM) is the existing modulation technology used in 4G networks. Its OOB emission is high because the signal is time-restricted. A novel modulation technique called orthogonal time frequency space (OTFS) modulation is used to support time-varying channels. It is used for time-varying channels with high Doppler spread. It multiplexes QAM information symbols in a new signal representation called the delay-Doppler representation. The multiple access scheme which is fundamental to all preceding and existing wireless communication networks is orthogonal multiple access (OMA). But OMA can support only a restricted number of users due to restrictions in the number of resource blocks which limits spectral efficiency. To support dissimilar classes and an enormous number of users various non-orthogonal multiple access (NOMA) methods are used.*
Key Words:*5G, OTFS, NOMA*

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I. Introduction

5G wireless technology which is an innovative platform is developing at an explosive rate and is probably the greatest region of research inside the scholarly community and industry. The challenges in designing the 5G network include enormous connectivity with great system throughput and better spectral efficiency. Novel modulation techniques in addition to multiple access systems can be used to encounter these demands. OFDM is the modulation technique that has been adopted in 4G networks. It is capable to struggle with the delay spread of communication channels with a suitable cyclic prefix. But OFDM fails to encounter many novel demands necessary for 5G networks. The Out-of-band (OOB) emission is more, specifically if the users are asynchronized because the signal is time-restricted. Several categories of modulation methods which are based on pulse shaping, sub-band filtering, and precoding are used to address the novel trials in 5G systems. Orthogonal multiple access (OMA) is fundamental to all previous and current wireless networks: TDMA, FDMA, CDMA, and OFDMA are the orthogonal multiple access schemes used. Here only a negligible interfering among neighboring blocks because the source blocks are orthogonally allocated in frequency, time, and code domains which makes the signal discovery easier. But OMA can support only a restricted number of users which limits spectral efficiency and capacity of wireless networks. Therefore various non-orthogonal multiple access techniques can be used to support a huge amount of users and dramatically diverse sets of users.

II. Modulation techniques for exploiting heterogeneous user mobility profiles

OFDM is the modulation method that has been adopted in 4G networks. It is capable to struggle the delay spread of communication channels with a proper cyclic prefix. But OFDM fails to encounter many unique difficulties essential for 5G. Since the OFDM signal is time-restricted the Out-of-band (OOB) emission is high, specifically when the users are asynchronized. Several classes of modulation techniques that are based on pulse shaping, sub-band filtering, and precoding are used to address the novel trials in 5G systems**.**

1. Modulations based on pulse shaping

To limit transmit wave inside a constricted bandwidth to lessen the out-of-band (OOB) release modulation strategies which are dependent on pulse shaping is utilized. Modulation based on pulse shaping can be viewed as sub-carrier based sifting which can successfully lessen the OOB spillage. Generalized frequency division multiplexing (GFDM) and Filter bank multicarrier (FBMC) are the two typical modulation patterns based on pulse shaping. FBMC contains IDFT and DFT, analysis, and synthesis polyphase filter banks. Pulse shaping is performed by a prototype filter that is designed for a particular application. OQAM structure is used to achieve the best spectral efficiency. The intervention from the neighboring overlapped symbols which is initiated by the matched filter receiver can be canceled easily by using a filter and OQAM structure. Unlike FBMC, GFDM uses circular shifted filters for pulse shaping. To retain better spectral efficiency the waveforms created on pulse shaping are mutually non-orthogonal in frequency and time domain. The OOB leakage can be reduced by carefully selecting a circular filter. Also, the linear filters' long tail in FBMC can be avoided by circular shifted filters in GFDM.

2. Modulations based on sub-band filtering

An alternative technique to reduce OOB discharge efficiently is sub-band filtering. Filtered orthogonal frequency division multiplexing (f-OFDM) and Universal filtered multicarrier (UFMC) are the modulation methods based on sub-band filtering. The sub-bands are with equivalent size and each filter is a shifted form of the same prototype filter in Universal filtered multicarrier (UFMC). OFDM is adapted within a sub-band for this modulation method. The intervention affected by the tail of the filter can be simply eradicated by accepting zero-padding prefix with realistic length. The main difference of f-OFDM from UFMC is that f-OFDM hires a cyclic prefix and permits remaining inter-symbol interference (ISI). Hence matched filter is applied at the receiver side instead of zero-padding and decimation. Also, the cyclic prefix length and the sub-carrier spacing need not be similar for diverse users as in f-OFDM.

3. Other modulation techniques

To destroy the OOB emission and to encounter the necessities for 5G networks there are also some extra modulation methods separately from pulse shaping and sub-band filtering. The other three modulations techniques are Spectrally-precoded OFDM (SP-OFDM), Guard interval discrete Fourier transform spread OFDM (GI DFT-s-OFDM), and the Orthogonal time frequency and space (OTFS) modulation. A well-known series is used as the guard interval as a replacement for a cyclic prefix (CP) in GI DFT-s-OFDM. Zero series and a well-made distinctive word can be used as a known sequence. By utilizing proper sequence as a guard interval, the disjointedness among the nearby time blocks in OFDM can be avoided. In Spectrally-precoded OFDM (SP-OFDM) the data symbols which are plotted on subcarriers are precoded by a rank-deficient matrix to facilitate the precoded signal that can be high order continuous and outcomes in much lesser outflow in contrast with the ordinary OFDM. All these modulation techniques can attain high spectral efficiency for a time-invariant frequency selective channel. They are not robust to time-varying channels with high Doppler spread. Hence to support time-varying channels orthogonal time frequency space (OTFS) modulation is used. OTFS modulation technique is used for time-varying channels with high Doppler spread. It multiplexes QAM information symbols in a new signal representation called the delay-Doppler representation. Then it is mapped to samples using Inverse symplectic finite Fourier transform (ISFFT). The transmitting signal is obtained by applying the Heisenberg transform to these samples. Wigner transform and symplectic finite Fourier transform (SFFT) is applied for the reception.

III. Multiple access techniques for exploiting heterogeneous user mobility profiles

Orthogonal multiple access (OMA) is core to all previous and current wireless networks: TDMA and FDMA are the multiple access schemes used in 2G networks, CDMA in 3G networks, and OFDMA in 4G systems. Here the source blocks are orthogonally distributed in frequency, time, and code domains and hence there is only slight intervention amid neighboring blocks which makes the signal discovery easier. But OMA can support the only restricted number of users which limits spectral efficiency and capacity of wireless networks. Therefore various non-orthogonal multiple access techniques can be used to maintain the huge number of users and dramatically diverse classes of users. The fundamental quality of NOMA is to help various users at the same time/frequency/code, yet with differing power levels. In NOMA, users having pitiable channel conditions obtain more power. Specifically, the user with the more fragile channel condition is distributed more transmission power, which affirms that this user can identify its message straightly by considering the other user's information as noise. Conversely, the user with the more grounded channel condition needs to initially detect the message for its companion, at that point subtract this message from its perception, and lastly translate its own data. This methodology is called successive interference cancellation (SIC). The NOMA structures can be categorized into three major groupings as Code-domain NOMA, Power-domain NOMA, and NOMA multiplexing in multiple domains.

1 Power-domain NOMA

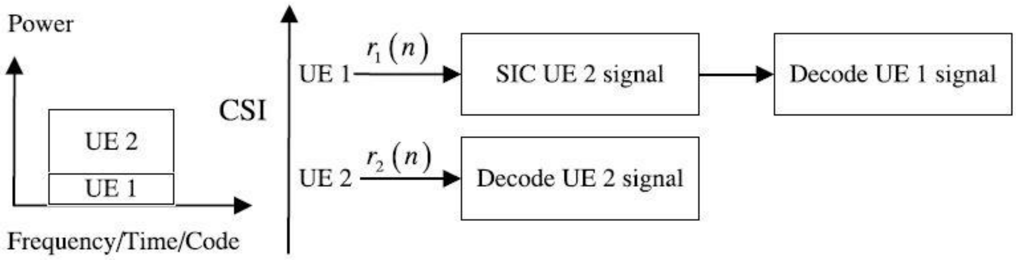

Figure 1: Power-domain NOMA

Power-domain NOMA is measured as a hopeful multiple access scheme for 5Gnetworks. Power-domain NOMA maintains several users inside the similar frequency/time/code source block by differentiating the usersbydissimilar power levels. The user with greater transmit power is decrypted first by considering the other user's data as noise. Once it is identified and decrypted its symbol component is deducted from the received signal so as to detect the data of succeeding users. As a result intervention from the users with better CSI is loweredmeaningfully as fewer powers are allotted to them.

2 Code- domain NOMA

By assigning various codes to diverse users code-domain NOMA can keep up a few transmissions inside similar time-frequency source blocks. Conversely, with power-domain NOMA it has clear spreading gain and shaping gain. Low-density spreading OFDM (LDS-OFDM), Low density spreading CDMA (LDS-CDMA) and Sparse code multiple access (SCMA) are the current answers for code-domain NOMA. Out of these LDS-CDMA is one of a kind sort of CDMA. The essential component of LDS-CDMA is that for the codebook development a low-density signature, which is like a low-density parity check (LDPC) framework is utilized. A low-complication near-optimal multiuser recognition arrangement can be used in the LDS-CDMA recognition, due to the sparse arrangement of the signature which meaningfully improves the performance of the system. In LDS-OFDM the output of the signature is plotted into the subcarriers of OFDM. In SCMA a definite quantity of source blocks can maintain additional users through spreading by using a sparse codebook. Other than the sparse spreading, SCMA employs multidimensional constellations to lessen the receiver complication and additional improvement in the spectral efficiency.

3.NOMA multiplexing in multiple domains

Aside from multiplexing the waves which are in the code domain or power domain, different goals for NOMA have been offered to multiplex in a few domains to help gigantic availability for 5G remote systems. The various domains are power, code, and spatial domain. The three kinds of classic NOMA arrangements multiplexing in multiple domains are Block sparse-constellation based orthogonal multiple access (BOMA), Pattern division multiple access (PDMA), and Lattice partition multiple access (LPMA). To perform multiplexing non-orthogonal configurations are assigned to diverse users in Pattern division multiple access (PDMA). To achieve the SIC-amenable property these configurations are designed with care in the several domains of space, code, and power. The data as of a user with fine CSI are devoted to the symbols of a user with reduced CSI in BOMA. And therefore the capacity of a multiuser structure is improved meaningfully. The code and the power domain are joined to multiplex the users in Lattice partition multiple access (LPMA). Practically identical to control multiplexing in power-domain NOMA, the code in LPMA outfits a multilevel lattice that assigns various code to focus the users with various CSI. For users with decreased CSI, the assigned codes have greater least separation that can increase the performance of detection.

IV. Conclusion

Here ample study covering the main promising applicants for modulation methods and multiple access schemes in fifth generation (5G) networks for exploiting user mobility profiles is done. It is noticed that novel modulation techniques for orthogonal multiple access can be accepted to reduce the out-of-band emission and to exploit time-varying channels while meeting the diverse demands for 5G networks. The modulation techniques discussed so far can provide advantages over current modulation techniques that are adopted in existing wireless networks. Also, it provides high spectral efficiency, loose synchronization, and flexibility when compared to existing modulation techniques. Non-orthogonal multiple access is an alternative promising attitude that marks deviance from previous throughput, ultra-high connectivity, low transmission latency, and improved spectral efficiency.

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