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5g Wireless Networks Based On Generalized Frequency Division Multiplexing

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Abstract— Cellular systems of the fourth generation (4G) have been optimized to provide high data rates and reliable coverage to users. Cellular systems of the future generation will face more diverse application requirements: the demand for higher data rates exceeds 4G capabilities; battery-driven communication sensors need ultra-low power consumption; control applications require very short response times. introdusing a physical layer waveforms, referred to as Generalized Frequency Division Multiplexing (GFDM), to address these requirements. Analyse main characteristics of the proposed waveform and highlight the main features. by introducing the principles of GFDM, this contributes to the following areas: (i) means for engineering the waveform's spectral properties, (ii) analysis of SER performance over different channel models, (iii) concepts for Multiple input Multiple Output-GFDM to achieve diversity technique (iv) preamble-based synchronization that preserves the excellent spectral properties of the waveforms, (v) BER performance for channel coded GFDM transmission using receivers, (vi) different application scenarios and suitable GFDM parameters, (vii) GFDM proof-of-concept and implementation aspects of the prototype using hardware platforms available today. The flexible nature of GFDM makes this waveform a suitable candidate for future 5G networks.

***Index Terms*—5G scenarios, physical layer, non-orthogonal waveform, GFDM, pulse shaping,MIMO, synchronization, proofof-concept.**

I. Introduction

Mobile communication has become an essential tool for the modern society. The first generation of cellular sys-tems provided basic, yet innovative, voice transmission. Communication started to become personal rather than being connected to fixed locations. The second generation has digitalized the voice in order to increase system capac-ity, battery life of devices and Quality of Service (QoS). It also introduced the Short Message Service, which revolutionized the way people communicate. The third generation enabled mobile Internet access and data rates not too far behind of wired solutions of that time. The advent of smartphones with large storage and processing capabilities equipped with high definition screen and cameras, in combination with social networks that turned users from media consumers into content providers, has pushed the fourth generation towards even higher throughput. Starting with the first two generations, the growth of the mobile communication has focused on increasing the throughput. However, the scenarios foreseen for future fifth generation (5G) networks have requirements that clearly go beyond higher data rates. The main scenarios for 5G networks are machine type communication (MTC). Tactile Internet and Wireless Regional Area Network (WRAN) while classical bit pipe communication is still considered an important applica-tion.

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II. EXISTING SYSTEM

A. *OFDM*

one cyclic prefix per symbol would present a prohibitive low spectral efficiency. The low spectrum efficiency due to the CP insertion is also a problem for WRAN application, where the typical channel impulse response has adjuration of tenths of microseconds. Additionally, the high out-of-band emission of OFDM poses a challenge for opportunistic and dynamic spectrum access. All these challenges make OFDM not the most promising waveform for the next generation networks. In this context, alternative multicarrier schemes are currently being evaluated as candidates for the PHY layer of next generation of mobile communication systems. In Filter Bank Multi carrier, one of the most investigated filtered multicarrier systems the subcarriers are pulse shaped individually in order to reduce the OOB emissions. Because the subcarriers have narrow bandwidth, the length of the transmit filter impulse response is usually long. Typically, the filter has four times the length of the symbols. As a consequence, FBMC can only achieve good spectral efficiency if the number of transmit symbols is large. This solution is not suitable for low latency scenarios, where high efficiency must be achieved with short burst transmissions. Universal of subcarrier is filtered to reduce the OOB emission.

B. *4G*

4G is the fourth generation of mobile communications technology is the more advanced version of 3G and proposing 5G.a 4G system, in addition to the common voice and other service of 3G.provides mobile broadband internet access.

Examples are Laptops with wireless modems,Smart phones,Mobile web access,IP telephony,Gaming services,High-definition mobile TV,Video conferencing,3D televi-sion,Cloud computing.Advantages of 4G are ,Quickly download files over a wireless network,Extremely high quality,Easily access internet,Video calling,Higher band-width,4G is 10 times faster than 3G.Disadvantages of 5G are,New set of frequency need new towers,Higher data prices for consumers,Consumer is forced to buy a new phone support the 4G.

III. PROPOSED SYSTEM

A. GFDM

GFDM is a promising solution for the 5G PHY layer because its flexibility can address the different re-quirements. For real-time applications, the signal length must be reduced to full fill certain latency requirements. Because GFDM is confined in a block structure of MK samples, where K subcarriers carry M sub symbols each, it is possible to design the time-frequency structure to match the time constraints of low latency applications. Different impulse responses of filter can be used to filter the subcar-riers and this choice affects the OOB emissions and the SER performance. As will be shown, GFDM allows engi-neering signals in their frequency and time characteristics.

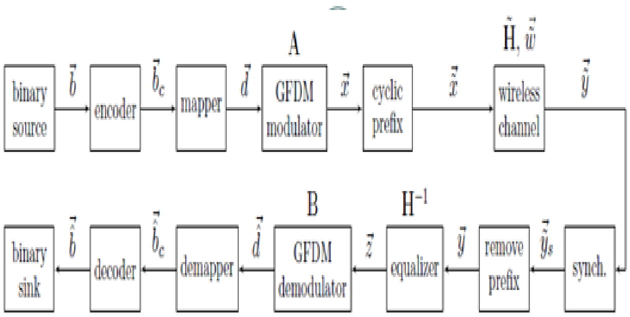

Fig. 3. 1 GFDM Transmitter and Receiver

The bandwidth of the filter covers several subcarriers, its impulse response can be short, which means that efficiency of spectrum is very high can be reached in short burst transmissions. UFMC does not require a CP and it is possible to design the filters in order to obtain a total block length equivalent to the CP-OFDM. However, because there is no CP, UFMC is more sensitive to small time misalignment than CP OFDM. Hence, UFMC might not be suitable for applications that require loose time synchronization in order to save energy. Bi-orthogonal Frequency Division Multiplexing (BFDM) employs well localized pulse shapes at the transmitter and receiver side that are bi-orthogonal to each other. The good frequency-localization of the transmit pulse makes the system robust against frequency dispersion (Doppler Effect) while the good time-localization of the pulse provides robustness against time dispersion (multipath). The flexibility of GFDM allows it to cover CP-OFDM and single-carrier frequency domain equalization (SC-FDE) as special cases. GFDM is based on the modulation of independent blocks, where each block consists of a number of subcarriers and sub symbols. The subcarriers are filtered with a prototype filter that is circularly shifted in time and frequency domain. This process reduces the OOB emissions, making fragmented spectrum and dynamic spectrum allocation feasible without severe interference in incumbent services or other users. The subcarrier filtering can result in non- orthogonal subcarriers and both inter-symbol interference (ISI) and inter-carrier interference (ICI) might arise. Nevertheless, efficient receiving techniques can eliminate this interference, i.e. a matched filter receiver with iterative interference cancellation can achieve the same symbol error rate (SER) performance as OFDM over different channel models.

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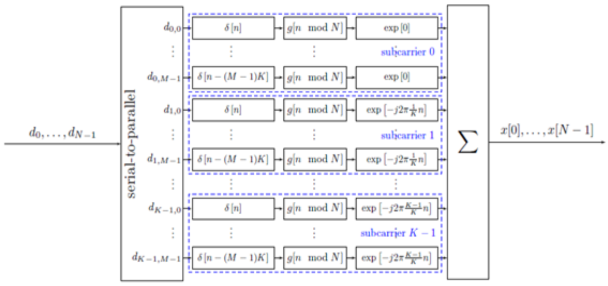


Fig. 3. 2 GFDM Modulator

The waveform engineering for GFDM, where several prototype filters are analysed in terms of OOB emissions analyses the SER performance of GFDM. Assuming zero-forcing receiver under different channel models. combines time-reversal STC with GFDM to achieve diversity over time-variant frequency-selective channels provides solutions for time and frequency domain synchronization, based on state- of-art approaches developed for OFDM extends the basic matched filter receiver by successive interference cancellation (SIC) and compares its performance in a coded system shown how GFDM can be parameterized in order to meet the channel and applications.

B. SYSTEM DISCRIPTION AND PROPERTIES

For waveform engineering, low out-of-band emission is a crucial requirement to allow fragmented and opportunistic spectrum allocation with cognitive radios (CR). Orthogonal Frequency Division Multiplexing (OFDM) with −35dBc OOB emissions will hardly be able to attend the emission mask without additional filtering, which renders the deployment of OFDM questionable in the next generation standards. As presented in Section IV, GFDM can achieve OOB emission several dBs below OFDM and, therefore, is more suitable to explore vacant and fragmented spectrum. Besides the low OOB emission, GFDM configuration with large M can reduce the impact of the CP length in the overall throughput and can significantly increase the spectrum efficiency. GFDM combined with Coordinated Multipoint Transmission can increase the spectrum re-use in small cell networks without increasing the interference between cells.

C. FIFTH GENERATION WIRELESS SYSTEM

We are introdusing a uniq physical layer waveform, referred to as generalized frequency division multiplexing (GFDM), to address these requirements.
GFDM proof-of-concept and implementation aspects of the prototype using hardware platforms available today. 5G Technology offer high resolution for crazy cell phone users and bi-directional large bandwidth shaping,The high quality services of 5G technology based on policy to avoid interference,5G technology is providing large broadcasting of data in gigabits which supporting almost 65,000 connec-tions,The traffic statistics by 5G technology makes it more accurate,Through remote system management techniq

by 5G technology a user can get better and fast solution,The re-mote diagnostics also a great features of 5G technology.

Several standard receiver options for the GFDM demodulator are readily available in literature: The matched filter (MF) receiver BMF = AH maximizes the signal-to-noise ratio per subcarrier, but with the effect of introducing self-interference when a non-orthogonal transmit pulse is applied, i.e. the scalar product hg0, 0, gk, mi CN 6= δ0, kδ0, xm with Kronecker delta δi, j. The zero-forcing receiver BZF = A−1 on the contrary completely removes any self-interference at the cost of enhancing the noise a trade-off between self-interference and noise enhancement. Here, R2 w denotes the covariance matrix of the noise. Note that in case of MMSE reception, the channel is jointly equalized in the receiving process.

IV. HARDWARE ARCHITECTURE

A. SPACE-TIME CODEDGFDM

Any 5G system shall be able to exploit the benefits of multiple transmit and receive antennas. Transmission diversity is a crucial feature for future wireless networks to achieve the required reliability and robustness under frequency-selective and time-variant channels. Due to the orthogonally of the symbols the Alamouti-STC is easily applied in OFDM. For GFDM, the overlapping sub symbols in the time domain impede the direct application of the Alamouti-STC within one GFDM block. However, as a major contribution of this section, we show that the block-structure of GFDM enables the application of time-reversal STC, which has been developed for single carrier systems to achieve diversity under frequency- selective channels.

Two transmitting antennas and two receiving antennas have been used in this simulation. STC-GFDM and STC-OFDM achieve the same diversity gain. In a practical system setup, α shall be chosen small because the NEF can be neglected. Again, STC- GFDM uses the CP more efficiently which leads to a better performance than STC-OFDM when small α is used. The NEF becomes significant for high values of α, resulting in a performance loss.

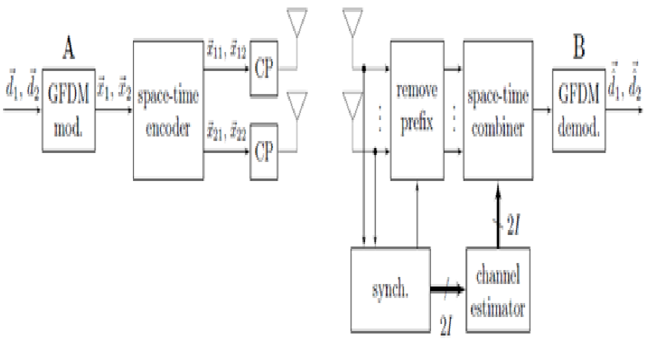


Fig. 4.1 Transceiver block diagram of the STC-GFDM.

This synchronization procedure is robust for single path channels, but in a time-variant FSC, the primary echo can be lower than other echoes and the strongest peak will not represent the correct STO. Thus, an additional search before no can reveal if there is another yet undetected peak to be considered as the primary one. For samples that do not belong to the preamble, the output of the cross-correlation can be interpreted as a complex Gaussian random sequence and a threshold criteria, depending on an acceptable probability of false alarm pFA, can reveal the presence of multipath .The performance evaluation in terms of variance of normalized STO and CFO estimations is presented.. For a SNR range higher than 5 dB the variance of the STO estimation stabilizes within tenths of a sample due the time variant fading effect in the multipath channel. The variance of the estimation of CFO starts from thousandths of the subcarrier bandwidth and gets linearly better (in log scale) with increasing SNR.

4.2 ADVANCED RECEIVER

In this section, the previously presented basic matched filter approach is extended by successive interfe-rence cancellation (SIC), yielding the MF-SIC receiver. We investigate its performance compared to the ZF and to the linear MMSE receiver in terms of bit error rates (BER). In some other methods error control coding is introduced in the setup. The results show that although ZF can severely enhance the noise in the system, it can be a better alternative to the iterative approach in some cases, mainly when small values of α and M are employed. A non-orthogonal waveform like GFDM inherently introduces correlation across all subcarriers and sub symbols within a block, data symbols are then fed back to calculate a cancellation signal for each pair of (k, m), which is based on all but the (k,m)th element partially cleaned of interference.

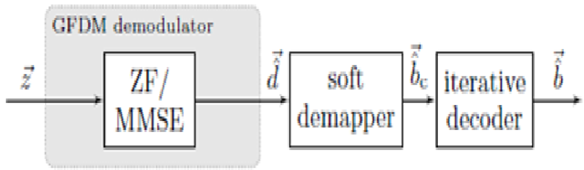


Fig. 4. 1(a) ZF and MMSE Transmitter configuration

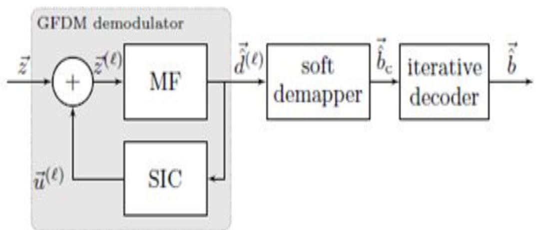


Fig. 4.2(b) MF-SIC Receiver configuration

This method has been shown to be effective, even for high order of QAM mapping. However, for large K and M this can significantly increase the computational complexity of the receiver. In this case, using a Nyquist filter allows to eliminate self-inter symbol-interference and thus requires to iterate only through the subcarriers in the system. Additionally, an interesting question is, to what degree can coding help to overcome the impairments of the non-orthogonal waveform. To investigate this encoder. The parallel concatenated convolutional code (PC-CC) from with code rate R = 1/3 is considered for this decoder with JTD iterations is employed. In the following, the two configurations depicted shall be considered. If we take setup, a linear receiver, i.e. ZF or linear MMSE, is utilized in combination with the turbo decoder. The second setup employs MF with several SIC iterations prior to decoding.

V. EXPERIMENTAL RESULT

A. *WAVEFORM ENGINEERING*

The flexibility of GFDM allows designing a signal that has a very low OOB radiation. This section contains a theoretic analysis of the OOB radiation of GFDM. The main contribution is a detailed description and numeric evaluation of techniques for reducing OOB radiation.

The choice of the pulse shaping filters strongly influences the spectral properties of the GFDM signal and the symbol error rate. The frequency responses of candidate filters employed are summarized in where Ts is the time duration of one sub symbol, v is the block index that ranges from− T 2MTs to + T 2MTs , and k,m range over all allocated subcarriers and sub symbols. The OOB radiation of the GFDM signal is defined as the ratio between the amount of energy that is emitted into the frequency range OOB and the amount of energy within the allocated bandwidth B by O = |B| |OOB| Between B and OOB a number of guard subcarriers is insert. the concept of guard subcarriers for OOB measurement and shows a comparison of the PSD of OFDM and GFDM. By default, due to the abrupt changes of the signal value between GFDM blocks, the OOB radiation of GFDM is approximately 15dB below OFDM. In order to make the pulse shaping even more effective in reducing the OOB radiation, two suitable techniques are discussed:

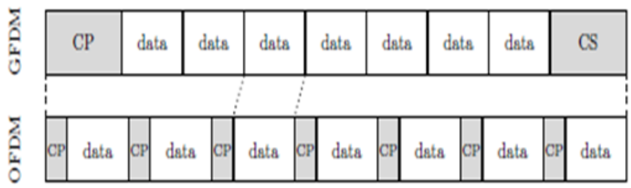
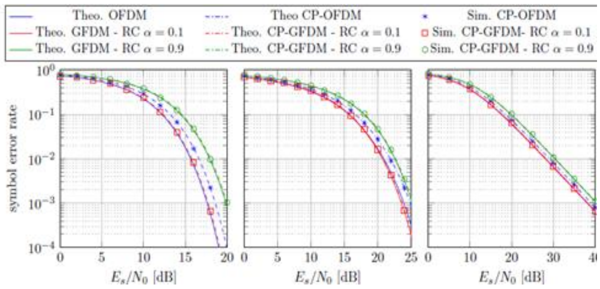


Fig. 5. 2 GFDM and OFDM frame comparison for the MTC scenario.

B. *SYMBOL ERROR RATE PERFORMANCE ANALYSIS*

Consider that a time-variant channel can be modelled as a multiplicative channel where the amplitude gain is a Rayleigh random variable with parameter σr and phase uniformly distributed between−π and π. It is assumed that the channel remains static during the transmission of one GFDM symbol. In this case, the GFDM SER follows the OFDM SER with the penalty of the noise enhancement when a ZF receiver is employed. Due to the flat property of the channel, the NEF is constant for all subcarriers. Closed-form solutions for the SER performance under AWGN of the matched filter receiver are available in . The MF receiver outperforms the ZF receiver in low SNR regions due to the significant influence of the noise enhancement. However, since the MF receiver suffers from self-interference, it cannot reach the performance of the ZF approach at high SNR values.

The MMSE receiver balances the noise enhance- ment and self-interference so that it converges to the MF receiver for low SNR and to the ZF receiver for high SNR regions. However, no closed form solutions for the SER in Rayleigh fading channels do exist.



(a)AWGN (b)freq-selective (c)Time- varient

Fig. 5. 3 GFDM and OFDM SER performance in different channel.

The modulated signals are delivered to the space-time encoder to produce the signals that will be transmitted by the two antennas in two successive time frames. In a practical system setup, α shall be chosen small because the NEF can be neglected.. Given that r[n] is a set of received samples containing at least one complete W-GFDM preamble, the two identical halves are identified with an autocorrelation metric, which is integrated along the CP and CS length to remove plateau effects leading to the metric To suppress side peaks that arise from the two halves and from the CP and CS parts, c[n] is combined with μ[n] and an optimized estimation of the STO is obtained by searching the peak value in the range around the coarse STO .

This synchronization procedure is robust for single path chan- nels, but in a time-variant FSC, the primary echo can be lower than other echoes and the strongest peak will not represent the correct STOThe variance of the CFO estimation starts from thousandths of the subcarrier bandwidth and gets linearly better (in log scale) with increasing SNR. The results obtained with the double pinching configuration show that burst synchronization can be achieved without penalties to the performance when compared with the results presented in the smooth block boundaries at the edges of the preamble and the the previously presented basic matched filter approach is extended by successive interference cancellation (SIC) .

VI. CONCLUSION

A novel modulation proposal for a 5G physical layer needs to address the specific requirements described in this paper. The first key property of a future waveform is flexibility, so that different applications can be addressed by a single solution with different parameter settings instead of multiple solutions. But doing so, chances are that orthogonally will be forfeit. Nevertheless, the proposed scheme should still be capable of MIMO, and synchronization and channel estimation should preferably be easy to implement. Also error rate performance should not be neglected, once the focus is shifted towards robustness for certain applications. In this respect, the proposed scheme needs to be as good as state-of-the art orthogonal waveforms, if not outperform them. Lastly, a laboratory proof-of-concept is desirable, in order to validate the feasibility of the proposal Presented GFDM as a candidate waveform modulation scheme for the air interface of future 5G networks . Introduced two techniques, which in addition to the subcarrier filter address the requirement of low out-of-band radiation and presented a preamble based synchronization scheme that preserves these low spectral emission Analysed the error rate performance of GFDM analytically and numerically for various channel conditions and with iterative receivers, yielding several GFDM configurations that have no penalties compared to OFDM and SC-FDE. We have addressed MIMO-GFDM as a mean to obtain diversity in the system and lastly presented a proof-of-concept implementation. Certainly, many more issues still need to be resolved. Never the less, this paper has shown that GFDM is a novel modulation technology with the potential to fulfill the requirements of the next generation of mobile wireless systems.

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