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A New Method for using Wavelet-OFDM and Its Applications in Healthcare to Improve the Services of the 5G Mobile Network and IoT-Related Communication Devices

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Abstract: *The orthogonal frequency division multiplex (OFDM), which is based on the Fourier transform, is at the center of the current wireless communication systems, including 5G.Due to its performance and capacity to support network-intensive applications like the Internet of Things (IoT), numerous studies have suggested that wavelet transform-based OFDM is a superior alternative to Fourier in physical layer solutions. In this paper, we compare the performance of wavelet transforms to the requirements of the future wireless application system and offer guidelines and methods for wavelet applications in the design of 5G waveforms. A comprehensive discussion of the impact on healthcare follows. Taking into consideration the following 5G key performance indicators (KPIs), a comprehensive performance comparison has been conducted using an image as the test data: energy savings, complexity of modulation and demodulation, dependability, latency, spectral efficiency, effect of transmission and reception under asynchronous transmission, and resistance to time- and frequency-selective channels are all factors to consider. The usage guidelines for the wavelet transform are then discussed. The guidelines are sufficient to act as a guide for future developments and as approaches to tradeoffs.*

Keywords: Orthogonal Frequency Division Multiplex

I. INTRODUCTION

The number of internet-connected devices is on the rise. The Internet of Things (IoT) will be an explosive development [1, 2].To meet the ever-increasing demand for quick and dependable connections, a new wireless communication standard is developed almost every ten years.

Customers of wireless services have witnessed the development and maturation of 2G, 3G, and 4G mobile network systems. The expectations for 5G New Radio (NR) have now been established by the International Telecommunication Union (ITU).Enhanced mobile broadband (eMBB), ultrareliable low-latency communication (URLLC), and massive machine-type communication (mMTC) are the three types of requirements for 5G. All these categories are subsets of the requirements for IOT. Multi-gigabit-per-second (Gbps) data rates, low latency, high spectral efficacy, high mobility, and a high connection density are just some of their requirements [3].As a result, we are able to draw the conclusion that 5G will need to deal with a significant amount of service and requirement heterogeneity. Surprisingly, the growing number of brand-new and previously unconceived applications will necessitate even higher data rates than 5G NR can provide [4], and some of those applications may not even fall entirely within a single defined use-case [5].Virtual/augmented reality (VR/AR), wireless cognition, and wireless backhaul are a few examples.In addition, given the diversity of 5G, it is possible that there are additional undiscovered areas of application, such as healthcare, for which IoT is clearly the enabler. The other research areas will be affected by advances in one;Similar to a chain reaction, itFor instance, IoT capabilities that were previously unavailable on 4G networks will now be possible thanks to 5G, which is the underlying technology. It will introduce significant innovations like faster connections, more storage, and lower latency. These advantages will eventually result in technological milestones that will significantly affect healthcare and other fields.As a result, a diverse network like 5G is necessary for an effective IoT system. The introduction of 5G has prompted additional research into new methodologies, hardware, waveform design, underutilized millimeter-wave (mm-wave) frequency, and other topics. The design of waveforms for effective 5G signaling is the most prominent but also the most difficult of these explorations. [6] provides a summary of the proposed waveforms.

In the design of waveforms for numerous multicarrier wireless communication schemes, OFDM remains an essential component [7].Most of the proposed waveforms for 5G are based on OFDM. This is in part because OFDM is used in 4G LTE and other standards, is common in the wireless community, and is a mature technology [8, 9].However, due to OFDM's inherent flaws, the gradual shift from cell-centric to user-centric processing is rendering OFDM unusable. The proposed waveforms thereby solve a number of OFDM problems, including reduced transmission capacity caused by the usage of cyclic prefix (CP), high peak-to-average power ratio (PAPR), sensitivity to carrier offset, and out-of-band emissions (OOB).

Understanding the underlying causes is required in order to combat some OFDM limitations. Band egress noise to neighboring bands and ingress noise from neighboring bands, for instance, introduce OOB emission, also known as spectral leakage. This is because there is spectral leakage as a result of the subcarriers' poor spectral localization. By using special filters, the filter bank multicarrier (FBMC) method attempts to address the aforementioned issue by directly suppressing the sidelobes. FBMC is resistant to narrow-band jammers, uses less spectrum, and does not require redundant CP. However, practical applications reveal that FBMC lacks CP, making it susceptible to multipath distortion. Therefore, in actual situations where channel even though the data is imperfect, OFDM will perform better. In [10], an attempt to improve FBMC and implement it in MIMO channels with an emphasis on channel uncertainty was reported.

The introduction of overhead due to overlapping symbols in the filter bank in the time domain and a loss in bandwidth efficiency when transmitting short data packets are two additional obvious drawbacks of FBMC. Consequently, the generalized frequency division multiplex (GFDM) was added to FBMC in [11].An adjustable pulse shaping filter applied to each carrier controls the transmitted signal's OOB in GFDM [12].When user synchronization is not accurate, GFDM can be used without issue. However, there are flaws in the GFDM plan; Interference has some effect on adjacent synchronization. In [12, 13], attempts to resolve this issue have been made, albeit with a significant increase in transmitter complexity.

Circular FBMC (C-FBMC), a concept developed from GFDM and FBMC, was the result of progress in research. C-FBMC is simpler, can be easily extended to the multiple-input, multiple-output (MIMO) antenna, and keeps the subcarrier symbols in their orthogonal position. The aforementioned schemes serve as the foundation for the majority of the other waveforms proposed. In either the time or frequency domains, they either perform windowing or filtering operations—or both. This section's objective is not to provide a literature review but rather to serve as the foundation for the waveform design. As a result, in order to keep the content of this article brief, no additional research will be conducted here.[14] provides a comprehensive analysis.

Another possible waveform for OFDM design is the discrete wavelet transform (DWT).The term "orthogonal wavelet division multiplex" (OWDM) refers to its use in OFDM. Numerous research studies followed the introduction of the DWT-based signal coding in [15].[16–22] provides documentation of some of them. However, the research insights into the requirements for future wireless applications are generally not supported by these research scopes. The suitability of OWDM for 5G is rarely discussed in the literature. This issue is addressed in this paper by weighing the advantages and disadvantages of OWDM against the requirements of future wireless applications. CP-OFDM, a legacy from 4G, has been chosen by the 3rd Generation Partnership Project (3GPP) group as the 5G signaling option for Release 15.As a result, OWDM and CP-OFDM were compared. Using MATLAB, we compared Fourier transform-based CP- OFDM and OWDM in great detail, explained how it affects healthcare, and offered advice on how to apply wavelet applications in 5G and beyond.

The following is the structure of the remainder of this paper: In Section 2, the 5G design criteria and their effects on healthcare are discussed. The OFDM and OWDM system model is the subject of sections 3 and 4.Results and simulations are included in Section 5.Section 7 draws conclusions and reviews based on the results, while Section 6 evaluates the results in light of the requirements.

II. THE IMPACTS OF 5G DESIGN CRITERIA ON HEALTHCARE

To provide a thorough simulation and comparison, we have taken into account all of the required 5G KPIs [23] for assessing the performance of transmitter/receiver systems.

2.1 High Efficacy with Energy

We defined PAPR as the transmission and reception energy's peak-to-average power ratio in Section 1.The PAPR and the degree of computational complexity most commonly define energy efficiency. Peaks and lows are seen in waveforms at the physical layer. At transmission (or reception), if the difference (ratio) between the peaks and lows is large, power amplifiers will absorb more transient energy, resulting in increased energy consumption. Power-saving transmissions at the uplink (UL), downlink (DL), and side link (SL) require therefore a low PAPR. Furthermore, especially in power-constrained (battery-operated) devices like a mobile phone or an IOT field sensor, computational complexity should be kept to a minimum. A recent study in [24] reported a further attempt to improve energy efficiency at the network layer in an IoT system. It uses Packet Update Caching (PUC) to present an information-centric networking (ICN) caching strategy that works well in the IoT environment that saves energy.It is safe to assume that the longevity of battery life and performance will be enhanced to ensure uninterrupted remote monitoring in light of all these research advancements. In fact, in 5G, low-power sensors will be designed to run continuously on the same battery throughout medical procedures. This can last as long as ten years [25].

2.2 Device Complexity is Low.

Transceiver baseband complexity is another name for this section. It refers to the minimum number of operations that must be carried out in order to successfully transmit and, more importantly, receive a signal. RF impairments can be severe at very high frequencies (like millimeter wave) and wide bandwidths. The waveform design standard should minimize the amount of computational complexity and processing overhead that can be caused by filtering, reducing inter symbol interference (ISI) and intercarrier interference (ICI), windowing, interference cancellation, and other techniques in the event that impairments exist. Battery life is directly impacted by this. Similar to what was discussed earlier, this.

2.3 Highly Dependable Bit Error Rate (BER)

It is used to measure reliability; It refers to a network's capacity to carry out a preferred operation with extremely low error rates. Error-sensitive biomedical sensors with IoT capabilities generate a lot of data. Furthermore, a significant number of errors may increase latency. Taking into account the signaling traffic generated by a large number of these sensors would even increase latency as each sensor tries to retransmit. The low BER plan will be backed. through the 5G network Low BER in comparison to OFDM is one of the main benefits of the wavelet-OFDM scheme that is proposed in this article.

A. Low Delay

The network that is designed to process enormous quantities of data packets with a very low tolerance for delay is known as ultralow latency. For ultrareliable low-latency communication (URLLC) applications, the maximum allowed 5G latency is less than 1 millisecond. This is because of features like machine-to-machine communication, which necessitates a quick response time to enable the effective sporadic transmission of small packets. As a result, very short frames necessitate a transmission mode with low air-interface latency. In telesurgery, for instance, the maximum acceptable latency (end-to-end) is 200 milliseconds [26]. This means that the effective transmission of short frames is absolutely necessary for medical IoT. When compared to the typical latency of the 5G network, which is less than one millisecond, "telesurgeons" can be assured of low latency communication, optimal stability when receiving haptic feedback, and enhanced wireless data rates for improved visualization and precision. This technology will enable new telesurgery applications and other real-time applications with higher latency requirements in the future. Emerging e-health fields that require some forms of wireless transfer of big data and machine learning for early disease detection may also benefit from this technology. Heart disease [27], Parkinson's disease [28], and breast cancer [29] are just a few examples. Refer to [30] for additional studies on the reduction of latency in 5G.

2.4 High Bandwidth or High Spectral Efficiency

The transmission capacity of a network at any given time is referred to as bandwidth. The term "spectral efficiency" refers to how effectively bandwidth is utilized. Due to limited bandwidth, biomedical sensors can only send a limited amount of data over 3G and 4G networks [31].Exploring the untapped spectrum at higher frequencies (up to 10 GHz) mitigates this limitation in 5G.Additionally, a higher transmission rate of about Gbps is achieved at such high frequencies. This makes it possible to carry out seamless remote monitoring; Ultra-high-definition content, including videos and images, can help doctors make better decisions. Patients, ordinary citizens, various civic organizations, experts, and executive bodies can also participate in online consultations to share medical information.

It is necessary to note that a number of factors could also contribute to the degradation of 5G's spectral efficiency (Sections 5.3 and 5.4), despite the benefits of its high spectral efficiency. Because of this, the nature of the waveform is of greater significance. The waveform scheme proposed in this article addresses one of these issues.

2.5 Large-Scale Asynchronous Transmission

5G will enable enormous asynchronous broadcast or asynchronous coexistence of a large number of nodes through the use of D2D [32].Each party in D2D communications terminal can communicate with each other directly without routing through gateways and base stations. Therefore, a highly dense network problem can be solved through D2D communications. D2D communications will enable asynchronous coexistence between a large number of medical sensors, wearables, and devices, and monitoring equipment can communicate with minimal interference.

In the 4G network, all communications are routed through gateways and base stations. This routing is inefficient, especially when devices are near each other. Achieving D2D communication will require waveforms with less strict synchronization requirements [33]. The effect of poor synchronization is phase noise. Phase noise including carrier frequency offset (CFO) is both caused by differences in the transmitter and receiver oscillator. The mathematical description of the CFO is the multiplication of a signal in the

2.6 OFDM System Model

OFDM is the most popular multicarrier modulation scheme that is currently being employed in many standards such as the downlink of 4G LTE and the IEEE 802.11 family [34]. In an OFDM system, at the transmitter, data to be transmitted are mapped to a constellation, split into parallel, and modulated using the inverse fast Fourier transform (IFFT). The modulation process is shown in Figure 1. Guard band and cyclic prefix (CP) are inserted to prevent a delayed version of symbol overlapping with the adjacent symbol and mitigate the delay spread, respectively. The orthogonal signals are then mixed. The key process here is modulation, where signals are mapped from the frequency domain to the time domain and multiplexed. The modulation process is mathematically the summation of N tones described in [35] and mathematically expressed in the following equation:

time domain by a time-varying complex exponential function. CFO will cause a received signal to be shifted in the frequency. Therefore, sampling of the received signal will be less complex and practicable.

Robustness to Frequency-Selective and Time-Selective Channels. Very harsh propagation conditions can cause poor performance in a wireless communication system and result in a loss of signal power without loss of noise power, consequently resulting in a poor signal-to-noise ratio (SNR). OFDM is generally used to combat selective fading because of its robustness to frequency-selective channels. Among other methods are MIMO, rake receivers, space- time codes, forward error correction, interleaving, etc. The robustness of the 5G waveform design should include adapting to this impairment as well as time-selective fading occurring in high-speed scenarios. An example of such a case is the vehicle to anything (V2X). In this case, we can consider the (efficient) transmission of the medical ultra- sound video stream from a fast-moving ambulance to the host hospital. After modulation, the CP denoted as p is added by copying the last part of the modulated IFFT signal and appending it to the beginning as a guard interval to prevent ISI. In the 4G LTE system, the CP is hard-coded into the waveform, while for 5G NR Release 15, the CP is determined by the maximum delay present in individual channels.

At the receiver, the transmitting process is reversed to decode the received data. For demodulation, the fast Fourier transform (FFT) is employed. OFDM, as opposed to a single-carrier system, has the ability to cope with frequency-selective fading because data are divided and transmitted in parallel streams on a modulated set of subcarriers. This approach results in the efficient use of bandwidth.

2.7 OWDM System Model

Some of the wavelet transform applications are in source and channel coding, signal denoising, and data compression [36,37]. DWT and inverse discrete wavelet transform (IDWT) are used in OWDM [38, 39]. This replacement is - The proposed application guidelines are given in Table 6 based on the 5G NR design criteria and waveform assessment discussed in [54].

III. CONCLUSION

This paper's research sheds light on how to take OWDM into account when designing the physical layer for 5G NR and beyond. Both OFDM and OWDM's performance simulation results and key performance indicators have been evaluated. Based on our findings, OWDM is a more effective IoT enabler for healthcare and other crucial areas because it outperforms OFDM in many of the KPIs. However, our findings also demonstrate that OWDM's primary drawback is its high memory and time costs. Because of this, careful consideration of tradeoffs is required. Uplink, downlink, side link, V2X, and backhaul links are also included in our evaluations. For the establishment of OWDM waveform numerology for the various applications of 5G, these various link assessments are necessary. Last but not least, we discovered that CP will not be required for the creation of OWDM waveform numerologies for 5G.As a result, the establishment procedure may be simpler than OFDM's.

REFERENCES

[1]. Ijaz, L. Zhang, M. Grau et al., “Enabling Massive IoT in 5Gand beyond systems: PHY radio frame design considerations,”IEEEAccess,vol.4,pp.3322–3339,2016.

[2]. S. K. Goudos, M. Deruyck, D. Plets et al., “A novel designapproach for 5G massive MIMO and NB-IOT green networks using a hybrid Jaya-differential evolution algorithm,” IEEEAccess,vol.7,pp.105687–105700,2019.

[3]. T. S. Rappaport, Y. Xing, O. Kanhere et al., “Wireless com-munications and applications above 100 GHz: opportunitiesandchallengesfor6Gandbeyond,”IEEEAccess,vol.7,pp.78729–78757,2019.

[4]. A. B. Kihero, M. S. J. Solaija, and H. Arslan, “Inter-numerology interference for beyond5G,” IEEE Access, vol. 7,pp.146512–146523,2019.

[5]. Y.Medjahdi,S.Traverso,R.Gerzaguetetal.,“Ontheroadto5G: comparative study of physical layer in MTC context,”IEEEAccess,vol.5,pp.26556–26581,2017.

[6]. F. Kalbat, A. Al-Dweik, B. Sharif, and G. K. Karagiannidis, “Performance analysis of precoded wireless OFDM with carrier frequency offset,” IEEE Systems Journal, vol. 14,2020.

[7]. O. Daoud, “Power reallocation and complexity enhancement for beyond 4G systems,” China Communications, vol. 16,no.6,pp.114–128,2019.

[8]. M.Payaro,A.Pascual-Iserte,andM.Najar,“Performance comparison between FBMC and OFDM in MIMO systems under channel uncertainty,” in Proceedings of the European Wireless Conference (EW), pp. 1023–1030, Lucca, Italy, April2010.

[9]. N. Michailow, I. Gaspar, S. Krone, M. Lentmaier, and G. Fettweis, “Generalized frequency division multiplexing: analysis of an alternative multi-carrier technique for next generation cellular systems,” in Proceedings of the 2012 International Symposium on Wireless Communication Systems(ISWCS),pp.171–175,Paris,France,August2012.

[10]. M. Matthe, L. L. Mendes, and G. Fettweis, “Space-time coding for generalized frequency division multiplexing,” in Pro-ceedings of the 20th European Wireless Conference, pp. 1–5, Barcelona, Spain, May 2014.

[11]. B. Farhang-Boroujeny and H. Moradi, “OFDM inspired waveforms for 5G,” IEEE Communications Surveys & Tutorials, vol.18,no.4,pp.2474–2492,2016.

[12]. M.A.Tzannes and M. C. Tzannes, "Bit-by-bitchannel coding using wavelets," in Proceedings of the [Conference Record] GLOBECOM' 92-Communications for Global Users, vol. 2,pp.684–688, Orlando, FL, USA, December1992.

[13]. M. Chafii, Y. J. Harbi, and A. G. Burr, "Wavelet-OFDM vs. OFDM: performance comparison," in Proceedings of the 23rd International Conference on Telecommunications(ICT),pp.1–5, Thessaloniki, Greece, May 2016.

[14]. S. A. Dawood, F. Malek, M. S.Anuar, and S. Q. Hadi, "Discrete multiwav eletcritical-sampling transform-based OFDM system over Rayleigh fading channels," Mathematical Problems in Engineering, vol. 2015, Article ID676217,10 pages,2015.

[15]. K. Lavish, V. Sharma, and J. S. Malhotra, "MIMO-WiMAX systemincorporatedwith diverse transformation for 5G applications," Frontiers of Optoelectronics, vol. 12, pp. 1–15,2019.

[16]. R. Ayeswarya and N. Amutha Prabha, "Fractional wavelet transform based OFDM system with cancellation of ICI," Journal of Ambient Intelligent Humanized Computing,2019.

[17]. S. Tripathi, A. Rastogi, K. Sachdeva, M. K. Sharma, and P. Sharma, "PAPR reduction in OFDM system using DWT with nonlinear high-power amplifier," International Journal of Innovative Technology and Exploring Engineering (IJITEE),vol.2,no.5,pp.2278–3075,2013.