A Novel Uplink Multiple Access Technique Based on Index-Modulation Concept With Filtered OFDM

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Abstract- *Theoretical—A frightfully confined waveform is proposed dependent on sifted symmetrical recurrence division multiplexing (f-OFDM). By permitting the channel length to surpass the cyclic prefix (CP) length of OFDM and planning the channel suitably, the proposed OFDM waveform can accomplish an attractive recurrence restriction for transmission capacities as tight as two or three many subcarriers, while keeping the between image impedance/between transporter obstruction (ISI/ICI) inside a satisfactory breaking point.*

Empowered by the proposed f-OFDM, a nonconcurrent separated symmetrical recurrence division various access (f-OFDMA)/sifted discrete-Fourier change spread OFDMA (f-DFT-S-OFDMA) conspire is presented, which utilizes the range forming channel at every transmitter for side projection spillage end and a bank of channels at the beneficiary for between client obstruction dismissal. Per-client down sampling and short quick Fourier change (FFT) are utilized at the beneficiary to guarantee a sensible multifaceted nature of usage. The proposed plot eliminates the interuser time-synchronization overhead required in the coordinated OFDMA/DFT-S-OFDMA. The exhibition of the offbeat f-OFDMA is assessed and contrasted and that of the universal filtered OFDM (UF-OFDM),

Keywords- f-OFDM, f-OFDMA, nonconcurrent numerous entrance, UF-OFDM, OFDMA, DFT-S-OFDMA.

I. INTRODUCTION

Symmetrical recurrence division multiplexing (OFDM) has been embraced as the transmission waveform in the condition of-the art remote correspondence principles, including 3GPP LTE and IEEE 802.11 standard families. It is likewise utilized as a various access transmission strategy, considered symmetrical recurrence division different access (OFDMA). Notwithstanding its preferences, for example, strength against multi-way blurring and simplicity of execution, OFDM experiences various disadvantages, including high top to-average force proportion (PAPR) and high side projections in recurrence. spread OFDMA (DFTS-OFDMA) in the uplink, a.k.a. single-transporter FDMA (SCFDMA), the last is as yet considered as a hindrance.

II. PROBLEM FORMULATIONS

Specifically, ordinary OFDM utilizes a rectangular heartbeat shape, i.e., sinc in recurrence, whose side projections drop with recurrence f as gradually as 1/f. This prompts a recurrence range that isn't very much restricted, which ruins its conjunction with different frameworks in contiguous transporters. So as to conform to the recurrence cover guidelines, a bit from the two closures of the transfer speed, e.g., 10% in LTE, is saved as recurrence monitor band, which thus brings about a misfortune in phantom effectiveness. Additionally, high side projections of the sinc beat shape cause two principle issues for the ordinary OFDMA.

$$s(n)=\mathrm{X}s\grave{}(n-\grave{}(N+N\mathrm{g})), \quad (1)$$

$\grave{}=0$
with
$m0+M-1$

$$s\grave{}(n)\ ,\mathrm{X}d\grave{},mej2\pi mn/N, \quad -N\mathrm{g}\leq n<N, \quad (2)$$

$m=m0$

where Ng is the CP length, $d\grave{},m$is the data symbol on subcarrier m of OFDM symbol\`, L denotes the number of OFDM symbols, and $\{m0,m0+1,\cdots,m0+M-1\}$is the assigned sub carrier range. The f-OFDM signal is then obtained by passing the signal $s(n)$ through an appropriately designed spectrum shaping filter, i.e.,

$$s\tilde{}(n)=s(n)*f(n). \quad (3)$$

The spectrum shaping filter $f(n)$ is centered in frequency at the assigned subcarriers, its bandwidth is equal to the total frequency width of the assigned subcarriers, and its time duration is a portion of an OFDM symbol duration.

At the receiver side, the received signal is first passed to through the filter $f*(-n)$, which is matched to the transmitter filter. The resulting signal is then passed through the regular OFDM receiver as depicted in Fig. 1, i.e., after splitting the filtered signal in to consecutive OFDM symbols and CP removal, a length-N FFT is applied to each OFDM symbol and, after channel equalization, the data symbols are extracted from the corresponding subcarriers. One should note that, the end-to- end channel, i.e., $f(n) * h(n) * f*(-n)$ is estimated and equalized by the equalization block.

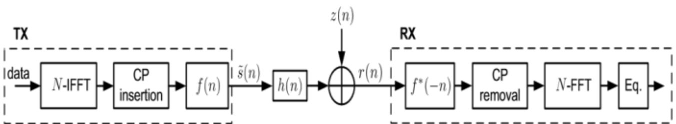


Fig. 1.Proposed f-OFDM for a point-to-point link.

A. BS Operations

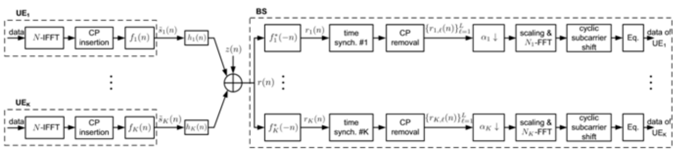


Fig. 2.Proposed asynchronous f-OFDMA/f-DFT-S-OFDMA. Down sampled with an integer factor of $\alpha i \geq 1$, such that b$N/\alpha i$c

The received signal at the input of the BS can be written as

$$r(n) = \sum_{i=1}^{K} \tilde{s}_i(n - n_i) * h_i(n) + z(n) \quad , \qquad (4)$$

Where n_i is the aggregation of the propagation delay and time offset of UEi, $h_i(n)$ is the channel impulse response between UEi and BS, and $z(n)$ is the AWGN. As shown in Fig. 2, the received signal is passed through K chains of operations corresponding to the K scheduled UEs. The output of each chain is the demodulated sequence of the corresponding UE. The BS operations of the i'th chain is summarized as follows:

1) Filtering: The received signal is passed through the filter $f_i^*(-n)$, which is matched to the filter used at UEi,i.e.,

$$r_i(n) = r(n) * f_i*(-n). \qquad (5)$$

The role of this matched filtering is twofold: Firstly, it rejects the contributions of the other UEs from the signal. This ensures that the OFDM receiver, i.e., the combination of subsequent CP removal and FFT blocks in the chain, does not grab any interference from the neighboring UEs. Secondly, it maximizes the received signal-to-noise ratio (SNR) of UEi.

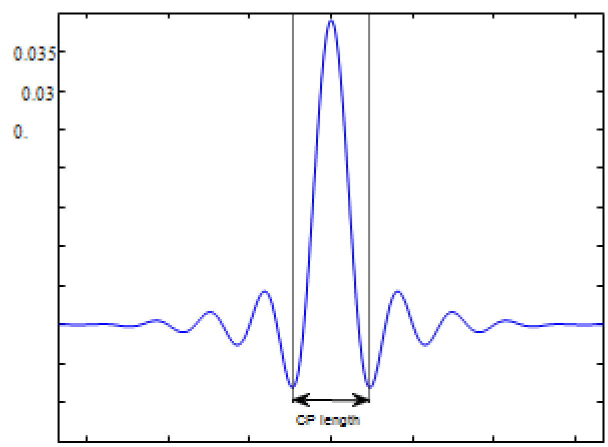
2) Per-UE time synchronization: The operational window at the output of the i'th filter is shifted appropriately to be time synchronized to UEi. The time shift is equal to the summation of n_i and the aggregate delay of the end-to-end filter $g_i(n)$, $f_i(n) * f_i^*(-n)$, which is equal to the length of $f_i(n)$.

The beginning and end time transitions of the signal, due to the end-to-end filter $g_i(n)$, are truncated. Then, the signal is split into OFDM symbols, and the CP is removed from each symbol to obtain the OFDM symbols $\{r_{i,\ell}(n)\}_{\ell=1}^{L}$.

foreover, the windowing provides a reasonable time-localization in the truncated filter's impulse response, and thus, keeps the induced ISI in the resulting f-OFDM signal within an acceptable limit. A candidate for the windowing is the Hanning window of duration T_w, given by

$$w(t) = \begin{cases} 0.5\left[1 + \cos\left(2\pi|t|/T_w\right)\right], & |t| \leq \frac{T_w}{2} \\ 0, & |t| > \frac{T_w}{2} \end{cases}$$

improvement of the proposed f-OFDMA scheme over the asynchronous UF-OFDM is clearly observed in the figures.



OFDM. The UF-OFDM signal is obtained using RB-based Dolph- Chebyshev filtering as proposed in [1], [2]. The figure demonstrates that the proposed f-OFDMA provides a better frequency-localization compared with UF-OFDM.

The communication takes place in a typical urban (TU) channel with UE speed of 3 km/h and the transmission delays of UEs are distributed uniformly and independently between 0 and T. Figures 5 to 7 show the BLER curves of the proposed asynchronous f-OFDMA scheme for QPSK, 16QAM, and 64QAM, respectively, with forward error correction (FEC) rate 1/2, and compare them with those of the synchronous OFDMA and asynchronous UF-OFDM. The

LTE specified turbo code is used as the FEC code for all simulations [10].

It can be seen from the figures that for QPSK, the proposed asynchronous f-OFDMA shows the same BLER performance as synchronous OFDMA. For 16QAM, the incurred performance loss is less than 0.3 dB. For 64QAM, it achieves

Remark 1: The additional complexity of the proposed asynchronous scheme compared with synchronous OFDMA/DFTS-OFDM A is mainly due to the filtering operations at both UE and BS. In fact, the rest of per-UE processing at BS does not add to the complexity, since each processing chain involves a small-size FFT. It is notable that the complexity of K FFTs each with size N/K is of order $N \log(N/K)$, which is less than that of one FFT with size N,i.e., $N\log N$. More over, further complexity reduction can be done on the filtering operations of BS using effective FFT domain convolution techniques such as overlap-save [11] and the fact that all filtering blocks of Fig. 2 have the same input $r(n)$.

Remark2: As a result of the spectrum filtering operations at both UE and BS as well as the guard subcarrier between UEs that are adjacent in frequency, the proposed system is less sensitive to CFO mismatch between UEs compared with the regular OFDMA. Therefore, it can very well support applications such as M2M communications, which typically require low-cost UEs.

Remark 3: The spectrum shaping filter corresponding to each UE is a function of its assigned resource bandwidth, and thus, is known to both the UE and BS. Hence, the system does not incur any signaling overhead by using the filters.

III. CONCLUSIONS

A spectrally-localized multicarrier waveform, called fOFDM, was proposed which can achieve a desirable frequency localization while enjoying the benefits of CP-OFDM. This was attained by allowing the filter length to exceed the CP length of OFDM and designing the filter appropriately. As an application of the proposed waveform, an asynchronous fOFDMA scheme was also introduced with interference avoidance via a spectrum shaping filter at each UE, and interference rejection via a bank of filters at the BS. The proposed per-UE down sampling operations followed by the short FFTs enabled the realization of the proposed scheme with a reasonable complexity.

Link simulations show that the proposed scheme achieves the performance of OFDMA with QPSK modulation and its performance gap with OFDMA with higher order modulations is marginal. The proposed asynchronous f-OFDMA/fDFT-S-OFDMA removes the inter-UE time-synchronization overhead required in the regular OFDMA/DFT-S-OFDMA. Among other benefits of the proposed f-OFDM waveform are the less sensitivity to CFO mismatch between UEs, capability of more flexible dynamic spectrum sharing by enabling coexistence with other systems in adjacent carriers, and possibility of different time-frequency granularities in the system so that different parts of the waveform can be optimized for different transmission conditions and applications.

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