5GNOW: Unified Frame Structure and Waveforms for 5G

Research Challenge: Unified Frame Structure

- Can we realize the vision of handling different traffic types, especially synchronous and asynchronous in a Unified Frame Structure within the same band?
- Which building blocks (waveform, multiple access scheme, layering ...) are enabling this vision under the new requirements appearing in 5G wireless systems?

<table>
<thead>
<tr>
<th>Traffic Type</th>
<th>Orthogonality intended?</th>
<th>Synchron. intended?</th>
<th>Access Type</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Bit pipe</td>
<td>Yes</td>
<td>Yes</td>
<td>Scheduled</td>
<td>Classical high volume data services</td>
</tr>
<tr>
<td>II Layered bit pipe</td>
<td>No</td>
<td>(Yes)</td>
<td>Scheduled</td>
<td>HetNet and/or cell edge multi-layered high data traffic</td>
</tr>
<tr>
<td>III MTC-like</td>
<td>No</td>
<td>No</td>
<td>Sporadic, contention-based</td>
<td>Few bits, supporting low latency, e.g. smartphone apps</td>
</tr>
<tr>
<td>IV Sensor-like</td>
<td>No</td>
<td>No</td>
<td>Contention-based</td>
<td>Energy-efficient, high latency, few bits</td>
</tr>
</tbody>
</table>

Our building blocks for handling synchronous and asynchronous traffic with different requirements within the same band in a Unified Frame Structure:

- A filtered multicarrier approach with reduced side-lobe levels of the waveform seeks to minimize inter-carrier interference (ICI)
- Layering follows principles of interleave division multiple access (IDMA) [2]

Uplink CoMP Joint Reception: UFMC gains

- Scenario: 2 cells, 2 user scenario
- Full frequency reuse
- Carrier frequency offsets (CFO)
- CP-OFDM vs UFMC

Downlink CoMP with FBMC

- 2 cells, 2 user scenario
- Multi-user downlink CoMP with timing and frequency offsets
- CP-OFDM vs FBMC

Summary

- The concept of a Unified Frame Structure was introduced. Enabling tools were discussed
- Universal Filtered Multi-Carrier (UFMC) is investigated as a potential extension of OFDM with improved time-frequency localization properties
- Simulation results for UFMC in uplink coordinated multi-point joint reception in a multiuser environment show its benefits over OFDM.
- Simulation results for FBMC in downlink CoMP highlight its benefits over OFDM:
  - FBMC allows for high time delays without correction and without CP.
  - FBMC has been proven to be more efficient than OFDM for the estimation and correction of high CFO after FFT.

References


Waveforms

Universal Filtered Multi-Carrier (UFMC)

Spectrum of one physical resource block (PRB) with CP-OFDM (black) vs UFMC (green)

Filter Bank Multi-Carrier (FBMC)

- Spectrally well shaped prototype filter
- Overlapped time symbols
- No Cyclic Prefix
- Almost perfect separation of frequency subbands without strict synchronization
- Suitability for fragmented spectrum and for CoMP

Selected Design Objectives of Multicarrier Waveform:

- Sporadic Access: Short bursts, thus filter lengths have to be short
- Increased robustness (less ICI) in presence of frequency/timing offsets
- For CoMP, MTC devices and Unified Frame Structure
- Supporting QAM symbols (avoiding offset QAM problems)
- Suitability for fragmented spectrum

Approach: Frequency-Block-wise Filtering