Flexible Multicarrier PHY Design for Cognitive Radio in White Space

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WP4: PHY architecture

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QMCC’11 WInnCom

'The research leading to these results was derived from the European Community’s Seventh Framework Programme (FP7) under Grant Agreement number 248454 (QoSMOS)'.

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Content

- Motivation
- Technical Highlights
  - FBMC
  - IA – PFT
  - GFDM
  - Reconfigurable RF
- Conclusion
Motivation for looking Beyond OFDM

FBMC, GFDM and IA-PFT

- Fragmented White Space
- Flexible MC approach
- Extremely low out-of-band radiation
- Digital Implementation

- Multi-branch filter bank approach
- Adjustable out-of-band radiation
- Lesser CP compared to OFDM
- Simple Equalization → Performance is as good as OFDM
- Reconfigurable RF front – end for flexibility of the architecture
Interference Avoidance Transmission (IA-PFT)

- An OFDM-based-transmitter capable of suppressing out-of-band emission for opportunistic spectrum access in White Space
- Parallel concatenation of partitioned frequency-domain (Cancellation Carriers) and time-domain (windowing) processing
- 6-12 dB of suppression gain in power spectral density

IA-PFT transmitter

IA-PFT: Interference Avoidance transmission by Partitioned Frequency- and Time-domain processing
IA-PFT: BLER and PAPR Performance

- IA-PFT achieves almost the same BLER as those of conventional CC and TW schemes in multipath fading channels
- Negligible level of increase in PAPR confirmed

Power spectrum density of IA-PFT with variable $Q$

PAPR performance (QPSK)
Filter Bank Multi Carrier System

• FBMC / OQAM OFDM is being considered
• Motivations for FBMC have been presented
  • Frequency transition bands are sharper
  • Benefits in terms of spectral efficiency have been measured
  • Larger complexity of implementation
• FBMC DSP Architecture

Structure of the FBMC modulation and demodulation
Channel equalization in FBMC

- For small delay spread: channel equalization using MMSE channel equalization
- Larger delays introduce error floor in the BER
- Novel iterative equalization scheme for FBMC to achieve better performance

Power spectral density comparison in IEEE 802.11a/g

FBMC and OFDM MMSE, AWGN and multipath channels

<table>
<thead>
<tr>
<th>Standard</th>
<th>Spectral Efficiency Gain relative to OFDM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency Domain</td>
</tr>
<tr>
<td>DVB-T</td>
<td>10 %</td>
</tr>
<tr>
<td>IEEE 802.11a/g</td>
<td>3.8 %</td>
</tr>
</tbody>
</table>
Generalized Frequency Division Multiplexing

Symbol mapping

Transmit filter

Digital subcarrier upconversion

Add cyclic prefix

Binary data

$\tilde{g}_f[n-iN]$ $d[K-1,i]$ $\ldots$ $d[0,i]$ $\tilde{g}_f[n-iN]$ $x_{K-1}[n]$ $x[n]$ $n[n]$ $\text{CP}$

Digital subcarrier down-conversion

Receive filter

Sampling

Detection

Remove cyclic prefix

Equalization

Binary data

$\tilde{g}_f[n]$ $\ldots$ $\tilde{y}_{K-1}[n]$ $\ldots$ $\tilde{y}_0[n]$ $\tilde{g}_f[n]$ $\tilde{d}[K-1,i]$ $\tilde{d}[0,i]$ $\ldots$ $\ldots$
Tail-biting CP

- In OFDM we have 1 CP for every OFDM sym Block
- In GFDM, we have for M-sym blocks, 1 CP
- If we have frequency selective Channel, the influence of CP on $\frac{E_B}{N_0}$

$10 \log_{10} \left( \frac{T_{\text{data}} + T_{\text{CP}}}{T_{\text{data}}} \right)$
GFDM performance
Flexible RF Transceiver Front-End

Main objectives:
• Flexible spectrum exploitation
• Supporting spectrum aggregation

Architecture of the multi-band RF receiver front-end

Frequency selection and conversion for spectrum aggregation
Conclusion

- State of the art architectures have been studied.
- Parameter and system requirements have been researched.
- A flexible PHY design is being researched; with several options identified.
- Simulations going on in FBMC, GFDM, IA-PFT etc. etc.
- Performance of these PHY techniques are being studied and simulated.
- Reconfigurable RF front-end is being researched.
Thank You!!