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Adaptive low-complexity MB-OFDM for ultra-wideband wireless communication

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ADAPTIVE LOW-COMPLEXITY MB-OFDM FOR ULTRA-WIDEBAND WIRELESS COMMUNICATION

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from

UNIVERSITY OF WOLLONGONG

by

Darryn W. Lowe
School of Electrical, Computer and Telecommunications Engineering
2010
Abstract

Ultra-wideband (UWB) is seen as the foundation of future pervasive, wireless personal area networks (WPANs). The ability to provide tremendous capacity without the expense of multiple antennas or the power of narrowband transmissions makes it ideal for low-cost high-speed wireless communications. The realization of WPANs that encompass these UWB properties, however, hinges on solutions to the following key challenges.

The high data rates demanded of multimedia WPANs mean that spectral resources must be used efficiently. This requires an UWB device to be able to accurately estimate channel conditions. Unfortunately, current signal processing algorithms cannot be applied directly without prohibitively increasing receiver complexity given the tremendous bandwidth of UWB systems. The result is that first-generation UWB receivers are using simple zero-forcing (ZF) approaches that work poorly in short impulsive channels. Accordingly, this thesis proposes several low-complexity channel estimation techniques that perform comparably to optimal minimum mean square error (MMSE) estimation.

UWB WPANs must be reliable even when channels are highly frequency-selective or suffer from interference. With cost constraints limiting the current ECMA-368 UWB standard to low-complexity block-spreading and convolutional codes, this thesis adopts a holistic approach that exploits the interactions between diversity techniques to reduce packet error rates and improve error recovery. Furthermore, this
thesis proposes and investigates the following novel heuristics for mitigating interference: adaptive sizing the overlap-add window so as to balance recovery of delayed signal energy with noise; adaptive changing the time-frequency interleaving pattern to avoid interfering signals; and adapting the degree of companding to minimize both nonlinear distortions from clipping and noise.

The contributions of this thesis grant significant performance and reliability improvements whilst minimizing incremental complexity and maintaining backwards compatibility with existing UWB devices. Furthermore, specific recommendations to revise the ECMA-368 standard are justified through theoretical analyses and Monte Carlo simulations.
Statement of Originality

I, Darryn W. Lowe, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy – Research, in the School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged.

The document has not been submitted for qualifications at any other academic institution.

______________________________
Darryn W. Lowe
16 May 2010
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What can change the nature of a man?

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