MIMO block spread OFDMA system for next generation mobile communications

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University of Wollongong

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MIMO Block Spread OFDMA System for
Next Generation Mobile Communications

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

Master of Engineering by Research

from

UNIVERSITY OF WOLLONGONG

by

Yiwei Yu
Master of Engineering Studies

School of Electrical, Computer and Telecommunications Engineering

March 2008
Statement of Originality

I, Yiwei Yu, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Engineering - 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.

Yiwei Yu

March 26, 2008
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Acronyms

1G  First-generation
2G  Second-generation
3G  Third-generation
4G  Fourth-generation

AWGN  Additive white Gaussian noise
BER  Bit error rate
BPSK  Binary phase shift keying
BS-OFDM  Block spread OFDM
BS-OFDMA  Block spread orthogonal frequency division multiple access
CDMA  Code division multiple access
CP  Cyclic prefix
DFE  Decision feedback equalizer
DFT  Discrete Fourier transform
DMB  Digital multi media broadcasting

DVB  Digital video broadcasting

DVB-C  DVB-cable

DVB-H  DVB-handheld

DVB-S  DVB-satellite television and satellite Internet

DVB-T  DVB-terrestrial

EC  Eurppean Commission

FFT  Fast Fourier transform

FWA  Fixed wireless access

GSM  Global system for mobile communications

HAP  High altitude platforms

ICI  Inter-carrier interference

IFFT  Inverse fast Fourier transform

ISDB  Integrated services ditial broadcasting

ISDB-C  ISDB-cable

ISDB-S  ISDB-satellite television

ISI  Intersymbol interference

M2M  Machine-to-machine
MAC  Media access control

MAGIC  Mobile multimedia; Anytime, anywhere, anyone; Global mobility support; Integrated wireless solution; and Customized personal service

MC-CDMA  Multicarrier CDMA

MC-DS-CDMA  multicarrier direct sequence CDMA

MIMO  Multi-input and multi-out

MISO  Multiple input and single output

MLSE  Maximum likelihood sequence estimator

MMSE  Minimum mean square error

M-PSK  M phase shift keying

M-QAM  M quadrature amplitude modulation

NLOS  non-line-of-sight

OFDM  Orthogonal frequency division multiplexing

OOB  Out of band

PAN  Personal area network

PAPR  Peak to average power ratio

PHY  Physical layer

PN  Pesudo-noise
<table>
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<th>Term</th>
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<tr>
<td>P/S</td>
<td>Parallel to serial</td>
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<tr>
<td>QoS</td>
<td>Quality of service</td>
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<tr>
<td>QPSK</td>
<td>Quadrature phase shift keying</td>
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<tr>
<td>SNR</td>
<td>Signal to noise ratio</td>
</tr>
<tr>
<td>S/P</td>
<td>Serial to parallel</td>
</tr>
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<td>SS</td>
<td>Spread spectrum</td>
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<td>STBC</td>
<td>Space-time block coding</td>
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<td>STC-MIMO</td>
<td>Space-time coded MIMO</td>
</tr>
<tr>
<td>STTC</td>
<td>Space-time trellis coding</td>
</tr>
<tr>
<td>TCM</td>
<td>Trellis-coded modulation</td>
</tr>
<tr>
<td>TD-SCDMA</td>
<td>Time division synchronous CDMA</td>
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<tr>
<td>UMTS</td>
<td>Universal Mobile Telecommunication system</td>
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<td>WCDMA</td>
<td>Wideband CDMA</td>
</tr>
<tr>
<td>W-CPN</td>
<td>Wireless customer premise network</td>
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<tr>
<td>WiMAX</td>
<td>Worldwide interoperability for microwave access</td>
</tr>
<tr>
<td>W-LAN</td>
<td>Wireless local area network</td>
</tr>
<tr>
<td>WLL</td>
<td>Wireless local loop</td>
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<tr>
<td>ZF</td>
<td>Zero-forcing</td>
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Abstract

Wireless communications are developing at a booming speed, with plenty of research emerging on the next generation wireless communications. This thesis presents an advanced system for the next generation wireless communications. The proposed system is called block spread OFDMA combined with STC-MIMO (STC-MIMO BS-OFDMA). The system is based on OFDM, which is able to deliver high data rates in highly dispersive channels and is thereby considered as a good candidate of modulation techniques for 4G. The block spreading technique and STC-MIMO scheme are used to provide the system with frequency and spatial diversity, therefore significantly improving system performance.

In this system, there are two stages to combine block spreading and STC-MIMO with OFDMA. Firstly, a novel block spreading approach is applied to effectively achieve frequency diversity in the OFDMA system without any explicit precoding process. The STC-MIMO using Alamouti code is then incorporated on block basis and performs in space and frequency. Accordingly, the signal model and architectures of the proposed system are presented. Two receiver architectures are designed for different STC-MIMO schemes: the receiver with one antenna and receiver with two antennas.
Simulations are carried out to demonstrate the expected performance improvement. The BER performance comparisons indicate that the proposed system can achieve significant performance improvement. The research project also investigates the system performance when different parameters are used. Our results show that using a larger block spreading size and more receive antennas can further improve system performance because of higher order of diversity advantages. In terms of linear equalizations, the MMSE equalization achieves better performance than the ZF equalization.
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