Single- and Multi-Carrier CDMA

Multi-User Detection, Space-Time Spreading, Synchronisation and Standards

by

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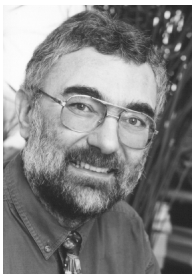
We dedicate this monograph to the numerous contributors of this field, many of whom are listed in the Author Index

About the Authors



Lajos Hanzo received his degree in electronics in 1976 and his doctorate in 1983. During his career in telecommunications he has held various research and academic posts in Hungary, Germany and the UK. Since 1986 he has been with the Department of Electronics and Computer Science, University of Southampton, UK, where he holds the chair in telecommunications. He has co-authored 10 books on mobile radio communications, published about 400 research papers, organised and chaired conference sessions, presented overview lectures and has been awarded a number of distinctions. Currently he heads an academic research team, working on a range of research projects in the field of wireless multimedia communications sponsored by industry, the Engineering and Physical Sciences Research Council (EPSRC) UK, the European IST Programme and the Mobile Virtual Centre of Excellence (VCE), UK. He is an enthusiastic supporter of industrial and academic liaison and he offers a range of industrial courses. He is also an IEEE Distinguished Lecturer. For further information on research in progress and associated publications please refer to http://www-mobile.ecs.soton.ac.uk

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Other Wiley and IEEE Press Books on Related Topics [1]

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- L. Hanzo, M. Münster, T. Keller, B-J. Choi: OFDM and MC-CDMA for for Broadband Multi-user Communications, WLANs and Broadcasting, John Wiley - IEEE Press, 2003

[1] For detailed contents please refer to http://www-mobile.ecs.soton.ac.uk)

Contents

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Part I

Multi-User Detection for Adaptive Single-Carrier CDMA

Part V

Standards and Networking

Glossary

ACL	Auto-correlation of a sequence
adaptive-rate	a term applied to techniques that adapt the bit rate according to certain criteria
AQAM	Adaptive Quadrature Amplitude Modulation, a transmission scheme where the modulation mode is adapted according to certain criteria
ARIB	Association of Radio Industries and Businesses in Japan
AWGN	Additive White Gaussian Noise
BCH	Bose-Chaudhuri-Hocquenghem, A class of forward error correcting codes (FEC)
BER	Bit error rate, the number of the bits received incorrectly
blind detection	A data or parameter estimation technique that does not require reference sequences to be transmitted or parameter estimation to be carried out separately
BPS	Bits Per Symbol, indicates the throughput performance
BPSK	Binary Phase Shift Keying, a type of data modulation scheme
BS	A common abbreviation for Base Station
CATT	Chinese Academy of Telecommunication Technology
CCL	Cross-correlation, usually of two different sequences
CDMA	Code Division Multiple Access, a multiple access scheme where multiple users transmit simultaneously within the same bandwidth and are separated through the use of a unique spreading code for each user
CIR	Channel Impulse Response
CRAD	Coherent Receiver Antenna Diversity, where the received signals from more than one antenna are coherently combined to obtain signal gain.
DBPSK	Differential Binary Phase Shift Keying, a type of data modulation scheme
decorrelator	A detector that removes the correlation of all the interferer signals with the signal of the desired user

diversity A technique employed to obtain performance gain where different received versions of the same source signal are combined in order to improve the system performance

DS-CDMA Direct Sequence Code Division Multiple Access, a sub-class of CDMA where each transmitted bit is directly multiplied with a spreading sequence in order to spread its bandwidth.

ETSI European Telecommunications Standards Institute

FDMA Frequency Division Multiple Access, a multiple access scheme where different users transmit in different bandwidths in order not to interfere with each other

FFH Fast Frequency Hopping

FH-CDMA Frequency Hopping Code Division Multiple Access, a sub-class of CDMA where the carrier frequency of the CDMA user is switched according to a pattern determined by its unique code

IC Interference Cancellation, a type of multiuser receiver for CDMA where the received signal is regenerated from previous data estimates and cancelled from the composite received signal, in order to provide more reliable estimates after the cancellation stages

IMT-2000 International Mobile Telecommunications 2000

interleaving A technique employed to randomize burst errors caused by fading in the mobile channel. The transmitted bits are arranged according to a known order before transmission and at the receiver the received symbols are re-arranged into the pre-transmission order so that the bursty errors can be separated. This helps improve the performance of the channel decoder.

IS-95 Interim Standard 95, the definition of the cellular (800 MHz) CDMA Common Air Interface

ISI Inter-symbol Interference, interference caused by the time dispersion of the wideband channel where the transmitted symbols interfere with each other

JD Joint Detection or Joint Detector, a type of multiuser receiver that uses equalization techniques to detect jointly detect the symbols of multiple users

JD-CDMA Joint Detection CDMA system, a CDMA system that employs joint detection receivers

LMS Least Mean Square algorithm, a linear adaptive filtering algorithm that recursively optimizes the filter tap weights in order to obtain the minimum mean square error at the output of the filter

MAI Multiple Access Interference, the interference caused by multiple users transmitting simultaneously within the same bandwidth and is usually used in the context of CDMA systems

MAP Maximum A Posteriori, the maximum a posteriori probability criterion maximizes the probability of making a correct decision

matched filter A filter that has an impulse response that is matched to the waveform of the desired signal and maximizes the SNR at the output of the filter

MC-CDMA Multi-Carrier Code Division Multiple Access, a sub-class of CDMA where a data symbol is spread with a spreading sequence into say, Q chips and each chip of the spread data symbol is transmitted over a narrowband subcarrier in the frequency domain.

MLSE Maximum Likelihood Sequence Estimation, a sequence estimation technique that produces the most likely transmitted sequence based on a metric that is optimized for a certain criterion

MMSE Minimum Mean Square Error

MMSE-BDFE Minimum Mean Square Error Block Decision Feedback Equalizer, a type of joint detection receiver that minimizes the mean square error and feeds back already detected symbols to improve the reliability of the output estimates

MMSE-BLE Minimum Mean Square Error Block Linear Equalizer, a type of joint detection receiver that linearly minimizes the mean square error

MRC Maximal Ratio Combining, a diversity combining technique where multiple received signals are coherently combined

MS A common abbreviation for Mobile Station

multipath diversity Multiple versions of the transmitted signal are obtained at the receiver due to the different multipaths in a channel and the signals of these paths can be combined in order to provide performance gain

multiuser receiver A receiver that employs available knowledge on the properties of all the transmitting users in order to detect the data symbols of all the users

near-far effect The phenomenon that occurs when the signals from different users arrive at the base station with different signal strengths. The stronger signals swamp out the weaker signals, thus severely degrading the performance of the weaker signals.

PDF Probability Density Function

PIC Parallel Interference Cancellation, an interference cancellation receiver where the received signals of all the interferers are cancelled from the received composite signal at each cancellation stage in order to generate a more reliable signal for the data estimation of the desired user

PN sequence Pseudo-noise sequence, or pseudo-random sequence, which is a generated sequence that exhibits noise-like properties

power control A technique used to combat the near-far effect where the power control algorithm attempts to regulate the transmitted powers of all the users such that the signals of all the users arrive with similar strengths at the receiver.

PSD Power Spectral Density

PSP Per Survivor Processing, a trellis-decoding algorithm, where the required parameters, for example CIR estimates, are unknown. The parameter estimation is carried out in a ”per-survivor” fashion, which means that a parameter estimator is assigned to each surviving data sequence of the trellis.

QAM Quadrature Amplitude Modulation

RAKE A multipath diversity combiner, that inherited its name from the way it "rakes" in all the incoming pulses to form an equalized signal. The signal energy from different multipaths are combined according to the chosen diversity combining technique.

RLS Recursive Least Squares, an adaptive filtering technique where a recursive method is used to adapt the filter tap weights such that the square of the error between the filter output and the desired response is minimized

SFH Slow Frequency Hopping

SIC Successive Interference Cancellation, an interference cancellation receiver where only the received signals of all the interferers that are more reliable than the desired signal are cancelled from the received composite signal in order to generate a more reliable signal for the data estimation of the desired user

SINR Signal to Interference plus Noise ratio, same as signal to noise ratio (SNR) when there is no interference.

SNR Signal to Noise Ratio, noise energy compared to the signal energy

SOVA Soft Output Viterbi Algorithm, a trellis algorithm that generates the most likely sequence in soft decisions according to the constraints of the trellis and the received signal

SSMA Spread Spectrum Multiple Access

TDD Time Division Duplex, a transmission protocol where the uplink and downlink transmissions are carried out in the same frequency but separated in time

TDD-CDMA Time Division Duplex Code Division Multiple Access, a multiple access scheme that combines TDD and CDMA

TDMA Time Division Multiple Access, a multiple access technique where multiple users transmit in the same bandwidth but are separated in time through user-designated timeslots

TH-CDMA Time Hopping Code Division Multiple Access, a sub-class of CDMA where each user transmits in the timeslots determined by its spreading sequence

TIA Telecommunications Industry Association in USA

UMTS Universal Mobile Telecommunications Systems

UTRA UMTS Terrestrial Radio Access

Viterbi algorithm A trellis algorithm that generates the most likely sequence according to the constraints of the trellis and the received signal

VSF Variable Spreading Factor, an adaptive rate transmission scheme for CDMA, where the bit rate is adapted by varying the spreading factor but keeping the chip rate constant

W-CDMA Wideband Code Division Multiple Access, a high chip-rate and bit-rate CDMA air interface, where the mobile channel bandwidth is very wide and the fading within the channel is frequency-selective. In general, the minimum bandwidth of wideband CDMA is 5 MHz.

WMF	Whitening Matched Filter, a filter that whitens the received noise and maximizes the SNR at the output of the filter
ZF-BDFE	Zero Forcing Block Decision Feedback Equalizer, a type of joint detection receiver that eliminates all the interference at the expense of noise enhancement and feeds back already detected symbols to improve the reliability of the output estimates
ZF-BLE	Zero Forcing Block Linear Equalizer, a type of linear joint detection receiver that eliminates all the interference at the expense of noise enhancement

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