



UNIVERSITI PUTRA MALAYSIA

**PERFORMANCE ENHANCEMENT OF ULTRA-WIDEBAND POWER
CONTROL USING RANGING AND NARROWBAND INTERFERENCE
MITIGATION**

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FK 2008 1



**PERFORMANCE ENHANCEMENT OF ULTRA-WIDEBAND POWER
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MITIGATION**

By

RASHID ABDELHALEM SAEED

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfilment of the Requirements for the Degree of
Doctor of Philosophy**

January 2008



DEDICATION

To my family; Rania, Shahd, and Mohammed

To my grant family thank you for every thing



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

PERFORMANCE ENHANCEMENT OF ULTRA-WIDEBAND POWER CONTROL USING RANGING AND NARROWBAND INTERFERENCE MITIGATION

By

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January 2008

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Power control is a critical parameter for the design and evaluation of ultra-wideband (UWB) based ad-hoc networks due to its distributed control nature and non-fixed topology. Since the ad-hoc networks are infrastructure-less only local information is available for each node to maintain the limited resources available in the network. In UWB indoor networks the main issues in power control are the channel gain fluctuations induced by dense multipath and interference arising from the narrowband systems. In this thesis we have introduced a joint UWB physical/ medium access control layer (PHY/MAC) design for direct-sequence-based UWB (DS-UWB) power control design by exploiting the high time resolution of the UWB signal for channel gain improvement and mitigates the narrowband interference to reduce bit error rate (BER) and so enhance the throughput.



The fine time resolution of UWB signals enables high ranging estimation resolution, which leads to more accurate transmitted power control. However, in dense multipath fading an accurate ranging is a problematic due to non-line-of-sight (NLOS) propagation environments. In this thesis we propose a maximum likelihood algorithm enhanced with synchronization scheme to estimate the time delay of direct-path signal in NLOS multi-path fading environment and mean acquisition time. The algorithm is examined under various doublet Gaussian pulse widths (T_p) and bit energy-noise ratio (E_b/N_0) and gives lower ranging error (0.32m) compared to others (eg. CRLB is 0.84m).

The closer the narrowband interference band to the centre frequency of the UWB signal, the more signal-to-interference-noise ratio degrades. In this thesis we discussed a mitigation approach by using the flexibility of the doublet Gaussian pulse generation, where a notched band is contributed in the pulse spectrum to avoid the narrowband interferer frequencies. In this case worldwide interoperability for microwave access (WIMAX) and wireless local area network (WLAN) are used. The results are compared with orthogonal frequency division multiplexing-based UWB (OFDM-UWB) before and after mitigation. It was observed that DS-UWB shows better performance after pulse adaptation (1dB better than cognospectrum).

The performance of power control using the proposed ranging and pulse adaptation schemes is investigated for different number of nodes. It is seen that, bit error rate of 10^{-4} can be achieved for 20 users maintaining 14.2dB SINR. Also the same bit error



rate can be achieved for bit error rate for 12.3 dB SINR using 40 pulses per bit (N_s). The results have been indicated that the proposed approach is able to achieve better BER (1.6 dB) and throughput (12% more for 40 users) than previous related research works.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor of Falsafah.

**PENINGKATAN PRESTASI DALAM KAWALAN KUASA JALUR LEBAR
LAMPAU MENGGUNAKAN PENJULATAN DAN PENGURANGAN
GANGGUAN JALUR NIPIS**

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Kawalan Kuasa Penghantaran adalah satu parameter kritikal untuk rekabentuk dan penilaian Jalur Lebar Lampau (UWB) dalam rangkaian ad hoc disebabkan jenis kawalannya yang tertabur dan topologi yang tidak tetap. Oleh kerana rangkaian ad hoc adalah tidak berperasarana hanya maklumat tempatan terdapat dalam setiap nod untuk mengekalkan sumber-sumber terhad yang sedia ada dalam rangkaian. Dalam rangkaian UWB isu isu utama yang dibangkitkan dalam masalah kawalan kuasa adalah perubahan gandaan saluran disebabkan oleh pergerakan nod dan gangguan yang timbul dari sistem-sistem jalur nipis yang lain. Dalam tesis ini kami telah memperkenalkan rekabentuk kawalan gabungan lapisan capaian medium/fizikal UWB untuk rekabentuk kawalan kuasa UWB berasaskan jujukan langsung (DS-UWB) dengan mengeksploitasikan resolusi masa isyarat UWB yang tinggi untuk peningkatan gandaan saluran dan mengurangkan gangguan kuasa penghantaran gangguan jalurnipis.

Resolusi masa UWB yang halus membolehkan resolusi penganggaran penjulatan yang tinggi. Walau bagaimanapun, pemudaran berbilang laluan padat, gangguan capaian berbilang (MAC), dan persekitaran perambatan bukan garis-pemandangan (NLOS) membuatkan penjulatan yang tepat sangat mencabar. Dalam tesis ini kami mencadangkan algoritma kemungkinan maksimum untuk menganggarkan lengah masa isyarat laluan-langsung dalam persekitaran pemudaran laluan-berbilang NLOS dan menggunakan parameter parameter kod perolehan, dipertingkatkan dengan skim penyegerakan. Algoritma tersebut adalah dikaji dalam beberapa lebar dedenyut (T_p) Gaussian berkembar, dan nisbah tenaga-ke-bisingan (E_b/N_0) dan telah ditunjukkan memberikan ralat penjulatan yang rendah (0.32m) berbanding dengan yang lain (eg. CRLB is 0.84m).

Lebih dekat jalur gangguan jalurnipis ini ke frekuensi tengah isyarat UWB, lebih teruk lagi sistem ini akan merosot. Dalam tesis ini kami membincangkan pendekatan pengurangan dengan menggunakan fleksibiliti penjanaan dedenyut Gaussian berkembar, di mana satu jalur takuk adalah disumbangkan kepada spektra dedenyut untuk mengelakkan frekuensi frekuensi gangguan jalurnipis. Dalam kes in Capaian Tetap Wayerles (FWA) dan Rangkaian Kawasan Tempatan Wayerles (WLAN) digunakan. Hasilnya dibandingkan dengan UWB berasaskan pemultipleksan pembahagi frekuensi orthogonal (OFDM-UWB) sebelum dan selepas pengurangan. Adalah didapati bahawa DS-UWB menunjukkan prestasi yang lebih baik selepas adaptasi dedenyut (1dB).



Prestasi kawalan kuasa penghantaran menggunakan kaedah cadangan skim-skim penjumlahan dan adaptasi dedenyut telah dikaji untuk beberapa bilangan nod. Ia digambarkan bahawa 10^{-4} boleh dicapai untuk SINR=14.2dB, kadar ralat bit yang sama juga dicapai untuk SINR=14.2dB menggunakan 20 pengguna dan kadar ralat bit 10^{-4} untuk SNIR 12.3dB adalah diperolehi menggunakan 40 dedenyut per bit (N_s). Keputusannya menunjukkan bahawa pendekatan cadangan ini boleh mencapai BER (1.6 dB) dan daya pemerosesan (12% untuk 40 pengguna) yang lebih baik dari hasil kajian sebelum ini.



ACKNOWLEDGEMENTS

I would like to thank God for His love and grace which has carried me throughout my life. The work presented in this thesis would not have been possible without the support of a number of individuals and organizations, and they are gratefully acknowledged below.

- Special thanks to Assoc. Prof. Dr. Sabira Khatun, the chairman of my supervisory committee for her insightfully advice, consistence encouragement and understanding throughout my doctoral studies.
- I am grateful to supervisory committee members, Prof. Dr. Borhanuddin Mohamad Ali, the director of Wireless Networks and Protocols research lab (WNPR), MIMOS Berhad, and Prof. Dr. Mohamad Khazani Abdualah, the deputy dean of admission, School of Graduate Studies (SGS), UPM, for their professional and constructive inputs throughout my research, and insightful reviews in this thesis.
- I thank the staff in the department of Computer and Communication System Engineering for providing a harmonious working environment. I would like to express my thanks to my colleagues in Wireless Broadband Research Group, for their many supports and encouragement.



- Credit for this work must, of course, be shared with people who helped along the way. Special thanks to Dr. Sharlene Thiagarajah the Head of Radio Propagation Unit, Telekom Research & Development Sdn. Bhd., UPM-MTDC, and Dr. Hafizal Mohamad, Head of PHY layer Dept., MIMOS Berhad for their invaluable suggestions and great discussions that directly resulted in the contributions in this thesis.
- I would like to acknowledge the financial support from Sudan University of Science and Technology (SUST) and Malaysian Intensification of Research in Priority Areas (IRPA 04-02-04-0186EA001) Program, School of Graduate Studies (SGS), Universiti Putra Malaysia.
- Last, but definitely not least, I would like to thank my family: my wife, Rania for all her love, fruitful discussions and suggestions, encouragement and understanding, my daughter Shahd, and son Mohammed, my parents, brothers, and sister for their love, sacrifice and moral support.



I certify that an Examination Committee has met on 11 January 2008 to conduct the final examination of Rashid Abdelhaleem Saeed on his Doctor of Philosophy thesis entitled “Performance Enhancement of Ultra-Wideband Power Control by using Ranging and Narrowband Interference Mitigation” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Member of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

RASHID ABDELHALEEM SAEED

Date: 20 January 2008



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LIST OF ABBREVIATIONS

AJ	Anti Jamm
AoA	Angle of Arrival
AP	Access Point
ARake	all Rake
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BER	Bit Error
BGI	Background Interference
BI	Burst Interference
BPSK	Binary Phase-Shift Keying
CDMA	Code Division Multiple Access
CIR	Channel Impulse Response
CLD	Cross Layer Design
CR	Cognitive Radio
CRLB	Cramer – Rao Lower Bound
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
DCF	Distributed Coordination Function
DEV	DEvice
DSP	Digital Signal Processor
DS-UWB	Direct Sequence UWB



ESD	Energy Spectral Density
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FDM	Frequency Division Multiple Access
FEC	Forward Error Check
FFT	Fast Fourier Transform
FHSS	Frequency Hopping Spread Spectrum
FSK	Frequency Shift Keying
FWA	Fixed Wireless Access
GML	Generalized Maximum Likelihood
GPS	Global Positioning System
GSM	Global System for Mobile communication
HDR-UWB	High Data Rate - UWB
HDTV	High Density TV
i.i.d	independent and identically distributed
IBI	In-Band Interference
IEEE	International Electrical and Electronics Engineers
IF	Intermediate Frequency
IFFT	Inverse Fast Fourier Transform
IR	Impulse Radio
ISM	Industrial Scientific and Medical
ISO	International Standard Organization

