



UNIVERSITI PUTRA MALAYSIA

**A STATISTICAL MULTI-CLUSTER INDOOR CHANNEL MODEL IN AN
OFFICE ENVIRONMENT FOR ULTRA-WIDEBAND SIGNALS**

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By

Sharlene Thiagarajah

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

April 2005



DEDICATION

“To my parents”

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

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Chairman: Professor Borhanuddin Mohd. Ali, PhD

Faculty: Engineering

This thesis presents a new statistical multi-cluster indoor channel model for ultra-wideband (UWB) communications between 0.1 to 2 GHz. The proposed model has been developed based on 924 measured channel impulse responses conducted at 24 different locations over a single floor in a typical modern office environment.

The multi-cluster channel characteristics are modeled according to 10 independent channel parameters extracted from the large-scale and small-scale statistical analysis of the received energy delay profiles (EDP). Three new channel parameters were introduced to better describe the time and energy dispersion statistics of the UWB signal. They are the maximum excess delay (MED), decay factor, γ within the MED and energy gains variations between adjacent bins, χ .

The pulse propagation characteristics were further modeled according to several path topographies. In addition, two new path loss prediction models were developed to take into account the attenuation factor (AF) due to gypsum and brick wall, the two main obstructing walls in this experiment.

The proposed multi-cluster channel model improves the prediction accuracy of the UWB pulse characteristics for various path topographies due to its detailed parameterization of the channel statistics. In comparison, the channel model of Cassioli et al. in 2001 was developed using only three independent lognormal parameters, i.e. shadowing, σ , decay factor, γ and the energy gains ratio, r . Furthermore, Cassioli et al. proposed a single cluster channel model without topographical classification. The channel model of Alvarez et al. in 2003 however was developed based on five channel parameters extracted from analysis conducted in the frequency domain. This method does not accurately capture the time delay statistics of the transmitted pulse.

The experimental results indicate the UWB signal's high immunity against fades and its attractiveness for propagation in tunnels. In addition the UWB channel was observed to exhibit a wide-sense-stationary-uncorrelated-scattering (WSSUS) characteristic which simplifies the transfer function between the time and frequency domains via a single Fourier transform.

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

**MODEL PERANGKAAAN BERBILANG KELOMPOK UNTUK SALURAN
DALAM RUANG PEJABAT MENGGUNAKAN GELOMBANG JALUR
ULTRALEBAR**

Oleh

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April 2005

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Tesis ini akan mengemukakan sebuah model perangkaan baru berbilang kelompok untuk saluran komunikasi dalam bangunan menggunakan gelombang jalur ultralebar (UWB) dari 0.1 ke 2 GHz. Model yang dikemukakan ini telah digubal berasaskan 924 ukuran gerakbalas dedenyut saluran dari 24 lokasi yang berbeza di aras tingkat yang sama dalam sebuah ruang pejabat moden yang lazim.

Ciri-ciri saluran berbilang kelompok dimodelkan mengikut 10 parameter saluran bebas yang dihasilkan dari analisa perangkaan skala besar dan skala kecil menggunakan gambaran susutan tenaga yang diterima (EDP). Tiga parameter saluran baru telah diperkenalkan untuk menggambarkan perangkaan serakan masa dan tenaga gelombang UWB dengan jelas. Ia terdiri daripada tempoh susutan

maksimum (MED), faktor susutan, γ dalam lingkungan masa MED dan perbezaan tenaga gandaan di antara bin yang bersebelahan, χ .

Ciri-ciri perambatan dedenyut telah dimodelkan selanjutnya mengikut beberapa laluan topografi. Sebagai tambahan, dua model ramalan kehilangan laluan baru telah dibangunkan dengan mengambil kira faktor pengecilan (AF) yang disebabkan oleh dinding gipsium dan batu, iaitu dua jenis dinding penghadang utama yang terdapat dalam ujikaji ini.

Model saluran berbilang kelompok yang disarankan ini dapat memperbaiki ramalan kejituan ciri dedenyut UWB untuk pelbagai laluan topografi disebabkan hasil perangkaan saluran yang terperinci yang telah dikemukakan. Ini berbanding dengan model saluran Cassioli et al. pada 2001 yang dibangunkan menggunakan hanya tiga parameter lognormal bebas, iaitu pembayangan, σ , faktor susutan, γ dan nisbah tenaga gandaan, r . Tambahan pula, Cassioli et al. telah mencadangkan model saluran sekelompok tanpa perbezaan topografi. Model saluran Alvarez et al. pada 2003 pula telah dibangunkan mengikut lima saluran parameter yang dihasilkan menerusi analisa domain frekuensi. Namun kaedah ini tidak dapat menawan perangkaan susutan masa dedenyut pemancar dengan jitu.

Hasil keputusan ujikaji menunjukkan bahawa gelombang UWB mempunyai daya kekalisan yang tinggi terhadap resapan dan sangat sesuai untuk perambatan dalam terowong. Tambahan pula, saluran UWB didapati menunjukkan sifat lebar-pegun-

tanpa-hubungan-penyerakan (WSSUS) yang memudahkan fungsi menjelmaan di antara domain masa dan frekuensi iaitu menerusi satu aliran penjelmaan Fourier.

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TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	viii
APPROVAL	x
DECLARATION	xii
LIST OF TABLES	xvi
LIST OF FIGURES	xviii
LIST OF ABBREVIATIONS	xxv

CHAPTER

1	INTRODUCTION	1.1
1.1	Bandwidth Definition	1.2
1.2	Limitation And Advantages	1.3
1.3	Applications	1.6
1.4	Thesis Objective and Scope	1.7
1.5	Research Contribution	1.9
1.6	Thesis Outline	1.11
2	ULTRA-WIDEBAND TECHNOLOGY	2.1
2.1	Ultra-Wideband Radio Principles	2.1
2.1.1	Transmission Schemes	2.2
2.1.2	Time-Hopping Format	2.5
2.1.3	Receiving Monocycle Transmissions	2.10
2.2	Research Issues and Design Challenges	2.14
2.3	Channel Characterization	2.17
2.3.1	Narrowband Channel Modeling	2.17
2.3.2	Wideband Channel Modeling	2.18
2.3.3	Ultra-Wideband Channel Modeling	2.19
2.4	Conclusion	2.27

3	EXPERIMENTAL SET-UP	3.1
3.1	Indoor Measurement Site	3.1
3.1.1	Building Floor Plan	3.2
3.1.2	Location Topography	3.5
3.2	Equipment Configuration	3.7
3.3	Measurement Procedures	3.9
3.3.1	Observation Window	3.11
3.3.2	Temporal Bin Width	3.12
3.4	Multi-Cluster Impulse Response	3.16
3.5	Polarization Diversity	3.17
3.6	Conclusion	3.20
4	LARGE-SCALE STATISTICS	4.1
4.1	Global Parameters	4.1
4.2	Time Delay Statistics	4.2
4.2.1	Path Arrival Time (PAT)	4.5
4.2.2	Maximum Excess Delay (MED)	4.11
4.2.3	Decay Factor (γ)	4.18
4.2.4	Cluster Hard Decay Time (τ_H)	4.28
4.3	Energy Dispersion Statistics	4.34
4.3.1	Energy Gains Ratio (r)	4.35
4.3.2	Energy Gains Variation in Adjacent Bins(χ)	4.44
4.3.3	Zero Crossing Rate (ZCR)	4.51
4.4	Path Loss Prediction Models	4.59
4.4.1	Distance-Dependent Path Loss Model	4.60
4.4.2	Attenuation Factor Path Loss Model	4.70
4.4.3	Distance-Dependent Attenuation Model	4.77
4.5	Conclusion	4.82
5	SMALL-SCALE STATISTICS	5.1
5.1	Local Parameters	5.1
5.1.1	Local Path Arrival Statistics	5.2
5.1.2	Local Maximum Excess Delay Statistics	5.4
5.2	Fast-Fading Characteristics	5.6
5.3	Scattering Characteristics	5.10
5.4	Wide-Sense-Stationary-Uncorrelated-Scattering (WSSUS) Channel	5.15
5.5	Conclusion	5.18

6	CONCLUSION	6.1
6.1	Original Contributions	6.1
6.2	Future Works	6.5
 BIBLIOGRAPHY		R1
APPENDIX		A1
BIODATA OF THE AUTHOR		B1

LIST OF TABLES

		Page
Table 2.1	A Summary of Analysis Methods and Research Results on Characterization of the UWB Channel	2.28
Table 3.1	Description of the Measurement Locations A-X	3.4
Table 3.2	Classification of Location Topographies According to Building Floor Plan	3.6
Table 3.3	Equipment Specification	3.8
Table 3.4	TOA and Maximum Excess Delay for Different Bin Widths	3.15
Table 3.5	Energy Captured with Different Antenna Polarization	3.17
Table 4.1	Path Arrival Time (PAT) For Locations A-X	4.8
Table 4.2	Vertical Deviation (d^2) and Number of Obstructing Walls	4.10
Table 4.3	Maximum Excess Delay (MED) For Locations A-X	4.12
Table 4.4	Maximum Excess Delay (MED) Statistics	4.14
Table 4.5	Decay Factor For 24 Locations (A-X)	4.21
Table 4.6	Decay Factor Statistics	4.22
Table 4.7	Comparison Of Decay Factor Statistics	4.24
Table 4.8	Cluster Hard Decay Time Statistics (τ_H)	4.30
Table 4.9	Comparison Of Hard Cluster Decay Time, τ_H Statistics	4.33
Table 4.10	Statistics Of The Energy Gains Ratio (r) Parameter	4.40
Table 4.11	Weibull Distribution Statistics of the Energy Gains Variation Between Adjacent Bin For All Topographies	4.48

Table 4.12	Summary of ZCR Statistics For All Topographies	4.58
Table 4.13	Measured Path Loss (Normalized to Reference 1 m)	4.62
Table 4.14	Mean Path Loss Exponent, n and Shadowing Parameter For Different Topographies	4.65
Table 4.15	Comparison Of Mean Path Loss Exponent, n	4.68
Table 4.16	Comparison Of Shadowing Parameter, σ	4.69
Table 4.17	Measured Path Loss (Absolute) and Free Space Path Loss	4.72
Table 4.18	Attenuation Factor (AF) for Gypsum Wall at 1.2GHz	4.74
Table 4.19	Attenuation Factor (AF) for Brick Wall at 1.2GHz	4.75
Table 4.20	Comparison Between The Standard Deviation For The n^{th} Path Loss Model And The Attenuation Factor Model For Various Topographies	4.77
Table 4.21	Comparison Of Standard Deviation For Proposed Path Loss Models	4.80
Table 4.22	Summary of the Large-Scale UWB Indoor Channel Parameters	4.86
Table 5.1	Local Path Arrival Statistics	5.3
Table 5.2	Small-Scale Maximum Excess Delay Statistics	5.5
Table 5.3	Signal Quality Statistics For Locations A-X	5.8
Table 5.4	Fade Margin Statistics for Various Topographies	5.9
Table 5.5	Correlation Coefficient, ρ For Locations A-X	5.12
Table 5.6	Mean Correlation Coefficient for Various Topographies	5.13
Table 5.7	Fast-Fading and Scattering Parameter of the UWB Indoor Channel	5.20

LIST OF FIGURES

		Page
Figure 1.1	Fractional Bandwidth Of A Received Power Spectrum	1.3
Figure 2.1	A 2 GHz Center Frequency Gaussian Monocycle In Time And Frequency Domains	2.2
Figure 2.2	A Regular Interval Monocycle Pulse Train In The Time And Frequency Domain	2.4
Figure 2.3	Energy Distribution of a Pseudo-Random Time Modulation Monocycle Pulse Train in the Time and Frequency Domain	2.4
Figure 2.4	Transmission Scheme for a TH-UWB Signal	2.8
Figure 2.5	A Typical Idealized Received Monocycle At The Output Of The Antenna Subsystem	2.11
Figure 2.6	Receiver Block Diagram For The Reception Of The First User's Signal	2.12
Figure 2.7	Example Of The Correlator Output Waveform	2.13
Figure 2.8	Network Components And System Performance Issues Of An UWB System	2.14
Figure 2.9	Signal Reflection In An Ellipse	2.23
Figure 3.1	Building Floor Plan With Measurement Locations Marked A-X	3.2
Figure 3.2	A Block Diagram Of The Measurement Apparatus	3.7
Figure 3.3	Geometry And Indexing Of The Measurement Grid	3.10
Figure 3.4	Received Energy Response at Location P (0,0)	3.11
Figure 3.5	EDP With Temporal Bin Width Of $\Delta t = 0.2\text{ns}$	3.13
Figure 3.6	EDP With Temporal Bin Width of $\Delta t = 0.5\text{ns}$	3.14

Figure 3.7	EDP With Temporal Bin Width of $\Delta t = 1\text{ns}$	3.14
Figure 3.8	EDP With Temporal Bin Width of $\Delta t = 2\text{ns}$	3.15
Figure 3.9	The Clustering Phenomenon At 1m Tx-Rx Separation (Along Corridor)	3.16
Figure 3.10	Channel Impulse Response With Both Antennas Vertically Polarized	3.18
Figure 3.11	Channel Impulse Response With Transmitting Antenna Vertically Polarized And Receiving Antenna Horizontally Polarized	3.19
Figure 3.12	Channel Impulse Response With Both Antennas Horizontally Polarized	3.19
Figure 4.1	Average -EDP for Location A	4.6
Figure 4.2	Average -EDP for Location B	4.6
Figure 4.3	Average -EDP for Location C	4.7
Figure 4.4	Average -EDP for Location M	4.7
Figure 4.5	Path Arrival Time (1 st Path) vs. Tx-Rx Separation	4.9
Figure 4.6	Cumulative Distribution Of The Maximum Excess Delay	4.16
Figure 4.7	Maximum Excess Delay vs. Tx-Rx Separation	4.17
Figure 4.8	Decay Factor for Location A	4.20
Figure 4.9	Cumulative Distribution Of The Decay Factor, γ_{MED}	4.25
Figure 4.10	Decay Factor, γ_{MED} vs. Distance	4.26
Figure 4.11	Decay Factor, $\gamma_{300\text{ns}}$ vs. Distance	4.27
Figure 4.12	Cluster Time Structure	4.29
Figure 4.13	Cumulative Distribution Of The Hard Cluster Decay Time, τ_{H}	4.32

Figure 4.14	Correlation between Hard Cluster Decay Time τ_H and Distance	4.34
Figure 4.15	Energy Gains, G_k vs. Excess Delay, t_k For Locations A, B, C and M	4.36
Figure 4.16	A Typical Idealized Received Monocycle Waveform	4.37
Figure 4.17	Energy Gains (G_k) vs. Excess Delay (τ_k) For Locations A, B, C and M (with time axis translation)	4.38
Figure 4.18	Cumulative Distribution Of Parameter, r	4.41
Figure 4.19	Scatter Plot of the Parameter r vs. Tx-Rx Distance Separation	4.43
Figure 4.20	Scatter Plot of the Parameter r For All Topography	4.43
Figure 4.21	PDF Of The Energy Gains Variation in Adjacent Bins	4.45
Figure 4.22	Weibull Approximation of the Energy Gains Variation for Location A	4.46
Figure 4.23	Weibull Approximation of the Energy Gains Variation for Location B	4.47
Figure 4.24	Weibull Approximation of the Energy Gains Variation for Location R	4.47
Figure 4.25	Shape Parameter of the Weibull Distribution vs. Distance	4.49
Figure 4.26	Scale Parameter of the Weibull Distribution vs. Distance	4.50
Figure 4.27	Channel Impulse Response for Location M	4.52
Figure 4.28	ZCR ($t < \tau_H$) Histogram and PDF for NLOS Location H	4.54
Figure 4.29	ZCR ($t < \tau_H$) Histogram and PDF for PAC Location T	4.54
Figure 4.30	ZCR ($t > \tau_H$) Histogram and Probability Distribution Function for Location D (NLOS)	4.56

Figure 4.31	ZCR ($t > \tau_H$) Histogram and Probability Distribution Function for Location A (Part-LOS)	4.57
Figure 4.32	ZCR ($t > \tau_H$) Histogram and Probability Distribution Function for Location M (PAC)	4.57
Figure 4.33	Relative Path Loss vs. Distance (dB) for PAC, NLOS and Part-LOS Topographies	4.63
Figure 4.34	Path Loss Regression Analysis For The Hard-NLOS and Soft-NLOS Topographies	4.63
Figure 4.35	Regression Analysis of the Part-LOS with the PAC, NLOS and Soft-NLOS Topographies	4.64
Figure 4.36	Path Loss Cumulative Distribution For Various Topographies	4.67
Figure 4.37	Scatter Plot Of The Average Attenuation Per Wall vs. Receiver Distance For Both Gypsum And Brick Wall	4.78
Figure 5.1	Correlation Coefficient vs. Distance for Various Topographies	5.14
Figure 5.2	Relationship Between Correlation Functions in a WSSUS Channel	5.17
Figure A.1	Averaged-EPD for Location A	A.2
Figure A.2	Averaged -EPD for Location B	A.2
Figure A.3	Averaged -EPD for Location C	A.3
Figure A.4	Averaged -EPD for Location D	A.3
Figure A.5	Averaged -EPD for Location E	A.4
Figure A.6	Averaged -EPD for Location F	A.4
Figure A.7	Averaged -EPD for Location G	A.5
Figure A.8	Averaged -EPD for Location H	A.5
Figure A.9	Averaged -EPD for Location I	A.6
Figure A.10	Averaged -EPD for Location J	A.6

Figure A.11	Averaged -EPD for Location K	A.7
Figure A.12	Averaged -EPD for Location L	A.7
Figure A.13	Averaged -EPD for Location M	A.8
Figure A.14	Averaged -EPD for Location N	A.8
Figure A.15	Averaged -EPD for Location O	A.9
Figure A.16	Averaged -EPD for Location P	A.9
Figure A.17	Averaged -EPD for Location Q	A.10
Figure A.18	Averaged -EPD for Location R	A.10
Figure A.19	Averaged -EPD for Location S	A.11
Figure A.20	Averaged -EPD for Location T	A.11
Figure A.21	Averaged -EPD for Location U	A.12
Figure A.22	Averaged -EPD for Location V	A.12
Figure A.23	Averaged -EPD for Location W	A.13
Figure A.24	Averaged -EPD for Location X	A.13
Figure A.25	Energy vs. Excess Delay (dB) for Location A	A.14
Figure A.26	Energy vs. Excess Delay (dB) for Location B	A.14
Figure A.27	Energy vs. Excess Delay (dB) for Location C	A.15
Figure A.28	Energy vs. Excess Delay (dB) for Location D	A.15
Figure A.29	Energy vs. Excess Delay (dB) for Location E	A.16
Figure A.30	Energy vs. Excess Delay (dB) for Location F	A.16
Figure A.31	Energy vs. Excess Delay (dB) for Location G	A.17
Figure A.32	Energy vs. Excess Delay (dB) for Location H	A.17
Figure A.33	Energy vs. Excess Delay (dB) for Location I	A.18
Figure A.34	Energy vs. Excess Delay (dB) for Location J	A.18

Figure A.35	Energy vs. Excess Delay (dB) for Location K	A.19
Figure A.36	Energy vs. Excess Delay (dB) for Location L	A.19
Figure A.37	Energy vs. Excess Delay (dB) for Location M	A.20
Figure A.38	Energy vs. Excess Delay (dB) for Location N	A.20
Figure A.39	Energy vs. Excess Delay (dB) for Location O	A.21
Figure A.40	Energy vs. Excess Delay (dB) for Location P	A.21
Figure A.41	Energy vs. Excess Delay (dB) for Location Q	A.22
Figure A.42	Energy vs. Excess Delay (dB) for Location R	A.22
Figure A.43	Energy vs. Excess Delay (dB) for Location S	A.23
Figure A.44	Energy vs. Excess Delay (dB) for Location T	A.23
Figure A.45	Energy vs. Excess Delay (dB) for Location U	A.24
Figure A.46	Energy vs. Excess Delay (dB) for Location V	A.24
Figure A.47	Energy vs. Excess Delay (dB) for Location W	A.25
Figure A.48	Energy vs. Excess Delay (dB) for Location X	A.25
Figure A.49	Energy Gains vs. Excess Delay for Location A	A.26
Figure A.50	Energy Gains vs. Excess Delay for Location B	A.26
Figure A.51	Energy Gains vs. Excess Delay for Location C	A.27
Figure A.52	Energy Gains vs. Excess Delay for Location D	A.27
Figure A.53	Energy Gains vs. Excess Delay for Location E	A.28
Figure A.54	Energy Gains vs. Excess Delay for Location F	A.28
Figure A.55	Energy Gains vs. Excess Delay for Location G	A.29
Figure A.56	Energy Gains vs. Excess Delay for Location H	A.29
Figure A.57	Energy Gains vs. Excess Delay for Location I	A.30

Figure A.58	Energy Gains vs. Excess Delay for Location J	A.30
Figure A.59	Energy Gains vs. Excess Delay for Location K	A.31
Figure A.60	Energy Gains vs. Excess Delay for Location L	A.31
Figure A.61	Energy Gains vs. Excess Delay for Location M	A.32
Figure A.62	Energy Gains vs. Excess Delay for Location N	A.32
Figure A.63	Energy Gains vs. Excess Delay for Location O	A.33
Figure A.64	Energy Gains vs. Excess Delay for Location P	A.33
Figure A.65	Energy Gains vs. Excess Delay for Location Q	A.34
Figure A.66	Energy Gains vs. Excess Delay for Location R	A.34
Figure A.67	Energy Gains vs. Excess Delay for Location S	A.35
Figure A.68	Energy Gains vs. Excess Delay for Location T	A.35
Figure A.69	Energy Gains vs. Excess Delay for Location U	A.36
Figure A.70	Energy Gains vs. Excess Delay for Location V	A.36
Figure A.71	Energy Gains vs. Excess Delay for Location W	A.37
Figure A.72	Energy Gains vs. Excess Delay for Location X	A.37