# INTERCELL INTERFERENCE STUDIES IN BROADBAND WIRELESS ACCESS NETWORKS

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*To my Beloved Parents, The Great Father: DR. Ibrahim Abo-Zeed, The Brilliant Mother: Hakum Barguth, my brothers and my sister for their support and prayers throughout my study days.*

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# ABSTRACT

Capacity has become of primary importance in broadband wireless access (BWA) networks due to the ever-increasing demand for multimedia services and the possibility of providing wireless Internet, leading to their standardization by IEEE (802.16WirelessMAN) and ETSI (BRAN HIPERACCESS). The major factor limiting capacity in such systems is interference originating from co-channels and cells, namely intercell interference. This thesis presents a general analysis of intercell interference for a spectrally efficient BWA cellular configuration. It examines the statistical properties of the carrier-to-interference ratio in downstream channels. The focus is on the spatial inhomogeneity of rain attenuation over multiple paths, which is the dominant fading mechanism in the frequency range above 20 GHz, especially when two-layered [i.e., line-of-sight (LOS) and non-LOS] architectures are involved. Besides attenuation from precipitation, various architectural and propagation aspects of local multipoint distribution service systems are investigated through simulations, and worst-case interference scenarios are identified.

# ABSTRAK

Kapasiti telah menjadi kepentingan yang utama di dalam rangkaian BWA kerana permintaan yang semakin banyak dan kemungkinan membekalkan internet tanpa wayar, kearah standard oleh IEEE (802.16Tanpa wayarMAN) dan ETSI(BRAN HIPERACCESS). Faktor utama yang meyekat kapasiti dalam sistem tersebut adalah gangguan yang berasal dari co-saluran dan sel iaitu gangguan inter-sel. Thesis ini mempersembahkan analisis yang lazim dalam gangguan inter-sel untuk konfigurasi sellular BWA. Ia mengkaji sifat statistik pembawa kepada gangguan di dalam saluran ke bawah. Tumpuan adalah berkenaan ketidakseragaman pelemah hujan terhadap laluan yang pelbagai di mana ia adalah penyebab utama mekanisma pelemah di dalam lingkungan frekuensi 20Ghz ke atas terutamanyer apabila dua lapis [i.e., (LOS) and non-LOS] arkitektur terlibat. Selain pelemah yang cepat dan pantas, pelbagai aspek arkitektur dan penyebaran servis pelbagai titik tempatan telah di siasat melalui simulasi and senario kes yang paling teruk di kenalpasti.

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| | | |
|---|---|---|
| ACI | - | Adjacent Channel Interference |
| ADSL/VDSL | - | Asynchronous/Very High– Rate Digital Subscriber Line |
| ATM | - | Asynchronous transfer mode |
| BER | - | Bit Error Rate |
| BS | - | Base Station |
| BWA | - | Broadband wireless access |
| C/B | - | Channel Capacity |
| CCI | - | Co-Channel Interferance |
| CDF | - | Cumulative Distribution Function. |
| C/I | - | Carrier to Interference ratio |
| CPE | - | Customer Premise Equipment |
| FCC | - | Federal Communications Commission |
| FDMA | - | Frequency Division Multiple Access. |
| FEC | - | Forward error correction |
| HS | - | Hub Station |
| HS | - | Inter-symbol Interference |
| ITU | - | International Telecommunication Union Radio-Broadcasting |
| LMCS | - | Local Multipoint Communication Systems |
| LMDS | - | Local Multipoint Distribution Services. |
| LOS | - | Line of sight. |
| MCMC | - | Malaysian Communications and Multimedia Commission |
| MSS | - | Mobile Satellite Service |
| NOC | - | Network Operations Center |
| PDF | - | Probability Density Function |

| | | |
|---|---|---|
| PONs | - | Passive Optical Networks |
| PSTN | - | Public Switch Telephone Networks |
| QAM | - | Quadrature Amplitude Modulation |
| QPSK | - | Quadrature Phase Shift Keying |
| S/I | - | Signal-to-Interference Ratio. |
| SNR | - | Signal to noise ratio |
| SRSP | - | Standard Radio System Plan |
| TDMA | - | Time Division Multiple Access. |
| TS | - | Terminal Station |

## LIST OF SYMBOLS

| | | |
|---|---|---|
| $A$ | - | Attenuation |
| $A_{0.01}$ | - | Attenuation at 0.01% of time |
| dB | - | Decibel unite |
| $f$ | - | Frequency |
| GHz | - | Giga Hertz |
| k, α | - | Regression coefficients |
| km | - | Kilometer |
| L*eff* | - | Effective Path length |
| L | - | Rain cell diameter |
| *mm* | - | Millimeter |
| P (%) | - | Percentage in time of the year |
| $R_{(i)}$ | - | Rain rate at percentage in time of the year |
| $R_{0.01}$ | - | Rain rate at 0.01% of time of the year |
| $\gamma_R$ | - | Specific attenuation |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The growing demand for high-speed data connection to serve a variety of business and personal uses has driven an explosive growth in telecommunications technologies of all sorts including optical fiber, coaxial cable, twisted-pair telephone cable, and wireless.

Nowadays wireless recognized as one of the most important technology in order to have comfortable type of communication.

Broadband wireless access is the most challenging segment of the wireless revolution due to the dire need of Gigabit data transport and processing technologies.

There is a growing interest in providing broad-band services through local access networks to individual users. Millimetric-wave radio solutions are considered as the optimal delivery systems for these services. They are termed as broad-band wireless access (BWA) systems or local multipoint distributed services LMDS. [15]

The new broadband networks and services are developed continuously to serve the different demands, Internet, mobile Internet, broadcasting, telephony, e-commerce, and Video on Demand. Point-to-multipoint wireless system could be a promising solution to connect the users to the backbone network instead of broadband wired networks because of its cost efficiency, easy and fast installation, and re-configurability; however due to the time and location variable channel conditions the system should apply fade mitigation techniques to reach the quality of service requirements.[17]

Capacity has become of primary importance in broadband wireless access (BWA) networks due to the everincreasing demand for multimedia services and the possibility of providing wireless Internet, leading to their standardization by IEEE (802.16WirelessMAN) and ETSI (BRAN HIPERACCESS). [15]

The focus is on the spatial inhomogeneity of rain attenuation over multiple paths, which is the dominant fading mechanism in the frequency range above 20 GHz, especially when two-layered [i.e., line-of-sight (LOS) and non-LOS] architectures are involved. [15]

The Ka (20/30 GHz) and V (40/50 GHz) frequency bands are becoming increasingly attractive for user oriented future commercial satellite services, due to their large available bandwidths. However, they suffer more from rain fades in comparison to the almost congested Ku (12/14 GHz) band. Therefore, prediction models for annual rain attenuation, such as the ones developed by several research groups over the past three decades are required to provide guidance in the course of balancing availability requirements and cost.[15]

A rain-cell degrades the system performance at a part of the service area but the rain can improve the carrier-to-interference ratio C/I conditions elsewhere depending on the locations of the base station, terminal station and the rain-cell. Interference fluctuation is a very important thing in LMDS network planning procedures, which needs countermeasure techniques to avoid degradation of the quality of service. [17]

The comprehension from the previous paragraphs, it is clarified that the problem statement of this project that the high quality of LMDS cannot be obtained under rain effects, so there is need to have such study on the intercell interference in BWA.

## 1.2 Objective of the Project:

i. To examine the Intercell interference in LMDS networks over clear sky and rainy condition.

ii. To determine the statistical properties of the carrier-to-interference ratio in downstream channel.

## 1.3 Scope of the Project

The scope of this project includes:

i. Calculation of Rain Attenuation in a given BWA network for multidistances.

ii. To analyze the intercell interference in LMDS network under heavy multilocation rains ( in the downstream channel) .

## 1.4 Methodology of the Project

To consummate this project, the following methodology has been designed as the following steps:

First Step, establishing of LMDS Network by determining

i. Frequency used and sectorisation
ii. Structure of system (BS & TS)
iii. Distance or cell size

Second Step, calculation of Rain Attenuation based ITU-R Model by using Rainfall rate of different locations over Malaysia in order to cover all Malaysia region weather and therefore the study can be generalized to include the regions that have the same climate (tropical climate weather).

Third Step, analyzing of Rain cell Movement within LMDS, this is done by taking all possibilities or terminal station situations over LMDS area and effect of Interference signals.

## 1.5 Thesis Outline

The layout of this report is as follows:

Chapter one embodies an introduction about BWA, LMDS system and rain attenuation. Furthermore it includes the objective of this project, research scope, methodology of the work, and the outlines of this thesis.

Chapter two is the first chapter of the literature review, presents the Local Multipoint Distribution Service Systems and its specifications and components as will as rain fading and its effects on the signal, also this chapter includes steps to calculate rain attenuation.

Chapter three is the brief about the rain fading mechanism and effects of rain fading on the efficiency of the Ka-Band LMDS System and how to calculate rain attenuation, based ITU-R Model.

Chapter four represents the methodology of this project, including the details of how to establish LMDS, rain attenuation calculation, effects of rain over LMDS area.

Chapter five presents the whole results of this work and discussions of these results as well as some of analyses. The results include specific rain attenuation, rain attenuation and different LMDS cell sizes.

Chapter six contains summary, conclusion and the recommendations or future works which are presented based on the obtained results.

# REFERENCES


[1] A. D. Panagopoulos and J. D. Kanellopoulos, “Cell-site diversity performance of millimeter-wave fixed cellular systems operating at frequencies above 20 GHz,” IEEE Antennas Wireless Propag. Lett., vol. 1, pp. 183–185, 2002.

[2] Sinka and János Bitó, “Site Diversity Against Rain Fading in LMDS Systems” VOL. 13, NO. 8, AUGUST 2003

[3] Athanasios D. Panagopoulos “Intercell Radio Interference Studies in Broadband Wireless Access Networks” VOL. 56, NO. 1, JANUARY 2007

[4] Broadband Wireless Access over two-layer LMDS with an IEEE 802.16 future Petri M?h?nen (petri.mahonen@vtt.fi), Zach Shelby (zach.shelby@vtt.fi) VTT Research, Wireless Internet Laboratory Finland

[5] Wirelessman The IEEE 802.16 Working Group on Broadband Wireless Access Standards. wirelessman.org

[6] The international Engineering Consortium [IEC]

[7] Agne Nordbotten, Telenor R&D. LMDS Systems and their Application. IEEE Communications Magazine June 2000.

[8] Blake, R. Wireless Communication Technology. Wadsworth Inc. (2001).

[9] Agne Nordbotten, Telenor R&D. LMDS Systems and their Application. IEEE Communications Magazine June 2000.

[10] Salem Salamah (2000). Transmit power control in fixed broadband wireless systems”, M.Eng. Thesis, Carleton University Aug. 2000.

**[11]** Douglas A. Gary (1997). A Broadband Wireless Access System at 28 GHz. IEEE, Wireless Communications Conference, Aug11-13, pp.1-7.

**[12]** Federal Communications Commission

**[13]** Hikmet Sari Trends and Challenges in Broadband Wireless Access, 2000 IEEE

**[14]** ACTS Project 215, Cellular Radio Access for Broadband Services (CRABS), Feb. 1999.

**[15]** Chang-Hoon Lee Dynamic Modulation Scheme Consideration of Cell Interference for LMDS International Conference on Communication Technology ICCT'98 October 22-24, 1998 Beijing, China.

**[16]** Georg Bauer, and Rolf Jakoby, "Two-Dimensional Line of Sight Interference Analysis of LMDS Networks for the Downlink and Uplink" IEEE, VOL. 52, NO. 9, SEPTEMBER 2004

**[17]** Ranjan Bose, Andreas Hayn, and Rolf Jakoby, "Intra- and inter-cell interference investigations for broadband radio access systems above 10 GHz" Journal of Telecommunications and Information Technology 2/2001

**[18]** Peter B. Papaeian "Study of the Local Multipoint Distribution Service Radio Channel" IEEE transactions on broadcasting, vol. 43, no 2, June 1997

**[19]** Chih-Yuan Chu and K. S. Chen "Effects of Rain Fading on the Efficiency of the Ka-Band LMDS System in the Taiwan Area" VOL. 54, NO. 1, JANUARY 2005

**[20]** RECOMMENDATION ITU-R P.1410-4 Propagation data and prediction methods required for the design of terrestrial broadband radio access systems operating in a frequency range from 3 to 60 GHz (1999-2001-2003-2005-2007)

**[21]** Site diversity against rain fading in lmds systems, Zaid Ahmed Shamsan Abdo, Master thesis, UTM Malaysia, MAY 2007

**[22]** Panagopoulos, A. D, Liolis, K. P. and Cottis, P. G. "*Cell-Site Diversity Against Co-Channel Interference in LMDS Networks"* Wireless Personal Communications 39: 183–198, Springer. 2006

**[23]** Sinka, C., Bito, J. (2003). *Site diversity against rain fading in LMDS systems*. IEEE Microw. Wireless Comp. Lett., vol 13, no. 8, pp. 317-319, August 2003.