論文 / 著書情報
Article / Book Information

題目(和文)	次世代ヘテロジニアス無線ネットワークのための60GHz帯電波伝搬特性に関する研究
Title(English)	Study of 60 GHz Millimeter Wave Radio Propagation for Future Heterogeneous Wireless Networks
著者(和文)	カラマ ワンチュー
Author(English)	Karma Wangchuk
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	国際開発工学　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	Karma Wangchuk	指導教員（主）： Academic Advisor(main)	高田　潤一　教授
		指導教員（副）： Academic Advisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Chapter 1, "Introduction", explains the background and the motivation. The existing spectral resources in the sub 6 GHz bands are not sufficient to meet the expected mobile data traffic demands. This has necessitated the escalation of the operating frequencies to the millimeter wave bands in between 24 GHz and 86 GHz. Among these bands, the 60 GHz unlicensed band is particularly interesting as it is considered for both indoor, under the IEEE 802.11 standards, and outdoor, for 5G, wireless networks. There are a lot of works at the 60 GHz band in indoor environment. However, the amount of measurement based work, in outdoor environment and those addressing the polarimetric double directional properties in both the environments, are scarce. Due to the highly directional nature of the millimeter wave propagation channel, the directional and the polarimetric properties are necessary to be studied. The work in this thesis attempts to fill these gaps.

Chapter 2, "Millimeter Wave Propagation Channel", briefly describes the different physical propagation mechanisms that are relevant to the millimeter wave radio propagation. The double directional channel concept used to describe the channel is explained. The synthesis of delay and angular domain power spectra from the double directional impulse response is also introduced. The formulation of condensed parameters used to characterize the channel are presented. The importance of these parameters in system and antenna design is then discussed. The applicability of the 60 GHz band in cellular networks is explained based on the heterogeneous network concepts.

Chapter 3, "Millimeter Wave Channel Sounding", presents the development of the 60 GHz channel sounding system and the procedure to obtain of the double directional channel from the measurement. First, the signal design and the hardware implementation of the developed sounding system is provided. The system is capable of full polarimetric double directional channel measurement, with a sampling rate of 800 MHz and has a dynamic range of 64 dB. Then, the methodology to obtain the double directional channel from the directional measurements is formulated. A modified CLEAN algorithm to de-embed the antennas from the propagation channel is proposed. Recognizing that the millimeter wave channels are highly directional in nature, clustering of the multipath components (MPCs) based on KPowerMeans algorithm and intra-cluster parameters based channel characterization is introduced.

Chapter 4, "Millimeter Wave Propagation In Outdoor Environment", presents the measurement campaign carried out in an urban outdoor pico-cell environment, corresponding to a street level millimeter wave access link. The MPCs detected from the double directional impulse response are clustered. The channel is very sparse with few prominent clusters. Under co-polarization, more than one clusters are always detected for both line of sight (LOS) and obstructed-LOS (O-LOS) cases. However, under cross-polarization one or at most only two clusters are observed. Under O-LOS and cross-polarization, no clusters were detected. Comparing the path history of the cluster centroid with the results form a ray-tracing (RT) simulation, the prominent propagation mechanism within a cluster is determined. The clusters are then classified based on polarization and the propagation mechanisms. The LOS cluster followed by the first order reflection clusters are the strongest for all polarizations. However, under O-LOS condition the diffracted clusters are the strongest followed by the first order reflection clusters. The vertical polarization clusters are seen to be stronger than other clusters; which follows the Fresnel reflection coefficients. The average BS side intra-cluster angular spread, $S_\Omega < 6^\circ$, is relatively lower than the average MS side intra-cluster spread, $S_\Omega < 10.5^\circ$. The angular spread does not show any dependence on polarization. The

intra-cluster delay spread were comparable to the system delay resolution of 2.5 ns. These results show that in outdoor environment the strength and the inter-cluster spreads due to the significant clusters can be approximated by RT. However to predict the intra-cluster spread, methods based on physical optics (PO) and physical theory of diffraction (PTD) would be more appropriate.

Chapter 5, “Millimeter Wave Propagation In Indoor Environment”, gives the analysis results from measurements in a typical indoor environment, corresponding to a WLAN access link. Similar to outdoor the case the MPC clusters are determined first. Using MBRT technique and comparing the centroids with the RT results, the physical scattering object and the prominent propagation mechanisms corresponding to the clusters were identified. Unlike in the outdoor case, the gain of the scattering clusters are comparable to the first order reflection and diffraction clusters. Therefore in the outdoor case the RT simulation will not be able to predict all the significant clusters. The result would be particularly erroneous if there are many small scattering objects in the vicinity of the receiver. The overall average delay spread, $\tau_{rms} < 8.6$ ns, is found to be higher for co-polarization configuration compared to the cross-polarization. this is due to the visibility of more clusters under co-polarization. The average overall angular spread, $S_{\Omega} < 8.4^{\circ}$, is comparable to outdoor case and also does not show dependence on the polarization.

Finally, in Chapter 6, a summary of the important conclusions of this thesis and a brief discussion on future direction is presented.