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Interference Impact of Mobile Radio Backhaul on Fixed Service

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Abstract

Mobile radio backhaul system on the basis of millimeter waves has been developed recently. It can resolve a problem that throughput is lower when many users use data in an area such as subway. It can supply data rate of over Gbps to numerous users in confined space quickly. This system consists of an internal network to make up small cells using sub 6 GHz frequency installed in a vehicle and an external backhaul network using millimeter waves. The system has been implementing currently in order to verify the functions and performances before commercialization. However, a study for the coexistence with other radio communications has not been conducting. Therefore, in this paper, the impact of interference to the existing fixed service is illustrated. The separation distance was calculated to meet the interference probability of 5 % below using Minimum Coupling Loss and Monte Carlo method.

Keywords: Interference, Millimeter waves, Mobile Radio Backhaul, Minimum Coupling Loss, Monte Carlo

INTRODUCTION

Diverse media services such as Ultra High Definition(UHD) video, Virtual Reality(VR), Augmented Reality(AR), real-time mobile game and streaming service has been appearing through performance advancement of internet access device such as smartphone, etc. These services are required high data rate to operate smoothly. However, in a place where many users are densely populated, there are difficulties in using the service because the data rate for individuals significantly decreases. Especially, a severe problem can be occurred within restricted area that moves at a high speed like a subway. Thus, in order to provide high data rate to multiple users, various technologies have been developing. Among them, mobile radio backhaul system based on millimeter waves has attracted great attention. The mobile radio backhaul is connected to small cell within subway, and transfers data that is gathered from end users to backbone network of mobile communication provider. Currently, a study for coexistence between surrounding radio communication service has not been performed although various test beds have been currently implementing for commercialization. To utilize the spectrum effectively considering the limited frequency resource, it is required to analyze the interference with other services operating at the same or adjacent frequencies. This paper thus described the analysis results on the interference of the mobile radio backhaul to the existing fixed service through Minimum Coupling Loss(MCL) and Monte Carlo(MC) method.

THE INTERFERENCE SCENARIO AND SYSTEM CHARACTERISTICS

The mobile radio backhaul has two layers system to comprise backhaul link based on millimeter waves and access link used sub 6 GHz frequency within a vehicle. This paper considered the interference of backhaul link based on millimeter waves outside vehicle. In outside vehicle, the mTE(Mobile Hotspot Network Terminal Equipment) that is Tx/Rx device based on millimeter waves is installed. It communicates with mRU(MHN Radio Unit) which contains base station RF/antenna[1]. The fixed service means a radio station that conducts fixed work in fixed location. The control tower at an airport has been examined as an interference subject in this paper. The control tower needs an absolute protection because it transmits important information on air service. The interference scenario between the mobile radio backhaul system and the control tower is depicted in Fig.1.

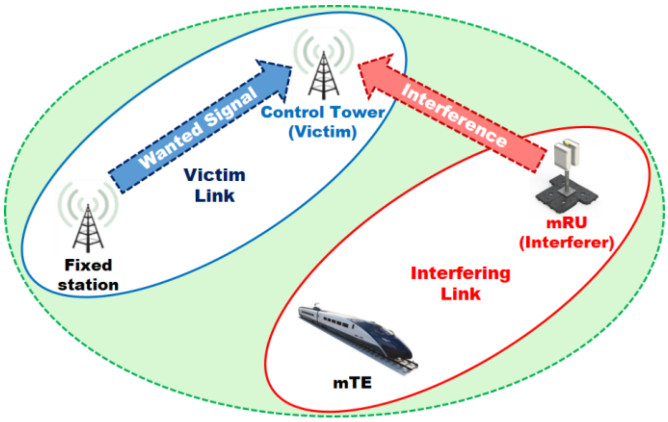


Figure 1: An interference Scenario between the Mobile radio Backhaul System and the Control Tower

In the interference scenario of Fig. 1, the control tower is established as a victim link and the mobile radio backhaul system is established as an interfering link. Here, the wanted signal means the received signal of the control tower from a fixed station and the interference means the received signal of the control tower from mobile radio backhaul mRU. The worst case was assumed that the transmission beam of mRU enters at reception beam of the control tower exactly. Then the required separation distance between the control tower and the mRU was calculated to meet the interference probability of 5 % below

In order to analyze the interference, system parameters about victim link and interfering link such as center frequency, transmit power, and channel bandwidth are required. The following Table 1 and 2 indicate the system parameters of interfering link and victim link, respectively. In Table 2, the protection ratio(I/N) is ratio of interference signal strength to noise level. To protect victim from interference, the ratio of I/N should be satisfied according to the required criterion.

Table 1: System Parameters of Mobile Radio Backhaul

Parameters	Value	Unit
Center Frequency	22.4	GHz
Transmit power	17	dBm
Channel bandwidth	600	MHz
Antenna peak gain	19	dB
mTE height	3	m
mRU height	3	m
Coverage	1	Km

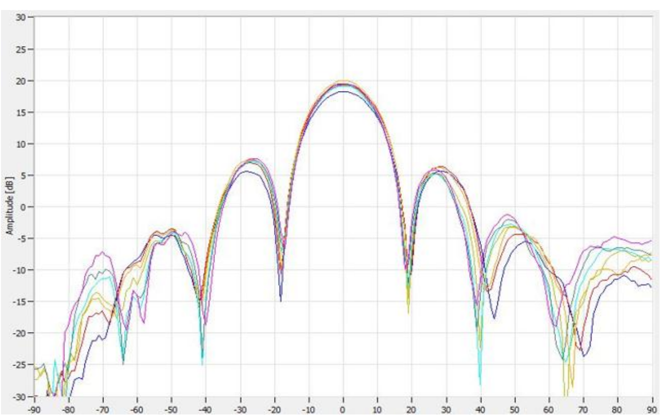
Table 2: System Parameters of Control Tower

Parameters	Value	Unit
Center Frequency	21.5	GHz
Transmit power	14.77	dBm
Channel bandwidth	20	MHz
Receiver sensitivity	-68	dBm
Noise floor	-95	dBm
Protection ratio (I/N)	0	dB
Antenna peak gain	34	dB
Fixed station height	10	m
Control tower height	30	m
Link length	1.5	km

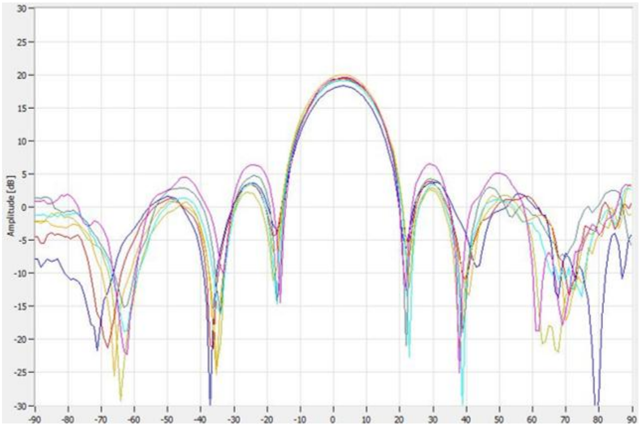
The emission level of the mobile radio backhaul on frequency domain is essential characteristics to analyze the interference because the mobile radio backhaul and the control tower are not co-channel. The following Table 3 summarizes the spectrum emission level of mobile radio backhaul obtained from a measurement. Here, the reference bandwidth used in the measurement is 1 MHz. And, next Fig. 2 shows an antenna beam pattern about horizontal and vertical.

Table 3: Spectrum Emission Mask of Mobile Radio Backhaul

Offset frequency	Value	Unit
100 MHz	-43.2	dBc
200 MHz	-61.2	dBc
300 MHz	-77.2	dBc



(a) Horizontal Antenna Beam Pattern



(b) Vertical Antenna Beam Pattern

Figure 2: An Antenna Bema Pattern about mTE of Mobile Radio Backhaul as Interfering Link

INTERFERENCE ANALYSIS METHOD

The MCL method assumes the free space path loss that minimizes the coupling loss, and calculates the separation distance to protect a victim from an interferer [2]. The following equation means maximum allowable strength of interference.

$$I_{max} = Noise\ floor + \frac{I}{N} \quad (1)$$

The *MCL* is calculated with equation 2.

$$MCL = P_{int} + Corr + I_{max} \quad (2)$$

Here, P_{int} means the transmit power of interferer, *Corr* means the bandwidth compensation factor. The obtained *MCL* is converted to the required propagation loss including the antenna gain.

$$L_p = MCL + G_{vic} + G_{int} \quad (3)$$

Here, G_{vic} and G_{int} mean the antenna gain of victim and interferer, respectively. Finally, the separation distance is calculated by substituting the required propagation loss into the free space path loss model.

$$d = 10^{\frac{L_p}{20}} \times \frac{c}{4\pi f} \quad (4)$$

The MC method computes the wanted value through repeatable experimentation stochastically. This paper used the Spectrum Engineering Advanced Monte Carlo Analysis Tool(SEAMCAT) based on MC. Probability of interference is computed through comparing ratio of iRSS to noise floor with the required interference to noise[3]. The following Fig. 3 depicts C/I(Carrier to Interference ratio) as an example of interference criterion.

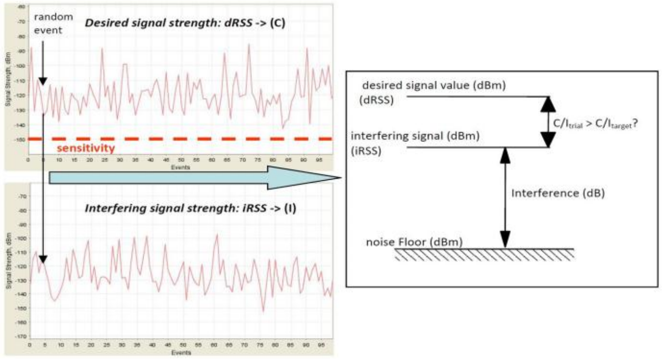


Figure 3: The criterion for evaluating interference

RESULTS OF ANALYSIS

The considering -95 dBm noise floor and 0 dB I/N of mobile radio backhaul, the allowable interference power is – 95 dBm. Then, the MCL is calculated as 20 dB by a power of -10.8 dBm/1MHz and a bandwidth compensation of 10log(20). Next, The Lp is calculated as 73 dB including the antenna gain of victim and interferer. By substituting this into equation 4, the separation distance to ensure that there is no interference at victim was calculated as 4.95 m.

As a result of the MC simulation, the iRSS according to the separation distance between the victim and the interferer is shown in Fig. 4 and the interference probabilities are summarized in Table 4.

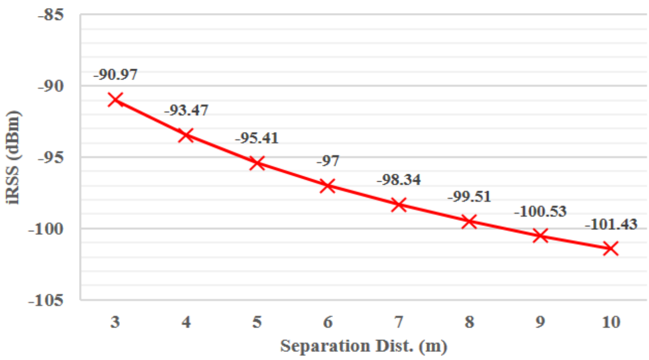


Figure 4: The iRSS in respect of the Separation distance

Table 4: Probability of Interference according to the separation distance between Mobile Radio Backhaul and Control Tower

Separation distance [m]	Interference Probability [%]
3	100
4	93.91
5	34.38
6	2.2
7	0.02

As the result of simulation based on MC, in order to satisfy interference probability of 5 % below from the interference of interferer, at least the separation distance of 6 m is required.

CONCLUSIONS

This paper analyzed interference impact of the mobile radio backhaul system operating at 22 GHz frequency band on the existing control tower(fixed service) operating at 21 GHz frequency band in an airport. In the MCL method, the separation distance to ensure no interference from mobile radio backhaul at control tower was calculated as about 4.95 m. As the MC method, the separation distance between mobile radio backhaul and the control tower to meet the interference probability of 5 % below was computed to be 6 m. This results will be useful for frequency sharing with fixed service if mobile radio backhaul system is commercialized in the future.

ACKNOWLEDGMENTS

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REFERENCES

[1] H. S. Chung et al., "Trend Analysis of Moving Wireless Backhaul Technologies for Mobile Hotspot Networks," Electronics and Telecommunications Trends, vol. 30, no. 1, pp. 12-20, Feb 2015.

[2] ECC, "A comparison of the minimum coupling loss method, enhanced minimum coupling loss method, and the monte-carlo simulation," CEPT, ERC Report 101, 1999.

[3] ECC, "SEAMCAT Handbook Edition2," CEPT, ECC Report 252, April 2016.