

Measurement and Analysis for 3.5GHz Small-cell Environment with Time and Spatial Ratio

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Abstract— Recently, researches regarding spectrum sharing has been underway due to the insufficiency of spectrum resources. Basically, it is necessary to solve the temporal or spatial environment in order to share the frequency. In this paper, we will introduce to our own channel sounder and we use this system to generate path loss modelling based on time and space ratio.

Keywords— Channel sounder, small-cell, time and spatial ratio

I. INTRODUCTION

The radio propagation investigation is always required for usage of new technology and frequency band. Recently, there are several organization and countries to consistently study the propagation feature and modelling under 6GHz band [1]-[3]. The frequency band for lower 6GHz has mainly considered the candidate for next generation of 5G standardization even though mm-Wave band such as 28GHz or 31GHz is much considered. Especially, 3.5GHz band which is one of the 5G candidate frequency is designated for mobile bands of IMT-2020 in company with 1.4GHz band [4]. And small-cell TD-LTE systems consider the 3.5GHz frequency band by the qualcomm which is the leading company of 3GPP. In [5], 3.5GHz band is also considered for supplementing the downlink heavy traffic. By above several situations, 3.5GHz frequency band is regarded as promising spectrum resources for upcoming wireless communication circumstances. Because many mobile communication systems want to use the 3.5GHz band, the best efficient solution is to share the frequency band in time or space. If the specific frequency band is not always utilized in time or space, each of the system can share the same spectrum resources. So, we measure and analyse the radio propagation characteristics for 3.5GHz band with time and spatial ratio to share the frequency.

In this paper, we introduce our measurement system and measurement scenario in brief. And analysis results following time and space ratio is also explained.

II. SYSTEM AND MEASUREMENT

In this section, we introduce our channel sounding system and briefly explain the measurement scenario.

A. Channel Sounder

Like below Fig. 1, our developed channel sounder is composed of five major factor which are baseband digital signal processing module, RF transceiver module, timing module, antenna and monitoring panel and storage module. The baseband digital signal processing module is implemented by universal NI PXI modules and output signal is generated by direct sequence spread spectrum (DSSS) BPSK with 100Mcps. And RF transceiver module is also formed of NI universal modules and high power amplifier (HPA) is utilized the commercial component which is RFHIC RUM43020 with maximum 20Watt output power. To generate the timing signal to RF module and baseband, rubidium oscillator with 10MHz reference signal is employed. And antenna module is developed to be operated from 3.5GHz to 3.7GHz. The antenna is obtained the almost 5dBi gain to add the total power gain with HPA. Finally, data acquisition of system and sensor function is displayed in the monitoring panel. The power level, spectrum mask, I/Q data flow and channel impulse response (CIR) is mainly monitored in our panel. And NI HDD RAID system is utilized for our storage module to save the measurement data to increase data exchange speed between NI HDD RAID and NI PXI which is a factor of RF and baseband module. The detailed implementation parameters are displayed in below table.



Figure 1. Developed Channel Sounder System Shape

TABLE 1. IMPLEMENTATION PAREMETERS FOR OUR CHANNEL SOUNDER

Parameters	Specification
Frequency	400MHz – 4GHz
Bandwidth	5MHz – 130MHz

Channel Impulse Response	68dB (below 10ns resolution, above 65dB)
Transmit Power	Max 7dBm
Receive Auto Gain Control (AGC)	Min -70dBm
File Save and Replay	Receive data save and replay possible
Transmit and Reception Filter	0.1 ~ 1 (SRRC Filter, roll-off factor variable)
User Interface (UI) for Tx/Rx	Function check for Tx/Rx UI

B. Measurement Scenarios

The measurement scenario should be classified according to two different categories which are time and spatial ratio. So, we explain our measurement scenarios like in below.

1) *Time Ratio Measurement Scenario*: The measurement is performed near Daejeon Metropolitan City Hall. The location of the transmitter and receiver is shown below. Measurement of the time ratio was measured by fixing the location of the transmitter and receiver. The measurement time duration is about seven and a half hours from 11:30 a.m. to 19:00 p.m., considering lunch time and working hours. Because the measurement period is short, the reliability of the results is less, but the results are analysed accordingly.

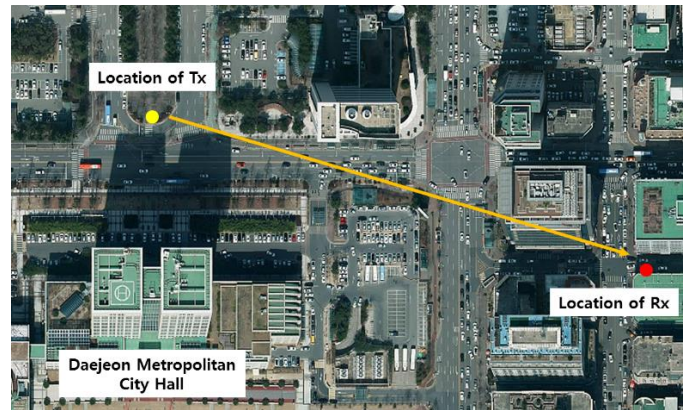


Figure 2. Measurement Map for Results of Time Ratio

2) *Spatial Ratio Measurement Scenario*: The measurement for spatial ratio was measured by driving in the car around Daejeon Metropolitan City Hall. The receiver is placed inside the driving vehicle and the transmitter is fixed to the transmission point which is same place with time ratio measurement. The area of measuring areas is mostly congested with high buildings and a large proportion of the traffic and flow of traffic. Measuring distances were approximately 0.5 km from the transmitter and measured at intervals of one second.

III. PERFORMANCE RESULTS

A. The performance results for time ratio

The results of the measurement of the time ratio are shown in the following Figure 4.

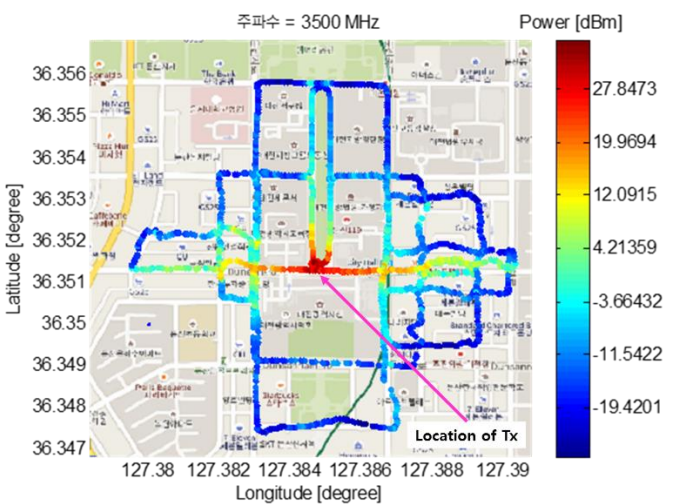


Figure 3. Measurement Map for Results of Spatial Ratio

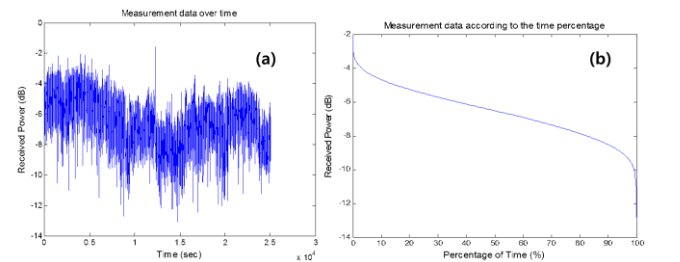


Figure 4. Measurement Results for Time Ratio and Receiving Values according to Time Ratio

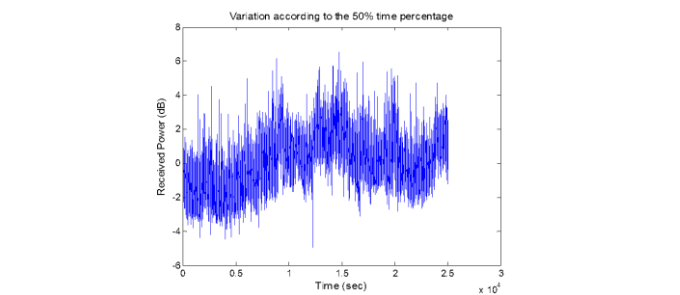


Figure 5. The Variation Value for Signal according to the 50% Time Percentage

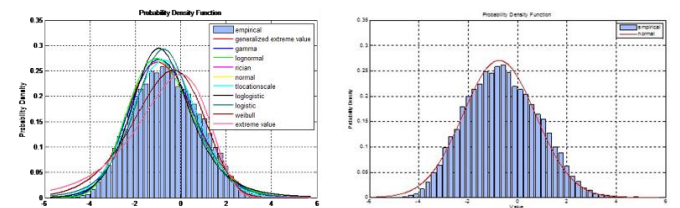


Figure 6. Probability Distributed Function Fitting

In our measurement, receiving values according to time ratio for 10%, 50% and 90% is -4.85dB, -6.19dB and -8.07dB, respectively. Next, variation value of measurement data is obtained based on the 50%-time ratio which is illustrated by below figure 5. And we express the probability distributed function (pdf) based on the variation value and find the pdf

showing almost same trend. And we can obtain the pdf which is showed the most same trend with Fig. 6 (b) is normal distribution with 1.47 standard deviation. The results for path loss with applying time ratio is represented by below Table 2.

TABLE 2. MEASUREMENT ENVIRONMENT CONSTANT VALUE

$PL(d) = L_0 + 10n\log_{10}(d/d_{ref}) + X_\sigma + \Delta T(\text{CORRELATION FACTOR})$							
Measurement Condition			Path Loss			ΔT	Std
f	h_b	h_m	L_0	n	X_σ		
3.5	7	2	20.06	4.204	8.91	$N^{-1}(p)*\sigma$	1.47

B. The performance results for spatial ratio

The path loss result based on the moving measurement is displayed by below figure 7.

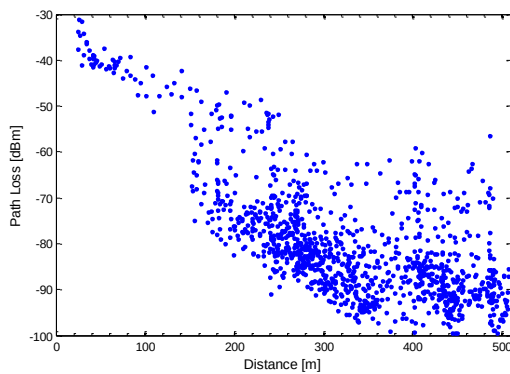


Figure 7. Measurement Data with Moving Vehicle

To analyse the results with spatial ratio, we should classify the LOS and NLOS region in above figure. And then, LOS signal distribution is displayed in Fig. 8 and curve fitting formula is expressed (1).

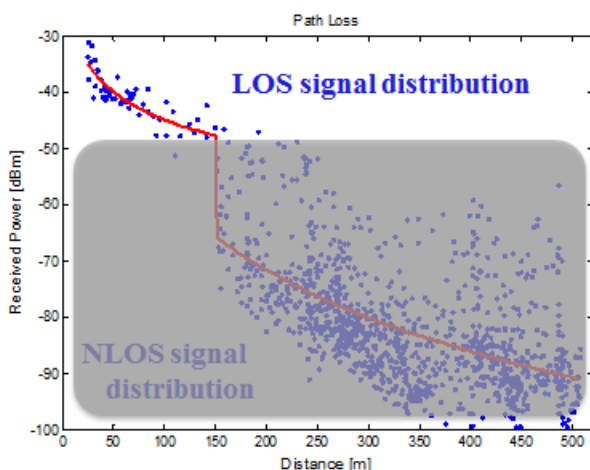


Figure 8. LOS Signal Distribution for Spatial Ratio

$$L_{LOS} = 30.12 - 9.344\log_{10}(f) - 24.62\log_{10}\left(\frac{d}{d_{def}}\right) \quad (1)$$

To obtain the signal variation according to the spatial ratio, we subtract LOS path loss model (1) from real measurement value. The result of variation is depicted by Fig. 9.

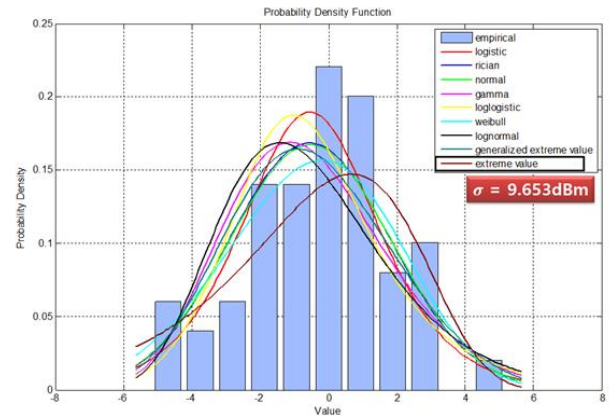


Figure 9. Deduction for LOS Signal Probability Distribution

From Fig. 9, we obtain the LOS signal pdf and we can check extreme value distribution is almost same as our measurement results. In NLOS case, NLOS path loss model formula is obtained by real measurement data curve fitting. The curve fitting graph and formula is represented by below.

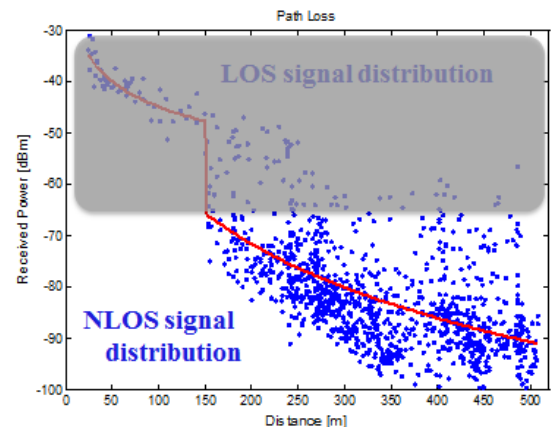


Figure 10. NLOS Signal Distribution for Spatial Ratio

$$L_{LOS} = 34.03 + 58.22\log_{10}(f) - 131.1\log_{10}\left(\frac{d}{d_{def}}\right) \quad (2)$$

From Figure 10 and formula (2), we can find the pdf function and we also check the most same pdf is t-location scale function like Fig. 11. From above results, we can obtain the path loss results according to the spatial ratio in Fig. 11. From Fig. 12, we can notify the path loss value for 10%, 50% and 90% spatial ratio is -46dBm, -49dBm and -78dBm, respectively, when the distance between transmitter and receiver is 200m. And we can check the path loss value is increased according to the increasing the spatial ratio from 10% to 90%.

IV. CONCLUSIONS

In this paper, we explain our channel sounding system and measurement analysis results for 3.5GHz small-cell circumstances. And we draw the path loss modelling according to the time and spatial ratio through our developed system. Because the measurement period is short, the reliability of the measurement and analysis results might be insufficient. However, we think the overall trend of measurement will be similar. In the following measurement, we will draw results based on the sufficient measurement data.

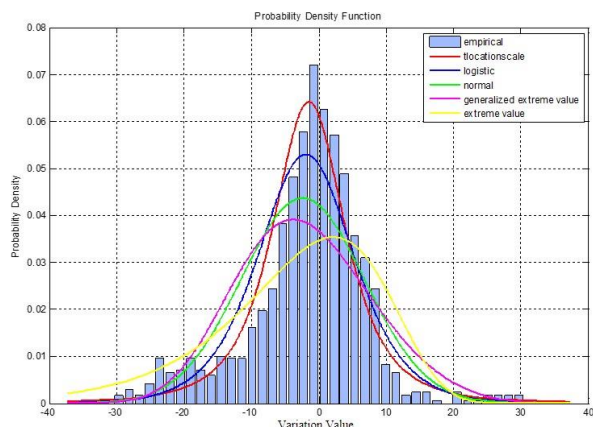


Figure 11. Deduction for NLOS Signal Probability Distribution

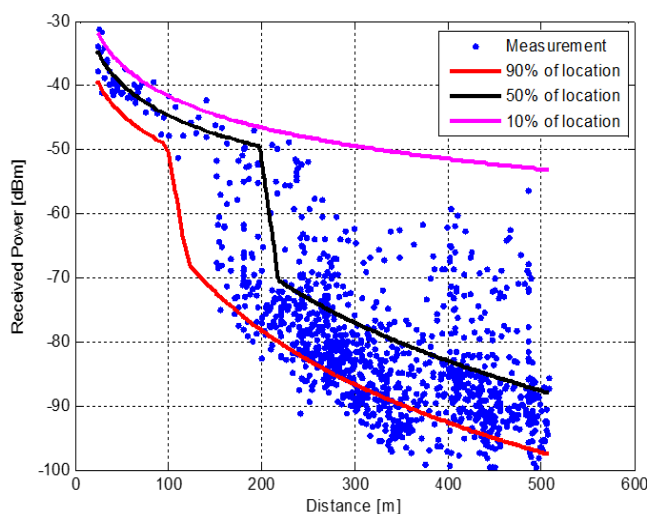


Figure 12. Path Loss Results according to the Spatial Ratio

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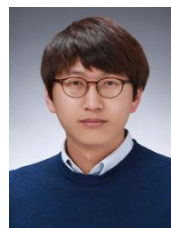
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