A Study of 2.3GHz bands Propagation Characteristic Measured in Korea

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ABSTRACT — **It is being examined that 2.3GHz frequency band is withdrawn and redistributed at the same new service for efficient use of the radio resource in the South Korea. In this paper, analysis of 2.3GHz band propagation path loss characteristics by investigating the raw data gathered from the practical measurement is presented. Also we have performed field measurement in the frequency band over several types of building to obtain the penetration loss and diffraction loss. 2.3GHz band propagation characteristics(path loss, diffraction loss, and penetration loss) and corrected theoretical model for path loss prediction which was presented will be useful to the application such as prediction of path loss in the consideration of domestic environment, cell planning and optimization for new service systems.**

I. INTRODUCTION

In Korea, the WLL(Wireless Local Loop) Service providing voice, data service by using wireless communications has allocated at 2.3GHz frequency bands. But the practical use of WLL service is inactive, Government did pronounce that it is withdrawn and redistributed at a high-speed portable wireless connection to the internet wherever you go. Service technology way decided to do by single standard technology way according to our country real condition, and technologies such as I-Burst, OFDM, PWLAN are discussed.

In this paper, for 2.3GHz band propagation characteristic analysis, we did divide the suburbs of Daejon in into LOS(Line of sight) area and OBS(Obstruction) area, and then measured in each area to collect the raw data of received field strength. We have also performed field measuring in the frequency band over several types of building and found that there is the diffraction loss, the penetration loss due to the effects. And then, the data were processed statistically and analyzed with the result only to grasp the path-loss , diffraction loss and penetration loss characteristics. As a result, path loss slope, and long-term fading·fading margin, which are parameters for representing propagation characteristics, were derived from the statistical analysis of the raw data. Also we had acquired the average diffraction loss, penetration loss of 2.3GHz frequency band.

II. MEASUREMENT SYSTEM

The illustration of measurement system for the propagation characteristics analysis is shown in [Fig. 1]. The testing transmitter site was consisted of signal generator and power amplifier. The power-meter was installed in the output terminal of power-amplifier to adjust output of power accurately. In the receiving part, receiver, multiplexer, pen recorder and notebook computer contained FSS(field strength survey system) software were installed in the measurement car. The clock pulses at the receiver are supplied by using GPS(Global Position System) data or a transducer, which is fixed in the wheel of car. The specification of the transmitter and receiver system for the measurement is shown in [Fig. 1]. The measuring process which was performed in each path constituted as follows; (1) compare the received field strength on the measuring day with the normal values in the reference points and adjust the measurement system properly (2) move to the target points in the suburbs of Daejon and set the measurement system (3) run the FSS on computer, and enters the system parameters and measuring frequency and then measure the field strength in dBm. By using this method, the field strength was

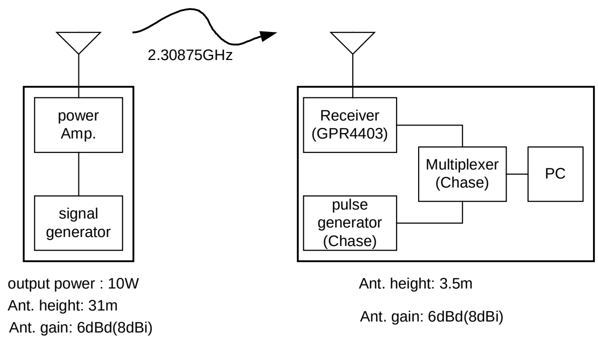

Fig 1. Illustration of measurement system

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measured in the various locations about the center of measurement object points by distance within the area of 40×wavelength in each path.

III. THE PROPAGATION CHARACTERISTICS OF 2.3GHz BANDS

1. PATH LOSS SLOPE

A path-loss slope is a different parameter depending on target of regional configures of the terrain or city shape. In this paper, as shown [Fig. 2], in the center of testing cell site in the suburbs of Dae-jon city, eight paths which are all different in the direction are determined and then, by measuring received field strength in 200m and 2km points, path-loss slope is obtained. By considering the configures of terrain profile and relative distribution of man-made structure, eight paths are divided into LOS and OBS, and they are compared by path-loss slope.

classification	path	terrain configures
LOS (line of sight)	Path1	flat terrain in all distant range
	Path2	flat, a low hill is located at 2 ˜ 2.5km
	Path3	flat terrain, open area at 1 ˜ 1.5km
OBS (obstruction)	Path7	hilly terrain which is higher than transmitter site exist on path, wide building town and hills piled on hills are distributed in path
	Path8	high hilly districts exist on the path

Table 1. Classification of measuring path

The result is shown in [Fig. 2]. At first, the average of path-loss slope in path 1, 2, 3 that were assumed as LOS path, which ensures the distance of sight, is 41.62dB/dec. And the average of path-loss slope in path 7, 8 defined as OBS path is 50.29dB/dec. The average of path-loss slope in all eight paths is 43.56dB/dec. By comparing this value, 43.56dB/dec, to the path-loss slope of suburban, 38.4dB/dec, which was the result of measurement at 900MHz band by Lee, it is confirmed that path-loss(or attenuation degree) at 2.3GHz band is higher than at 900MHz band as much as 5.16dB/dec.

2. FADING MARGIN

The fading margin is defined at the cell boundary for isolated cells as an allowance to overcome shadow fading [1]. To provide 90% signal availability at the cell edge, a 1.3×standard deviation lognormal fading margin is required. [Table 3] represents the correlation of confidence level P with standard deviation σ , and Confidence level is in the complementary relation of signal

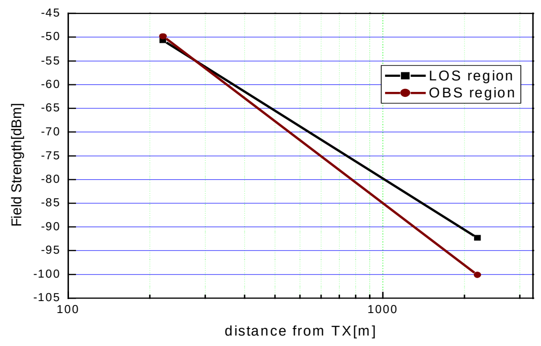

Fig 2. Path loss slope in the suburban of Daejon city at 2.3GHz band

availability. A confidence level can only be applied to the path-loss curve when the standard deviation σ is known. The values at any given distance over the radio path are concentrated close to the mean and have a normal distribution. A confidence level P means the probability that the measurement data are equal to or above a given level, i.e. [2],

$$P(x \geq C) = \int_{C}^{\infty} \frac{1}{\sqrt{2\pi}\sigma} e^{-(x-A)^2/2\sigma^2} dx \qquad (1)$$

where A is the mean level obtained along the path-loss slope, as follows

$$A = P_{r0} - \gamma \log \frac{\gamma_1}{\gamma_0} \qquad (2)$$

and C is a given signal level as shown in Table 2.

The factor $B\sigma$ in [Table 2] is fading margin. The fading margin for each confidence level is obtained by using the standard deviation of measurement data and the relation of [Table 2]. As concerning the relation of the confidence level and the signal availability and by using [Table 3], the fading margin for ensuring each signal availability depending on the distance is shown in [Fig 3]. In [Table 3], the value of fading margin at distance of 1.0km is the highest. It represents the characteristics in the path of propagation at the 2.3GHz band that shows that the effect of long-term fading is the severest at 1.0km from transmitter site. It is supposed that the values in [Table 3] may be useful of applying to determining a cell coverage of wireless communication services in the suburbs of Dae-jon which measurement been or other regions with similar terrain configures of Dae-jon.

$P(x \ge C)$, %	$C = B\sigma + A$
40	$0.25\sigma + A$
30	$0.55\sigma + A$
20	$0.85\sigma + A$
10	$1.3\sigma + A$

Table 2. Relation of confidence level and standard deviation [3]

clause	0.5km	1.0km	1.5km	2.0km	2.5km
10%	11.48	16.09	8.87	7.37	12.99
20%	7.51	10.52	5.80	4.82	8.49
30%	4.86	6.81	3.75	3.12	5.49
40%	2.21	3.10	1.71	1.42	2.50

Table 3. Fading margin [dB] for confidence level

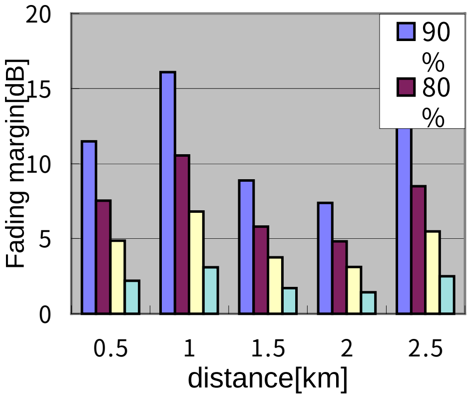

Fig 3. Fading margin [dB] for signal availability (%)

3. THE CHARATERISTIC OF DIFFRACTION LOSS

We have chosen several types of building like [Fig.4] to find that there is the diffraction loss. Building is situated more than distance that carries by Main Lobe of the transmitting antenna and situated in site where manmade terrains that can influence in diffraction loss do not exist.

The diffraction loss is defined received signal strength difference between the front of buildings, namely line-of sight and the back of building. This value is summarized in Table 4 in case of single and multiple obstructions, where the average diffraction loss is around 20dB.

4. THE CHARATERISTIC OF PENETRATION LOSS

The measurement for penetration loss has been performed at the buildings existing LOS (Line-Of-Sight) path.

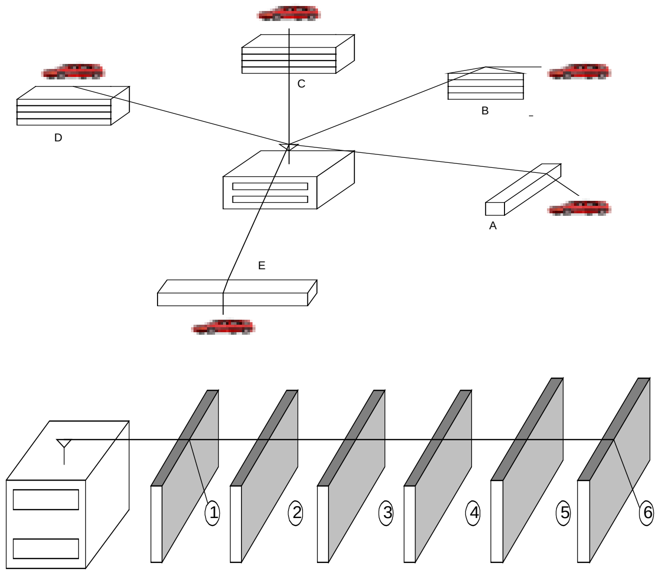

Fig 4. Diffraction loss measurement distribution map

	The front of Building		The back of Building		Diffraction Loss [dB]
	Average	deviation	Average	deviation	
A	-54.68	4.59	-72.43	5.23	17.75
B	-45.75	4.15	-67.58	6.01	21.83
C	-47.37	2.55	-65.15	5.72	17.81
D	-47.43	3.98	-70.99	5.04	23.56
E	-54.79	5.40	-72.13	7.08	17.34

(a) The characteristic of diffraction loss in single obstacle

	Front	The back of Building [dBm]							Loss [dB]
		1	2	3	4	5	6	aver	
F	-52.4	-69.1	-68.2	-72.7	-84.9	-84.3	-86.7	-77.6	25.25
G	-58.5	-82.0	-81.4	-84.2				-82.5	24.03

(b) The characteristic of Diffraction loss in multiple obstacles

Table 4. The diffraction loss result

We firstly have measured the received signal strength in buildings using the trolley and compared it with one of out of building.

Measurement result is shown in [Table 5], where the average penetration loss is around 20dB, although it can vary according of structure or material of the buildings.

	In the buildings		Out of building		Penetration Loss [dB]
	Ave.[dBm]	Devi.[dB]	Ave.[dBm]	Devi.[dB]	
A	-69.26	2.97	-48.69	9.98	20.57
B	-69.26	9.54	-45.75	4.15	23.51
C	-98.22	4.13	-79.57	4.44	18.65
D	-78.52	6.50	-54.79	5.40	23.73
E	-65.28	6.42	-46.48	4.36	18.80
Average Penetration Loss		21.05			

Table 5. The building penetration loss

IV. Application of path-loss prediction models at 2.3GHz band

The path loss prediction model of Lee was applied in order to know whether this model are able to be used in 2.3GHz band or not. For applying 2.3GHz frequency and real propagation environment in two of loss prediction model, correction is needed. The correction factor was obtained by using path loss slope from measured data and terrain database of pertinent area, and predicted values by those models were compared with the result from the measurement data.

Comparison of Lee Model

The field strength of received signal P_r can be expressed by Lee as below [4].

$$P_r = P_{r0}\left(\frac{r}{r_0}\right)^{-\gamma}\left(\frac{f}{f_0}\right)^{-n}\alpha_0 \qquad (3)$$

The prediction expression (3) requires two measuring parameters. One is the power at the 1mile point of interception, and the other is a path-loss slope related with each terrain characteristics. Lee takes measured data of received power at the 1mile intercept and at the 10-mile boundary. And he obtained the path-loss slope by connecting average of 1-mile data points and 10-mile data points. By the way, the path- loss slope in this paper is derived by using the measured data at the 200m points and at the 2km points, so the cardinal standard points are at 200m that basic distance is 200m. Since the average values of received power at the 200m points were substituted for, instead of the values at the 1mile points, and correction factor was calculated to consider of actual propagation environments at that frequency band for applying to prediction. Correction factor in equation (3) is the algebraic sum of factors. The values of (4) by using measured data were substituted for P_{r0} and γ.

$$\begin{cases} LOS: P_{r0} = -50.70dBm, \gamma = 41.62dB/dec \\ OBS: P_{r0} = -49.83dBm, \gamma = 50.29dB/dec \end{cases} \qquad (4)$$

Through the steps, the results of the predicted received power by Lee model and measurement are shown in [Table 6]. The average of gap between predicted values and raw data is 2.26dB, which is very small. Base on this result, it may be possible to predict the received field strength of Lee model by substituting parameters like (4) to the regions with similar terrain configures of suburbs at Dae-jon.

	Lee model		Measurement	
	LOS	OBS	LOS	OBS
0.5km	-67.42	-69.86	-62.61	-70.03
1.0km	-80.07	-85.00	-80.15	-95.49
1.5km	-87.46	-93.86	-85.31	-96.10
2.0km	-92.71	-100.14	-92.29	-100.12
2.5km	-96.78	-105.01	-97.98	-104.0

Table 6. The field strength by Lee model and measurement in [dBm]

V. CONCLUSION

As described above, path loss slope, fading margin, diffraction loss, penetration loss, which are parameters for representing propagation characteristics, they were derived from the statistical analysis of the raw data. It is supposed that those parameters may be useful of applying to determining a link budget of 2.3GHz band new services in the suburban of Daejon or other regions, which were similar to Daejon in the terrain, configures.

And, from the comparison between the result by using path loss prediction model, Lee's and Hata's, and the result of measurement, it was confirmed that the difference of path-loss is few. In the near future, the following research may be executed in order to know whether those path-loss prediction models are able to be used in 2.3GHz band or not, by additional applying to the dissimilar regions which terrain configures and man-made structures are different from those of Dae-jon, and through the correction process, development of the suitable prediction model for the domestic environment terrain is needed to be additional research items.

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