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mmWave Path-loss, Joint Rain and Gas losses Effect Analysis Based on ITU Street Canyons Scenarios

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요 약

Besides high phase noise, doppler spread, and limited range, path-loss is one of the prominent performance limiting factors at higher millimetre wave (mmWave) frequency bands. This work evaluates the path-loss for different setups at the frequencies 28 and 60 GHz. This study utilizes site-general and site-specific (mmWave propagation) models under street-canyons from ITU-R P.1411-10. Moreover, for mmWave propagation model, additional losses by rain and gasses are calculated by using the procedure given in ITU-R P.530-17 and ITU-R P.676-12, respectively. The results demonstrate that mmWave propagation model leads to higher path-losses as compared with site general model due to additional rain and gas losses. Moreover, higher frequencies and longer separation distances leads to significant path-loss for all the considered scenario. Furthermore, rain losses are observed to be more detrimental as compared with gas losses.

I. 서론

Future revolutionary applications will require greater data rates and lower latency than what fifth-generation networks (5G) will offer [1]. This requires new thinking, and advances in devices, circuits, software, signal processing, and systems. One such promising solution for beyond 5G is to use high frequency millimetre wave (mmWave) band to improve data rates with lower latency [1]. Recently, the study in [2] demonstrates the co-sharing of frequency bands above 100 GHz for terrestrial and satellite systems. It shows that there will be likely no interference among satellite sensors and terrestrial terminals conditioned on elevation angles for terrestrial emitters. In [3], [4], the authors discuss the challenges and opportunities for high frequency mmWave band. They further discuss different channel characteristics for frequencies greater than 100 GHz. Similarly, indoor channel measurements at mmWave and sub terahertz (sub-THz) can be found in [5]. Due to smaller wavelength at higher frequencies, atmospheric factors, such as rain, humidity, oxygen and pressure-induced nitrogen impact the signal strength significantly [6-8]. This motivates us to perform path-loss analysis (for higher frequencies) while assuming atmospheric losses along with various path-loss propagations models.

In this work, we evaluate and compare site-general and site-specific (mmWave propagation) models under the street-canyons scenario [6]. For mmWave propagation, we further calculate rain and gas losses using the procedure given in [7] and [8], respectively. Our analysis show that mmWave propagation models suffer higher path-losses as compared with site general models due to additional rain and gas attenuations.

II. 본론

This study evaluates the path-loss performance for (i) the site-general model (see Eq. 1 of [6]) and (ii) the mmWave propagation model (see Eq. 13 of [6]). Path-loss performance for both aforementioned models are calculated for frequencies 28 and 60 GHz, while distances between the stations ranges from 1 to 100 meters [9]. Based on the procedure given in [7-8], rain and gas losses at particular frequency and distance are summarized in Table 1. For Table 1, we consider dry air pressure = 1013.25 hPa and water-vapour density = 7.5 g/m^3.

Table 1 (R0.01 = 58 mm/h, Temp. = 288.15 k)

(Freq. (GHz), Dist. (m))	Rain loss (dB)	Gas loss (dB)
(28, 25)	2.4931	0.0025
(28, 50)	3.2860	0.0051
(28, 100)	4.3614	0.0101
(60, 25)	4.9986	0.3694
(60, 50)	6.5822	0.7388
(60, 100)	8.7253	1.4777

As an outcome of our analysis, Fig. 1 demonstrates that rain attenuation is more critical than gas losses for frequencies below 100 GHz. Further, combination of rain and gas losses leads to 10 dB path-loss at distance = 90 m as compared with the no-atmospheric losses scenario.

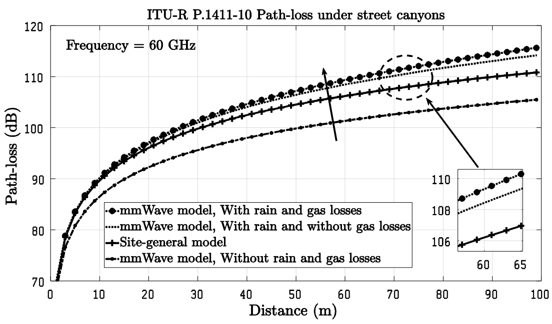

Fig. 1: Path-loss (dB) vs distance (m) for different atmospheric loss setups.

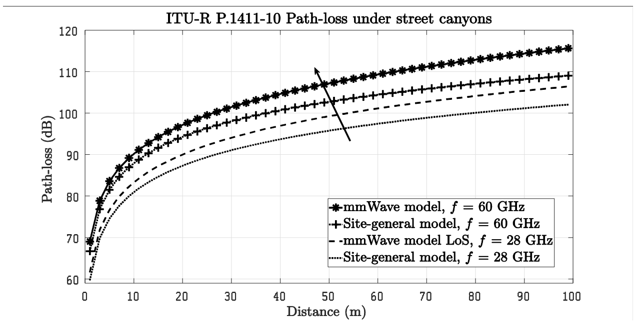

Fig. 2: Path-loss (dB) vs distance (m) for different propagation models as per ITU-R P.1411-10.

In Fig. 2, we show the path-loss performance comparison between mmWave and site-general path-loss models for frequencies 28 and 60 GHz. The result indicates significant path-loss by mmWave propagation model due to additional rain and gas attenuation. Moreover, it can be observed that, higher frequencies observe higher path-losses.

III. 결론

This work investigates the site-general and mmWave propagation path-loss models under street-canyons based on ITU recommendations. The analysis depicts that frequencies under 100 GHz and separation distances shorter than 100m, rain is significantly more critical factor as compared with gas losses.

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참고문헌

[1] Han, C., Wu, Y., Chen, Z. and Wang, X., 2019. Terahertz communications (TeraCom): Challenges and impact on 6G wireless systems. arXiv preprint arXiv:1912.06040.

[2] Jeong, J., Lim, S. H., Song, Y., and Jeon, S.-W., Online Learning for Joint Beam Tracking and Pattern Optimization in Massive MIMO Systems, in Proc. INFOCOM 2020.

[3] Xing, Y. and Rappaport, T.S., 2021. Terahertz Wireless Communications: Co-sharing for Terrestrial and Satellite Systems above 100 GHz. arXiv preprint arXiv: 2103.00604.

[4] Rappaport, T.S., Xing, Y., Kanhere, O., Ju, S., Madanayake, A., Mandal, S., Alkhateeb, A. and Trichopoulos, G.C., 2019. Wireless communications and applications above 100 GHz: Opportunities and challenges for 6G and beyond. IEEE Access, 7, pp.78729-78757.

[5] Xing, Y., Rappaport, T.S. and Ghosh, A., 2021. Millimeter Wave and sub-THz Indoor Radio Propagation Channel Measurements, Models, and Comparisons in an Office Environment. arXiv preprint arXiv:2103.00385.

[6] ITU-R., Recommendation ITU-R P.1411-10, Propagation data and prediction methods for the planning of short-range outdoor radio communication systems and radio local area networks in the frequency range 300 MHz to 100 GHz.

[7] ITU-R., Recommendation ITU-R P.530-17, Propagation data and prediction methods required for the design of terrestrial line-of-sight systems.

[8] ITU-R., Recommendation ITU-R P.676-12, Attenuation by atmospheric gases and related effects.

[9] 3GPP, “Technical specification group radio access network; study on channel model for frequencies from 0.5 to 100 GHz (Release 16),” TR 38.901 V16.0.0, October 2019.