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Radio Propagation Analysis of Low Base Station Antenna by Mobile Measurement in Urban Street Cell Environment

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Abstract **– In the 5th generation mobile communication system, high frequency bands over 6GHz are used to realize high speed and large capacity communication. Because of high path losses, these bands are considered to use in small cells at low base station antenna. In this paper, measured data with moving using a channel sounder at 20GHz is analyzed for a low base station antenna installed in an urban street cell environment to clarify the radio wave propagation characteristics.**

Keywords — 5G, Low base station antenna, Urban street cell, Radio propagation characteristics

I. INTRODUCTION

In the 5th generation mobile communication system, high frequency bands over 6GHz are used to realize high speed and large capacity communication. Small cells using low base station antennas are introduced to compensate for propagation loss and to increase system capacity [1]. The major installation environments of small cells are urban street cell environments. In such environments, the propagation environments are complicated due to the existence of many scatterers. Furthermore, 5G is studying the introduction of beamforming using Massive MIMO, and it is important to grasp the relationship between the actual urban structure and the multipath propagation paths. Channel models standardized in 3GPP and ITU-R are generally widely used channel models [2, 3]. However, since these models are statistical models, it is not possible to grasp the relationship between the actual urban structure and the propagation paths. In this paper, measured data with moving using a channel sounder at 20GHz is analyzed for a low base station antenna installed in an urban street cell environment to clarify the radio wave propagation characteristics.

II. MEASUREMENT ENVIRONMENT AND SPECIFICATIONS

Figure 1 shows the measurement area, and Fig. 2 shows a schematic diagram of the measurement system. Table 1 shows the measurement specifications. The measurement was conducted in an urban street cell environment where buildings are stand in a row on both sides of the street. The base station was fixed, and the transmitter moved in the direction of the arrow in Fig. 1 at about 0.26 m/sec. The data was measured in uplink and LOS environment. The data obtained by each element (complex amplitude of each subcarrier in the frequency domain) was IFFT-processed, then, a delay profile was obtained. Peaks above the noise floor were detected from the obtained delay profile, and the direction of arrival was estimated for each delay time. The SAGE algorithm [4] was used as the DOA estimation algorithm. The maximum number of detection paths for each delay time was 5, and the number of iterations was 20. The estimation result by the Beamformer method [5] was used to select the initial value for the SAGE.

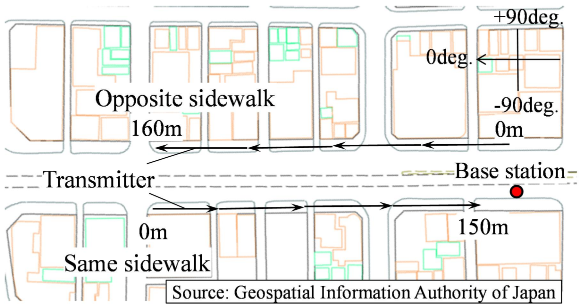


Fig. 1. Measurement environment

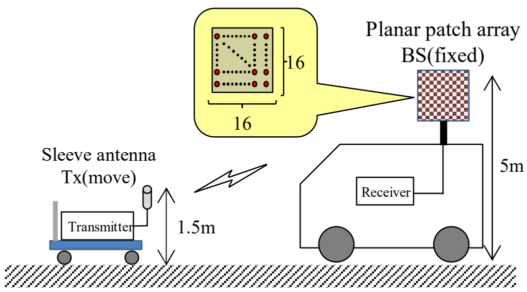


Fig. 2. Measurement system

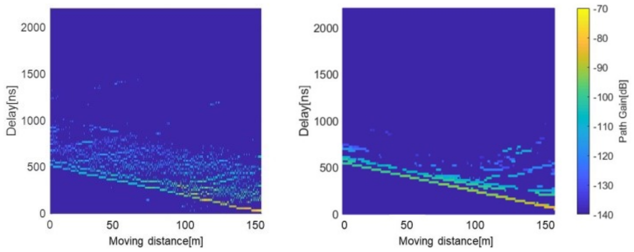
TABLE I Measurement specifications

Center frequency	19.85GHz
Bandwidth	44.8MHz
Transmission signal	OFDM
Number of subcarriers	449
Transmission power	30dBm
Transmission antenna height	1.5m
Transmission antenna	Sleeve antenna(2.4dBi)
Receiving antenna height	5m
Receiving antenna	Planar patch array antenna (16×16elements)
Receiving antenna element	Vertically polarized patch antenna

III. RESULTS OF MEASURED AND RAY TRACE

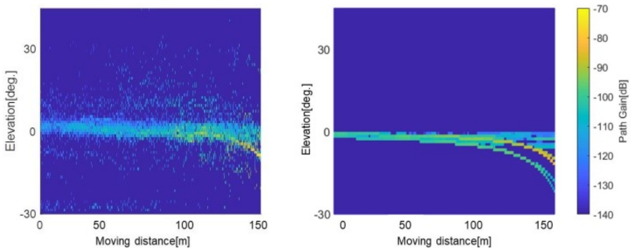
A. Delay profiles and Angle profiles

Figure 3(a) shows the measured the delay profile on the same sidewalk, and (b) shows the result of the ray trace composed of the building and the ground for comparison. Furthermore, Fig. 4 shows the angle profile in the elevation plane on the same sidewalk, and Fig. 5 shows the angle profile in the azimuth plane on the same sidewalk. As can be seen from the Fig.3-5, the direct wave and the reflected waves at wall are almost agreed between the actual measurement result and the ray trace result. However, there are many differences. Focusing on the delay profile, many paths with opposite slants from the direct wave are observed in the measurement. Also, many paths from the high elevation direction and the ground direction are observed from the angle profile in the elevation plane. Multiple steady paths whose angle of arrival does not change due to the movement of the transmitter are observed from the angle profile in the horizontal plane. The paths from the high elevation direction are considered to be scattered waves from trees, signboards, and irregularities on the building wall. As shown in Fig. 6, the paths with opposite slants and the steady paths are due to the scattering point on the opposite side of the base station when the transmitter is used as the reference.



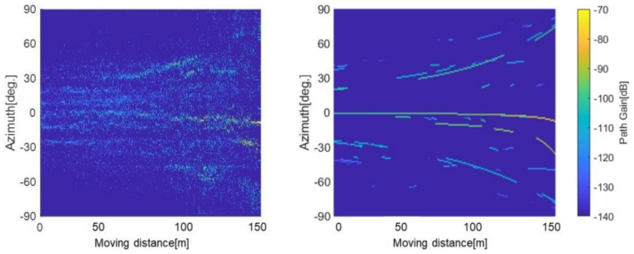
(a) Measured (b) Ray trace

Fig. 3. Delay profile on the same sidewalk



(a) Measured (b) Ray trace

Fig. 4. Angle profile in the elevation on the same sidewalk



(a) Measured (b) Ray trace

Fig. 5. Angle profile in the azimuth on the same sidewalk

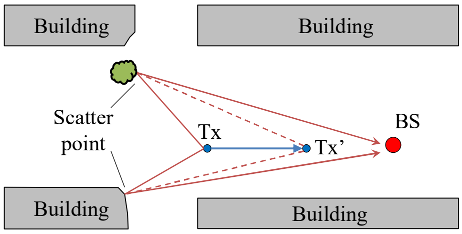
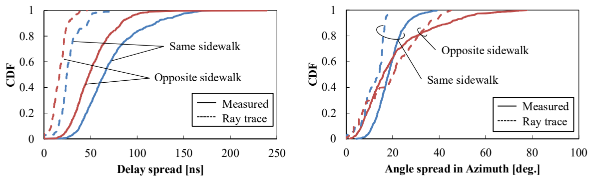


Fig. 6. Schematic diagram of the paths from the back scattering point

The path length between Tx and the scattering point becomes longer as Tx approaches BS. The path length between the scattering point and BS is constant regardless of the movement of Tx, and the arrival angle does not change (when the surrounding moving objects are not considered). Therefore, there are many paths with opposite slants and stationary paths in actual propagation with many scattering points.

B. Spread characteristics

Figure 7 shows the cumulative probability distribution of delay spread and angle spread in azimuth. It can be confirmed that the delay spread on the same sidewalk is larger than that of the opposite sidewalk. On the other hand, it can be confirmed that the angular spread in the azimuth plane is larger than that of the side of the opposite sidewalk.



(a) Delay spread (b) Angle spread in azimuth

Fig. 7. Spread characteristics

IV. CONCLUSION

This paper investigated the propagation characteristics of the urban street cell low base station environment based on the analysis of the actual measured data and the analysis of the ray trace. As a result, it was confirmed that the dominant propagation paths were the direct wave and the wall reflected wave. Also it was confirmed that the existence of paths that were thought to be caused by many scatterers in the actual propagation environment.

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