Automatic Deployment Planning of 300-GHz-Band Wireless Fronthaul Link in Metropolitan Areas

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***Abstract* - In 6G mobile wireless fronthaul, it is planned that 300-GHz-band remote antenna units (RAUs) are mounted on traffic lights and street lights in order to achieve a short transmission distance with line-of-sight (LOS) environments. It is difficult to deploy a lot of THz wireless links with high density in metropolitan area with LOS environment and without inter-cell interference. This paper proposes an algorithm for automatic planning of 300-GHz-band wireless fronthaul link deployment. 87 RAUs were placed at the location of traffic lights/street lights read from the map at Shinjuku, Japan, and installed 46 RAUs on the rooftops of the buildings by automatic deployment algorithm in order to connect all RAUs to the center base station (BS) with LOS environment. We conducted radio wave propagation simulation, and simulation results showed that SNR and SINR of the automatically deployed 300-GHz-band wireless fronthaul links is below required standard demand of SNR for 100-Gbit/s data transmission.**

***Keywords* — 6G, mobile wireless fronthaul, terahertz**

I. INTRODUCTION

In 6G mobile wireless fronthaul, it is ideal to communicate in a shorter distance with a line of sight (LOS) environment in order to achieve extreme high data rate [1]. It is planned that remote antenna units (RAUs) are mounted on traffic lights and street lights at a high density in order to achieve a short transmission distance with LOS environments [1]. 300-GHz-band wireless links are investigated to be used as 100-Gbps-class wireless fronthaul links that connect these RAUs [2]. However, it is difficult to deploy a lot of 300-GHz-band wireless fronthaul links at a high density at the metropolitan area, where skyscrapers of different heights are concentrated. Automatic deployment planning of 300-GHz-band wireless backhaul link installed on the rooftops of buildings have been reported [3,4]. However, the automatic planning of 300-GHz-band fronthaul links that connect RAUs on the traffic lights and street lights to RAUs on the rooftops of buildings had not been investigated. This paper proposes an algorithm for the automatic deployment planning algorithm for 300-GHz-band wireless fronthaul link that connects RAUs mounted on traffic lights and street lights to RAUs installed on the rooftops of buildings with LOS environment. All of the RUAs are connected to the center base station (BS) through RAUs on the rooftops. We conducted radio wave propagation simulation of the wireless backhaul links, and showed that that RAUs deployed by the automatic planning algorithm can achieve sufficient signal-to-noise ratio (SNR) and signal-to-interference-noise ratio (SINR) in case antennas with a gain of over 50 dBi are employed.

II. AUTOMATIC DEPLOYMENT ALGOLITHM

It is difficult to deploy a lot of 300-GHz-band wireless fronthaul links at a high density at the metropolitan area. We investigated the automatic planning algorithm for RAU deployment for connecting all RAUs to the center BS with LOS environment. Figure 1 shows the flow diagram of the automatic deployment planning of 300-GHz-band wireless fronthaul link. In this study, a 300 m x 300 m area at Shinjuku, Japan was divided into 9 (3 x 3) small cells. Each cell size is 100 m x 100 m. First, RAUs were placed at the location of traffic lights and street lights read from the map. The height of the RAUs were set to be 5 m from the road. Next, we selected the rooftop corners of the buildings that is closest to each RAUs installed on traffic lights or signal lights. We judged LOS between each RAU and the selected rooftop corner, and we installed RAUs on the selected rooftop corner in case LOS was obtained. In case LOS was not obtained between the RAUs and the selected rooftop corner, we selected other rooftop corner that is closest to Rx among unselected corners, and judged LOS between each RAU and newly selected rooftop corner. Next, we set RAUs on rooftops for connecting all RAUs with the center BSs that is installed at the center of the selected Shinjuku Area. We judged LOS between RAUs and center BS on the rooftops, and reselect the position of RAUs on the rooftops in case LOS environment was not obtained.

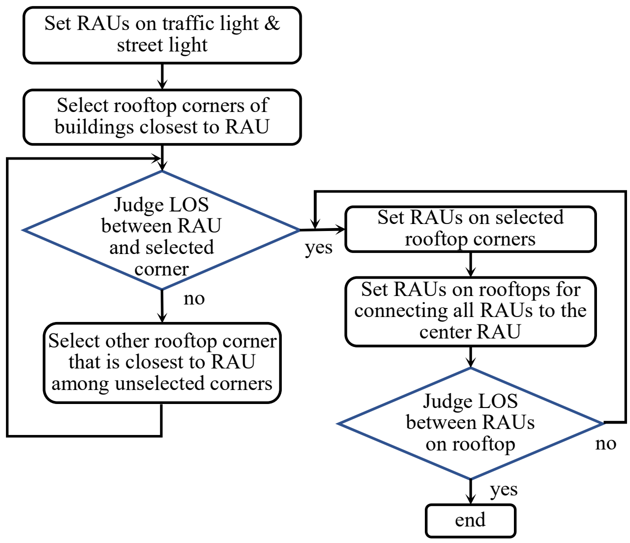

Fig. 1 Simplified flow diagram of the automatic deployment planning of fronthaul links.

III. RADIO WAVE PROPAGATION SIMULATION

We simulated the received power of the 300-GHz-band wireless backhaul links using the radio wave propagation simulator (Wireless Insite) that employs ray tracing method, and calculated the cumulative distribution of SNR and SINR of the 300-GHz-band wireless fronthaul links. In case of SNR, S is a received power from the opposite transmitter, and N is thermal noise of the receiver. In case of SINR, S is a received power from the opposite transmitter, and IN is a received power from transmitters other than the opposite transmitter. The specification of the 300-GHz-band wireless fronthaul link used in the simulation are based on the target specification of the 300-GHz-band wireless fronthaul links in the EU-Japan joint project ThoR [5]. Figure 2 shows radio wave simulation model at Shinjuku area in Japan. We set 87 RAUs installed on traffic light and street light, and 46 RAUs installed on the rooftops of buildings. As shown in the right figure of Fig. 2, we simulated the propagation paths between the RAU on the traffic lights/street lights and the RAUs on the rooftops. The RAU circled in blue indicates the center BS that was connected with base band unit (BBU). All RAUs installed on the traffic lights, street lights and rooftops of buildings are connected to the center BS within 4 hops.

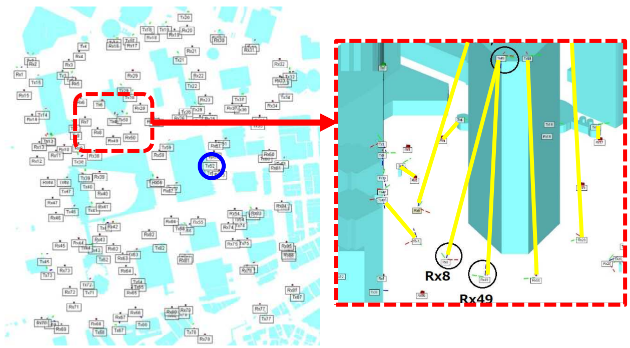

Fig. 2 Radio wave simulation model at Shinjuku area in Japan.

In Fig. 3(a), the impact of antenna gain on the resulting SNR in these scenarios is presented. The standard demand of SNR for the 300-GHz-band fronthaul link in ThoR project is 22 dB for 100-Gbit/s data transmission [5]. These results indicate that SNRs of all 300-GHz-band wireless fronthaul links exceeded the standard demand SNR for 100-Gbit/s data transmission in case the antenna gain is 50 dBi. On the other hand, SNR of 25 % of fronthaul links was below 22 dB when 40-dBi antennas are employed. These results indicate that over-50-dBi antennas are necessary for the 300-GHz-band wireless fronthaul link.

Figure 3(b) shows the cumulative distribution of SINR. SINR is below required standard demand of SNR for 100-Gbit/s data transmission. These simulation results indicate that RAUs deployed based on the automatic planning of RAUs can achieve sufficient SINR and the inter-cell interference does not occur.

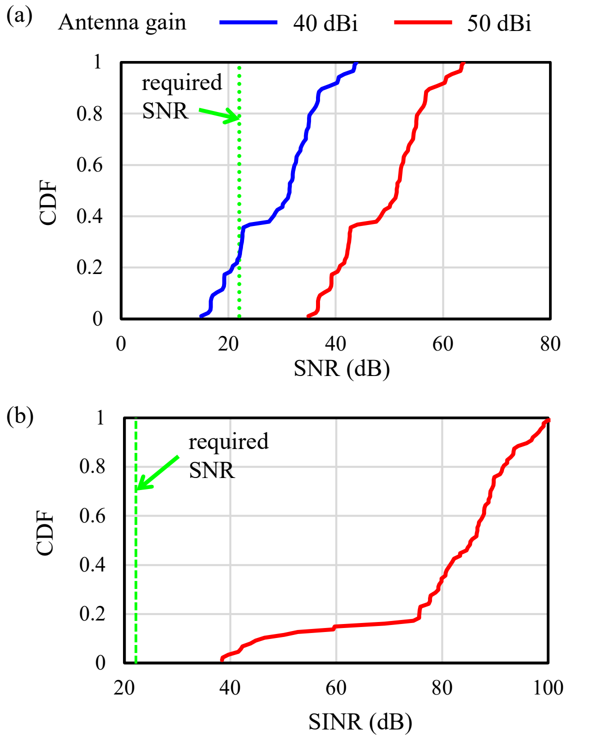

Fig. 3 Cumulative distributions of (a) SNR, and (b) SINR.

IV. CONCLUSION

This paper proposes an algorithm for automatic planning of 300-GHz-band wireless fronthaul link deployment. We set 87 RAUs on traffic light and street light based on the map information at Shinjuku, Japan, and installed 46 RAUs on the rooftops of the buildings by automatic planning algorithm in order to connect all RAUs to the center BS with LOS environment. We conducted radio wave propagation simulation of the wireless fronthaul link. The simulation results indicate that both of SNR and SINR of all 300-GHz-band wireless fronthaul links exceeded the standard demand SNR for 100-Gbit/s data transmission in case the antenna gain is over 50 dBi. On the other hand, SNR of 25 % of fronthaul links is below the standard demand SNR for 100-Gbit/s data transmission when 40-dBi antennas are employed.

ACKNOWLEDGMENT

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REFERENCES

[1] "White Paper 5G Evolution and 6G," *https://www.nttdocomo.co.jp/english/corporate/technology/whitepaper_6g/*

[2] T. Kurner et al., "Towards Propagation and Channel Models for the Simulation and Planning of 300 GHz Backhaul/Fronthaul Links," URSI GASS 2020, B03-01, 2020.

[3] B. K. Jung, et al., "Simulation and Automatic Planning of 300 GHz Backhaul Links," IRMMW-THz, Tu-AM-4-1, 2019.

[4] R. Okumura, et al., "Automatic Planning of 300-GHz-Band Wireless Backhaul Link Deployment in Metropolitan Area," ISAP, 3G3-7, 2021.

[5] https://thorproject.eu/wp-content/uploads/2019/07/ThoR_SIKLU_190417_F_WP2-D2.2-Overall-System-Design.pdf