A Study on mmWave Coverage Enhancement using Simultaneous Transmitting and Reflecting RIS

Dongsoo Jun
School of Integrated Technology
Yonsei University
Seoul, South Korea
dongsoo.jun@yonsei.ac.kr

Chan-Byoung Chae
School of Integrated Technology
Yonsei University
Seoul, South Korea
cbchae@yonsei.ac.kr

***Abstract*—The Reconfigurable Intelligent Surface (RIS) technology, which employs anomalous reflection to control propagation paths, has been investigated to compensate for path loss and shadowing regions in the mmWave bands crucial for 6G. Recently, the system which controls simultaneous transmission and reflection (STAR-RIS), has been proposed to enhance efficiency and functionality. This study aims to explore the relationship between communication performance and STAR-RIS application in indoor environments.**

Keywords—6G, mmWave, STAR-RIS, Meta-devices, Ray-tracing

I. Introduction

In 6G mobile communication, which demands high spectrum performance, the use of millimeter wave (mmWave) bands is inevitable. However, the mmWave bands face significant challenges, including high path loss, penetration loss, and reduced diffraction capabilities, resulting in a substantial reduction in coverage compared to conventional bands. To address these challenges, beyond conventional relaying techniques, the reconfigurable intelligent surface (RIS) system has been proposed, which manipulates propagation through a metasurface composed of controllable devices. Most of the previously researched RIS concepts primarily utilized anomalous reflection, known as reflecting type surfaces. Recently, systems capable of both transmission and reflection, namely STAR-RIS have been newly envisioned [1][2]. STAR-RIS systems can divide an incident wave into transmitted and reflected signals, extending the angular coverage that was previously limited to one side of the surface to a maximum of 360 degrees. In this study, we design beam-routing scenarios with STAR-RIS and evaluate the coverage performance gains at the system-level in comparison to the traditional reflecting type RIS.

II. System Design and Evaluation

From the perspective of hardware design, the reflecting type RIS features elements placed on one side of the substrate and is typically metallic and opaque. However, since STAR-RIS must allow for transmission in addition to reflection, it needs to be transparent at its operating frequency. Moreover, given its typical deployment in locations like windows where light penetration is required, optical transparency proves to be beneficial. Our research team has designed and implemented an optically transparent intelligent surface using electroforming [3][4].

Furthermore, in this study, we analyze the effects of coverage improvement through beam routing using STAR-RIS by employing 3D ray tracing. As illustrated in Fig. 1, we implement an indoor digital map environment and deploy 5,160 receivers in a grid layout throughout the map to compute the received signal strength. In conclusion, within a single transmitter and single RIS environment, this study aims to quantitatively demonstrate the improvements in shadowed areas and the relationship of increased coverage due to the differences in angular control range between STAR-RIS and the traditional reflecting type RIS.

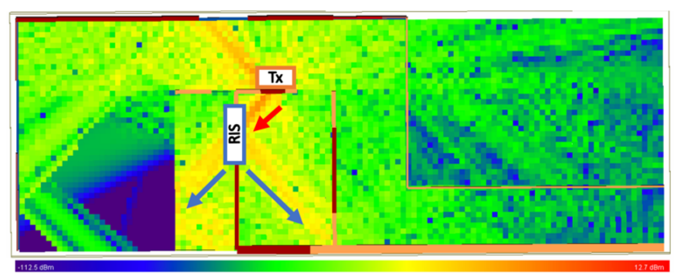

Fig. 1. Illustration of system-level evaluation with STAR-RIS

Acknowledgment

This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2021-0-00486, Augmented Beam-routing: Carom-MIMO, No. 2021-0-02208, Sub-THz Augmented Routing and Transmission for 6G)

References

[1] M. Xidong, et al. "Simultaneously transmitting and reflecting (STAR) RIS aided wireless communications," IEEE Transactions on Wireless Communications, vol. 21, 2021, pp. 3083-3098.

[2] L. Yuanwei, et al. "STAR: Simultaneous transmission and reflection for 360° coverage by intelligent surfaces," IEEE Wireless Communications, vol. 28, 2021, pp. 102-109.

[3] C. Lee, et al. "28 GHz 5G OTA Test Using Optically-transparent Reflective Surface Fabricated by Electroforming" in proc. ISAP, 2022.

[4] Y. Youn, et al. "Transparent intelligent surfaces for sub-6 GHz and mmWave B5G/6G systems." in proc. *IEEE ICC Workshops*, 2022.