Measurement of Reflectarray for Improving MIMO Channel Capacity of Outdoor NLOS Radio Channel

Qiang Chen, Jianfeng Li,
Yusuke Kurihara, Kunio Sawaya
School of Engineering
Tohoku University
Sendai, Miyagi 980-8579, Japan
chenq@ecei.tohoku.ac.jp

Qiaowei Yuan
Department of General Science
Sendai National College of Technology
Sendai, Miyagi 989-3128, Japan
qwyuan@cc.sendai-ct.ac.jp

Ngochao Tran, Yasuhiro Oda
Research Laboratories
NTT DOCOMO, INC.
Yokosuka, Kanagawa, 239-8536, Japan
ngochao.tran.fr@nttdocomo.com

***Abstract*—Reflectarray is used as a passive reflector for improving outdoor radio channel in none-line-of-sight (NLOS) environment. The proposed reflectarray is designed with a 58-degree scattering angle and installed on the roof of a high building to eliminate blind spots and enhance MIMO performance. The performance and effectiveness in improvement of the receiving signal noise ratio (SNR) and channel quality were experimental investigated. It was found that the received power level and channel capacity for 8×8 MIMO were improved by more than 10 dB and 4 bps/Hz compared to those without the reflectarray in NLOS environment, respectively. All of the experiments were performed using the 11 GHz reflectarray antenna and tested in typical wireless scenarios at Ishigaki-jima in Japan.**

I. Introduction

In urban areas with high and dense buildings, there is a serious problem that the radio wave from base stations of cellular mobile communications is blocked, particularly in narrow streets right under the buildings. This kind of areas are typically called blind spots. It weakens the signal level and greatly affects the quality of communications, especially for the next generation wireless communication system with ultra-high speed and high working frequency(e.g. 11 GHz). And the blockage of a propagation channel in a blind spots may also greatly decrease the channel capacity for a multi-input multi-output (MIMO) system. Many efforts were made to deal with this problem, which dramatically degrades the efficiency of data transmission between mobile users and base stations. Generally, in cases where a direct microwave path cannot be established (i.e., None-Line-of-Sight, NLOS) between two points, it is possible to rebuild a path by using a reflectarray [1–4].

Reflectarray (RA) consists of a low profile planar array of microstrip elements which are printed on a grounded substrate and illuminated by a primary feed source [5]. The planar reflectarray combines the advantages of reflectors and phased arrays and rapidly becomes an attractive alternative to the conventional parabolic reflector antenna. Since the 1980s, reflectarray has been developed for several decades and achieved wide range of applications for its advantages, such as surface-mountable, low mass and volume and easy deployment, etc [5, 6]. Planar reflectarray antennas with non-specular reflection performance can be embedded into the top part of the vertical building walls or integrated into firmly settled advertisement boards on the top of buildings to reflect wave beams covering different areas, especially blind spots for the primary source.

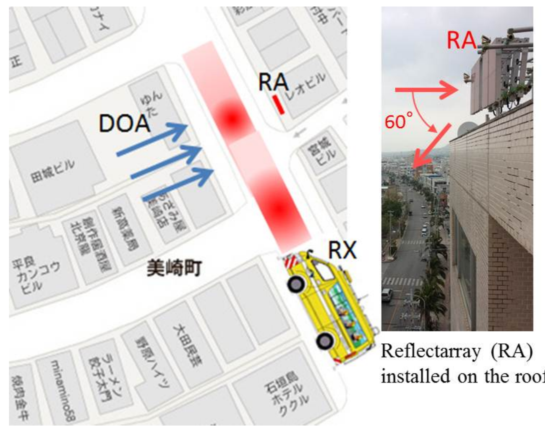

Fig. 1. Measurement environment in Ishigaki-jima

It is also should be noted that planar reflectarray has a passive structure and low profile. Compared with the general solution by using RF boosters for blindness elimination, the electric devices with active components and power supplies are not needed anymore. In our previous work [3], we proposed a reflectarray element using the interdigital gap loading structure. The performance of the element was validated by the simulated results and the measurement results in anechoic chamber. In this paper, we designed a 42×44-element reflectarray with similar structure in [3]. Outdoor experiments were performed in typical wireless scenarios to investigate the performance and effectiveness in improvement of the receiving signal noise ratio (SNR) and channel quality of 8×8 MIMO.

II. Measurement Results

The proposed reflectarray element has a similar structure with that in [3]. And a 42×44-element reflectarray operating at Ku-band (11 GHz) with a scattering angle of 58° for normal incidence is designed. All of the experiments were performed using the 11 GHz reflectarray antenna and tested in typical wireless scenarios at Ishigaki-jima in Japan for the

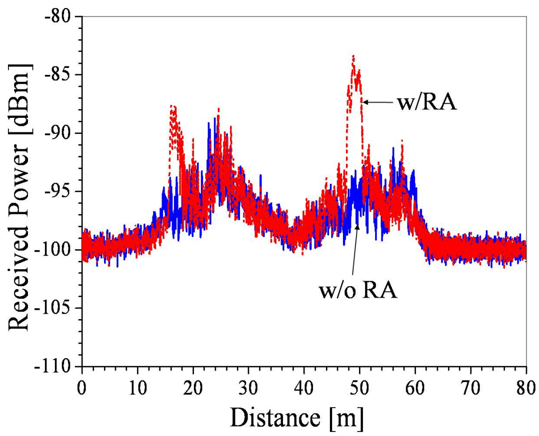

Fig. 2. Measured received power level with/without RAs at 11 GHz.

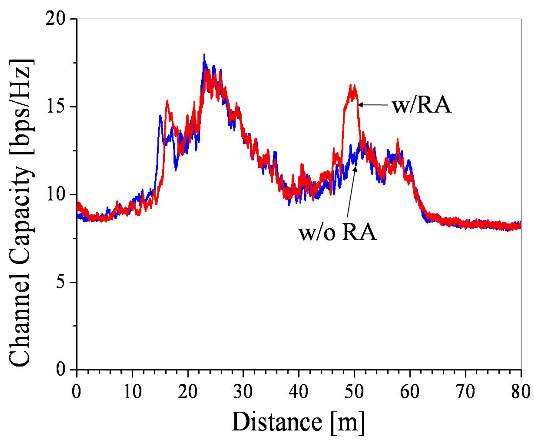

Fig. 3. Channel capacity for 8 × 8 MIMO with/without RAs at 11 GHz.

frequency license limitation. The reflectarrays (4 by 2 42 × 44-element RAs) with a size of 135 cm × 70 cm were vertically installed on the roof of a high building (9th-floor, 23 m) as shown in Fig. 1. The transmitting and receiving system are made by MEDAV (RUSK MIMO channel Sounder, 8 × 8, 100 MHz bandwidth). Transmitting antennas are sleeve antennas with vertical polarization installed 200 m away from the reflectarray. And the receiving antennas installed on the top of a car are microstrip patch antennas with horizontal polarization. For the blockage of buildings, it is a typically NLOS environment between the transmitting antenna and the receiving antenna in the street right under the building installed with RAs. The receiving car moved in the street, and the received power level (with and without RAs) were recorded with GPS location information. As depicted in Fig. 2 and Fig. 3, the received power level and capacity of 8 × 8 MIMO in about 2-meter area in front the building installed with RAs are improved by 10 dB and 4 bps/Hz, respectively.

III. Conclusion

Reflectarray antennas were used to improve wireless propagation channel in none-line-of-sight (NLOS) environment. Experiments for the elimination of blind spots propagation channel and enhancement of MIMO performance were investigated. The experimental results shows that the normal incident EM waves can be scattered to a more than 58° angle and the blind spots in NLOS environment can be sufficiently eliminated. More than 10 dB received power level was improved and 4 bps/Hz was enlarged for 8 × 8 MIMO compared with and without reflectarray. The reflectarray can be used to enhance the communication quality and increase the multipath richness for MIMO communication.

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