Multiple Base Stations’ Beamforming Gain Control Based on Spatial Information for Spectrum Sharing

Rei Hasegawa¹a), Yuzo Moriuchi¹, Noriyuki Shimizu¹, Takeshi Yasunaga¹ and Hideki Kanemoto¹

¹ Innovation Center, Connected Solutions Company, Panasonic Corporation
600 Saedo-chou, Tsuzuki-ku, Yokohama City, 224-8539, Japan
a) hasegawa.rei@jp.panasonic.com

Abstract: Local 5G is expected as a system to provide a communication service within a certain specific area and it is also supposed to apply the spectrum sharing which is attractive techniques to utilize the frequency resources. In order to utilize those shared spectrum, it is required to improve the interference control among systems which use the shared spectrum. In this paper, we examine and report the application of the control method with the arrangement of multiple base station when compensating for the coverage of the part where the received power locally decreases.

Keywords: Local 5G, Shared Spectrum, millimeter wave, Interference Control

Classification: Wireless communication technologies

References

[1] MIC, “Frequency re-organization action plan”, 2019-09.
[2] MIC, “Results of solicitation of opinions on the revision / enactment of the ministerial ordinance to partially revise the Radio Law Enforcement Regulations and related notifications, and the report from the Radio Control Council”, 2019-11.
[3] Hasegawa et al., “A Study on Beamforming Control under Interference Constraint for Efficient Utilization of Shared Spectrum”, IEICE General Conference, 2020-03.
[4] Hasegawa et al., “Beam Gain Management under 3-dimensional Interference Constraint for High Efficiency Spectrum Sharing”, ICETC, 2020-12.
[5] 3GPP TS 36.304 V13.1.0, “Evolved universal terrestrial radio access (E-UTRA), User Equipment (UE) procedures in idle mode (Release 13).”

1 Introduction

Spectrum resource scarcity is supposed to be becoming severe in accordance with widespread of 5th Generation Mobile Communication system. In Japan, MIC
(Ministry of Internal Affairs and Communications) has advanced R&D and experiments for dynamic spectrum sharing and interference avoidance according to the action plan for reorganization of frequency resources [1]. In this action plan, 2.3GHz, 2.6GHz, 5.8GHz, 5.9GHz, 26GHz, 28GHz and 38GHz band are targeted. Among of these bands, part of 28GHz band has allocated to local 5G, which can be used by various entities such as local governments and businesses, according to local and individual site specific needs, and it is expected that its utilization will begin in earnest in the future. Since local 5G shares frequency with an existing wireless system (PU: Primary user), in order to use the shared frequency efficiently, advanced interference control between systems is required.

In this paper, we report on the interference control technique to control the interference in a limited area where the local 5G consisting of multiple base stations is allowed to share the frequency with the PUs, so that the shared frequency can be used to the maximum extent.

2 Interference Control Required for Frequency Sharing

When local 5G shares frequency with the PU, it is necessary to consider the leakage of radio waves from the limited area to the outside, that is, the interference to the PU. The magnitude of the interference level is considered to be affected by the radio propagation environment specific to the area. In order to utilize the shared frequency by local 5G, the interferences need to be appropriately controlled according to the characteristics of the area.

The relevant laws and regulations for local 5G operation define the coverage area of the system and the coordination area that affect the frequency sharing [2]. However, as for propagation conditions, antenna directivity, loss of individual buildings, etc. are not considered in those regulations. Therefore, the interference is controlled based on the received power calculated simply based on the distance from the transmission point, and the effect of interference is excessively considered especially when the transmission point is indoors. Then local 5G uniformly reduce its transmission power regardless of the directivity based on the assumed maximum interference power in order to suppress the interference, the efficiency of shared frequency utilization of the limited area should be eliminated.

In beamforming transmission used in 5G NR, if the beam power can be individually adjusted so that the power reaching the coverage area, which affects propagation inside and outside of the limited area, the interference will be below the allowable interference power. It will be possible to correctly reflect the propagation conditions specified to the limited area, improve the spatial frequency

![Fig. 1. Concept of interference control.](image-url)
sharing conditions, and improve the efficiency of frequency utilization in the limited area. Fig. 1 shows the concept of this interference control.

### 3 Interference Control under Multiple Base Station Condition

We have proposed a interference control method for local 5G to share the frequency with other systems, such as PUs, by controlling the interference to the outside in the limited area where the permission to use is given, so that the shared frequency can be used efficiently [3][4]. However, the per-beam gain control method proposed in [3] and [4] is expected to have a problem that the coverage is locally reduced in areas where the transmission loss changes drastically, or where the transmission loss is small and interference outside the area is likely to occur, such as open areas of buildings and glass windows.

One way to compensate for coverage where the received power is locally small is to install multiple base stations. In the case where multiple base stations are installed and operated in the limited area, assuming that the mobile user terminal controls the connection cell switching based on the maximum SINR (Signal to Interference plus Noise power Ratio) [5], it is necessary to control the arrival power on the cell boundary below a certain level in order to suppress the interference between base stations in adjacent cells. Therefore, the per-beam gain control method is also adopted for the permissible interference level at the cell boundary in the multiple base station operation, and the interference power at the cell boundary is estimated for each beam by radio wave propagation simulation and reflected in the transmission gain control. In other words, each beam of each base station is controlled to satisfy both the PU acceptable interference level constraint at the limited area boundary and the inter-base station acceptable interference level constraint at the cell boundary.

### 4 Simulation Results

In order to confirm the effect of coverage improvement when multiple base stations are installed in the per-beam gain control method, a hypothetical building model shown in Fig. 2 was used for computer simulation. The area up to 2.25 m distance from the perimeter of the hypothetical building was defined as the limited area, and the inside of the building was defined as the service area. Ray-Trace simulations were performed for a limited area, and the received power on the receiving points arranged in a 0.5 m grid was evaluated. In this paper, we assume the allowable interference power on the limited area boundary to -90 dBm and the

**Fig. 2. Hypothetical building model.**
reference coverage power in the service area to -80 dBm. The directivity of the transmitting antenna was assumed to be a beam half-width of 10° in the azimuth and elevation directions.

Fig. 2 also shows the area definition. Tx01 shows the base station transmitter installed in the center of the area, and Tx02 and 03 show the base station transmitters installed to cover the upper right and lower right sides of the area, respectively, where the received power was locally low. For these base stations, the cell shown by the color-coded area are defined, and the allowable interference level between base stations at the cell boundaries is set to -70 dBm. Each beam of each base station is controlled to satisfy both the PU permissible interference level of -90 dBm or less at the boundary of the limited area and the inter-base station permissible interference level of -70 dBm or less at the boundary of the cell. The maximum composite of these power distributions is shown in the right side of Fig. 3. As a comparison, the power distribution for the case with only one transmitter is also shown in the left side of Fig. 3. Under the interference level constraint, Tx2 and Tx3 ensure the coverage of the upper right and lower sides of the area that cannot be covered only by Tx1. At the same time, they suppress the exceeded leakage of allowable power outside the limited area. The coverage in the service area with three transmitter was 94.0% while the coverage with only one transmitter was 69.0%, which was an improvement of approximately 1.4 times.

5 Conclusion
In this paper, we proposed the application method for per-beam power control in the beamforming transmission of 5G NR to a multiple base station environment by reflecting the propagation conditions specific to the limited area, with the aim of improving the frequency utilization efficiency in the area while controlling the interference to existing wireless systems outside the area. By applying the same method of per-beam power control to the interference between base station cells as we do to the interference in an existing wireless system, it was shown that the coverage in a limited area with multiple base stations improves while controlling the interference.

Acknowledgments
This research is supported by the Ministry of Internal Affairs and Communications in Japan (JPJ000254).