Clusters Effect in Urban Environments on Initial Cell Searching Procedure using Directional Array in mmWave Cellular Networks

Toan K. Vo Dai* (1), Ozlem Kilic(1), and Hang Liu(1)
(1) The Catholic University of America, Washington, DC, 20064

1. Extended Abstract

The high demand for cellular data in recent years has made millimeter wave (mmWave) technology attractive to researchers for the new generation of cellular networks (e.g. 5G) where the available spectrum is much broader than current technology [1-2]. Furthermore, the small wavelengths of mmWave signals allow the design of antenna systems with very high gain to occupy compact dimensions. The use of these high gain antennas plays an important role in compensating for the high propagation loss encountered in mmWave frequencies. However, the directivity of the antennas render the initial cell search problem more difficult because of their limited view of sight in a large angular space. Alternatively, the use of omnidirectional antenna makes it simpler in cell search problem, which would offer a reduced coverage capability.

Initial Cell Searching is the process when base station (BS) and user equipment (UE) try to locate each other before establishing the connection between them. With the use of highly directional antennas to compensate for the propagation loss in mmWave frequencies, cell searching problem is becomes more complicated due to the directional uncertainty at both BS and UE. Therefore, it is necessary to analyze and gain understanding of the performance (i.e. time required, scanning patterns, etc.) of the cell searching process between the use of omnidirectional and directional antennas in mmWave communication systems. There have been reports in the literature that focus on analyzing the coverage probability of the mmWave booster cell under different distribution densities of the booster cells [3]. Ref [4] constructs and analyzes a theoretical detector at the UE that enables the detection of BS at the UE based on extensive measured data in New York city [5].

In this work, we employ a statistical analysis based on those in [4] to assess the performance of the cell searching problem with the use of directional antennas. A searching algorithm will be proposed to achieve fast and efficient cell searching procedure under low signal-to-noise ratio (SNR) condition. Non-line-of-sight (NLOS) propagation or edge diffraction due to the presence of clusters based on empirical/theoretical model such as 2-ray propagation model [6], Bertoni model for propagation in presence of buildings [7], or NYC empirical model at 28 GHz [5] are also included in the scheme to analyze the searching algorithm efficiency in urban environments.

2. References

1. F. Khan, Z. Pi, "Millimeter-wave Mobile Broadband (MMB): Unleashing 3-300 GHz Spectrum," *Proc. IEEE Sarnoff Symposium*, March 2011.

2. T. Rappaport, J. Murdock, and F. Gutierrez, "State of the art in 60 GHz integrated circuits and systems for wireless communications," *Proceedings of the IEEE*, vol. **99**, no. **8**, August 2011, pp. 1390-1436.

3. Q. Li, H. Niu, G. Wu, and R. Q. Hu, "Anchor-booster based heterogeneous networks with mmWave capable booster cells," *Globecom Workshops, IEEE,* 2013, pp. 93-98.

4. N. C. Barati, et al., "Directional cell discovery in millimeter wave cellular networks," *IEEE Transactions on Wireless Communications,* 2015, pp. 6664-6678.

5. M. Samimi, et al., "28 GHz angle of arrival and angle of departure analysis for outdoor cellular communications using steerable beam antennas in New York City," *Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th*. IEEE, 2013.

6. A. Goldsmith, "Wireless communications", *Cambridge University Press*, 2005.

7. J. Walfisch, and Henry L. Bertoni, "A theoretical model of UHF propagation in urban environments," *IEEE Transactions on antennas and propagation* **36.12**, December 1988, pp. 1788-1796.