Performance Analysis of Dense Small Cell Networks

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Tian Ding declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor degree, in the School of Electrical and Data Engineering at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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[J2] T. Ding, M. Ding, G. Mao, Z. Lin, A. Y. Zomaya and D. López-Pérez, "Performance Analysis of Dense Small Cell Networks With Dynamic TDD," in IEEE Transactions on Vehicular Technology, vol. 67, no. 10, pp. 9816-9830, Oct. 2018.

[J1] T. Ding, M. Ding, G. Mao, Z. Lin, D. López-Pérez and A. Y. Zomaya, "Uplink Performance Analysis of Dense Cellular Networks With LoS and NLoS Transmissions," in IEEE Transactions on Wireless Communications, vol. 16, no. 4, pp. 2601-2613, April 2017.

[C2] T. Ding, M. Ding and G. Mao, “MAC Layer Performance Analysis of Dense Small Cell Networks with Full Duplex”, in 2018 24th Asia-Pacific Conference on Communications (APCC), pp. 1–5, November 2018, Invited Paper.

[C1] T. Ding, M. Ding, G. Mao, Z. Lin, and D. López-Pérez, “Uplink Performance Analysis of Dense Cellular Networks With LoS and NLoS Transmissions,” in 2016 IEEE International Conference on Communications (ICC), pp. 1–6, May 2016.

Abstract

It is envisaged that 5G wireless communications will embrace dense small cell networks (SCNs), which can achieve a high spatial reuse gain, further leading to a high network capacity. In this Thesis, I firstly analyse the coverage probability and the area spectral efficiency (ASE) for the uplink (UL) of dense SCNs considering a practical path loss model incorporating both line-of-sight (LoS) and non-line-of-sight (NLoS) transmissions. Compared with the existing work, I adopt the following novel approaches in my study: (i) I assume a practical user association strategy (UAS) based on the smallest path loss, or equivalently the strongest received signal strength; (ii) I model the positions of both base stations (BSs) and the user equipments (UEs) as two independent Homogeneous Poisson point processes (HPPPs); and (iii) the correlation of BSs' and UEs' positions is considered, thus making my analytical results more accurate. The performance impact of LoS and NLoS transmissions on the ASE for the UL of dense SCNs is shown to be significant, both quantitatively and qualitatively, compared with existing work that does not differentiate LoS and NLoS transmissions. Moreover, SCNs are envisioned to embrace dynamic time division duplexing (TDD) in order to tailor downlink (DL)/UL subframe resources to quick variations and burstiness of DL/UL traffic. The study of dynamic TDD is particularly important because it serves as the predecessor of the full duplex (FD) transmission technology. In this Thesis, I secondly study the performance of the dense SCNs with synchronous dynamic TDD, which has been widely adopted in the existing 4th-generation (4G) systems. I analyse the coverage probability and the ASE in the DL and UL of dense SCNs considering the synchronous dynamic TDD transmissions, and the performance impact of dynamic TDD transmissions on the ASE in the DL and UL of dense SCNs is discussed. Moreover, the performance impact of interference cancellation (IC) is also explored. Furthermore, SCNs are envisaged to embrace the FD transmission technology in order to increase the spectral efficiency of wireless systems. In this Thesis, I thirdly consider the FD communications in a practical SCN scenario, where BSs can select FD or half-duplex (HD) mode according to the real-time DL/UL traffic. I present analytical results on the probabilities of BS mode selection, which match the simulation results well. The analytical results in this Thesis shed new light on the performance of future 5th-generation (5G) dense SCNs.

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