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Master thesis 30 credit (ECTS) on "Load Balancing in Integrated Access and Backhaul Networks using Machine Learning"

The fifth generation of wireless networks (5G) must provide high-rate data streams for everyone, everywhere at any time. To meet such demands, it is required to use large bandwidths. Here, it is mainly concentrated on millimeter wave-based (potentially, massive multiple-input and multiple-output (MMIMO)) links as a key enabler to obtain sufficiently large bandwidths/data rates. Importantly, the presence of very wide bandwidths makes it possible to include the wireless backhaul transport in the same spectrum as the wireless access. For this reason, 3GPP has considered such integrated access and backhaul (IAB) network configurations where a (potentially, fiber-connected) access point (AP) provides other APs as well as the customer-premises equipment (CPEs) inside its cell area with wireless backhaul and access connections, respectively [1]-[4]. In this way, the IAB network can be considered as a complement for the existing fiber or wireless backhaul systems, with lower costs, no digging and shorter time-to-market.

In an IAB network, depending on the data traffic, network density and the number of hops, the network may suffer from traffic congestion in different nodes, which will affect the end-to-end performance of the network remarkably. Therefore, it is useful to develop efficient algorithms for load balancing. However, depending on the network size, deriving mathematical (semi)closed-form solutions for load balancing may be challenging. Here, machine learning (ML) tools can be well used as solutions for such complex problem formulations. With this background, this thesis concentrates on the design of load balancing algorithms for dense IAB networks.

The outline of this MSc thesis is as follows

- Literature study on recent publications related to mm-wave communications, backhauling and the few existing publications on IAB.
- Literature review on different ML-based algorithms with potential application in load balancing.
- Work on IAB network performance:
  - Identify realistic channel models for mmWave mostly line-of-sight backhauling scenarios.
  - Properly modeling the IAB network in urban areas, using stochastic geometry.
  - Developing an ML-based algorithm for load balancing in IAB networks.
  - Running simulations to evaluate the performance of the proposed algorithm, as well as the effect of different parameters, such as the blockage, on the system performance.
  - Performing comparisons between the performance of IAB and non-IAB networks.

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References

[1] O. Teyeb, A. Muhammad, G. Mildh, E. Dahlman, F. Barac, and B. Makki, "Integrated Access Backhauled Networks," in 2019 IEEE VTC-Fall'2019, Honolulu, HI, USA, Sept. 2019, pp. 1–5.
[2] C. Madapatha, B. Makki, C. Fang, O. Teyeb, E. Dahlman, M.-S. Alouini, and T. Svensson, "On integrated access and backhaul networks: Current status and potentials," arXiv preprint arXiv:2006.14216, 2020.
[3] M. Hashemi, M. Coldrey, M. Johansson and S. Petersson, "Integrated Access and Backhaul in Fixed Wireless Access Systems," 2017 IEEE 86th Vehicular Technology Conference (VTC-Fall), Toronto, ON, 2017, pp. 1-5. doi: 10.1109/VTCFall.2017.8288233
[4] C. Saha, M. Afshang, H. S. Dhillon, "Integrated mmWave Access and Backhaul in 5G: Bandwidth Partitioning and Downlink Analysis," 2018 IEEE International Conference on Communications (ICC), Kansas City, MO, 2018, pp. 1-6. doi: 10.1109/ICC.2018.8422149
[5] S. Singh, M. N. Kulkarni, A. Ghosh and J. G. Andrews, "Tractable Model for Rate in Self-Backhauled Millimeter Wave Cellular Networks," IEEE J. Sel. Areas Commun., vol. 33, no. 10, pp. 2196-2211, Oct. 2015.
[6] C. Saha, H. S. Dhillon, "Millimeter Wave Integrated Access and Backhaul in 5G: Performance Analysis and Design Insights," arXiv:1902.06300, Available at: https://arxiv.org/pdf/1902.06300.pdf
[7] M. Coldrey et al., "Small-Cell Wireless Backhauling: A Non-Line-of-Sight Approach for Point-to-Point Microwave Links," 2012 IEEE Vehicular Technology Conference (VTC Fall), Quebec City, QC, 2012, pp. 1-5. doi: 10.1109/VTCFall.2012.6399286
[8] M. Coldrey, J. Berg, L. Manholm, C. Larsson and J. Hansryd, "Non-line-of-sight small cell backhauling using microwave technology," in IEEE Communications Magazine, vol. 51, no. 9, pp. 78-84, September 2013. doi: 10.1109/MCOM.2013.6588654
[9] M. Peter, R. J. Weiler, T. Kuhne, B. Goktepe, J. Serafimoska and W. Keusgen, "Millimeter-Wave Small-Cell Backhaul Measurements and Considerations on Street-Level Deployment," 2015 IEEE Globecom Workshops (GC Wkshps), San Diego, CA, 2015, pp. 1-6. doi: 10.1109/GLOCOMW.2015.7414178
[10] M. Polese, M. Giordani, T. Zugno, A. Roy, S. Goyal, D. Castor, and M. Zorzi, "Integrated Access and Backhaul in 5G mmWave Networks: Potential and Challenges," IEEE Commun. Mag., vol. 58, no. 3, pp. 62–68, Mar. 2020.
[11] C. Saha and H. S. Dhillon, "On Load Balancing in Millimeter Wave HetNets with Integrated Access and Backhaul," 2019 IEEE Global Communications Conference (GLOBECOM), Waikoloa, HI, USA, 2019, pp. 1-6.