MOVING RELAY NODES ON-BOARD HIGH SPEED TRAINS IN AUSTRIA: IS IT WORTH IT?

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INTRODUCTION

A large number of passengers in Austria commute on a daily basis by using High Speed Trains (HSTs). Nowadays, a large amount of passengers can be considered active mobile phone users. Due to increased numbers of mobile users, the capacity problem is considerably introduced. To deal with this issue, the railway company in Austria (ÖBB) has implemented Wi-Fi on-board the railjet high speed trains. However, this solution is able to minimize only the issues on last-hop. The main problem is the deployment of base stations along a specific railway track. To deal with coverage issues, the signal strengths for all User Equipments (UEs), 2G/3G/4G, should be increased by minimizing the vehicular penetration loss. For this purpose we take the advantage of using two inter-connected multi-band multi-operator amplify-and forward Moving Relay Nodes (MRNs).

The use of relay nodes in mobile networks is common. They have gained more attention to be applied not only in fixed locations but on moving vehicles as well. By implementing the MRNs on-board the HSTs we gain on both capacity and coverage. I focus in this work on the coverage results of 4G user equipments along the railway that connects the two Austrian cities Vienna and Salzburg.

MEASUREMENTS

A large number of simulations consider installing different MRNs on-board trains such as in [1–3]. The authors show the performance improvement and the potential of MRNs. However, there are no available experiments performed in Austria.

One of the main challenges to conduct measurements and to evaluate the network performance for mobile users is how the measurement setup is established. We build such a setup which is able to evaluate the performance of MRNs as well as the mobile network itself (see Figure 1). This setup is used in our previous work in [4, 5]. The evaluation of 4G network is based on real-world measurements and the UEs used in this setup reflect the quality of experience for end user. On the left upper part of Figure 1 commercial UEs are shown, which are used during the measurement campaign. Along with UEs, we use various mini PC devices (Banana Pi) which enable us to monitor the measurement process at different positions on-board the HST. We distribute the UEs on different positions in the HST, because the MRNs are equipped with leaky cable antennas and the performance decays with increased distance from the MRN.

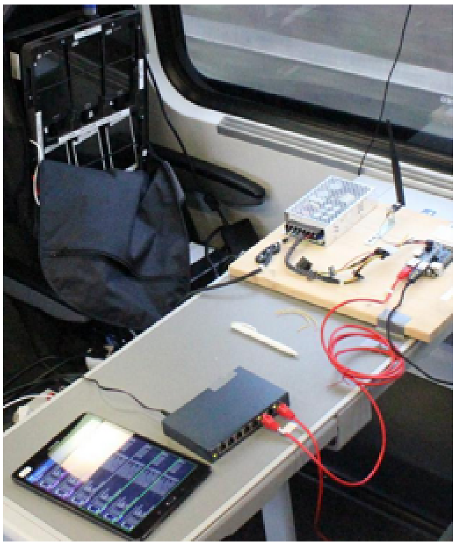

Figure 1: The measurement setup.

RESULTS AND DISCUSSION

One of the ways of showing the possible improvements in coverage for the whole route is by using descriptive statistics. Figure 2 shows a quantile-quantile plot for the Reference Signal Received Power (RSRP) of the UEs located strategically in the middle carriage of the HST. The gain for different operators can be read by drawing a vertical line from the red-dashed line to the scatter curve. The improvement in 4G is 17 dB and 10 dB for operator A and operator B, respectively. The green lines (trapezoid-like shape constructed by parameters such as minimum amplifier sensitivity, maximum gain, maximum output power, and red-dashed line) is the proposed model to optimize the gain and the output power of MRNs, in order to power them on-demand depending on radio-frequency conditions. Coverage increase does not necessary imply data rate improvement, but the MRNs employed here are particularly promising to boost the performance for cell edge scenarios.

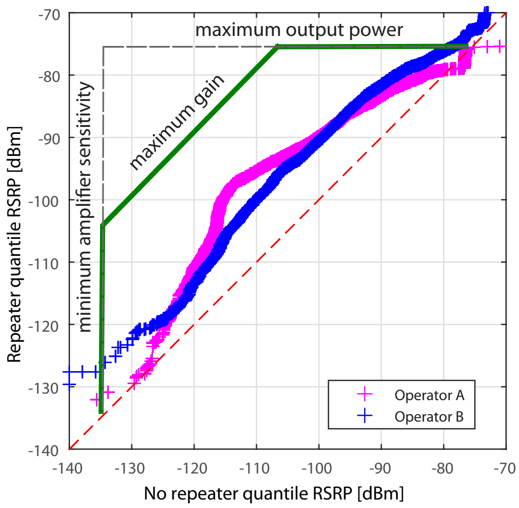

Figure 2: The estimated quantile-quantiles in RSRP 4G [5].

CONCLUSION

In this work, the effect of amplify-and-forward MRNs on coverage under high mobility scenarios is investigated. UEs are measured on-board railjet HSTs under realistic conditions. The obtained results are promising especially for the network areas where the received signal is normal, a gain of 17 dB in RSRP is achieved with MRN. In addition, MRNs can be powered-up on demand. The future work is likely to be towards optimizing different scenarios such as urban, sub-urban and rural scenarios.

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