

MIMO throughput measurement in an urban area using a LTE mobile terminal

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1. Introduction

Recently, Long Term Evolution (LTE) cellular mobile communication has been started in a number of countries. The LTE system employs a Multi Input Multi Output (MIMO) antenna array for achieving high-data-rate wireless communication. The radio propagation characteristics and antenna array configuration have a great impact on the MIMO performance [1]. Thus, MIMO propagation tests have been carried out to evaluate the MIMO characteristics in realistic environments [2]. So far, the MIMO channel capacity has been used in almost all investigations. However, the MIMO capacity is not sufficient for estimating MIMO data transmission characteristics in an actual wireless communication system.

This paper presents an outdoor MIMO throughput experiment using a commercial LTE cellular network in the 2.6 GHz band. The 2-by-2 MIMO throughput was measured in a radio propagation test in an urban area of Aalborg city in Denmark. At the same time, radio channel sounding was also conducted to obtain the radio path distribution. The throughput performance was investigated using the received signal strength indicator (RSSI) and the channel sounding data.

2. Experimental Setup

Fig. 1 depicts the test sites in an urban area of Aalborg in Denmark. At the measurement time, this area had only one base station (BS) on the LTE network using the 2.6 GHz band. Therefore, the throughput in this area could be measured without interference from other BSs. Ten measurement locations for a mobile terminal (MT) on the two routes A and B were selected so that the distance between the BS and the MT was from 300 to 700 m.

Fig. 2 illustrates the experimental setup for the radio propagation test. The LTE throughput and radio channel sounding measurements were performed simultaneously. The channel sounder [3] and a spherical horn array [4] for the receiving antenna were used to obtain wave distributions in the spatial and time domains. The MIMO antenna array of the LTE cellular phone and the sounding array were set on a car trailer, as shown in Fig. 3.

With regard to the data transmission measurements, a commercial LTE USB dongle and a laptop computer were used as the MT. This setup enabled us to obtain the channel quality indicator (CQI), RSSI and throughput, etc. The LTE dongle and the computer were set inside the leading car. The downlink MIMO throughput and the RSSI value of the MT were measured at each location for 1 minute, and evaluated using the mean values. A half wavelength dipole array with a half wavelength separation was used as a handset MIMO array. The antenna array of the MT was moved on a half arc of a circle with a radius of 51 cm, corresponding to 4.4 wavelengths at 2.6 GHz, during the measurements in order to prevent the reception at a local minimum from fading.

Fig. 4 shows a photograph of the BS. The antenna array of the BS of the commercial LTE system was located on a roof of the building at a height of 48 m. The antenna array of the channel sounding transmitter was mounted on the same building near the LTE BS.

3. Outdoor Propagation Experiment

Fig. 5 provides a plot of the average 2-by-2 MIMO throughputs received by the dipole array. It is found from Fig. 5 that the MIMO throughputs at locations 1-5 on route A were higher than those at locations 6-10 on route B, although the locations on route A are much further from the BS than those on route B. It is also observed that the MIMO throughputs of route A have almost the same value while those of route B gradually decrease as the distance between the BS and the MT increases.

Fig. 6 shows the average RSSI values of the dipole array. As can be seen in Fig. 6, almost all the RSSIs of route A are greater than those of route B, and are greater than -75 dBm. These high RSSIs of route A result in high MIMO throughput characteristics. It is also predicted from Figs. 5 and 6 that the throughputs of route A would be saturated with the received power since the values of the throughputs are almost the same while the RSSIs vary. With respect to route B, the throughputs decrease as the RSSI decreases.

Figs. 7 and 8 show the angle of arrival (AOA) characteristics obtained from the channel sounding measurement at locations 5 and 8, respectively. Location 5 on route A has one strong wave from the horizontal angle of -60 degrees, which is the direction of the BS. This strong wave was assumed to be a direct wave from the BS, and results in high throughput. Moreover, the radio environment at location 5 was thought to be a Nakagami-Rice fading environment with a line-of-sight (LOS) component. With regard to location 8 on route B, all the waves are almost the same and small in comparison with the strong wave at location 5. From this, location 8 was deemed to be in a Rayleigh fading environment.

4. Conclusion

An experimental investigation of the 2-by-2 MIMO throughput characteristics in the 2.6 GHz band using a commercial LTE network was performed in an urban area of Aalborg city in Denmark. Radio channel sounding with a spherical horn antenna array at 2.35 GHz was also conducted to obtain wave distributions for evaluating the throughput characteristics. It was found from the experiments that the throughputs of route A were higher than those of route B since route A had a strong wave directly arriving from the base station. We concluded that a LOS propagation environment has a great impact on the performance of the MIMO throughput.

References

- [1] K. Ogawa, H. Iwai, A. Yamamoto, and J. Takada, "Channel capacity of a handset MIMO antenna influenced by the effects of 3D angular spectrum, polarization, and operator," APS 2006, Albuquerque, USA, pp. 153 - 156, July 2006.
- [2] K. Nishimori, Y. Makise, M. Ida, R. Kudo, and K. Tsunekawa, "Channel Capacity Measurement of 8 x 2 MIMO Transmission by Antenna Configurations in an Actual Cellular Environment," IEEE Trans. Antennas Propagat., vol. 54, no. 11, pp. 3285 - 3291, Nov. 2006.
- [3] J. Ø. Nielsen, J. B. Andersen, P. C. F. Eggers, G. F. Pedersen, K. Olesen, E. H. Sørensen, and H. Suda, "Measurements of indoor 16x32 wideband MIMO channels at 5.8 GHz," Proc. 8th IEEE Int. Symp. on ISSSTA 2004, pp. 864-868, Aug. 2004.
- [4] A. Yamamoto, T. Sakata, T. Hayashi, K. Ogawa, K. Olesen, J. Ø. Nielsen, and G. F. Pedersen, "MIMO angular power spread characteristics obtained by an outdoor propagation experiment in the 2 GHz band," Proc. of the Society Conference of IEICE, B-1-35, September 2010.

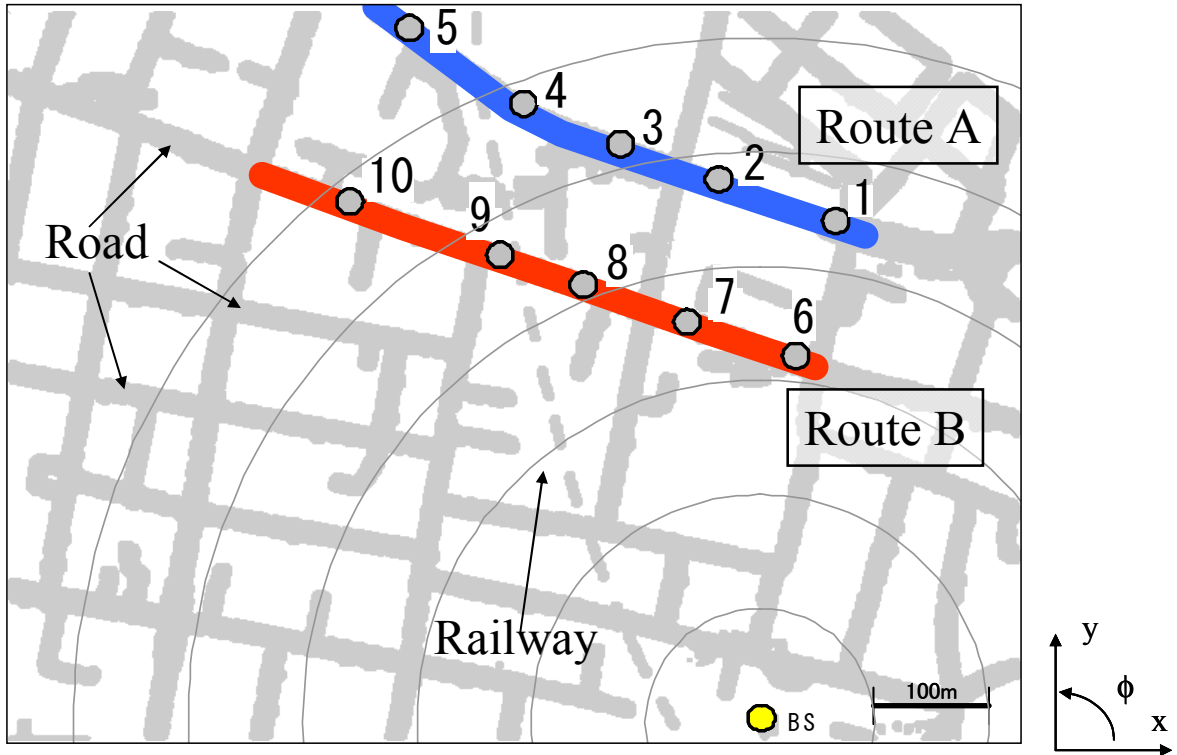


Figure 1: Test sites in an urban area

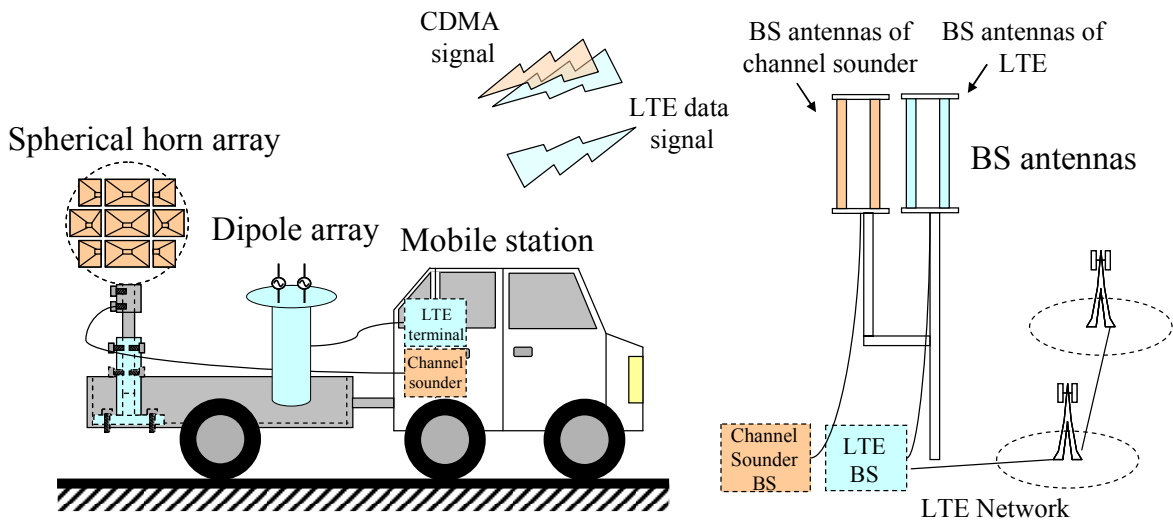


Figure 2: Experimental setup

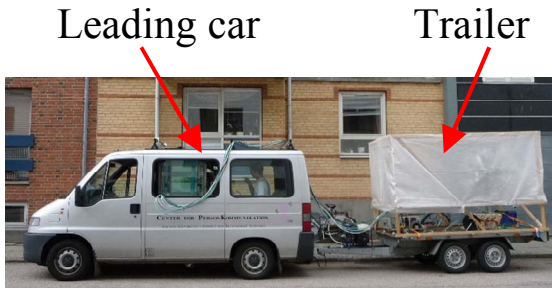


Figure 3: Mobile terminal



Figure 4: Base station on the building

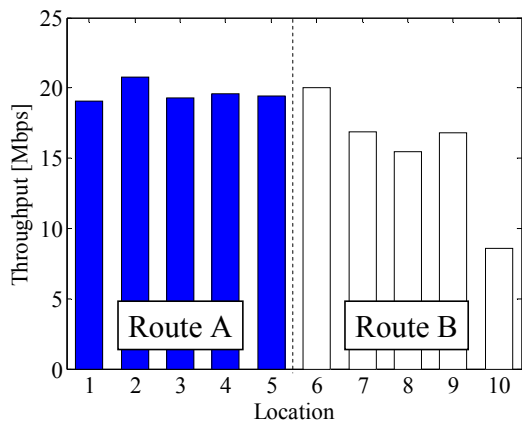


Figure 5: LTE throughput characteristics.

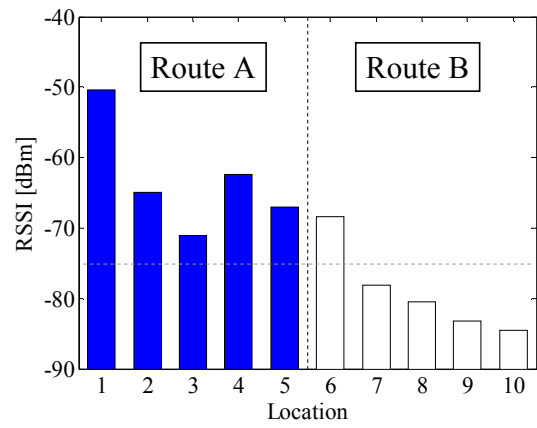


Figure 6: RSSI characteristics.

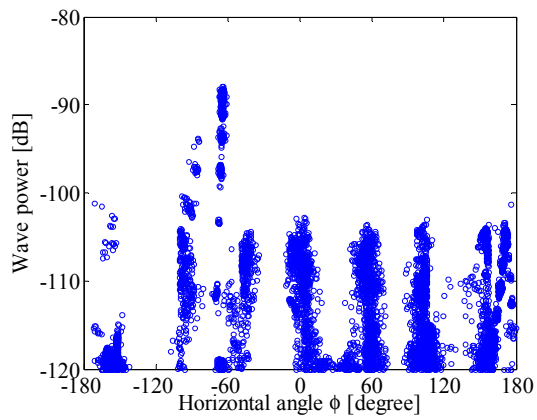


Figure 7: Wave power distribution at location 5.

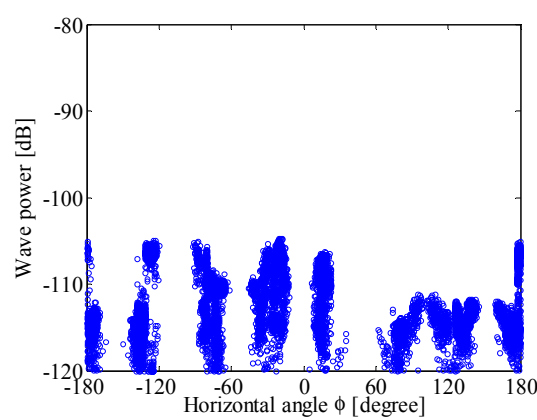


Figure 8: Wave power distribution at location 8.