Chapter 16
Massive MIMO-Based Network Planning and Performance Evaluation for High Speed Broadband Connection in Rural Areas of Tanzania

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ABSTRACT

The need for high speed broadband connection in rural areas is inevitable since services like e-governance, virtual classrooms, telemedicine, video-on-demand, home entertainment, etc. are needed. However, in order to provide broadband services, service providers must incur high deployment costs and wait for long time for return on investments. Thus, massive multiple-input multiple-output (MIMO) with its favorable propagation phenomenon can be exploited as an alternative to boost signal coverage in rural areas while providing high speed broadband connection. In this chapter, planning and performance evaluation for massive MIMO network has been conducted for rural areas in Tanzania. Infovista and MATLAB tools were used for network simulation. The results show that massive MIMO network at 5MHz bandwidth performs better in terms of RSRP and SINRu when compared to 10 MHz and 20MHz channel bandwidths.

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INTRODUCTION

People living in rural areas need broadband connection for services like e-governance, virtual class rooms, telemedicine, video-on-demand, home entertainment etc (Camp & Beaulieu, 2016). Therefore, the need for high speed broadband connection in rural areas is inevitable. However, in order to provide broadband services, service providers must incur high deployment costs and wait for a long time for return on investments (Simba, Mwinyiwiwa, Mjema, Trojer, & Mvungi, 2011). One of the technology that can help to bring down the cost is Long Term Evolution (LTE), which has been proposed in (Rekawt, Rahman, & Abdulrahman, 2014; Yogapratama, Usman, & Wibowo, 2015).

However, with LTE based proposals, a bandwidth of 5 MHz at 900MHz and 6 cells were required to serve 7582 users in average when eight villages with 14.6 km2 were considered. Study by Larsson et al. (2014) found that it is possible to reduce the reported bandwidth and number cells if massive MIMO is considered as an alternative. This is because massive MIMO can use hundreds or thousands of antennas to serve more users in the same bandwidth (Björnson, Larsson, & Debbah, 2015). In addition, massive MIMO has a potential to boost the coverage through a favorable propagation phenomenon (Ngo, Larsson, & Marzetta, 2014). Favorable propagation inherent in massive MIMO can be exploited to reduce the number of cells proposed in (Yogapratama et al., 2015) by deploying large cells. It is evident that massive MIMO based network can bring down the cost via bandwidth and cells reduction. However, before deploying the massive MIMO based network in rural areas it should be planned first.

Several works on planning and performance evaluation of broadband networks can be found in literature. Yogapratama et al, (2015) planned and analyzed the performance of 900 MHz and 1800 MHz LTE network for 5 MHz and 20 MHz channel bandwidths for rural Indonesia. Results show that using 900 MHz band at 20 MHz bandwidth would serve better throughput and smaller number of cells for selected areas.

Another study conducted by Tchao, Gadze and Agyapong (2018) evaluated performance of deployed 4G LTE network in Ghana at 2600 MHz frequency band. Throughput and coverage were computed to compare its performance based on different antenna configurations. The results of the research work indicated that better performance in terms of throughput and coverage can be achieved by using several numbers of antennas at base station.

Moreover, a near similar study conducted by Cueto, Mello and Rodriguez (2013) compared capacity and coverage of LTE-Advanced networks at 700 MHz and 2600 MHz bands. In this study higher channel bandwidths (20 MHz, 40 MHz, 60 MHz 80 MHz and 100 MHz) were considered. The results showed that a 700 MHz band to have better coverage and capacity. However, careful planning is required to properly benefit from this carrier frequency. To the best of our knowledge, a study that plans and evaluates performance of massive MIMO based network for high speed rural broadband connection in Tanzania is lacking in literature.

In this chapter, a broadband network for Tanzanian rural areas based on massive MIMO technology at 2.1 GHz carrier frequency was planned and its performance was evaluated. This was to support the initiative of the United Republic of Tanzania in bringing broadband services to rural areas so that at the end of 2021 and 2024 broadband population coverage in Tanzania should be 60% and 90% respectively (TCRA, 2018).

The rest part of this chapter is organised in the following sequence; overview of massive MIMO, favorable propagation phenomenon in massive MIMO networks, radio propagation models, network parameter planning and simulation methods, results and conclusion.