IMPLEMENTATION OF HIGH CAPACITY MOBILE NETWORKS BASED ON A RECONFIGURABLE ANTENNA, CARRIER AGGREGATION AND MIMO

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Abstract - This work is regarding the implementation of high capacity mobile networks based on a new reconfigurable antenna design, carrier aggregation and MIMO techniques. The developed antenna is based on the use of a leaky-wave structure, which operates from 1.3 to 2.7 GHz and provides a frequency-dependent reconfigurable radiation pattern for enabling multi-technology wireless coverage. Experimental results demonstrate a fractional bandwidth of 45% and gain maximum of 9.2 dBi. Furthermore, an implementation of three-band carrier aggregation in conjunction with MIMO in a real indoor LTE-A network is reported. Three noncontiguous 20MHz component carriers in the 700 MHz (B28), 1800 MHz (B3) and 2600 MHz (B7) bands have been applied in conjunction with 2x2 MIMO for enabling throughput of 600 Mbps at low levels of block error rate (BLER).

Keywords: Antenna; cellular networks; LTE-Advanced; reconfigurable antennas; wireless communications.

INTRODUCTION

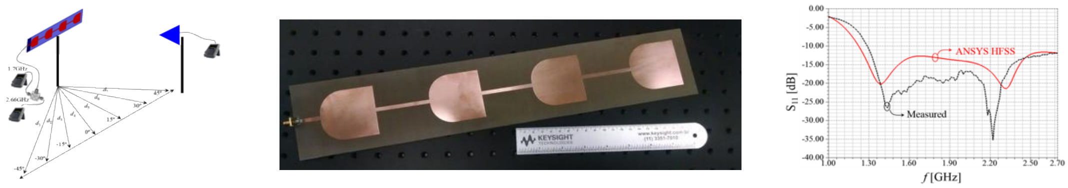
The technological evolution in mobile networks has introduced new features to the radio layer, enabling the progress for 4G LTE-Advanced Release 10 networks, since the first technical specifications of 4G mobile networks (Release 8). The advantages in terms of higher data rates for the user will be even greater, able to reach rates of 1Gbps, representing a significant improvement in the spectral efficiency [1]. Fully compatible with previous and future versions of LTE defined by 3GPP, LTE-Advanced allow mobile operators to make a wider use of the available electromagnetic spectrum.

Although many improvements have been proposed to increase spectral efficiency, it is still not possible to provide the data rates defined by the requirements of IMT-Advanced (International Mobile Telecommunications- Advanced), without increasing the transmission bandwidth used by the initial launches of the LTE standard. In order to provide a higher bandwidth, contiguous or not, the carrier aggregation (CA) technique was introduced in LTE-Advanced with the use of multiple Component Carriers (CC) for reaching a maximum aggregate band of 100MHz [2].

This paper aims to increase the mobile networks capacity by introducing a novel reconfigurable antenna and applying carrier aggregation, 2x2 multiple-input multiple-output (MIMO) and 256-QAM modulation in a real LTE-Advanced Network, operating in the 700, 1800 and 2600 MHz spectral bands.

LEAKY-WAVE RECONFIGURABLE ANTENNA

The leaky-wave reconfigurable antenna is based on an arrangement of periodic metallic resonators identically spaced and fed by a metallic line, which is a new concept recently proposed by our Research group [3]. The antenna prototype is presented in Fig. 1b, which relies on the use of a truncated ground plane for increasing its bandwidth. Fig. 1c. reports a comparison between the numerical simulation and measurement of the antenna reflection coefficient, giving rise a bandwidth of 1.4 GHz from 1.3 to 2.7 GHz. Fig. 1a shows the experimental setup for validating the proposed antenna reconfigurable radiation pattern as a function of frequency. It simultaneously transmits two frequencies (1.7 and 2.66 GHz) in the direction of the reception site, which is composed by a 5-dBi gain log-periodic antenna. The measured gain is highly frequency-dependent, since it dramatically reduces as function of the azimuth angle. A gain maximum of 9.2 dBi has been obtained for 2.66 GHz.

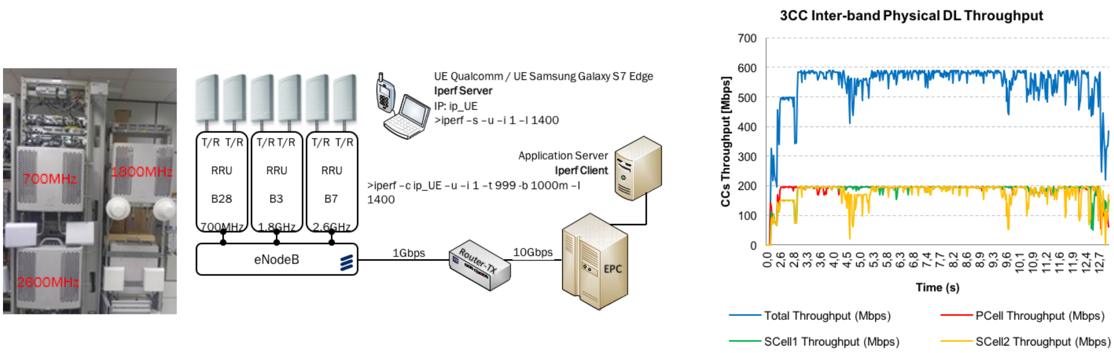


a) Experiment setup b) Leak-wave antenna prototype c) Antenna reflection coefficient

Figure 1 – Multi-technology wireless coverage based on a new leaky-wave reconfigurable antenna.

IMPLEMENTATION OF 700/1800/2600 MHz CARRIER AGGREGATION IN A LTE-ADVANCED NETWORK

This section reports the implementation of carrier aggregation in a real indoor LTE-Advanced network, using three different Remote Radio Units (RRUs) operating in the 700, 1800 and 2600 MHz frequency bands, as presented in Fig. 2a. The transmission power has been set to 30 dBm per RRU. By using low power level, we could confine the radiated signal free of interference from the neighboring cells and assigned only to the Cat-16 prototype used in the tests. The Signal to Interference Plus Noise Ratio (SINR) was approximately 30dB (CQI = 15), with the aim of allowing high values of Modulation and Code Scheme (MCS) index. An I_{MCS} = 27 has been obtained for the 3 CCs (PCell, SCell1 and SCell2) operating with all OFDM channel subcarriers modulated in 256-QAM. Fig. 2b reports the experimental results of the performance investigation as a function of throughput, which proves the success of the implemented LTE-Advanced with three-band CA in a practical proposed network. A maximum throughput has been experimentally obtained in the downlink for the Three-band CA scenario using SU-MIMO 2x2, TM3 (two-layer spatial multiplexing) and 20MHz per CC, totaling 60MHz of aggregated bandwidth, giving rise to a 600 Mbps throughput.



a) eNodeB 3xCC and 2x2 MIMO b) Throughput with three-band carrier aggregation

Figure 2 – Implementation of 700/1800/2600 MHz carrier ggregation in a LTE-Advanced Network.

CONCLUSIONS

We have successfully reported the implementation of high capacity mobile networks based on a new antenna design and carrier aggregation and MIMO techniques. The leaky-wave reconfigurable antenna was based on an array of truncated microstrip antenna elements. Numerical simulations and experimental results demonstrate bandwidth from 1.3 to 2.7 GHz, 9.2 dBi gain and frequency-dependent reconfigurable radiation pattern. The proposed antenna can be efficiently applied for the development of a multi-technology wireless network, which enables a spatial coverage of different wireless standards (Wi-Fi, 2G, 3G, 4G and even 5G) using a unique antenna.

A LTE-advanced network with three-band carrier aggregation, OFDMA and 2x2 MIMO in a real network has been implemented, using three noncontiguous 20MHz component carriers in the 700 MHz (B3), 1800 MHz (B7) and 2600 MHz (B28) bands. It has been obtained throughput of 600 Mbps at low levels of block error rate. A Qualcomm Snapdragon X16 LTE modem test device Cat-16 with 2x2 MIMO and 256-QAM modulation have been used as a handset. The obtained throughput is in accordance with the theoretical limits, calculated using the recommendations of LTE-Advanced Release 13.

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