Chapter 3
Applications of Advanced Reconfigurable Antenna for the Next Generation 4G Communication Devices

Massimo Donelli
University of Trento, Italy

ABSTRACT

The objective of this chapter is to show the applications of innovative reconfigurable antenna methodologies for the 4G devices. Microwave antenna technology can be very useful for the 4G devices, because these products will require high bandwidth and high velocity channel with respect to conventional antennas. This chapter presents a complete picture of possible applications of advanced microwave technologies for 4G devices and systems, it includes methodologies, such as phased and fully adaptive arrays, innovative multiple-Input and multiple-output (MIMO) antennas based on compact rotmans lenses or butler matrix, and the development of innovate reconfigurable antenna based on reconfigurable parasitic structures. The chapter ends with some conclusions and considerations related to ideas for future works.

INTRODUCTION

Modern mobile telecommunications systems such as mobile smart phones, offer multimedia applications and different services that require a high degree of reconfigurability in spite of the limited dimensions of the devices. In particular the fourth generation 4G mobile telecommunications technology succeeding the 3G generation. The 4G devices offer, in addition to usual voice and other services of standard 3G systems, ultra-broadband internet connection, IP telephony, mobile web access, gaming services and other interesting multimedia application (such as high definition television). In such a framework the design of a suitable radiating system could play a key role in the design of 4G devices. The antenna system for 4G devices must be light, cheap and able to keep the devices performances to a high level. In the last decades the use of reconfigurable antenna arrays with fully adaptive properties Donelli et al. (2003); Massa et al. (2004); Donelli et al.

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(2004); Sacchi et al. (2004); Donelli et al. (2004A); Donelli et al. (2006); Sacchi et al. (2007); Sacchi et al. (2007A); Sacchi et al. (2011), clearly demonstrated their effectiveness to dramatically improve the performances of a telecommunication system in particular if they are combined with a reconfigurable digital back end processing unit. Such kind of antennas, commonly used in several fields such as airport surveillance, missile detection and tracking, are unfortunately too much complex, expensive and bulky to be used for commercial portable devices such as mobile phone, and tablets. Attempts to reach high degrees of miniaturization have been reached considering pre-fractal geometries, adopted to obtain multi-frequency antennas in microstrip technology as in Azaro et al. (2006); Azaro et al. (2006A); Azaro et al. (2006); Fimognari et al. (2007), where low cost multiband antennas has been used with success for UMTS, GPS and WI-Fi practical applications. Unfortunately the main drawback of such kind of antenna system is their low impedance and the difficulty to fulfill the frequency bands requirements. F or low cost applications the use of switched beam antennas are generally adopted instead of adaptive arrays. Recently a new kind of reconfigurable parasitic antennas, able to electronically select different configurations of the radiation patters Fimognari et al. (2007); Viani et al. (2010); Donelli and Febvre (2012), Rocca et al. (2013), have been successfully adopted for different practical applications, such as WI-FI systems Donelli and Febvre (2012), wireless sensor networks applications Fimognari et al. (2007), Viani et al. (2010) and sum-difference radar Rocca et al (2013). Such kinds of antennas offer a good compromise between the fully adaptive arrays and the switched beam solution. In this chapter we discuss about different aspects of the use of different antenna systems, able to reconfigure their radiation properties, for the improvement of 4G communication systems. More specifically, the application of smart antennas, able to reconfigure their radiation properties, such as phased or fully adaptive arrays, and their integration with next generation communication systems, is analyzed and discussed. Several examples of smart antennas, such as phased arrays, MIMO antenna based on butler matrix or Rotmans lenses, and advanced new kind of reconfigurable antennas based on microstrip structures or changeable parasitic elements are reported and commented. The presented radiating structures are analyzed under various operative conditions and frequency bands. The chapter also includes a brief discussion concerning the computational burden and the different strategies that can be used to control the considered smart antennas, under different complex scenarios. The chapter ends with some conclusions and considerations related to ideas for future works.

PHASED AND FULLY ADAPTIVE ARRAYS

Adaptive arrays, namely phased and fully adaptive arrays are currently used as a fundamental component of telecommunications systems Steinberg (1976) with extensive applications in different practical fileds such as tracking, direction of arrival estimation (DOA) Donelli et al. (2009); Donelli et al. (2006), and in particular for signal-to-interference-plus-noise ratio (SINR) the maximization of a telecommunication channel. Phased arrays change their radiation properties by acting only on the phase of the power supply of each element while fully adaptive control both the amplitude and the phase. Fully adaptive arrays present more degrees of freedom and beam forming capabilities, but they are too much expensive especially at microwave frequencies since accurate variable attenuators, mandatory to control the amplitude of the signal delivered to the array elements, are quite expensive. The schema of a generic adaptive arrays is reported in Fig. 1. It consists of a set of variable phase shifter and attenuators. These devices are controlled by