Polygonal Dipole Placements for Efficient, Rotatable, Single Beam Smart Antennas in 5G Aerospace and Ground Wireless Systems

K.Pirapaharan[1], P.R.P. Hoole[2], Norhuzaimin Julai[2], Al-Khalid Othman[2], Ade Syaheda W Marzuki[2], K.S. Senthilkumar[3] and S.R. H. Hoole[4]

[1]*Department of Electrical and Communications Engineering, Papua New Guinea University of Technology, PNG.*
[2]*Deparment of Electrical and Electronic Engineering, Universiti of Malaysia Sarawak, Sarawak, Malaysia.*
[3]*Department of Computers and Technology, St. George's University, Grenada, WI.*
[4]*Electrical and Computer Engineering, Michigan State University, East Lansing, MI 48824, USA.*
pirapaharan_k@yahoo.com

***Abstract*—In telecommunication systems and radars, the common practice in using array antennas is to place a reflector behind the array so as to reflect the backward signal also in the forward direction. Moreover, in the 5G wireless systems, smart antennas, especially those with a single beam, are expected to play a critical role in its successful launching in 2020. We show in this paper that a linear array antenna necessarily ends up with symmetrical beamforming on both sides of the array axis. Thus, single direction (forward direction) beamforming cannot be achieved by placing the electromagnetic radiators (e.g. dipole elements) in a straight line. We propose that in situations where a smart array structure demands single rotatable beams, that single rotatable beamforming can be achieved by changing the geometrical shape of the array. However, the computational intensity involved in finding optimized weight coefficients for beamforming over the entire 360o space turns into the major challenge. In order to minimize the computational repetition of optimizing weights for every direction, a regular polygon array antenna is proposed. We show that an array antenna placed in a regular polygon yields a smart antenna with a highly effective and computationally fast, reduced memory and electronically rotatable single beam.**

***Index Terms*—Smart Arrays; Beamforming; Array Structure.**

I. INTRODUCTION

Wireless communications systems are prone to multipath phenomena and other impairments which can adversely affect their performance. A highly reflective environment would create primary and secondary reflected waves that interfere with a mobile user [1]. The problem is worsened with a smart antenna on a mobile station as well, as required by the 5G wireless system. While base stations in a highly reflective environment have a capability to use multiple waves to improve signal quality, this feature is not available in simple mobile devices which are used in highly reflective environments. Smart antennas hold great promise to surpass the communications challenges in highly reflective environments to provide reliable communications in emergencies and for mm-wave 5G technology [2].

Smart antenna research and development has largely focused on elements placed in a straight line. Such a linear antenna geometry produces a main beam and an image along the central array axis [3]-[5] The drawback of such an antenna is more significant at the receiving end, where reflected waves from both sides of the axis will be received and processed, degrading signal quality and performance. Therefore, we propose a single beam smart antenna with single beam acceptance at the receiving end, nullifying all other signals. We show that the possible, computationally efficient arrays with multiple numbers of element which will yield a rotatable single beam is an array with a polygonal geometry. Some different and complex smart antenna geometries were proposed and analyzed by others; however, the elements were arranged in a linear form with inefficient use of power [4], [5].

In Figure 1, it is shown a sixteen element (8 x 8) array antenna which produces a single steerable antenna beam. At the back of the patch array antenna is a ground plane over which the patch elements are placed as shown in Figure 2. The ground plane in the case of patch antennas acts as one part of a parallel waveguide to steer the signals to (when transmitting) or from (when receiving) signals. When such an antenna is used in the aerospace industry, for instance, the antenna needs to be placed on the fuselage of the aircraft. In the specific case shown in Figure 2, the antenna is placed on the top part of the center fuselage, for aircraft to satellite communication, where the satellite orbits, say, at an altitude of 800 km whereas the aircraft flies at 20 km altitude. For aircraft to ground communication, another antenna needs to be placed on the bottom of the fuselage, away from parts such as the landing gear to avoid obstruction of the transmitted or received electromagnetic signals.

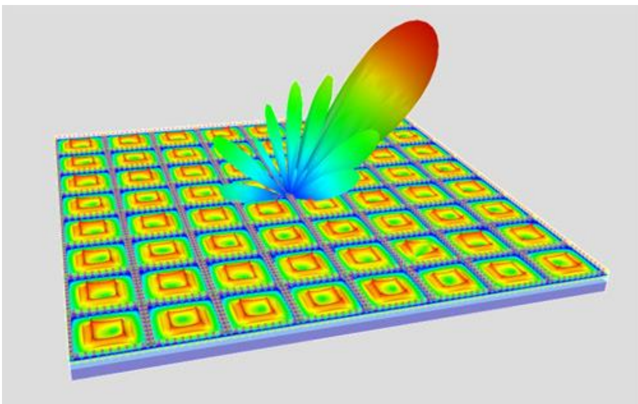

Figure 1: A Single beam 8x8 Array Antenna [6]