First Demonstration and Visualization of Receive Spatial Modulation Using the ”Radio Wave Display”

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First Demonstration and Visualization of Receive Spatial Modulation Using the "Radio Wave Display"

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***Abstract*— In this paper, a demonstration of new single processing candidate techniques for the future fifth generation of mobile networks and the internet of things, called Transmit Spatial Modulation and Receive Spatial Modulation, is described. These techniques exploit multiple antennas to boost the spectral efficiency of the wireless link. However, compared to multiple-antenna systems, they use less Radio-Frequency modules, and are expected to be lower in cost, size and energy consumption. They are thus promising to provide high data rate to/from small connected objects. In Transmit Spatial Modulation, the receiver, (a base station for instance), additionally to conventional demodulation, detects "where, in space, the signal comes from" to get additional data bits. In Receive Spatial Modulation, the receiver (a connected object for instance), additionally to conventional demodulation, detects "where, in space, the signal is arriving at" to get additional bits. Thanks to a new device called the Radio Waves Display and our spatial modulation test bed, for the first time, we visualize, in real time, the spatial repartition of the signal around and on the receiver. This enables even the general public to perform a spatial de-modulation, in a visual manner, and understand intuitively, the concept.**

Keywords—Green, 5G, massive MIMO, green, visualization, RF, propagation, spatial modulation, internet of things

I. INTRODUCTION

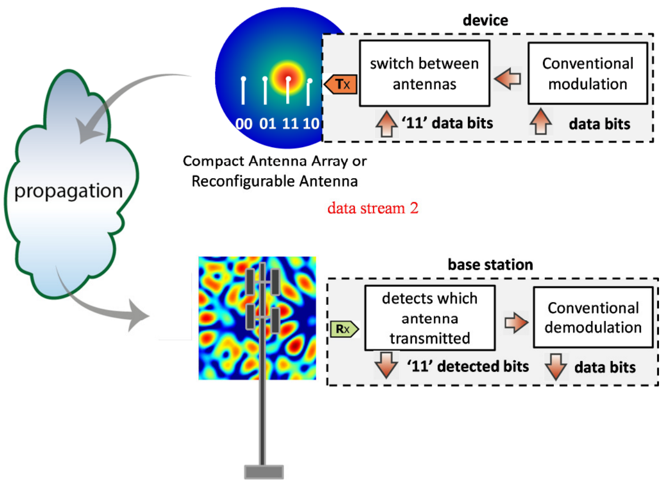

Fig. 1. Principle of Transmit spatial modulation with four transmit antenna elements or ports: the device is transmitting with only one antenna at a time, the base station has previously estimated the channel between the device and itself and is able to detect which of the four antennas of the device is currently transmitting. The index of each antenna of the device is coded in binary. By transmitting with one particular antenna, the device indicates the bits being sent. The base station recovers the bits by detecting which antenna is the current active antenna. Note that the RF signal bears a conventional modulation (in phase and amplitude).

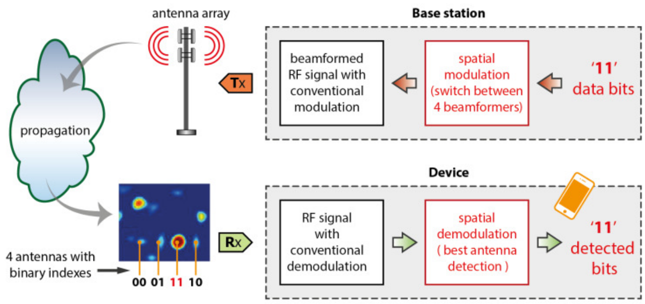

Fig. 2. Principle of Receive spatial modulation with four receive antenna elements: the base station has a set of beamformers (previously determined thanks to a channel estimation phase), and is able to focus towards any of the four antennas of the device. The index of each antenna of the device is coded in binary. By focusing onto a particular antenna, the base station indicates the bits being sent. The device recovers the bits by detecting which antenna is the current focusing target. Note that the RF signal bears a conventional modulation (in phase and amplitude).

Fig. 3. THE SPATIAL MODULATION TEST-BED CHARACTERISTICS

Parameter	Value
Carrier frequency	2.4 GHz
Bandwidth	40 MHz
FFT/IFFT size	256
CP length	64
Num. of pilot symb. (UL)	$5N_R$
Num of pilot symb. (DL)	N_R
Num. of OFDM symb (DL)	819
Carrier frequency	2.4 GHz
Bandwidth	40 MHz
FFT/IFFT size	256
CP length	64
Num. of pilot symb. (UL)	$5N_R$

Fig. 4. THE RADIO WAVES DISPLAY CHARACTERISTICS

Parameter	Value
Technology	Digital
Panel area	1m²
Number of sensors	400 (20×20)
Sensitivity	-60 dBm to 0 dBm (or max

	dynamic)
Minimal dynamic range	3dB
Bandwidth	50 MHz to 3 GHz
Number of displayed colors	1024
Sensitivity adjustment	Min and max threshold
Frequency of display	1 second or Instantaneous MaxHold
Number of color bars	4
Separate color for saturation (pink)	On or Off
Weight	30 Kg

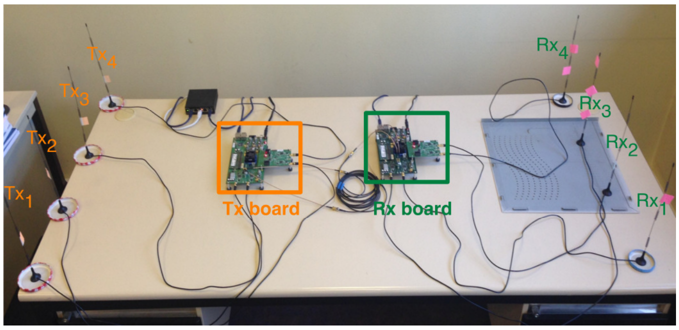

Fig. 5. Experimental set-up.

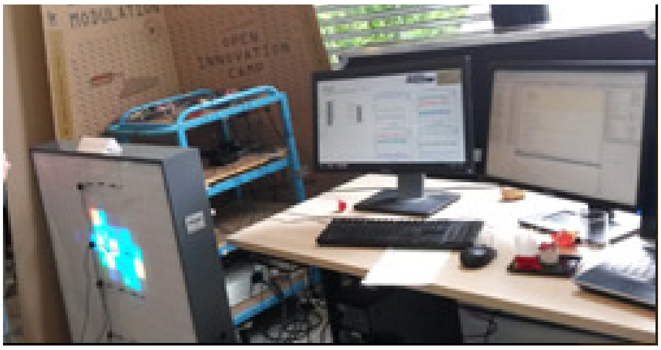

Fig. 6. Receive spatial modulation setup, with 4 receive antennas scotched on the front of the Radio Waves Display and the transmitter around 1 meter behind, focusing alternatively towards one of the 4 antennas.

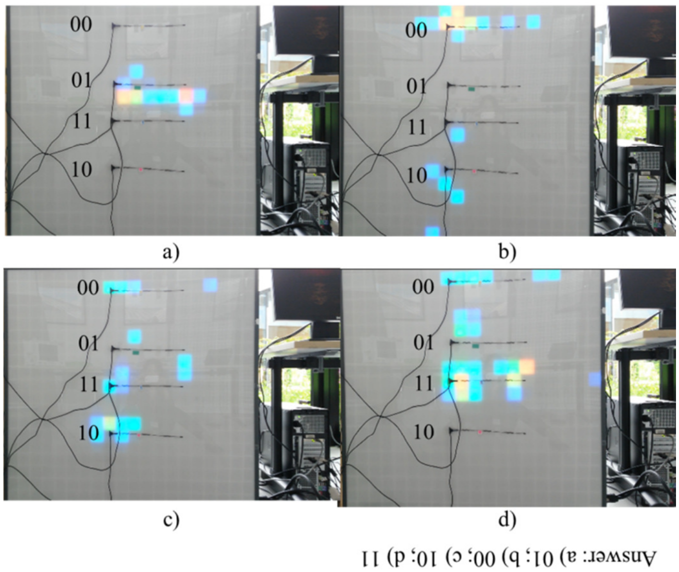

Fig. 7. Receive spatial modulation game: perform spatial demodulation by finding visually the detected bits for the four presented configurations

The Luxondes Radio Waves Display converts radiofrequency signals (between 50 MHz and 3 GHz) into light and directly displays the strength of the Electro-Magnetic-field of a wave which is passing through it. This device is represented in Fig. 6. The 1m x 1m display unit uses 400 (20×20) autonomous identical sensors working as elementary visualization pixels.

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