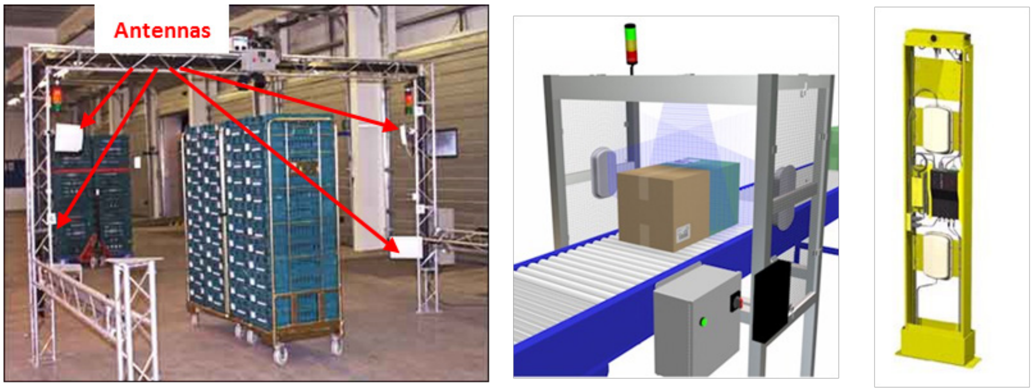
STATE OF ART ON UHF RFID PORTAL SYSTEMS AND DIVERSITY TECHNIQUES

Current RFID portal systems

Since a few years, some pioneer companies manage their supply chain with UHF RFID technology. Automatic inventories or traceability of incoming or outcoming goods are then greatly simplified. Fig. 1 represents some examples of UHF portals. It is composed of a structure where one or several antennas are mounted. Pallet or packets passing through radiated field are automatically inventoried.



Intellident portal   Blue bean portal   GAO TEK portal

Fig. 1. UHF RFID industrial examples

The great majority of UHF RFID commercial antennas are planar structures, circularly polarized, with a gain varying between 6dBi and 10dBi and a corresponding half power beamwidth between 45° and 100°. Their lateral sizes are from 100mm to 800mm. New systems propose more complex function as beam steering and localization (Fig. 3). In a general way, RFID manufacturers tend to multiply antennas varying their locations and/or polarization.

LAIRD S8655PR   Impinj Guardwall   MTI 243010/NRLH

Fig. 2. UHF RFID antennas examples

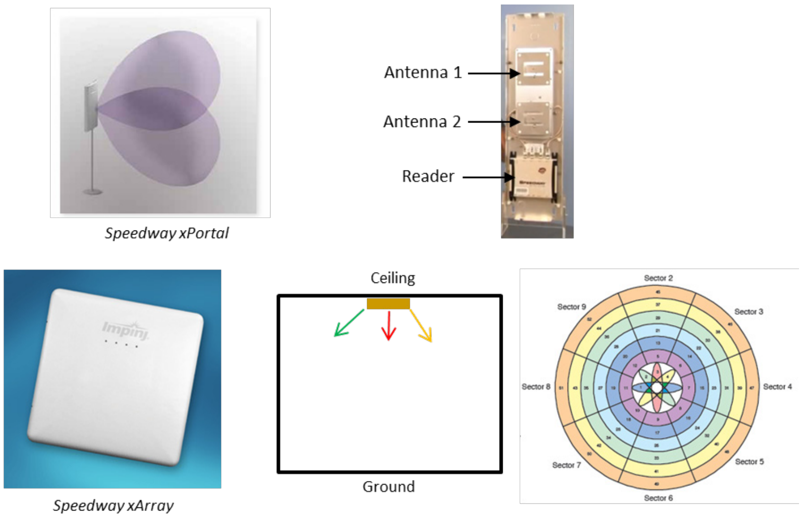


Fig. 3. RFID systems with complex functions as beam switching or localization

Diversity techniques in UHF RFID

To mitigate multipath propagation effects, diversity techniques have been proposed and used extensively in mobile communications [1,2]. The same multipath phenomenon in UHF RFID systems degrades the reader-tag link [3,4]. In Fig. 4, from [4], path loss is measured between in a room equipped by an RFID antenna (antenna height = 0.5m). Both vertical and horizontal polarizations show clear signal fading due to multipath phenomenon.

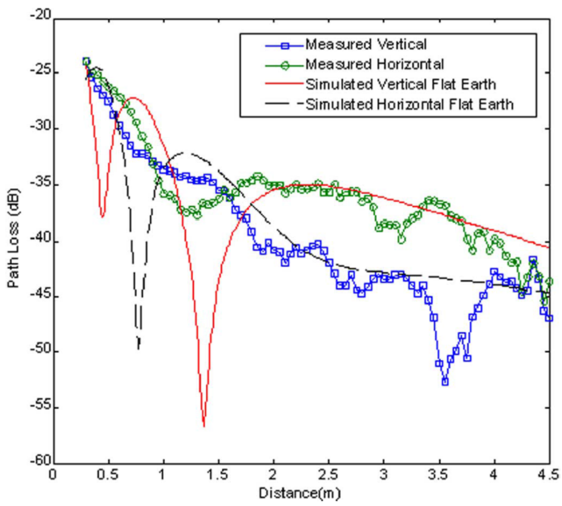


Fig. 4. Comparison between measured propagation loss and simulation using flat earth model as a function of distance between reader and tag for vertical and horizontal polarizations at 916 MHz, from [4].

In [5], authors compare theoretically single input-single output (SISO) and multiple input-multiple output (MIMO) read range for Nagakami-m fading channels. A MIMO configuration is introduced in [6] for a RF modulated backscatter link on several theoretical channels. Simulations show range improvement and a great increase of link capacity. Tag with multiple antennas have been studied in [7], the results show a reduction of the required power to maintain a constant bit-error-rate (BER). In the same way, an increase of read range and read reliability is measured with an emulated twoantenna tag for different diversity scheme combination [8]. Reader antenna diversity is implemented [9-10], they demonstrate a better radio coverage with phased arrays for bistatic situation. Another experimental result on spatial diversity provided in [11] shows performance improvement using random antenna selection in an auditorium coverage (Fig. 5). In [12], a maximal ratio combining scheme is implemented beyond a dual antenna receiver. The experimental comparison (Fig. 6) between random antenna selection and maximal ratio combining demonstrates the superiority of the latter but with an increase of system complexity.

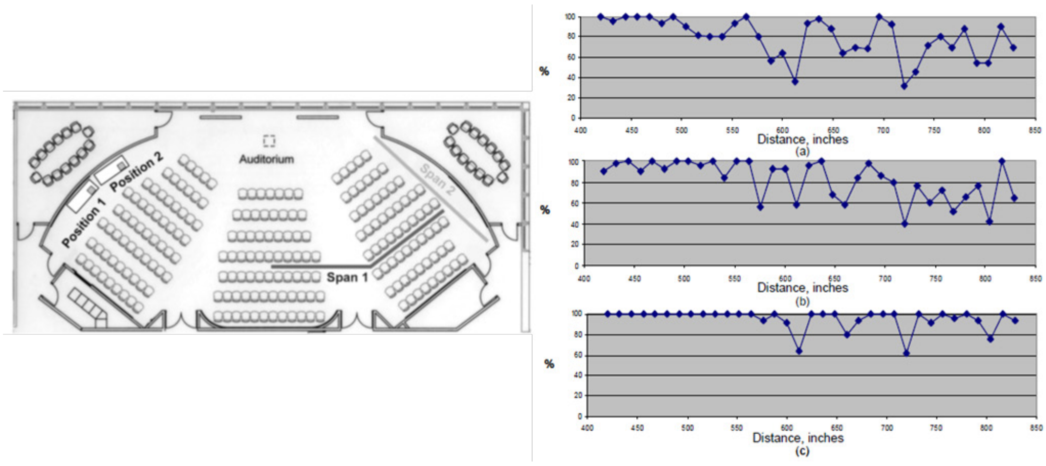


Fig. 5. Diagram of the test space. Position 1 and 2 indicate the location of the reader in the spatial diversity tests. Results of combining the spatial diversity of both positions for span 1 (a) Position 1, (b) Position 2, and (c) combined results, from [11].

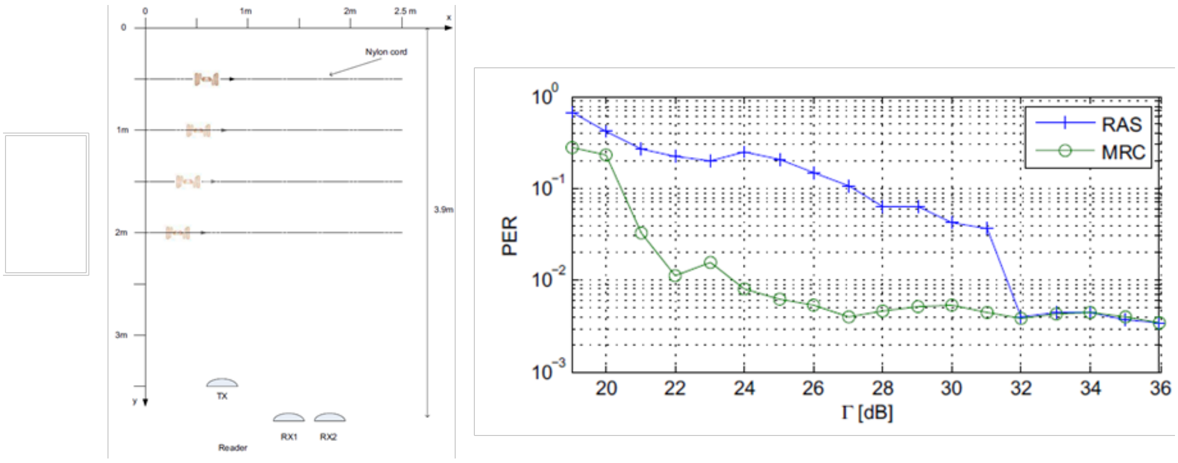
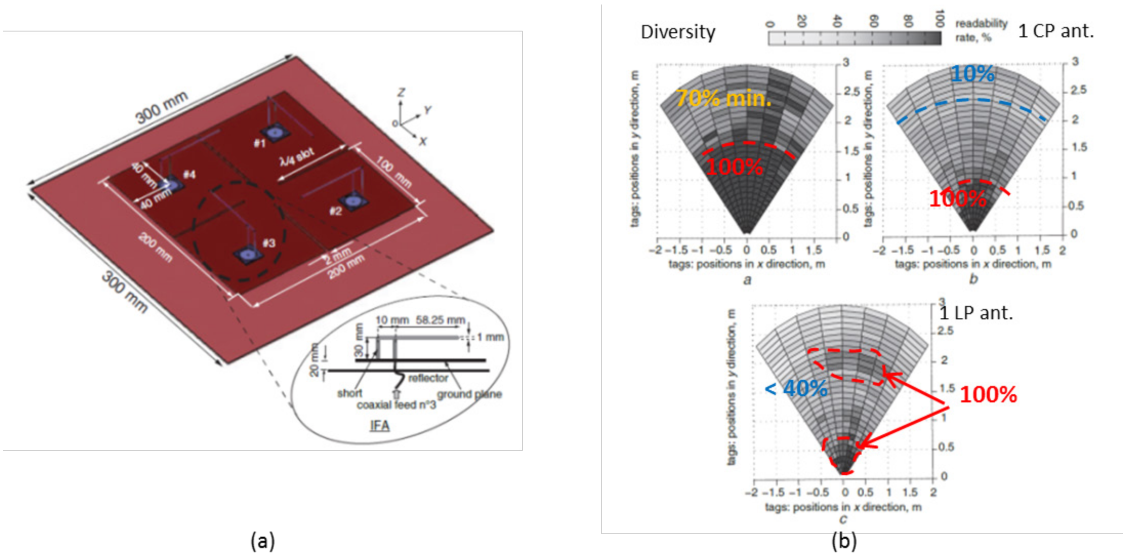


Fig. 6. The performance of the implemented MRC receiver is compared to a receiver with random antenna selection (RAS) by means of measurements of the Packet Error Ratio (PER), from [12].

RFID reader antenna diversity

As a consequence, in recent years, numerous works on reader antenna diversity have been presented. Compact structures achieving spatial and polarization diversity are experimentally demonstrated in [13,14] with planar inverted F-antenna (PIFA). Fig. 7 illustrates the geometry of the proposed four PIFA antenna in [14] and shows a great improve of read rate due to diversity



(a) (b)

Fig. 7. (a) Geometry of the proposed diversity antenna (b) Read rate is greatly improved by the diversity antenna, from [14].

Beam-steering arrays have been proposed [15,16], including miniaturized structures [17] and more complex “smart” antenna arrays [18,19]. But, diversity performance are most often characterized either in terms of S-parameters, and radiation pattern diversity or with a very simple RFID application case (Fig. 8), that does not represent realistic situations [14-26].

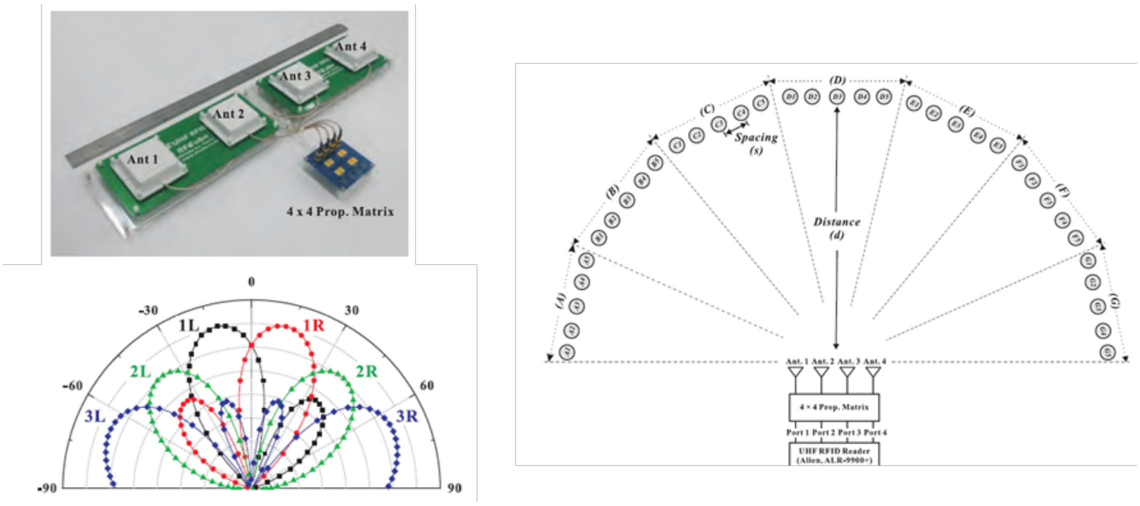
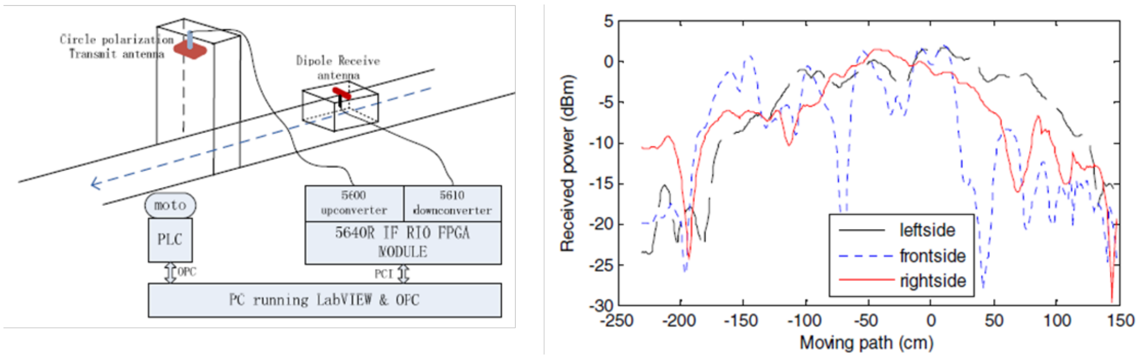


Fig. 8. Reconfigurable antenna array and simplistic diversity testing procedure, from [24]

UHF RFID portal

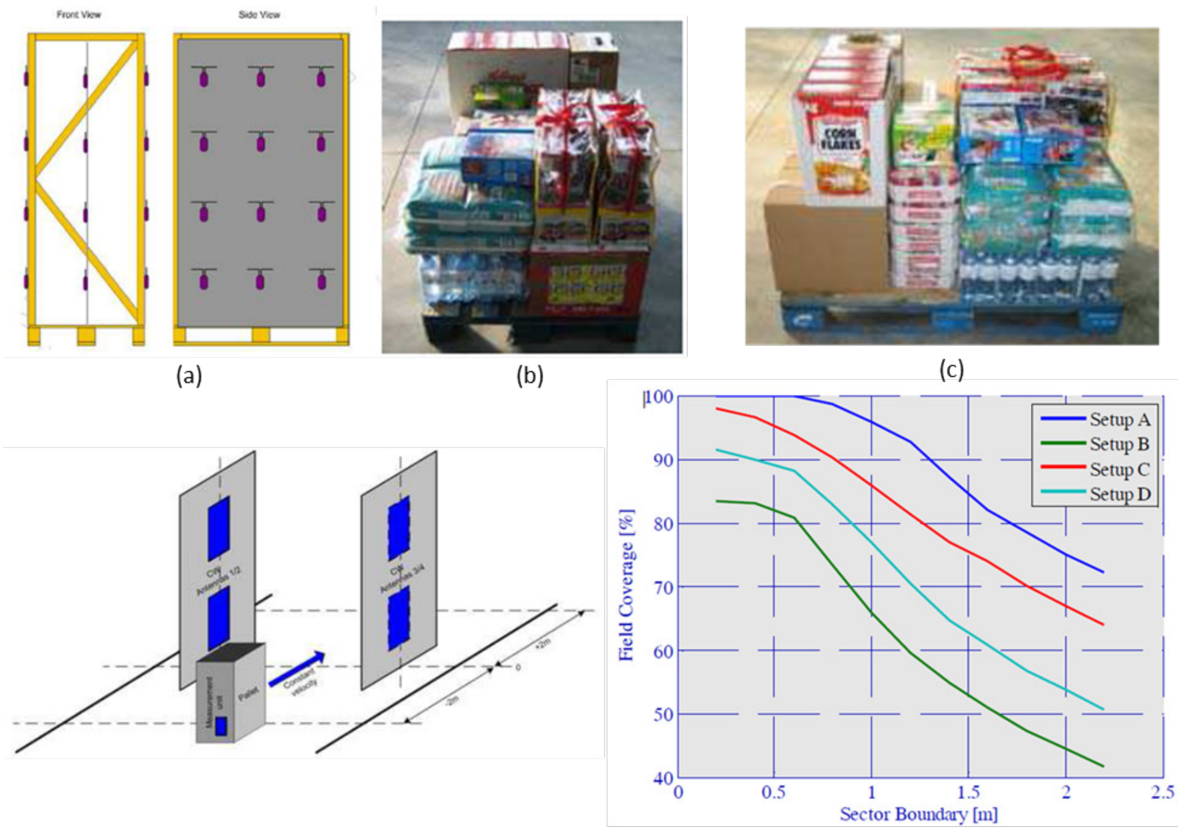
RFID portal applications are one of the most interesting case for industry. As said before, at UHF frequencies, reader-tag channel suffers from blind spots. Coverage simulations [20] and channel measurement have been carried out for empty portals [21] and with different pallet types moving through the portals [22]. These studies confirms the predicted deep fading (Fig. 9), along the pallet move. Coverage is the best at the center of the gate because antennas pattern have a dominant lobe toward this area.



(a) (b)

Fig. 9. UHF RFID portal coverage measurement (a) Experimental setup (b) Received power. Deep fading are observed according to tag position and location

In [23], the author presents a very complete study on this application case. Channel model is proposed from measurement data. The three missing reads causes are investigated: anti-collision algorithm, readability and field coverage. Fig. 10 shows variations up to 60% of field coverage according to pallet setup and pallet location. Anti-collision algorithm has an influence on read rate. Tag coupling or material properties affect tag sensitivity and causes a drop of readability in areas where field is normally sufficient [24]. But sensitivity improvement is insufficient in deep fading areas. As a consequence, field coverage is identified as the first problem to solve.



(a) (b) (c) (d) (e)

Fig. 10. Experimental setup of [23] (a) Setup A (b) Setup C (c) Setup D (d) Pallet and antenna locations (e) Measurement results. Field coverage is varying according to pallet setup. For one pallet setup, pallet location is the other influent parameter.

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