RFID Technology for Location Sensing

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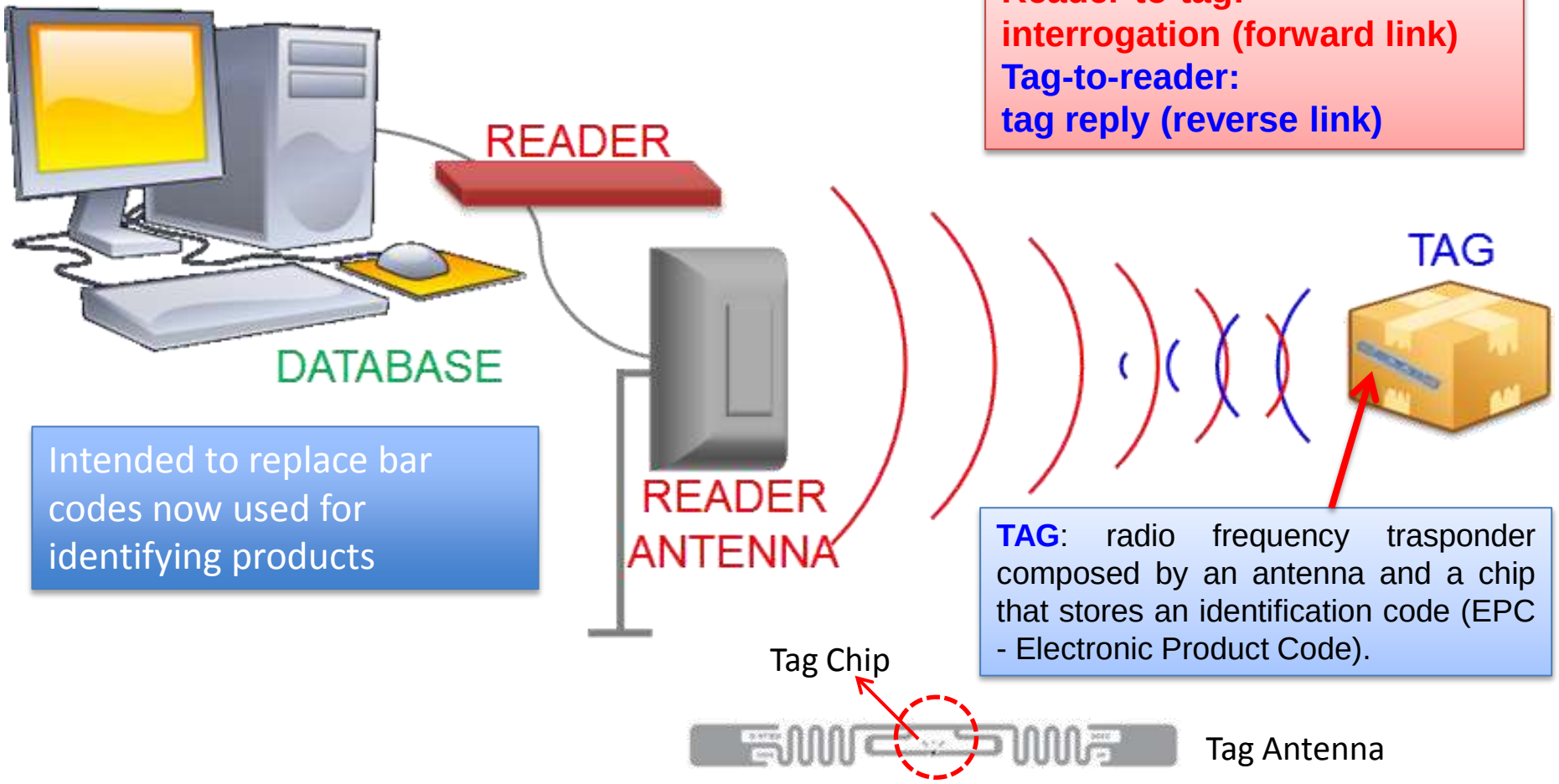
RFID - Radio Frequency IDentification

An automatic wireless Identification system



Reader-to-tag:
interrogation (forward link)
Tag-to-reader:
tag reply (reverse link)

Intended to replace bar codes now used for identifying products

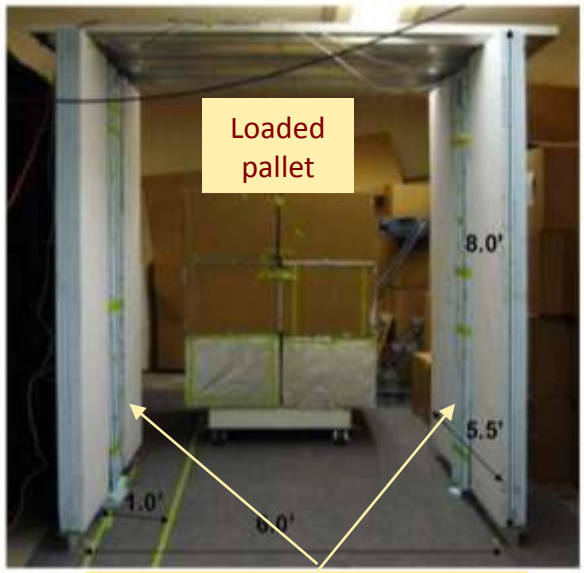
TAG: radio frequency trasponder composed by an antenna and a chip that stores an identification code (EPC - Electronic Product Code).

RFID Applications

Automotive industry

Logistics

www.vtt.fi



Two distributed reader antennas on each sidewall

http://www.barcodediscount.com

ID Cards

- Access control
- Logistics
- Documents/cards
- Manufacturing
- Automated inventory
- Anti-theft / Anti-counterfeiting
- Wireless pay systems
- Self chekout

Pharmaceuticals

RFID in Avionic Industry

Boeing 787 Dreamliner will have RFID tags on ~2000 critical parts

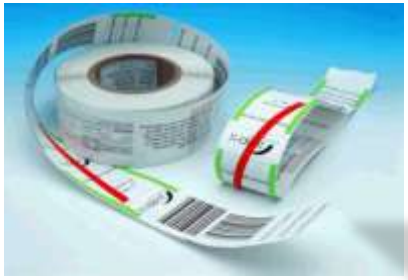
www.aviationnews.eu

Photo from Reuters,
See also article in Telegraph, UK. by Rowena Mason (09 Nov 2008)

- RFID for part tracking
  - Reduces time for:
    - Part identification and maintenance history
    - Locating spare parts
    - Service documentation
  - Prevents usage of counterfeit/used parts
  - Allows control of assembly procedures

RFID in Airports

- Passenger registration, passport control, passenger tracking
- Baggage and cargo tagging

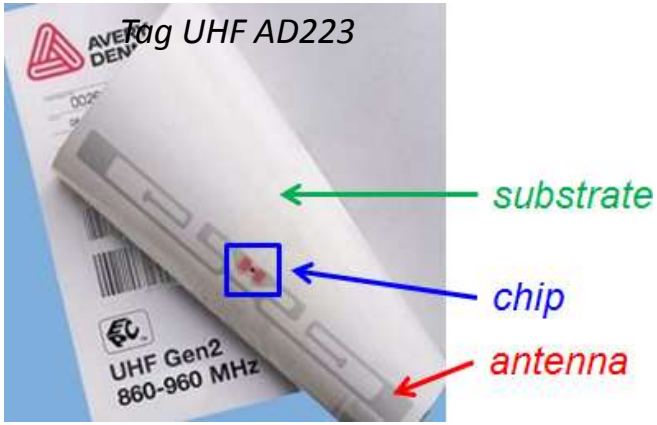


techfreep.com

www.tnooz.com

www.barryontheroad.com

UHF (865-928MHz)-RFID Passive Tags



Alien Squiggle ALN9640

96x9 mm²

Paperclip

20x8 mm²

Satellite

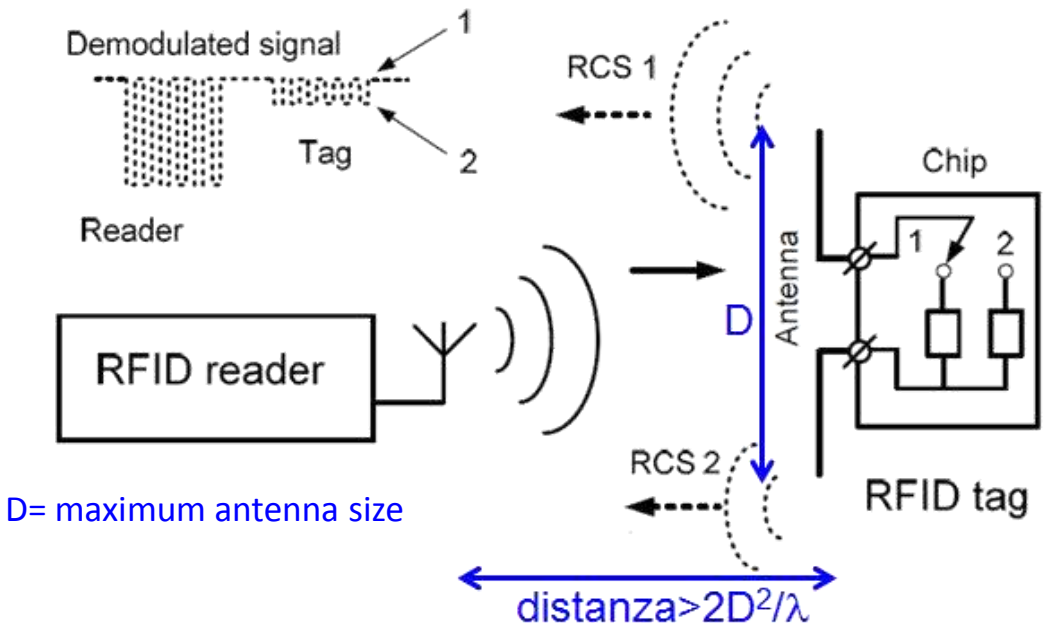
32x18 mm²

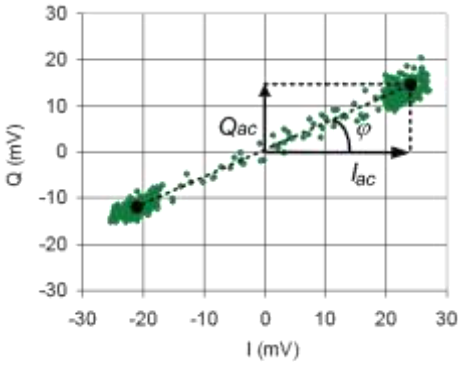
- Low cost (Inlay tags < 1 USD)
- Reading range ~2-5 m
- Data rate up to 640 kbps
- Multiple readings (100-200 tag/s)
- Low performance in presence of liquids, organic tissues, metals
- Tag readability affected by indoor multipath phenomena

(thick) platform tolerant tags

Tagged Item Location Sensing

Reader-tag communication occurs through electromagnetic propagation (or electromagnetic coupling, in UHF_RFID Near-Field systems) and modulated backscatter.





*Phase and amplitude of the backscattered signal embrace "**tag-location information**" (not only the identification code!)*

Tag Localization Applications

Hospitals

Warehouses

Retail stores

Libraries

Automatic payment

RFID-based Smart Drawer

RFID technology has been recently employed in pharmaceutical industries to get automatic real-time inventory and to avoid counterfeiting.

Pharmacy drawer applications

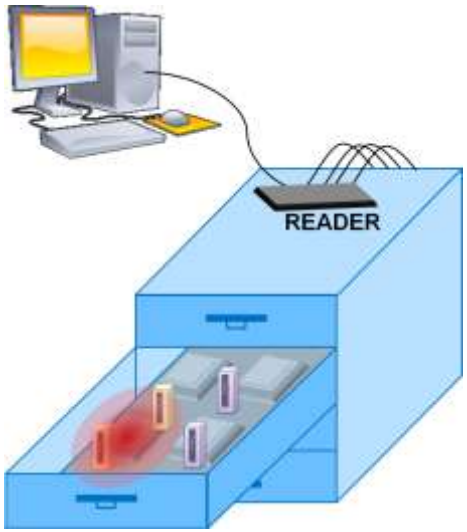
Smart drawer for drug monitoring

(http://www.mepsrealtime.com)

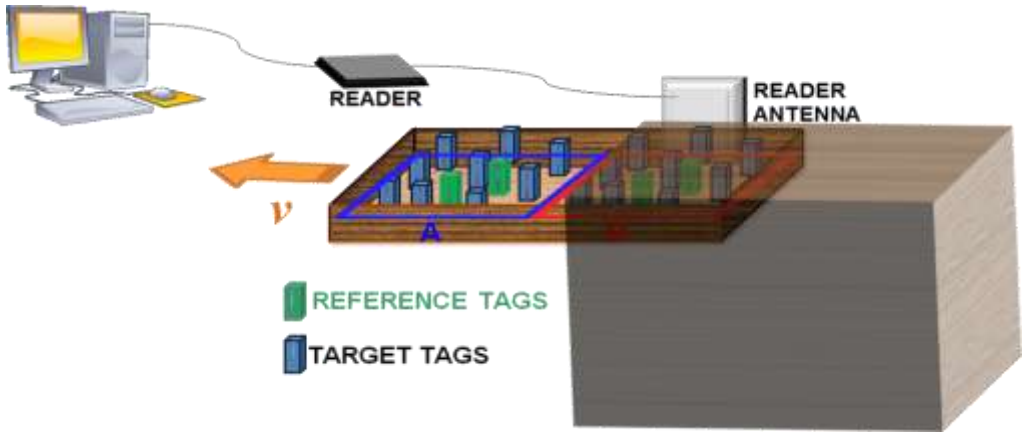
Localization of RFID tagged items can be useful to track misplaced items.

A Low-Cost Solution

Goal: tag classification within predefined regions inside the drawer.



A conventional approach requires a multi-antenna system

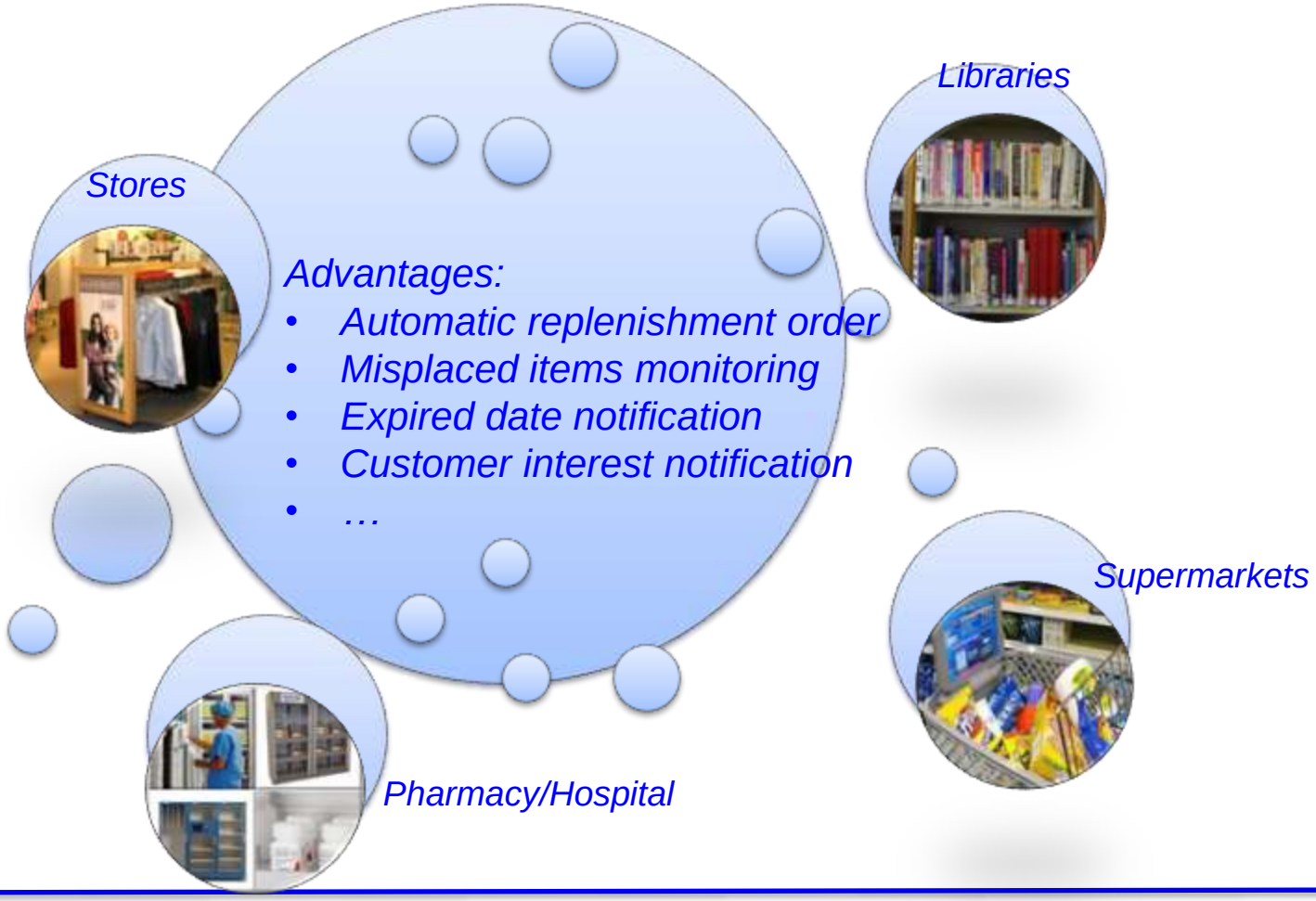


The proposed localization method exploits drawer opening/closing procedure; during such natural operations the relative position of tags and reader antenna changes, so allowing for **several RSS** (Received Signal Strength) measurements that can be exploited to determine tag belonging region (classification issue).

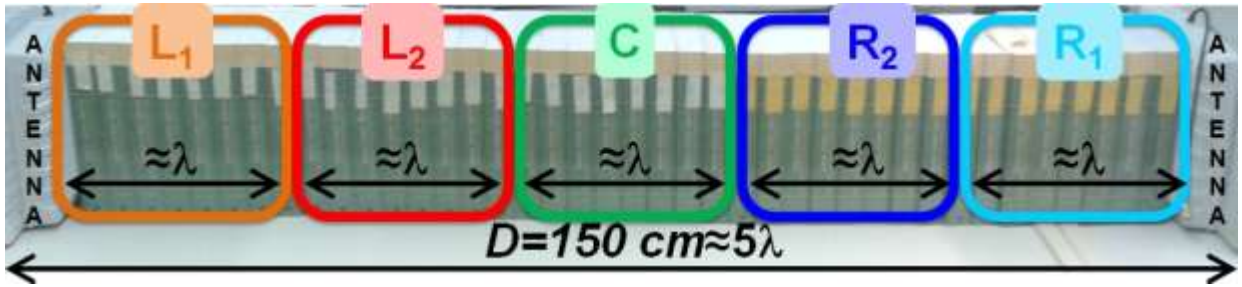
A. D'Alessandro, A. Buffi, P. Nepa, G. Isola,, "RFID-Based Smart Shelving Storage Systems", *2012 Asia-Pacific Microwave Conference Proceedings*, pp. 1019-1021, 4-7 December 2012.

RFID-based Smart Shelf

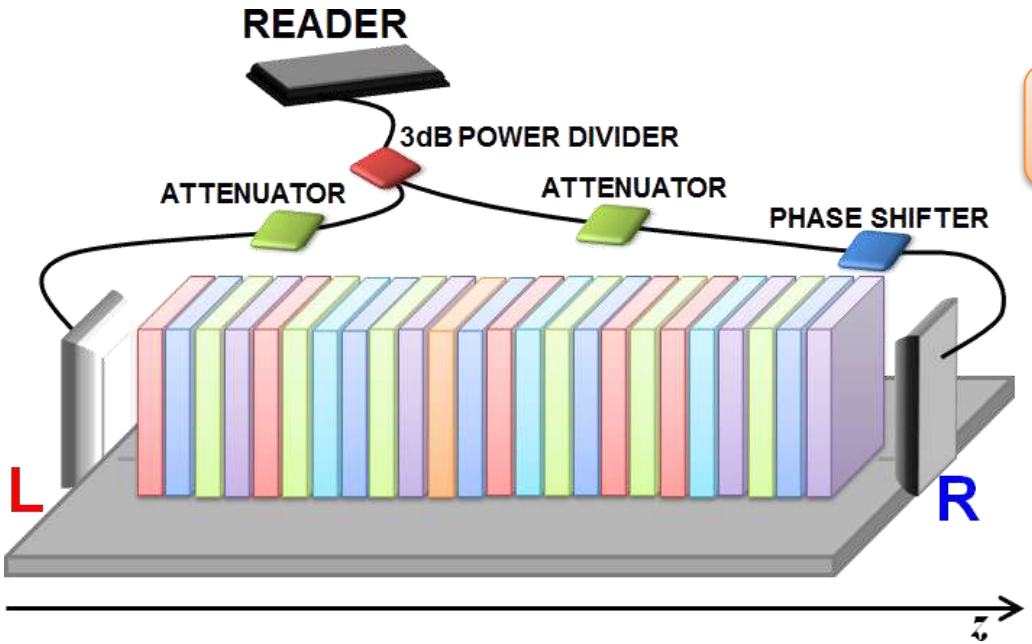
Shelf equipped with UHF-RFID reader and antennas, which allow to detect and identify tagged items, as well as to localize them.



RFID-based Smart Bookshelf



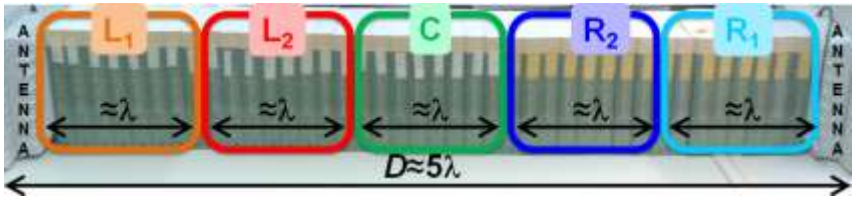
Example: Shelf of 150cm length and 40 tagged books



All of them are low-cost commercial devces !

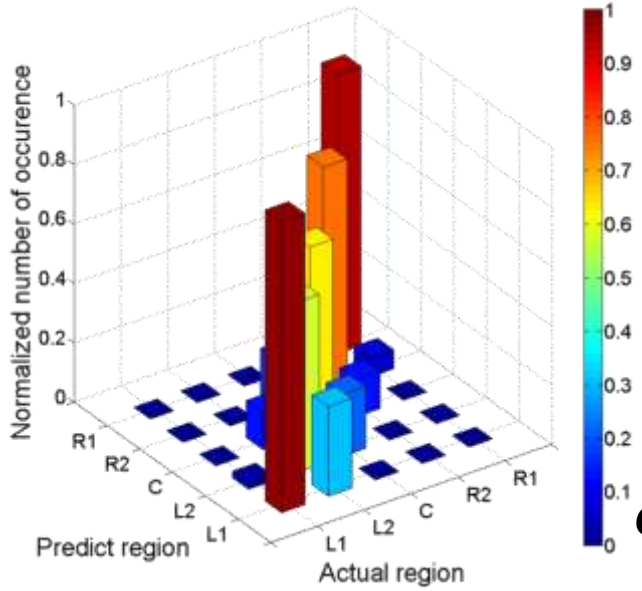
D'Alessandro, A. Buffi, P. Nepa, G. Isola, "A Localization Technique for Smart Bookshelves based on UHF-RFID Systems", *IEEE Antennas and Propagation Society International Symposium, 2013, APSURSI '13*, 7-13 July 2013

Measurement Results



- ***K-Means*** *classification algorithm*
- ***5*** *regions shelf*
- ***8*** *tags for each region*
- ***1*** *tag topology*

Alien ALN9640



Confusion Matrix

Predicted Region

Actual Region	% tags	L_1	L_2	C	R_1	R_2
	L_1	97.9	2.1	**0**	**0**	**0**
	L_2	30.2	57.3	12.5	**0**	**0**
	C	**0**	20.8	62.5	16.7	**0**
	R_1	**0**	**0**	12.5	76.1	11.4
	R_2	**0**	**0**	**0**	6.2	93.8

12 repeated tests

Overall Accuracy=78%

Conveyor Belt Applications

In conveyor belt applications, the correct management of tagged items allows to enhance the system productivity and efficiency: ***tag localization and sorting*** *are of interest.*

Express Couriers

Warehouse

Food Industry

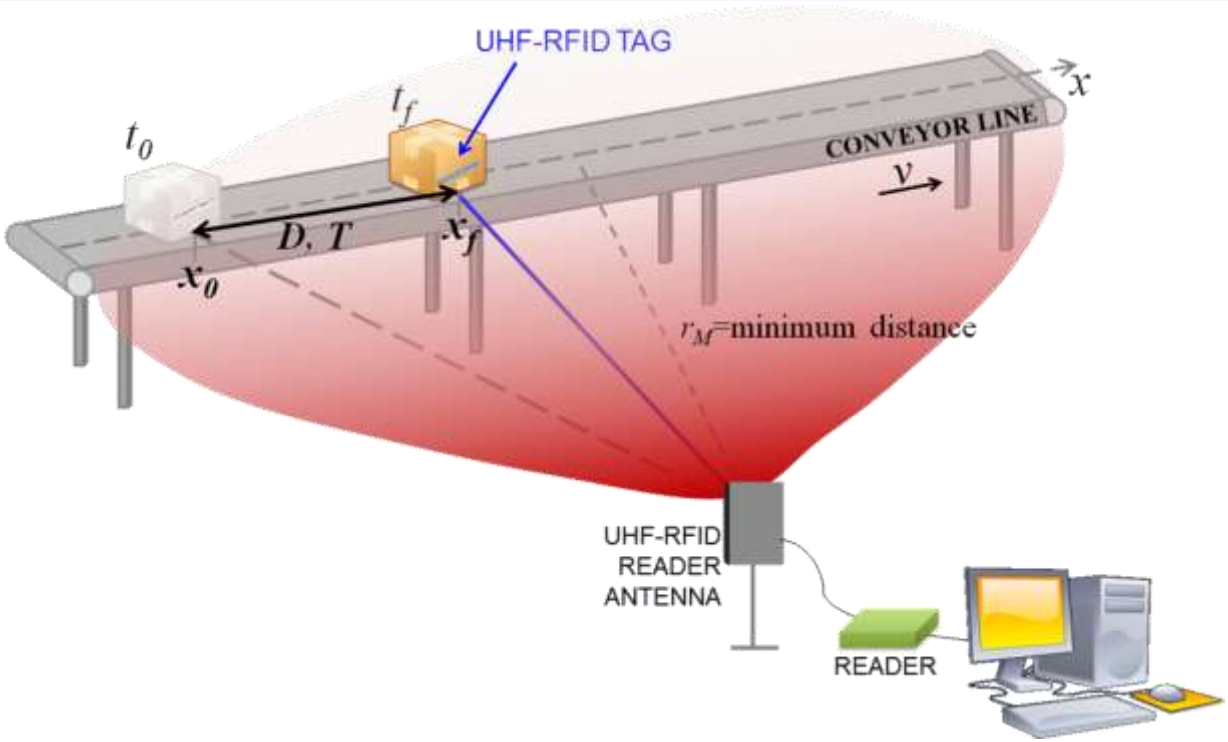
Airport

- *2007: 19 bags for 1000 passengers were being mishandled (SITA Baggage Report)*
- *2012: 9 bags for 1000 passengers were being mishandled (SITA Baggage Report)*

In 2012, 1% of worldwide baggage was still mishandled, costing around USD 2.58 billion.

A Phase-Based Technique

- **Phase-based:** the technique exploits phase data collected during tag movement along the conveyor belt
- **Knowledge-based:** the technique exploits *a priori* knowledge of belt path and speed



- **"Method for determing the location of a moving RFID tag"**
EU Patent Application EP12171018.0 / EP2533173, June 2011; IP: University of Pisa; Inventors, P. Nepa, F. Lombardini, and A. Buffi

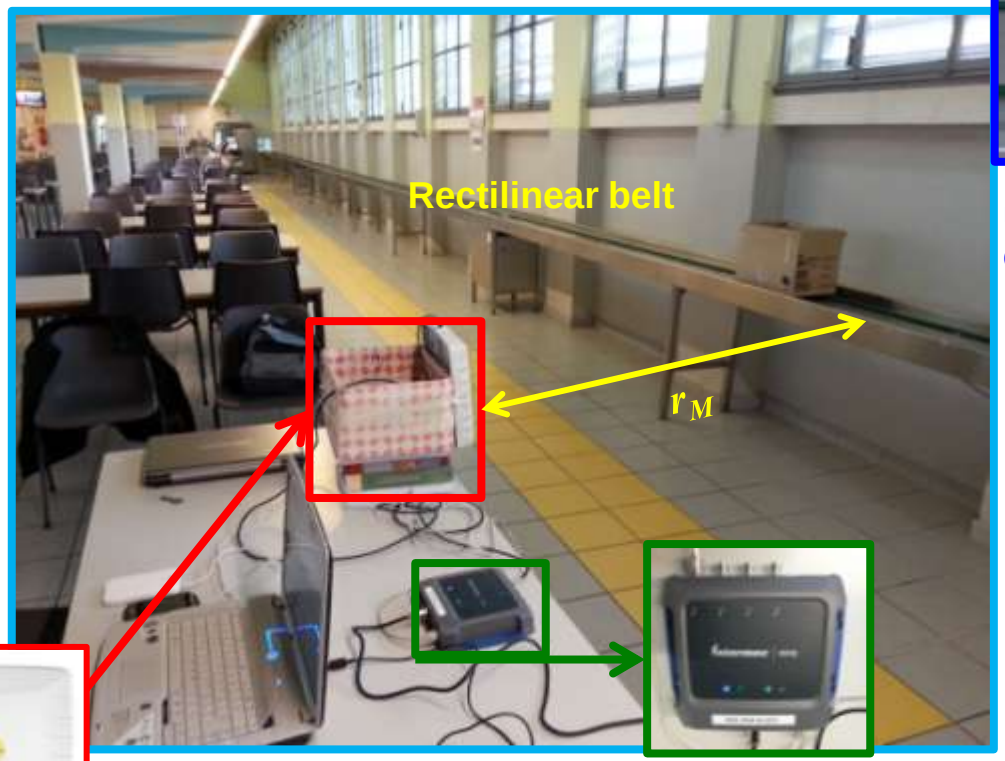
- P. Nepa, F. Lombardini, and A. Buffi, "Location and Tracking of UHF-RFID Tags", *IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications*, pp. 1062-1065, September 2011.
- P. Nepa, F. Lombardini, and A. Buffi, "Location and Tracking of Items Moving on a Conveyor Belt and Equipped with UHF-RFID Tags", *IEEE Antennas and Propagation Society International Symposium*, July 2012.
- A. Buffi, A. Baroni, P. Nepa, "Experimental Validation of Phase-Based Localization of UHF-RFID tags moving on a Conveyor Belt", *IEEE Antennas and Propagation Society International Symposium*, July 2013.

Measurements

Scenario and system parameters:

- *v=0.1 m/s (belt speed)*
- *r_M=2 m (antenna-belt minimum distance)*
- *f_0=866.2 MHz (CHANNEL 7)*

University restaurant
Via Cammeo, Pisa



UHF-RFID tags on cardboard box

Tag Alien ALN9640

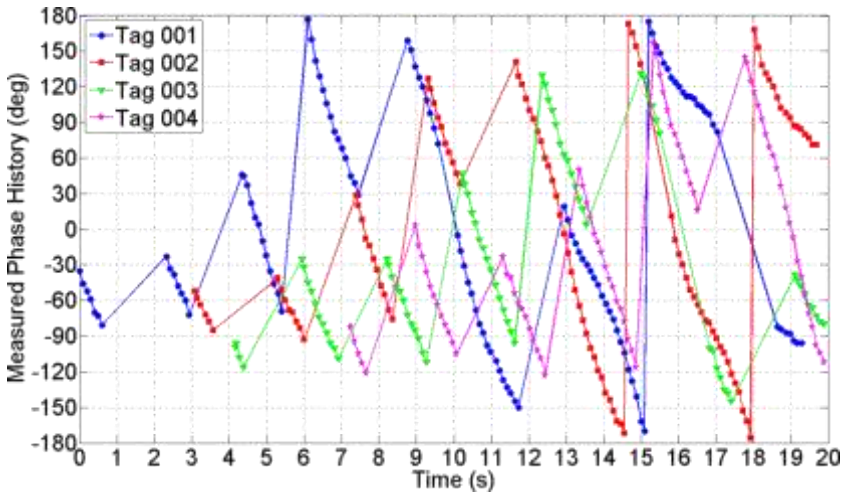
CAEN antenna

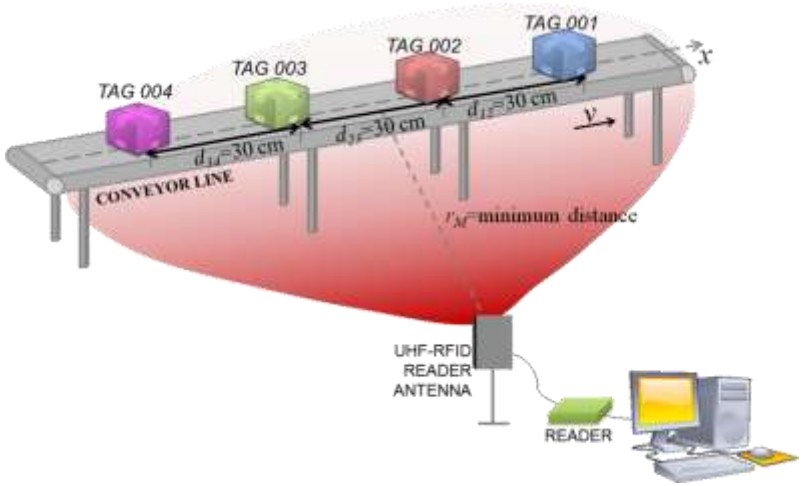
- Gain=7 dBi
- CP
- $HPBW_H$=67°
- $HPBW_V$=69°
- 25x25cm²

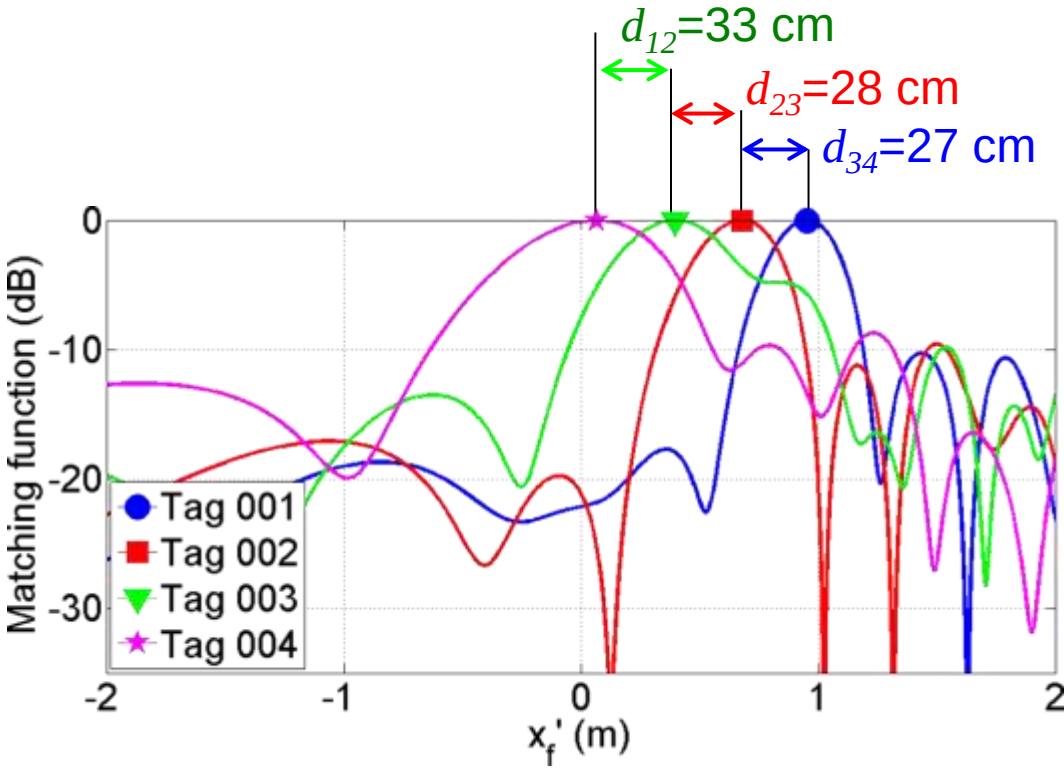
Reader Intermec IF2

- P_{IN}=200 mW
- IRT=100 ms (Interrogation Repetition Time)

Localization Accuracy







It is possible to simultaneously localize all the tags within the reader antenna beamwidth

Correct tag sorting

Application scenarios

Airport baggage handling system

Industrial laundry

*Any scenario **already equipped** with an automated conveyor/rail system!*

Automatic parcel routing

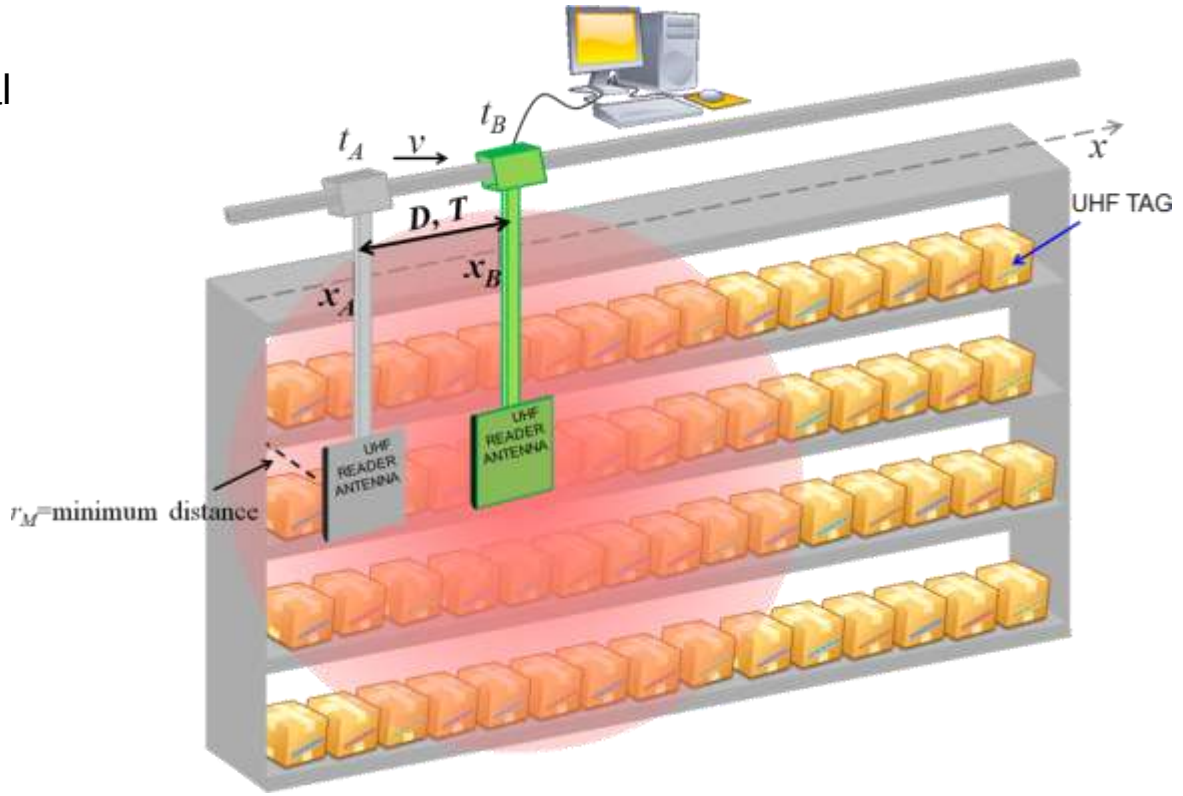
Tagged Item Localization in Warehouses

Item localization can be done also with a reader antenna shifting with respect to fixed tagged items (i.e. when the reader antenna is moving along a rail)

$T=t_B-t_A$=temporal observation interval

$D=x_B-x_A$=spatial observation interval

- Reader moves along a rail (speed $\underline{v}$ and path are known)
- Reader antenna starts to identify the tag at t_A
- At t_B, tag position is estimated



Application scenarios

Marble warehouse

Tyre storage

Cheese storage

Wine cellars

Any scenario where automated conveyor/rail system can be combined with an RFID system to get an accurate item localization (real-time automated inventory)

Acknowledgements

Project: **RFID SMART SHELF**
Fundings: CAEN RFID, Viareggio (LU)
PRSE 2007-2010 Linea d'intervento e POR CReO FESR 2007-2013 Linea d'intervento 1.3b – Aiuti alle PMI per l'acquisizione di servizi qualificati

Project: **OPERA – Advanced OPERAting Room**
Fundings: CAEN RFID, Viareggio (LU)
Regione Toscana Bando PAR FAS 2007-2013, Azione 1.1 PIR 1.1.B Promozione della Ricerca Industriale, del Trasferimento Tecnologico, dello Sviluppo Precompetitivo, Valorizzazione Ricerca e Innovazione

Project: **SARFID – A SAR approach to RFID tag location**
Fundings: Fondazione Cassa di Risparmio di Pisa
Avviso Luglio 2011 – Progetti di Ricerca Scientifica e Tecnologica
(Nov 2012-Nov. 2015)

Commissione Brevetti Università di Pisa
(co-finanziamento spese brevettuali: EU Patent Application EP12171018.0/EP2533173)