Keio University

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CALAMVS GLADIO FORTIOR

AUTO-ID LABS

Reader Performance Testing

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What do we mean by “testing”?

- **Performance measurement for certification.**
- **Comparative evaluation of commercial reader products.**
  - Packet error rate in fading environment
  - Reading (multiple tag reading) speed
- **Regular performance inspection during operation.**
  - Reader operation check
  - Interrogator area measurement

Characterization of Base Station (BS) performance in cellular phone can be a good reference.

Cellular phone BS performance spec. example:

3GPP TS 36.104 V8.4.0 (2008-12) T*echnical Specification :*

Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radiotransmission and reception (Release 8)

BS characteristics and BS performance

BS characteristics excerpts

- **Transmission characteristics**
  - Signal quality : frequency stability:
  - Adjacent channel leakage ratio (ACLR)
  - Spurious emission
  - Transmitter intermodulation:
- **Receiver characteristics**
  - Sensitivity
  - Blocking
  - Receiver intermodulation

Local radio regulation We need more for better performance?

This could be important to avoid interference.

BS performance

- **Performance requirements are defined by the throughput (packet loss rate) against the predefined fading channel.**

Number of RX antennas	Cyclic prefix	Propagation conditions (Annex B)	FRC (Annex A)	Fraction of maximum throughput	SNR [dB]
2	Normal	EPA 5Hz	A3-5	30%	-4.2
				70%	-0.4
			A4-6	70%	10.8
			A5-5	70%	18.3
		EVA 5Hz	A3-1	30%	-2.7
				70%	1.9
			A4-1	30%	4.3
				70%	11.4
			A5-1	70%	18.8
		EVA 70Hz	A3-5	30%	-4.1
				70%	0.1
			A4-6	30%	4.5
				70%	12.6

Minimum requirements for PUSCH, 10MHz channel bandwidth, p.45

Where do we define the performance at?

Cellular phone BS performance is defined at test port.

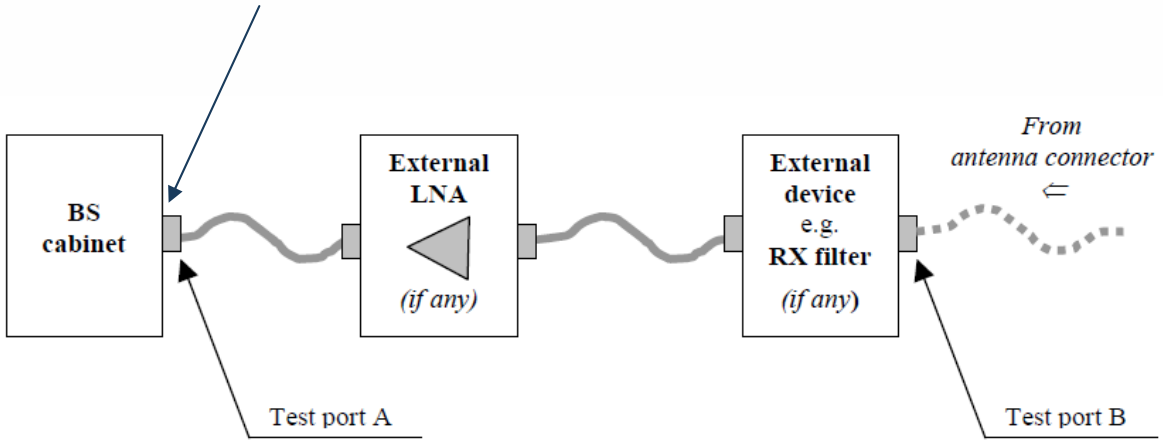
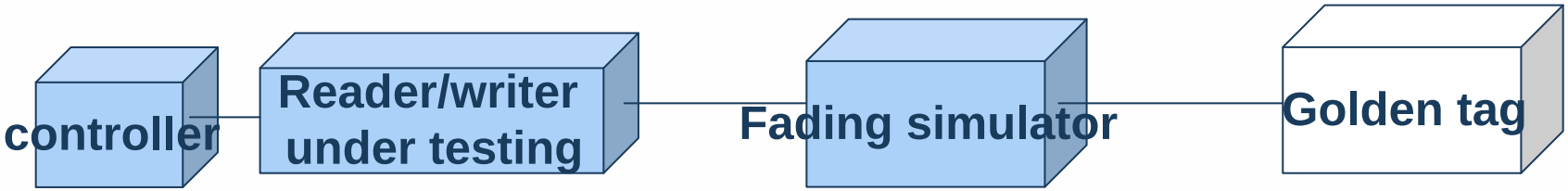


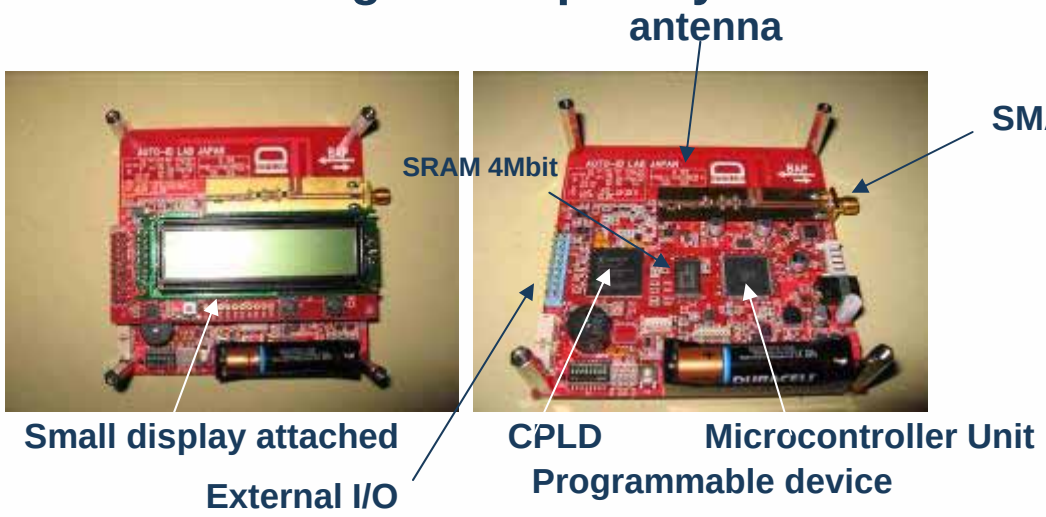
Figure 7.1: Receiver test ports

We'd like to have something like…



RFID system evaluation using a programmable tag

Programmable UHF Gen2 tag developed by Auto-ID Laboratory

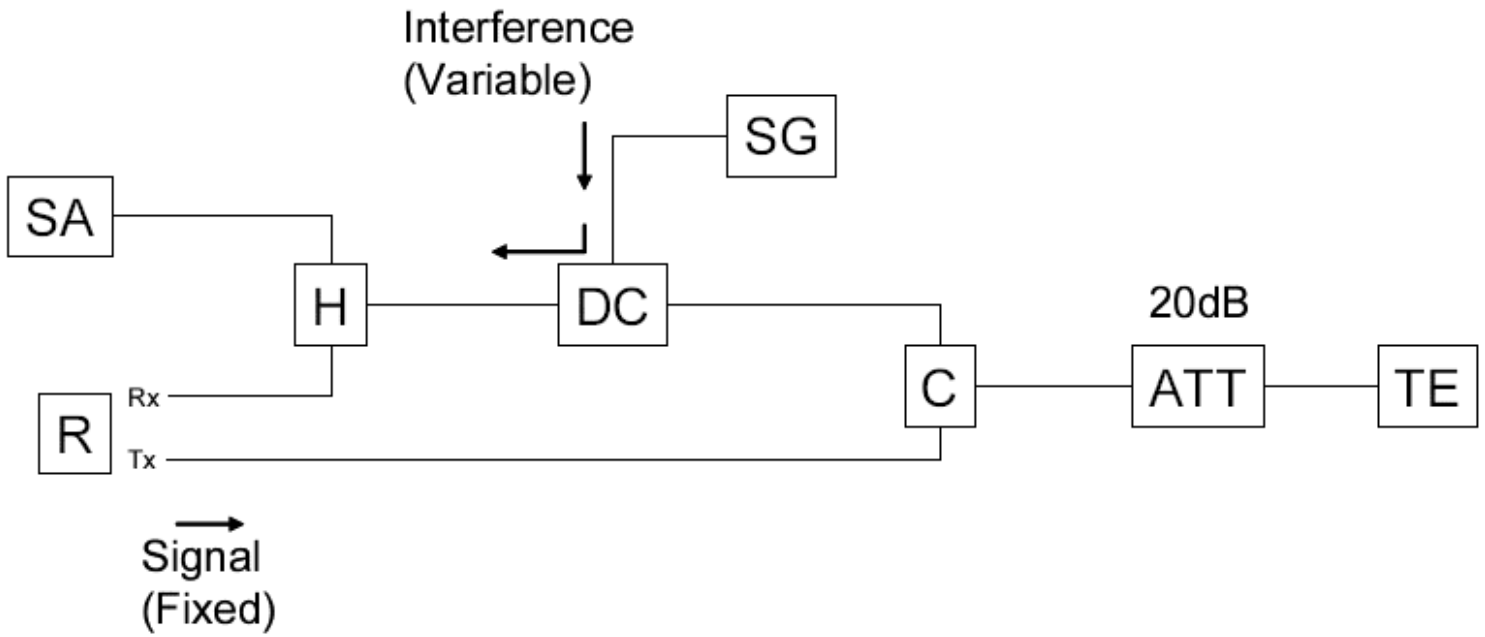


By changing the software in the microcontroller and the FPGA, the tag can

-evaluate the reading speed of interrogators (multiple RF tags emulator)
-evaluate the interrogation area of a portal
-analyze the peer interrogator command and protocol.
-measure the field power .

and a lot more if we write a software.

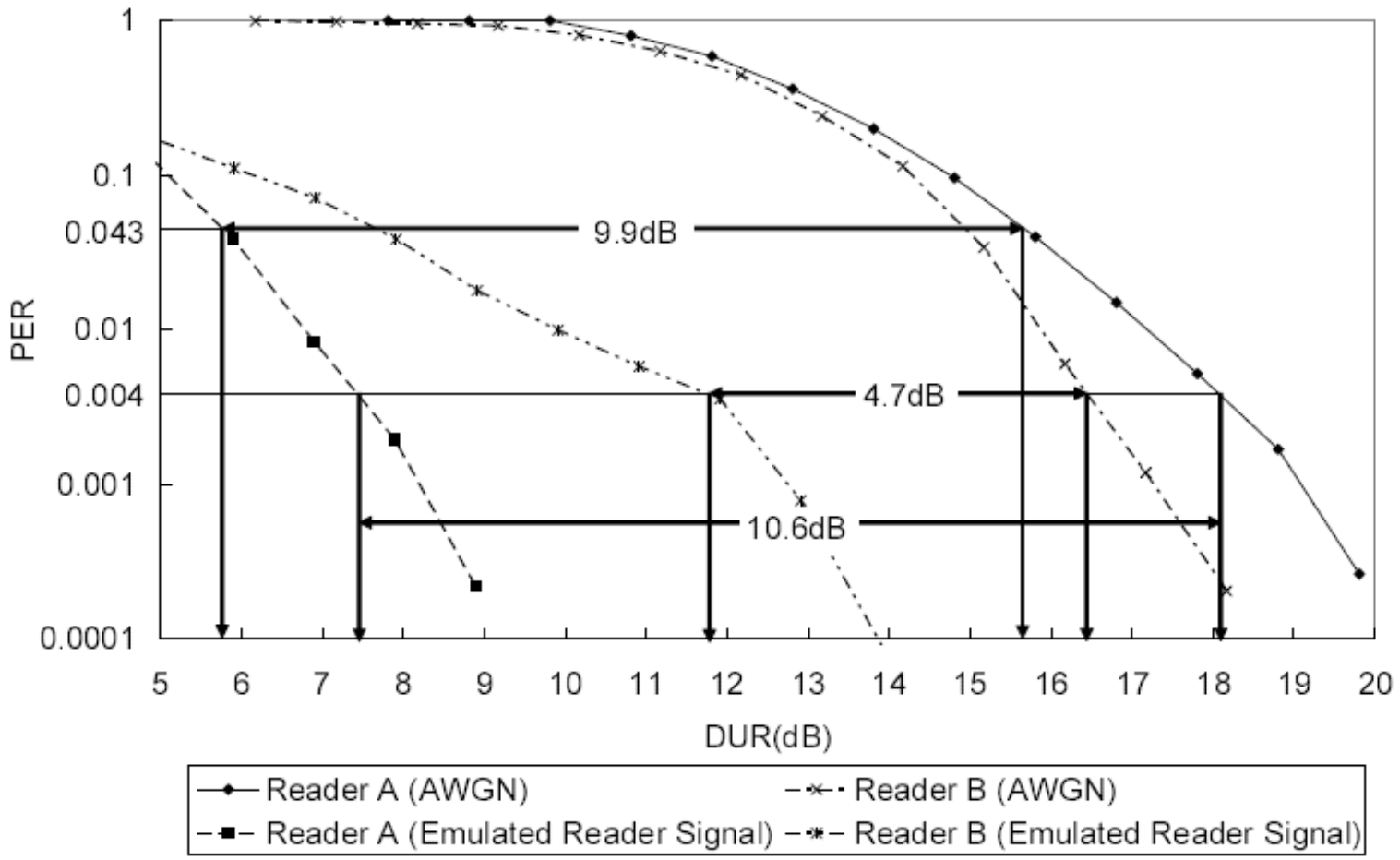
Packet error rate measurement



R: Reader
SG: Signal Generator
H: Hybrid Coupler
ATT: Attenuator

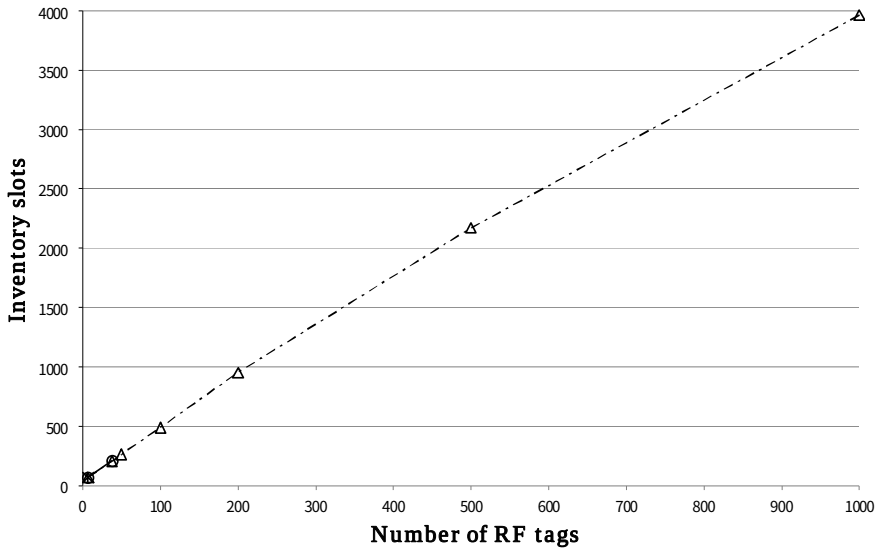
DC: Directional Coupler
SA: Spectrum Analyzer
C: Coupler
TE: Tag Emulator

Measured reader performance

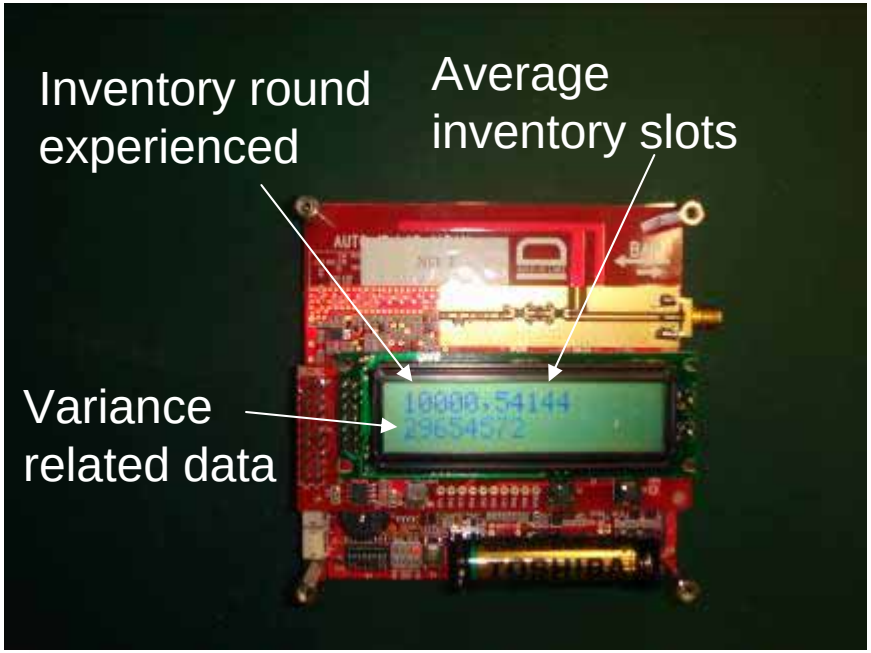


Multiple RF tags emulator

- **Features**
  - A novel mathematical treatment of the MAC behavior and sophisticated software implementations enable us to achieve more than 1,000 RF tags emulation with an 8bit micro-controller.

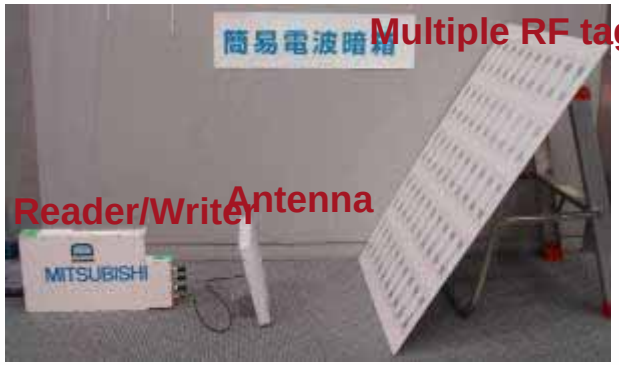


A measured inventory speed with a commercial interrogator

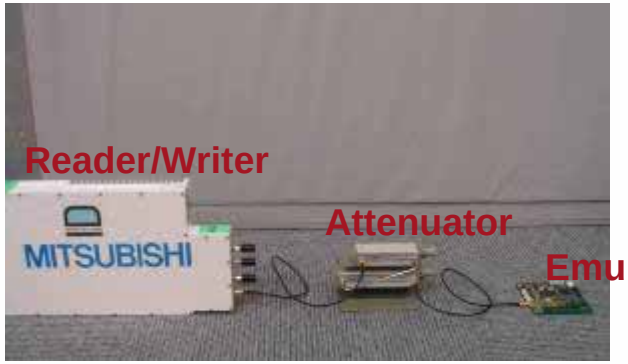


An emulator indicating the slot count and the its variance after 10000 times inventory iteration.

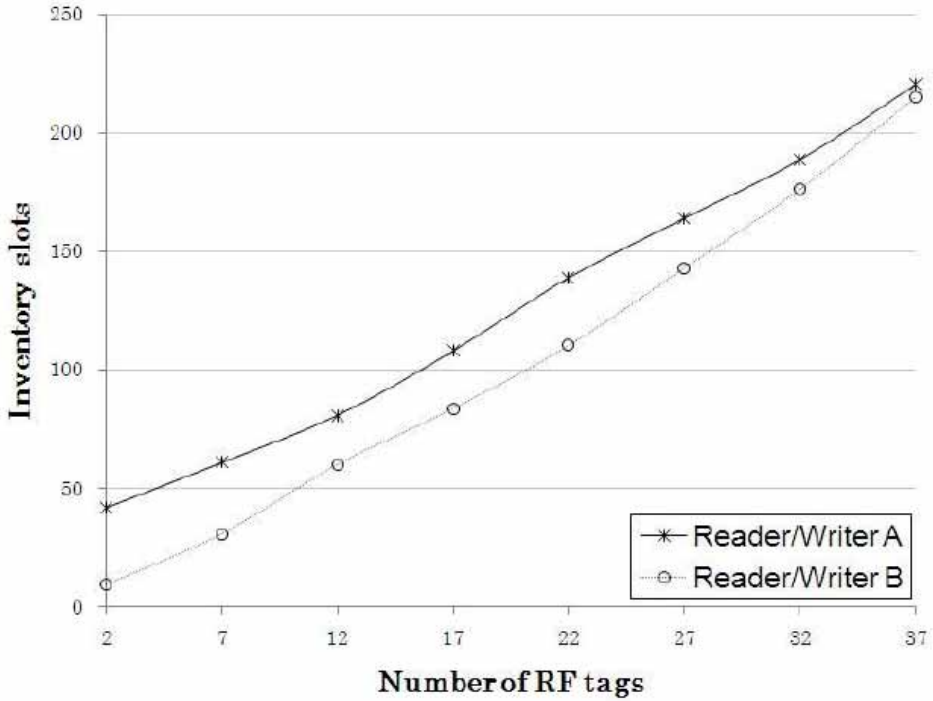
Illustrative usage of RF tags emulator interrogator reading speed evaluation



Conventional evaluation



new evaluation with emulator



Evaluation of two commercial interrogator reading speed with an emulator

Interrogator area measurement

- **Problem to solve**
  - The interrogation area of a UHF RFID depends on a number of factors thus is not predictable.
  - Un-intentional readings confuse the information system and applications.
  - Interrogation area measurement by an reader/writer may be inaccurate because of the filtering of the readings to reduce the traffic.

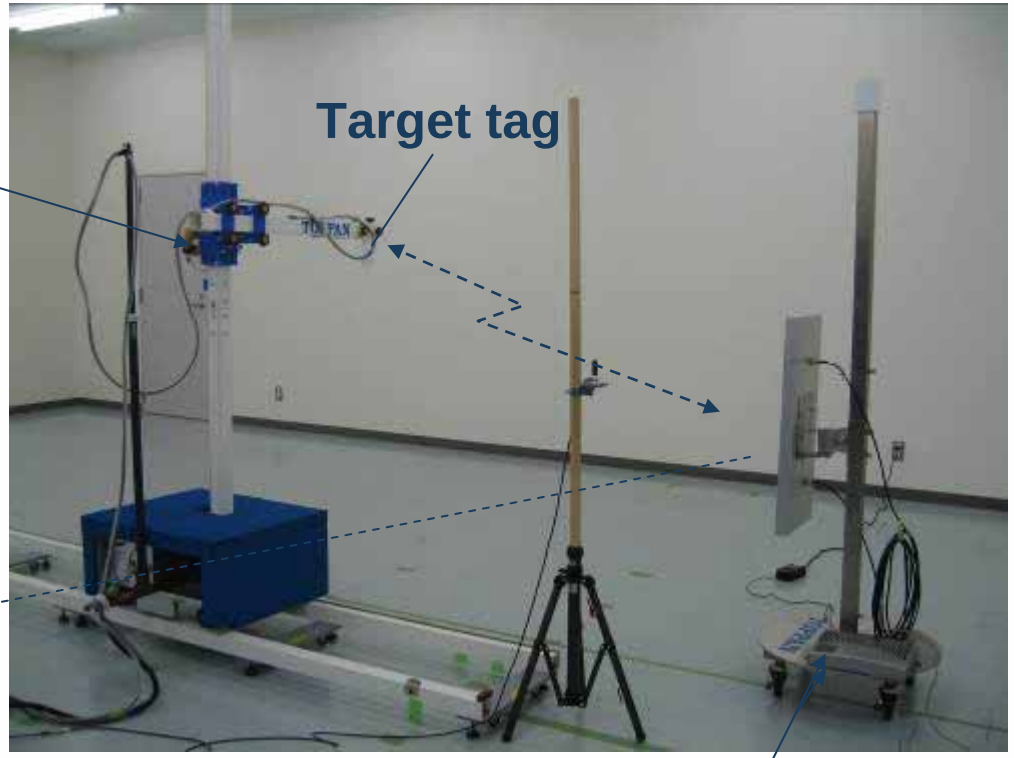
→Accurate and easy method to measure the interrogation area is needed.

Interrogation area measurement

2 dimensional positionor

Target tag

Battery assisted passive tag



Interrogator

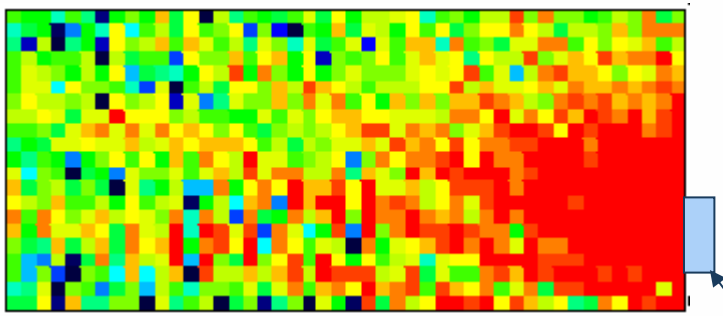
Detect the target tag read timings by analyzing series of the interrogator commands

Measurement results

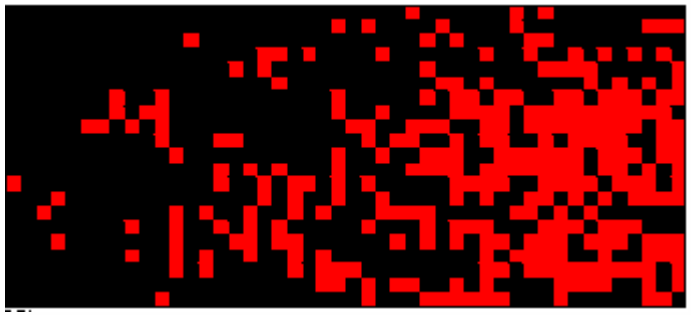
Signal strength at the position of the target tag

Interrogation area (red indicates readable)

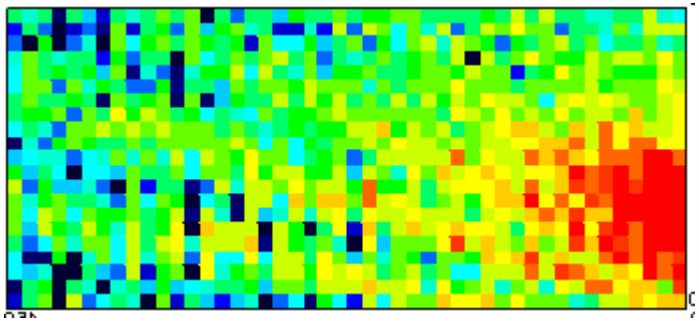
High power reading



Antenna



Low power reading



Strong co-relation between signal strength and tag reading

Summary

- **Sets of performance evaluation for**
  - conformance
  - commercial product selection
  - regular system inspection

  are important from the perspective of adopters.

- **A programmable passive tag is convenient for performance evaluation.**
  - What if we establish an open-source performance evaluation environment?

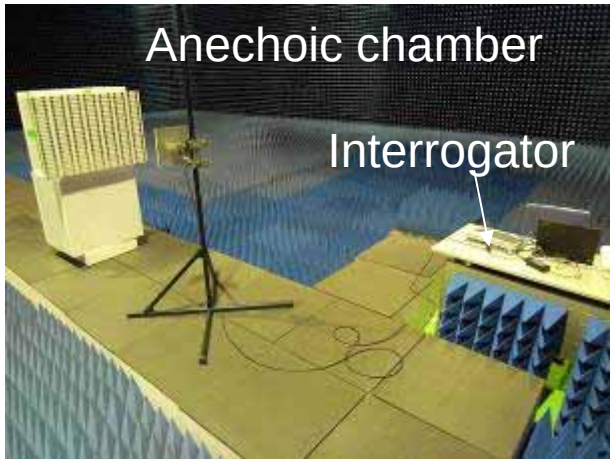
Advantages of the proposed method

- No dependency on the target tag and the target interrogator.
- Applied tags performance can be measured.
- Automatic repeated measurements.
- Interrogation area under an dense reader mode can be measured.

Background and research objective

- **Background**
  - In supply chain applications, especially with item level tagging, a number of tags are in the interrogation area. Reading speed is an important evaluation metric of interrogators.
  - The characterization of read rate in a portal is essential to evaluate the physical radio environment of the portal.
  - There are a number of novel fast reading MAC algorithms proposed. End users or adopters of the technology must conduct an physical reading measurement to evaluate the interrogator or the algorithm. The measurement might be deteriorated by the portal dependent radio environment.

RF tags



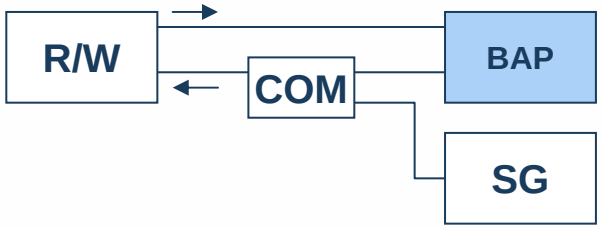
Objective
-Fair and easy evaluation of interrogator reading speed.
-Fair and easy evaluation of radio propagation characteristics of a portal
-Adjustable number of RF tags according to applications

→Multiple RF tags emulation algorithm and implementation to existing battery assisted passive tags.

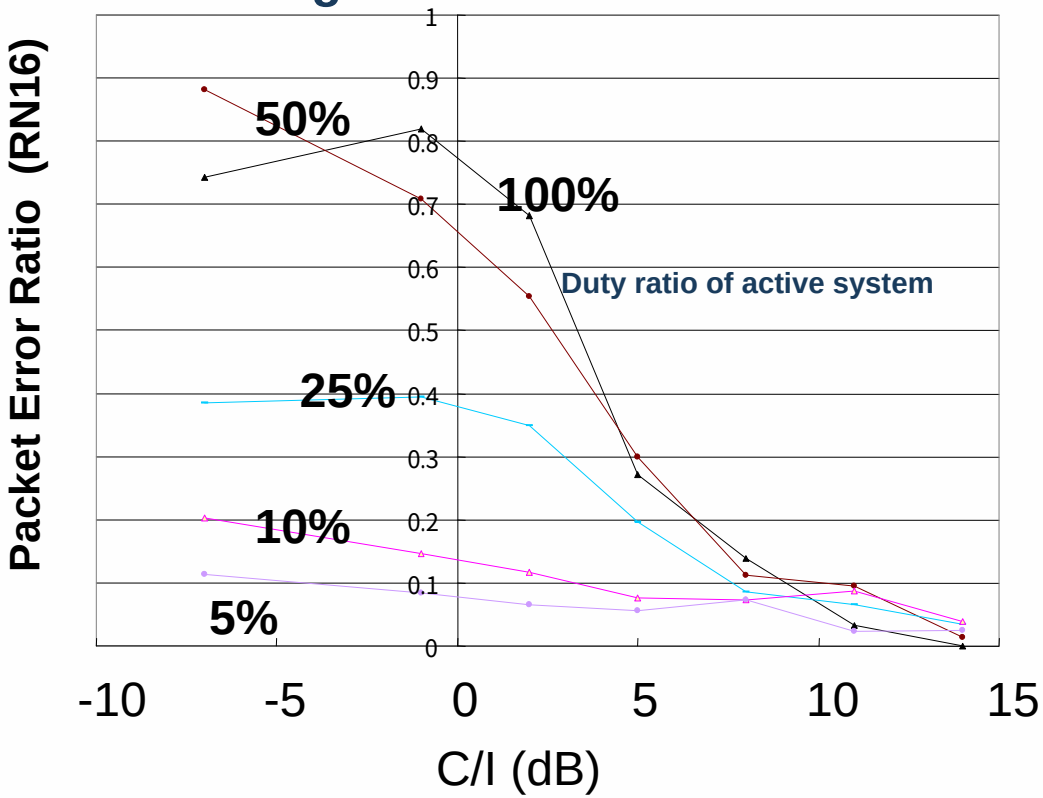
Conventional interrogator evaluation

Required CIR measurement for co-channel interference

53Byte@40kbps BPSK is generated in subcarrier channels by a Signal Generator (SG). A battery assisted passive tag works as the victim passive tag.



Packet loss of passive RFID due to active tag interference

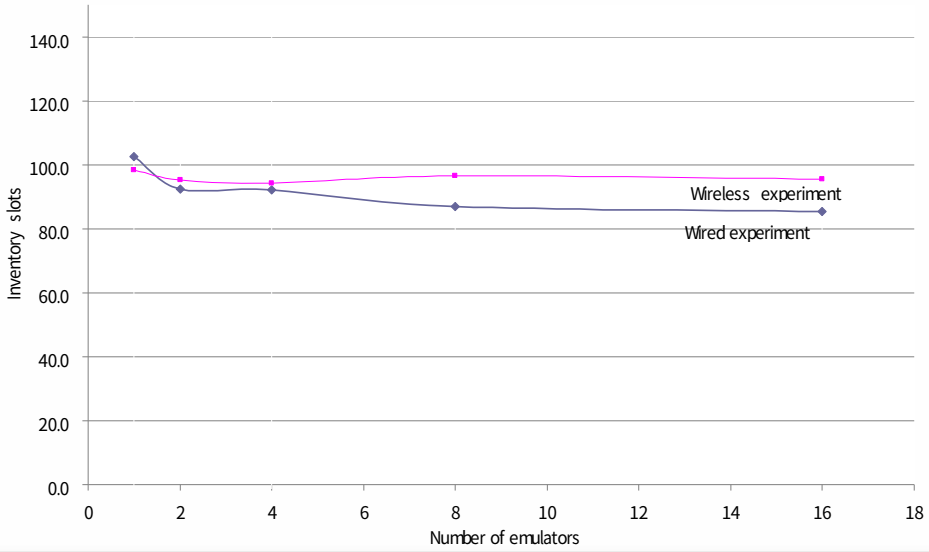


Short carrier sensing active RFID can share the frequency band with low duty ratio.

Multiple RF tags emulator(2)

parallel operation of 16 emulators (wireless communications)

parallel operation of 16 emulators (wired communications)



Emulators can be operated in parallel to represents a group of RF tags applied in different surfaces of the object.