Pervasive_RFID Executive Summary – IAC review 2016-11-29

Context and objectives

RFID is a key enabler for the IoT, pervasive computing and automation systems. In particular, UHF RFID can support applications requiring transparent data acquisition from many physical objects, an important feature for pervasive computing systems. This means that RFID tags data are often to be read in unfavorable conditions, instead of carefully controlled reading setup like in traditional RFID applications. In these situations, read error rate increase dramatically, and are often too challenging for current RFID systems. INRIA and IETR launched a joint effort supported by CominLabs to investigate these challenges: Pervasive_RFID. The project involves one INRIA research group, TACOMA, with a background in pervasive computing, and one IETR team with a strong expertise in antenna design and radio signal behaviour.

The main objectives of the project were (1) To identify and characterize the key challenges in terms of RFID radio design that affect application performance in uncontrolled situation, in particular for pervasive computing applications; and (2) to study solutions to overcome these challenges, or mitigate their impact, by experimenting explored approaches combining antenna diversity and data checking.

Project course

The project, planned for 18 months, started in July 2013. In addition to the permanent staff, two postdoctoral positions were opened (one at INRIA, one at IETR) and people recruited in july 2013 and October 2013. The initial phase of the project involved the design of a testbed in order to experiment the challenging reading conditions found in actual situations. In particular, the system has to be able to implement single and multi antenna reading, stationary and mobile reading, and support various ways of introducing radio diversity.

In parallel to the design of the testbed, we had two ongoing activities: on the radio side, a numerical model of the future testbed was developed, in order to explore the potential of reliability improvements that diversity would allow, in the context of dynamic protocols leveraging. A 4-elements diversity antenna was designed to allow dynamic reconfiguration of the radio conditions. On the software side, we developed a control environment for the testbed, and we worked on a new approach to improve RFID read reliability based on data distribution over a set of tags.

Unfortunately, the project ran into important difficulties beginning in 2014: the design of testbed was much more complex and time consuming than expected initially, and we decided to request the support of an external contractor[1] for the mechanical part (axles, and motion engines); administrative difficulties and albedo contamination in the building planned to host the testbed further delayed its deployment in an alternative place. Finally, one of the postdoc had to leave to project in September 2014. Overall, the project drift for about 6 months from its initial planning and the mechanical parts of the

[1] IVSYS with Rosier

[2] Olivier Roncière, Sylvain Collardey, Ronan Sauleau, Nebil Ben Mabrouk, Paul Couderc: Diversity contribution of a versatile UHF RFID antenna system in portal applications

testbed were effectively deployed in September 2014, and we started to integrate and test the control software in October 2014. The testbed began to be operational in early 2015, still with some aspects to complete (control software and diversity antenna).

Despite the testbed limitations at that time, initial experiments confirmed the potential of the application-driven diversity approach by taking advantage of movements. We also identified some unanticipated behavior of RFID tag in relatively common situations while experimenting on the testbed.

Achievements at IAC review

The project was reviewed by an IAC comitee in march 2015. At this time, the achievements were as follow :

- We showed the importance of diversity in the context of challenging RFID reading. A reconfigurable antenna was designed to support dynamic reading protocols[2].
- A software approach based on error correcting code was developed to support robust data storage in groups of RFID[3].
- An innovative RFID testbed for experimenting a large range of RFID situations/applications was operational (minus some features to be completed), supported by a simulation environment and a control environment.
- A patent was filed and some contacts made with RFID companies.

However, the support for implementing dynamic reading protocols were lacking, both on the software and the radio side, and our resources were exhausted. The IAC report was positive regarding the project and suggested extended funding.

Project extension

We requested additional resources to complete the testbed and facilitate the technological transfer potential of the project, which was granted by CominLabs. Overall, this allowed the project to run for 6 more months (Jan 2016-Jun 2016). Moreover, INRIA granted us an additional support for 2016, to help transforming the testbed into a more flexible tool and facilitate the valorization effort.

During this period, the following progress were made :

- The diversity antenna designed in first phase was implemented
- The control software has been greatly improved and offers a powerful and flexible python environment supporting easy programming of RFID reading scenarios.
- Motion-induced improvements of RFID reliability were experimented.
- A significant dissemination efforts toward the industry was made, and we have good hope that some of the contacts will lead to perspectives.

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[2] Olivier Roncière, Sylvain Collardey, Ronan Sauleau, Nebil Ben Mabrouk, Paul Couderc: Diversity contribution of a versatile UHF RFID antenna system in portal applications European Microwave Week : 2014

[3] Nebil Ben Mabrouk, Paul Couderc: EraRFID: Reliable RFID systems using erasure coding. IEEE International Conference on RFID 2015 : 2015

Conclusion and perspectives

First, we would like to stress that the initial objectives were highly speculative, targeting a problem usually considered very challenging. Without CominLabs, such a project would not have been possible. The people in the project belong to very different scientific communities (computer science and physics) and the explored approaches are unconventional, at least in the RFID domain to our knowledge. In spite of the risks and the difficulties, we think that the main goal was reached: smarter reading protocols combining diversity with distributed data checking can greatly improves the robustness of RFID in adverse conditions. Moreover, the testbed built in the project is a flexible tool for further researches.

An objective for us now is to build a new project with an industrial partner bringing actual challenging use cases around the foundations set up by Pervasive_RFID.