PhD thesis: Programmable wireless radio for long-life communications.

Olivier BERDER, Matthieu GAUTIER, Robin GERZAGUET
Univ Rennes, IRISA, GRANIT Team

1 Thesis Context

Software Defined Radio (SDR) is a wireless communication technology distinguished by its ability to define and manipulate radio parameters via software, rather than traditional electronic components. The concept was introduced in the early 1990s [Mit92]. Its advantages mainly lie in its flexibility, allowing for quick adaptation to changing communication needs (bandwidth, carrier frequency, signal processing tasks). SDR thus offers the possibility of improving its performance over time through software updates, making it an extremely scalable solution [MBGB22].

Within the framework of future communication standards, it is fundamental to ensure adaptability and long-term sustainability of deployed systems. The next generations of wireless standards will transition from static specifications of transceivers to end-to-end learning [AAH22], in order to adapt to their environment. This adaptability to the environment will enable regulators and industry stakeholders to propose systems that efficiently utilize radio frequency resources by reducing network congestion. A current obstacle is the ability of these networks to be remotely updated, and solutions involving the coupling of Software Defined Networks (SDNs) [KRV+15, CH] and SDRs allow for the envisioning of end-to-end reconfigurable networks, enabling the modification of services, referred to as intra-generation evolution, or even fundamentally evolving the standard [KVVK], inter-generation evolution.

These fully programmable wireless networks must allow for ultimate flexibility with the reconfiguration of the protocol stack at runtime for the deployment of all future wireless technologies on the same infrastructure. This is the objective of the collaborative project PERENNE, within which this thesis is situated.

2 Thesis Objectives

The objective of this thesis is to leverage the *Software-defined* paradigm (i.e., SDN and SDR [CSR]) and focus on the design of a programmable, scalable radio system that is aware of its environment and energy consumption. More specifically, the doctoral researcher will work on the following tasks:

- Low-power programmable radio: propose a software radio architecture with embedded software computing resources (or mixed, including hardware computing accelerators) and the associated prototyping flow. This architecture should be flexible to explore the trade-off between energy consumption, computing capacity, and programmability. The choice will be made from state-of-the-art SDRs (such as ADALM-Pluto, E310, ...) or a specific architecture (e.g., combining Raspberry Pi and radio front-end). A parametric modeling of this architecture will enable optimization for intra- and inter-generation evolutions of standards based on resources.
- Intelligent SDR: implement algorithms and protocols so that the device can analyze its environment and have control communication with the SDN. The analysis covers both device properties (hardware/software resources, number of antennas, energy management, ...) and propagation aspects (interference levels, available bands, ...). The control protocol should be reliable and relies either on existing resources or a dedicated channel.
- Practical implementation of these evolutions: through a simple case study (for example, the evolution from IEEE 802.15.4 to IEEE 802.11), mechanisms for remote reprogramming of the device must be established. Authentication, operational safety checks, and maintenance verifications must be in place to ensure the longevity of the device.

All of these axes are part of the collaborative project PERENNE and will be subject to discussions and cross-collaborations throughout the duration of the thesis.

3 Skills

Holder of a master's degree or an engineering degree, you have excellent skills in embedded systems, Linux, digital signal processing, and telecommunications. You have a strong interest in research and know how to conduct scientific research.

4 Information and Contacts

The thesis is carried out in the GRANIT team at the IRISA laboratory.

Olivier BERDER	olivier.berder@irisa.fr
Matthieu GAUTIER	matthieu.gautier@irisa.fr
Robin GERZAGUET	robin.gerzaguet@irisa.fr

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