IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

PhD Candidate Position

Title: Programmable Wireless Protocol Stack

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Keywords: Programmable Protocol Stack, Internet of Things (IoT)

Scientific context:

The networking research community started to investigate rather flexible network architectures enabling remote administration of the forwarding plane of switches or routers [1]. Those research efforts gave birth to Software Defined Networking (SDN) [2] in which the network intelligence is removed from network devices (e.g., routers and switches) to be centralized in a remote controller. The main idea of SDN is to disassociate the data plane (the actual forwarding process of network data packets) from the control plane (how to configure the data plane). Thanks to its complete view of the network, the controller can make optimal decisions on traffic forwarding. However, SDN is mainly deployed in core networks and will only unleash its full potential if the programmable data plane is extended beyond the mobile core and supports all underlying wireless elements, including user equipment. Moreover, these wireless elements are usually implemented by specific hardware and software resources dedicated to each wireless protocol.

In 1993, Mitola [3] introduced the paradigm of Software Defined Radio (SDR) to pave the way for flexible physical layer capable to target multiple bands. Mitola proposed a fully reconfigurable architecture that combines an analog part able to cover multiple frequencies and multiple bands and software means to implement the physical layer processing. Yet, SDR will unleash its full potential if it can be plugged to SDN network. In another perspective, it is envisioned that next generations of wireless standards will shift from static transceiver specifications towards end-to-end learning [4], to adapt to their environment. Indeed, adaptability to the environment would allow both regulators and industrials to propose systems making efficient use of the radiofrequency resources by lowering network congestion, noting that allocations of frequency bands for new services get more and more challenging. Such a paradigm requires flexibility on all layers of the communication stack, from the physical layer to the application one.

Objectives

The objective of this thesis is to leverage the software-defined paradigm (i.e., SDN and SDR) to make wireless networks fully programmable, enabling ultimate flexibility, from the reconfiguration of the protocol suite at runtime to the deployment of any future wireless technologies on the same infrastructure. More specifically, the PhD student will work on the following tasks:

1. Programmable Frame Processing Pipeline:

The controller should have full control of the in-node networking data paths, from frame parsing to the forwarding logic. The first task is to compare programmable match-action pipelines, lightweight virtual machine models (both programmed with P4 and Extended Berkeley Packet Filter (eBPF)), and interpretable bytecodes based on XFSM to select the best solution for wireless networking. Then, to extend the adopted solution to enable runtime reconfigurations.

2. Programmable Wireless NIC:

The physical wireless interface of nodes is an RF front-end where most of the signal processing is performed in software. The objective is to design a virtual wireless driver with extended feature sets to give full control of the transmit and receive chains to the SDN controller. This virtual driver exposes interfaces to enable communication with the programmable frame processing pipeline as a legacy network device driver.

Requirements:

- Good programming skills, in C language in particular, and embedded software development;
- Good knowledge of operating systems and system programming (the Linux kernel in particular);
- Wireless networks (protocols and radio propagation), energy efficiency.

Remark: This PhD thesis is funded in the context of the ANR PERENNE research project, and could start as early as September 2024.

Gratification:

2024:

- Annual gross salary: 27 000 €
- Estimated net monthly salary: 1 808 €

2025:

- Annual gross salary: 30 000 €
- Estimated net monthly salary: 2 009 €

2026 and 2027:

- Annual gross salary: 31 200 €
- Estimated net monthly salary: 2 089 €

Location:
IMT Atlantique, Campus of Rennes - 2, rue de la Châtaigneraie, 35576 Cesson Sévigné Cedex

Application:
Please send an email to Georgios Z. Papadopoulos <georgios.papadopoulos@imt-atlantique.fr>, Julien Montavont <montavont@unistra.fr> and Guillaume Le Gall <guillaume.legall@univ-rennes.fr>, with:

- A short paragraph with the reason why you are interested in this PhD candidate position;
- A CV;
- The link to a code repository with some software you have already produced or contributed to, if any;
- The link to, or a copy of, the resesearch papers you have already produced, if any.

References

1. N. McKeown, et al. OpenFlow: enabling innovation in campus networks. ACM SIGCOMM Computer Communication Review, 38(2), 2008.
2. D. Kreutz, F.M.V. Ramos, P.E. Verissimo, C.E. Rothenberg, S. Azodolmolky, and S. Uhlig. Software-defined networking: A comprehensive survey. Proceedings of the IEEE, 103(1), 2015.
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4. F. Ait Aoudia and J. Hoydis. End-to-End Learning for OFDM: From Neural Receivers to Pilotless Communi- cation. IEEE Transactions on Wireless Communications, 21(2), 2022.