# A Learning-based Cross-layer Opportunistic Approach for Tactical Communications

## PhD thesis proposed by the Safran Saint-Cyr chair

## Context

The subject of the thesis is rooted in both the field of opportunistic communications in mobile ad hoc networks and the field of mobile cognitive radio network (MCRN).

Without a fixed infrastructure network, mobility and the limited range of radios do not always allow for a complete mesh of the network, which causes the network to be fragmented into islands of connectivity. The opportunist approach consists in leveraging nodes mobility to carry and deliver messages through a fragmented mobile ad hoc network [1].

A cognitive radio [2] is a device able to adapt and optimize its signal depending on its environment. This adaptation capability relies on machine-learning techniques from the field of artificial intelligence. Some research works have already explored cross-layer approaches in MCRNs [3].

Military tactical communications enable the transmission of orders and alerts, blue force tracking, or even the collection of data from sensors. These ad hoc communications do not rely on usual infrastructures and could benefit from opportunistic networking techniques [4], since the links between units could be disrupted. In addition, field radiocommunications are constrained by the state of the radio spectrum. Communication channels can be occupied by primary users, or be the target of jamming attacks. Cognitive radios can provide more agility at the tactical network physical layer level.

The proposed PhD subject aims at addressing the following dual issue : enable information sharing between units in a fragmented network, while adapting to the constraints of the radio spectrum.

## Objectives

The main objective of this PhD thesis is to propose an implementation of opportunistic communication mechanisms in a mobile cognitive radio network, regarding both frequency bands access and peer selection enabled by nodes mobility. The work carried out during this thesis will be applied to tactical communications, and more particularly the transmission of orders and data at the infantry section level.

The first step will draw an overview of research works related to the fields of cognitive radios, opportunistic networks, and their intersection.

Then the PhD candidate will study and implement learning algorithms to optimize data transmission both at the radio link level and at the forwarding strategy level. The proposed approaches will be evaluated by experimenting both on actual networks and on simulated environments. Results will be published in international conferences and journals.

These works will be supported by the tools provided by team CASA : opportunistic communication middleware and LEPTON emulation platform ; and by the expertise and software radios provided by team CoSyDe.

This thesis will have to address several challenges, including :

- taking into account the constraints related to communication channel access that add up to the ones related to the mobility and range of nodes, in the data transmission process ;
- assessing the effectiveness of cognitive radios against channel interference ;
- getting or building datasets of mobility scenarios for experimentation purposes.

In addition to these objectives, investigation could be extended to cybersecurity issues that arise in distributed systems over fragmented networks.

## Safran Saint-Cyr Chair

The chair on « *The augmented soldier in the digitalized battlefield* » in partnership with Safran Electronics & Defense was created in 2017 at the Saint-Cyr Coetquidan Research Institute (CREC). The chair proposes to investigate several research direction at the *Félin* infantry section level. The thesis proposed in this document targets the « collaborative » line of the chair.

## Profile

Are eligible to this PhD offer European Union citizens holding a master degree, preferably in the field of telecommunications (in computer science or in electronics), or even in artificial intelligence.

Skills in one (or more) of the fields related to the subject of this thesis are recommended, e.g., in wireless networks or software radios. Knowledge in the field of AI would be an asset.

## Practical details

The PhD student will have to register to MathSTIC doctoral school and will be employed by Safran - Saint-Cyr chair (3-year contract, net remuneration of € 1900 per month).

**Workplace :** CASA team from IRISA lab at UBS (Université of South Brittany) located in Vannes. Days at CREC (Saint-Cyr Coetquidan Research Center) in Guer (Morbihan) should be expected.

**Supervision :** the thesis will be directed by Frédéric Guidec and supervised by Lionel Touseau (IRISA, CASA team) and Jérôme Le Masson (Lab-STICC, CoSyDe team).

**Contacts :** questions regarding further information and applications should be sent to :

Lionel Touseau <lionel.touseau@st-cyr.terre-net.defense.gouv.fr>

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Documents to be provided :

- resume,
- cover letter,
- transcript and master degree if already obtained,
- recommendation letters from the internship tutor.

Successful applications will be interviewed later. TO BE DEFINED

**Teaching :** Depending on its profile, the recruited PhD student may participate in teaching activities at Saint-Cyr Coëtquidan school.

**Position start date :** october 2021.

# References

[1] Luciana Pelusi, Andrea Passarella et Marco Conti. “Opportunistic Networking : Data Forwarding in Disconnected Mobile Ad Hoc Networks”. In : IEEE Communications Magazine 44.11 (nov. 2006), p. 134-141.

[2] J. Mitola. “Cognitive radio for flexible mobile multimedia communications”. In : 1999 IEEE International Workshop on Mobile Multimedia Communications (MoMuC’99) (Cat. No.99EX384). 1999, p. 3-10. doi : 10.1109/MOMUC.1999.819467.

[3] Qusay Medhat Salih et al. “Smart Routing Management Framework Exploiting Dynamic Data Resources of Cross-Layer Design and Machine Learning Approaches for Mobile Cognitive Radio Networks : A Survey”. In : IEEE Access 8 (2020), p. 67835-67867. doi : 10 . 1109 / access . 2020.2986369. url : https://doi.org/10.1109%2Faccess.2020.2986369.

[4] Artemios G. Voyiatzis. “A Survey of Delay- and Disruption-Tolerant Networking Applications”. In : Journal of Internet Engineering 5.1 (juin 2012), p. 331-344.