PhD position: Enabling Distributed Computing in Nanosatellite Constellations
University of Adelaide, and ENAC, Universtité de Toulouse, Adelaide, Australia

Job Title	PhD position: Enabling Distributed Computing in Nanosatellite Constellations
Department	Telecommunication
Institution	University of Adelaide, and ENAC, Universtité de Toulouse, Adelaide, Australia Toulouse, Occitanie, France
Date Posted	Jul. 12, 2024
Application Deadline	Jul. 27, 2024
Position Start Date	Available immediately
Job Categories	Graduate Student
Academic Field(s)	Mathematics/Applied Mathematics Computer/Information Sciences
Job Website	http://perso.recherche.enac.fr/~silvestre/jobs.html#nanosats2
Apply By Email	

Job Description

Keywords: orbital edge computing, distributed algorithms, cyber-physical systems, replication, distributed and resilient computing, fault tolerance, intermittent computing, nanosats' subsystems.

Context

The recent deployment of an increasing number of nanosatellites in low-earth orbit (LEO) presents new opportunities for space applications [DKL + 17, DL20]. Built atop small-sized yet powerful blocks,a.k.a. CubeSats or simply nanosats, nanosatellite constellations emerge as promising platforms for massive sensing and large-scale distributed computing. Indeed, they represent a cheaper, competitive alternative for traditional satellite systems for a wide range of application domains such as earth observation and defence.

However, the design of distributed, intelligent systems based on nanosats is particularly challenging: nanosats have more stringent physical limitations with respect to processing/networking capability,

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energy supply, and connectivity among nanosats. Moreover, the use of cheaper components and subsystems might expose the emerging nanosat applications to performance degradation or complex failures. Therefore, novel resilient distributed applications and protocols should be designed and evaluated to make efficient and reliable use of the resources of nanosats at the orbital edge. The proposed doctoral project aims to enable a first-of-its-kind orbital edge computing subsystems with nanosats and to design novel techniques to support reliable and efficient data processing for emerging sensing application like earth observation with the proposed orbital edge computing platform. In order to achieve this challenging goal, we will conduct interdisciplinary, collaborative research to answer the following questions:

- * How to enable distributed computing on a nanosat?
  We will survey the design and implementation of state-of-the-art building blocks including suitable communication protocols and specific subsystems interfaces and abstractions for computing on nanosats.
- * How to build a resilient computing system with a set of nanosats?
  We will investigate distributed systems problems and propose specific solutions for dynamic reconfiguration mechanisms, consensus algorithms, and data replication schemes on nanosats systems. For that, we will take into account the ongoing research on related topics at CNES, including clock synchronization.

Proposed research
This doctoral research project aims to address the above scientific challenges as follows:

- * Leveraging non-expensive, failure-prone nanosats' components. We will explore the design space and the performance evaluation of distributed system on nanosats constellations. Based on an existing, representative hardware platform proposed by the CNES, we aim to conduct a systematic study on how different choices of distributed systems primitives and designs affect the performance of key services, such as special-purpose sensing and distributed processing application. To this end, we will execute specific benchmarks to identify design opportunities, to assess the impact of different failures and to better understand the eventual trade-offs for distributed computing on nanosats.

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- * Resilient edge computing with constellations of nanosats: An interesting solution for processing large amount of sensing data is to build a distributed computing system with a set of nanosats. So that we will re-examine many assumptions in traditional distributed systems in the presence of processing and interconnectivity limitations of nanosats. In particular, we aim to design novel resilient applications and protocols for fault-tolerant distributed services, e.g., dynamic reconfiguration mechanisms, consensus protocols, and replication schemes. Based on these fundamental services, we will enable intelligent, distributed computing on nanosats constellations.

Currently, the availability and resilience of traditional, cloud-based distributed system are commonly guaranteed by a replication protocol based on replicated state machine (RSM). Such a protocol implements a consensus algorithm to enable strong consistency, like Fast Paxos [Lam06] and Raft [OO14]. Strongly consistent replication is key to efficient implementation of critical distributed systems' building blocks, like distributed lock manager, reliable configuration or transactional key-value store. To our knowledge though, such protocols have never been designed and extensively evaluated on nanosatellite constellations. Finally, it is important to highlight that this doctoral project is a joint work with our colleagues in University of Adelaide in Australia, therefore the doctoral student will spend at least one year working in Australia. In addition, the doctoral candidate will have a joint doctoral degree by the end of the project. Moreover, the project will be conducted in close cooperation with SpaceLocker company that will contribute with its invaluable experience in nanosat systems.

Requirements and application
In this research project, we intend to explore both a fundamental and an applied aspects. Candidates to this position should hold a Master's degree in Computer Science/Informatics, Mathematics or a related field by the starting date of the doctoral project. They must be excited by research in distributed systems/computing, distributed algorithms, orbital edge computing, and/or intermittent computing, and should have an excellent academic record in one of these areas. Familiarity with formal specification and verification, and graph theory/algorithms would be greatly appreciated. Teamwork and communication skills are key to this position, and industrial experience is a plus.
Excellent proficiency in English is required (CECR : C1; IELTS : 7.0; Cambridge English Scale : 185; or equivalent). Knowledge of French is not required.Knowledge of French is not required.
To apply, please send the following information to rs-resco-recruitment@lists.recherche.enac.fr (Subject=PhD position [ENAC-UoA-PhD24]: distributed computing for nanosats):

- * Curriculum Vitæ
- * Letter of motivation that should describe the applicant's background in the areas of the project, reason for interest in the project, and future plans
- * A list of courses and grades of the last three years of study (an informal transcript is OK).

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- * Names and contact details of at least two people who can write you references, whom we will contact directly.
- * If relevant, a link to your publications and/or open-source developments.

Application deadline: 27 July 2024.
This fully-funded PhD starts in November 2024 (or in January 2025, depending on the paperwork and the applicant's availability) and the duration of the contract/scholarship is 3 years.

Eligibility criteria and Benefits
Applicants of any nationality can apply, but applicants **must not have** a doctoral degree already or been enrolled in a PhD/doctoral program.
Benefits include:

- French government strongly subsidizes its higher education system, therefore our program grants tuition fee waiver at Université de Toulouse and UoA.
- Doctoral students are eligible for an accommodation in our own campus which contributes significantly to reduce the total cost of living (already much cheaper than bigger European cities)
- Social security coverage included
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events
- Subsidized meals
- Partial reimbursement of public transport costs
- Social, cultural and sports events and activities

About ENAC and UoA
The ENAC, National School of Civil Aviation, is located in Toulouse, France, the centre of the European aerospace industry (e.g., AirBus, Thales, and CNES). It offers an ideal working environment, where researchers can focus on developing new ideas, collaborations and projects.
Our research topics at ENAC Lab include emerging CPS design (e.g., drones and nanosatellites), aviation safety and security, sustainable transportation development, and aeronautical computer-human interactions. For further information, please consult our site.
The proposed research will be developed in the ENAC research laboratory, ENAC Lab, in close cooperation with TéSA, SpaceLocker, our industrial partner in Toulouse, and the University of Adelaide in Australia.

References
[DKL + 17] K. Devaraj et al. Dove high speed downlink system. 2017.

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[Lam06] L. Lamport. Fast paxos. Distributed Computing, 2006.
[OO14] D. Ongaro and . Ousterhout. In search of an understandable consensus algorithm. In the ATC, 2014.

EEO/AA Policy

UoA and Enac Lab are both fully committed to promote equal employment opportunity in employment compensation and other terms and conditions of employment without discrimination based on age, race, creed, color, national origin, gender, sexual orientation, disability, marital status, Vietnam Era Veteran status, genetic predisposition, or carrier status.

Contact Information

Please reference Academickeys in your cover letter when applying for or inquiring about this job announcement.

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