Offre n°2024-07271

**Post-Doctoral Research Visit F/M**
[campagne postdoc mi-nf-lys-2024]

**Advanced Schedule-Aware Bundle Routing for Deep Space Delay-Tolerant Networking**

*Le descriptif de l’offre ci-dessous est en Anglais*

**Niveau de diplôme exigé :** Thèse ou équivalent

**Fonction :** Post-Doctorant

**Niveau d’expérience souhaité :** De 5 à 12 ans

**A propos du centre ou de la direction fonctionnelle**

The Inria research centre in Lyon is the 9th Inria research centre, formally created in January 2022. It brings together approximately 300 people in 16 research teams and research support services.

Its staff are distributed at this stage on 2 campuses: in Villeurbanne La Doua (Centre / INSA Lyon / UCBL) on the one hand, and Lyon Gerland (ENS de Lyon) on the other.

The Lyon centre is active in the fields of software, distributed and high-performance computing, embedded systems, quantum computing and privacy in the digital world, but also in digital health and computational biology.

**Contexte et atouts du poste**

This postdoc will be developed in the Inria Agora research group in the La Doua Campus in Lyon. The student will work with three members of the group: Dr. Juan Fraire, Dr. Oana Iova, and Prof. Hervé Rivano. The applicant will work and further develop existing software tools, such as simulators and optimizers, made available by the group.

**Mission confiée**

*Context*

Effective communication with deep-space spacecraft vehicles and orbiters, particularly around Mars and the Moon, is crucial in space exploration. This communication underpins scientific exploration and is pivotal for future interplanetary colonization. The global enthusiasm for space exploration is evident, with significant advancements and increased missions to deep space. Challenges in deep-space communications parallel developments closer to Earth. Space communications face unique constraints, such as high end-to-end delays and frequent link disruptions, making standard Internet protocols inadequate. In this context, Delay-Tolerant Networking (DTN) [1] was introduced, paired with the Bundle Protocol (BP) [2], to address these challenges. DTN enables nodes to use a store-carry-forward method for messages termed 'bundles' with no expectations of immediate arrival. This setup allows bundles to propagate for long periods or be stored until a suitable transmission window, known as 'contact,' arises. Organizing end-to-end transmissions in such an environment is challenging, as routing cannot rely on statically determined routes and is often inadequate for timely correction strategy dissemination.

Contact Graph Routing (CGR) [3] is a crucial component in addressing the challenges of deep-space communications. A deterministic algorithm uses a contact plan to create a time-sensitive graph representation of the network. This approach allows for dynamic construction of paths as needed, using a DTN adaptation of Yen's K-shortest path
Over more than 15 years, CGR has evolved through research and development, culminating in the Schedule-Aware Bundle Routing (SABR) standard by the Consultative Committee for Space Data Systems (CCSDS) [5]. CGR's practical implementation and SABR's guiding specification signify a significant step forward in the field. However, as technology and space missions advance, the existing CGR approaches require reevaluation and enhancement to meet the growing demands of space exploration.

**Problem**

This project addresses critical scalability issues [6] in CGR that are essential for space exploration. Recent studies have identified significant problems, such as node unresponsiveness and system failure due to excessive memory consumption in specific scenarios [7]. These issues are particularly acute in last-hop contacts with delayed start times, leading to a combinatorial explosion of problems. Furthermore, the current CGR system needs help with accurate volume modeling and inter-regional support, limiting its scalability. The complexity of CGR, combined with its monolithic design, has made it challenging to identify and address these issues, highlighting the need for a more modular and scalable approach to space networking [8].

**Objectives**

This project uses recent advances to develop a new Advanced Schedule-Aware Bundle Routing (A-SABR) framework. It focuses on enhancing SABR's operability, reliability, and scalability. Key objectives include:

1. **Creating a Modular A-SABR Framework**: This objective focuses on developing a flexible framework for Advanced Schedule-Aware Bundle Routing that can be utilized in research and operational contexts. The modular design aims to enhance adaptability and ease of integration with different systems.
2. **Addressing Volume Management Challenges**: This goal involves tackling issues related to managing the data volume in space communications. Efficient volume management is crucial for optimizing limited resources like bandwidth and storage in space environments.
3. **Developing Strategies for Inter-Regional Support**: The project aims to create effective methods for supporting communication across different regions in space. This includes enhancing the network's ability to handle long-distance communications and varying conditions in space.
4. **Implementing a Test Bench for Method Validation**: The objective is to establish a testing framework for validating the newly developed methods and techniques. This will ensure robust and practical solutions in realistic space communication scenarios.

The ultimate goal is to integrate A-SABR into a realistic networking environment, achieving efficiency in space internetworking and boosting the impact of the outcomes through academic and industrial partnerships.

**Principales activités**

1. **Creating a Modular A-SABR Framework**:
   1. Literature Review: Conduct an in-depth literature review on existing CGR routing approaches to develop a new taxonomy for the A-SABR framework.
   2. System Modeling: Model and implement the framework interfaces.
2. **Addressing Volume Management Challenges**:
   1. Volume Management System Development: Focus on system modeling and implementation for volume management and multicast support.
   2. Computational Stress Tests: Develop and execute strategies to test the framework under computational stress.
3. **Developing Strategies for Inter-Regional Support**:
   1. Inter-Regional Support Strategy: Design and refine strategies for enhancing the framework's inter-regional support capabilities, including administrative aspects.
   2. Topology Modeling: Model and optimize regional topologies to cover edge cases and ensure robust inter-regional support.
4. **Implementing a Test Bench for Method Validation**:
   1. **Evaluation Platform Implementation**: Develop and implement an evaluation platform based on the underlying tools of the framework.
   2. **Comprehensive Evaluation**: Implement missing support elements for a thorough framework evaluation.
   3. **Benchmarking**: Conduct benchmarking activities to assess the performance and efficiency of the framework.

5. **Additional Activities**:
   1. **Documentation and Testing**: Create documentation for the framework and implement unit and integration tests.
   2. **Language Wrappers**: Develop wrappers to make the framework usable in different programming languages (C, C++, Python).
   3. **Field Testing**: Conduct tests with drones and OPS-SAT-like missions to validate the framework in realistic environments.

**Compétences**

Applicants with a Ph.D. in Computer Sciences, Engineering, or related domains are welcome. Mathematical background, performance evaluation, wireless networking, and practical skills with programming languages for resource-constrained systems are required. Expertise in algorithmic, protocol simulation, and network optimization will be positively valued. Fluent English level is mandatory. Speaking and writing French is optional but welcomed. We look for empathic, proactive, and self-driven applicants.

**Avantages**

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

**Rémunération**

2788 € gross salary / month

**Informations générales**

- **Thème/Domaine**: Réseaux et télécommunications
- **Système & réseaux**: (BAP E)
- **Ville**: Villeurbanne
- **Centre Inria**: Centre Inria de Lyon
- **Date de prise de fonction souhaitée**: 2024-09-01
- **Durée de contrat**: 1 an, 6 mois
- **Date limite pour postuler**: 2024-04-05

**Contacts**

- **Équipe Inria**: AGORA
- **Recruteur**:
  Fraire Juan Andres / juan.fraire@inria.fr

**A propos d’Inria**

fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

**L'essentiel pour réussir**

There you can provide a "broad outline" of the collaborator you are looking for what you consider to be necessary and sufficient, and which may combine :

- tastes and appetencies,
- area of excellence,
- personality or character traits,
- cross-disciplinary knowledge and expertise...

This section enables the more formal list of skills to be completed and 'lightened' (reduced):

- "Essential qualities in order to fulfil this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen."
- " Passionate about innovation, with expertise in Ruby on Rails development and strong influencing skills. A thesis in the field of **** is a real asset."

**Attention**: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

**Consignes pour postuler**

*Applications must be submitted online via the Inria website. Processing of applications submitted via other channels is not guaranteed.*

**Sécurité défense** :

Ce poste est susceptible d’être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L’autorisation d’accès à une zone est délivrée par le chef d’établissement, après avis ministériel favorable, tel que défini dans l’arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l’annulation du recrutement.

**Politique de recrutement** :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.