



Offre n°2024-08461

PhD Position F/M Decentralised Market-based Application Orchestration in Fog and IoT Environments

Type de contrat : Fixed-term contract

Niveau de diplôme exigé : Graduate degree or equivalent

Autre diplôme apprécié : Master's degree

Fonction : PhD Position

A propos du centre ou de la direction fonctionnelle

The Inria Centre at Rennes University is one of Inria's nine centres and has more than thirty research teams. The Inria Centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Contexte et atouts du poste

In the context of the TARANIS project (PEPR Cloud), we are offering a PhD position to investigate flexible and decentralised application orchestration in fog environments.

The work will be carried out within the MAGELLAN team (Inria Centre at Rennes University, IRISA) at Rennes. Rennes is the capital city of Brittany, situated in the western part of France. Well-connected to Paris via a high-speed train line, Rennes is a lively city and a major center for higher education and research. The work will

involve close collaboration with the STACK team (IMT Atlantique, Inria, LS2N) at Nantes.

PhD Advisors

- Nikos Parlavantzas (MAGELLAN team)
- Remous Aris Koutsiamanis (STACK team)

Mission confiée

Fog computing extends the traditional cloud computing model by distributing compute, storage, and network capabilities closer to users along a cloud-edge-IoT continuum [1]. The motivations for fog computing include supporting low latency, high bandwidth, data privacy, and energy efficiency [2]. Another significant motivation is democratising the network edge, enabling various actors such as individuals, companies, and communities to operate their own edge clouds, fostering sustained innovation and facilitating the emergence of new fog applications [3].

However, effectively delivering fog applications that optimally exploit fog capabilities poses significant challenges. First, fog applications are diverse and have varying requirements on QoS (Quality of Service) properties, such as latency, bandwidth usage, availability, and energy consumption [4]. Satisfying these requirements becomes even more challenging since the Fog/IoT infrastructure upon which these applications are deployed is often significantly constrained in the same axes. This makes it difficult for commonly-used, one-size-fits-all management approaches to optimise for application-specific QoS goals [5]. Second, fog applications must operate reliably despite dynamic and unpredictable changes in fog environments, resulting from user and device mobility, resource volatility, and topology changes. Coping with this dynamism requires making automated management decisions in a fast and scalable manner. Finally, fog applications must be able to use resources from multiple types of infrastructure providers, ranging from traditional cloud providers to small-scale edge cloud providers, which requires common interfaces and mechanisms for discovering and accessing these resources.

Principales activités

To address these challenges, this thesis will explore flexible and decentralised application orchestration for fog environments. Specifically, the proposed approach is to equip each application with an automated application manager that produces an initial deployment for the application, potentially across resources from multiple infrastructure providers. The manager will then dynamically and autonomously adapt this deployment to react to environment changes in line with application-specific QoS goals [6,11]. The managers will negotiate and interact with infrastructure providers through a pricing mechanism [7,10], incentivising providers to make their resources available [12] while enabling application owners to make flexible performance-cost trade-offs [8]. The implementation will support multiple

application types and QoS goals [9] and build on standardised APIs and tools including the Kubernetes resource orchestrator. The solution will be evaluated on both emulated and real fog infrastructures using environmental monitoring and smart city applications.

References

- [1] R. Mahmud, R. Kotagiri, and R. Buyya. "Fog Computing: A Taxonomy, Survey and Future Directions". In: *Internet of Everything: Algorithms, Methodologies, Technologies and Perspectives*. Ed. by B. Di Martino, K.-C. Li, L. T. Yang, and A. Esposito. Springer Singapore, Singapore, 2018, pp. 103–130. isbn: 978-981-10-5861-5. doi: 10.1007/978- 981-10-5861-5_5
- [2] A. Ahmed, HR. Arkian, D. Battulga, A. Fahs, F. Jawad, M. Farhadi, D. Giouroukis, A. Gougeon, F. Gutierrez, G. Pierre, P. Souza Jr, M.A. Tamiru, L. Wu, (2019). "Fog Computing Applications: Taxonomy and Requirements", *CoRR abs/1907.11621* (2019)
- [3] L. Peterson, T. Anderson, S. Katti, N. McKeown, G. Parulkar, J. Rexford, M. Satyanarayanan, O. Sunay, and A. Vahdat, "Democratizing the Network Edge", *SIGCOMM Comput. Commun. Rev.* 49, 2 (April 2019), 31–36. doi: 10.1145/3336937.3336942
- [4] B. Costa, J. Bachiega, L.R. de Carvalho, and A.P.F. Araujo. "Orchestration in Fog Computing: A Comprehensive Survey". *ACM Comput. Surv.* 55, 2, Article 29 (February 2023), 34 pages. doi: 10.1145/3486221
- [5] C. Gabriele, E. Flavio, and R. Fulvio, "A service-defined approach for orchestration of heterogeneous applications in cloud/edge platforms", *IEEE Transactions on Network and Service Management* 16, 4 (2019), 1404–1418. doi: 10.1109/TNSM.2019.294163
- [6] S. Ghafouri, A. Karami, D.B. Bakhtiarvand, A.S. Bigdeli, S.S. Gill, and J. Doyle. "Mobile-Kube: Mobility-aware and Energy-efficient Service Orchestration on Kubernetes Edge Servers", doi :10.36227/techrxiv.20324841.v1
- [7] N.C. Luong, P. Wang, D. Niyato, Y. Wen, and Z. Han. "Resource Management in Cloud Networking Using Economic Analysis and Pricing Models: A Survey". *IEEE Communications Surveys Tutorials* 19:2, 2017, pp. 954–1001. issn: 2373-745X. doi: 10.1109/ COMST.2017.2647981
- [8] N. Parlavantzas, L.M. Pham, A. Sinha, C. Morin. "Cost-effective Reconfiguration for Multi-cloud Applications". *PDP 2018 - The 26th Euromicro International Conference on Parallel, Distributed and Network-Based Processing*, Mar 2018, Cambridge, United Kingdom
- [9] S. Costache, S. Kortas, C. Morin, and N. Parlavantzas. "Market-Based Autonomous Resource and Application Management in Private Clouds". *Journal of Parallel and Distributed Computing* 100, 2017, pp. 85–102. issn: 0743-7315. doi: 10.1016/j.jpdc.2016.10.003
- [10] R.-A. Koutsiamanis and P. S. Efraimidis, "Implementing PacketEconomy: Distributed money-based QoS in OMNET++," *International Journal of Communication Systems*, no. 1099–1131, 2016.
- [11] D. Hauweele, R.-A. Koutsiamanis, B. Quoitin, and G. Z. Papadopoulos, "Thorough performance evaluation & analysis of the 6TiSCH minimal scheduling function (MSF)," *Journal of Signal Processing Systems*, vol. 94, no. 1, pp. 3–25, 2022.
- [12] V. Parol-Guarino, N. Parlavantzas, "GIRAFF: Reverse Auction-based Placement for Fog Functions", 9th International Workshop on Serverless

Compétences

- Excellent communication and writing skills in English
- Strong programming and scripting skills in Linux environments
- Knowledge and experience in one or more of the following areas: distributed systems, IoT, cloud, edge, adaptive systems

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking (90 days per year) and flexible organization of working hours
- Partial payment of insurance costs

Rémunération

Monthly gross salary amounting to 2100 euros for the first and second years and 2190 euros for the third year.

Informations générales

- **Thème/Domaine** : Distributed Systems and middleware System & Networks (BAP E)
- **Ville** : Rennes
- **Centre Inria** : [Centre Inria de l'Université de Rennes](#)
- **Date de prise de fonction souhaitée** : 2025-09-01
- **Durée de contrat** : 3 years
- **Date limite pour postuler** : 2025-06-29

Contacts

- **Équipe Inria** : [MAGELLAN](#)
- **Directeur de thèse** :
Parlavantzas Nikolaos / Nikolaos.Parlavantzas@irisa.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut 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.

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

Please submit online : your resume, cover letter and letters of recommendation eventually

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.