SPRINT Joint Call University of Manchester/FAPESP

Case for Support Pro Forma

Please note - this form should be no longer than two sides and in a readable and reasonably sized font.

Principal investigator – FAPESP: Rodolfo Ipolito Meneguette

Principal Investigator – MANCHESTER: Sandra Sampaio

1. Project Title and Lay summary of proposed research activities:

Title: Dynamic Resource Management for Intelligent Transportation System Applications

Providing traffic information services to road users in an efficient manner has become paramount as we move to a greener economy that requires city pollution levels to be decreased. At the same time, the envisaged (post-Covid) way of life is predicted to become increasingly dependent not only on efficient transportation of physical goods, but also on efficient provision of services based on the availability of data/information collected/delivered anywhere anytime via mobile devices. To realise these objectives, numerous challenges need to be overcome, being fast and real-time data processing one of the major problems to be faced when meeting the service requirements of Intelligent Transportation System (ITS) applications, since, in these applications, the data to be processed comes from a variety of fixed and moving devices such as cars, unmanned aerial vehicles and sensors. To address this challenge, this project seeks to assess the suitability of existing cloud resource management strategies for fulfilling the requirements of ITS services and propose improved strategies for managing storage and computing resources for ITS data processing, taking into account quality-of-service requirements. In other words, the project focuses on the management of the resources involved in data processing and information provision of ITS services, which requires efficiency and dynamicity, considering that these services are underpinned by a mobility driven infrastructure shared by numerous and varied devices.

2. Please provide a substantive description of the proposed activities, emphasising their relevance:

The activities involved in this project are associated with the following two main contributions:

(A) An investigation into the suitability of existing (Cloud) resource management strategies for the fulfilment of ITS service requirements.

In recent years, much research has investigated resource management for the urban setting [1-6], with focus on resource allocation for providing better services to users. However, the proposed solutions generally incur high costs due to the complexity resulting from associated decision-making mechanisms, which affects computational cost and inference time. Furthermore, these solutions do not take into account time of service or end-user mobility. An in-depth investigation of these solutions is to be carried out to identify their advantages and limitations which will guide the next steps of the research. Other activities associated with this contribution are: investigation into the resource requirements of common ITS applications and identification of challenges associated with the impact of user mobility on the allocation of resources for data processing, considering time-sensitive and data-intensive ITS applications (e.g., route switching for minimizing congestion, provision of security related information, such as license plates, road conditions, etc.). It is envisaged that techniques for application and data profiling will be used as well as empirical evaluations and simulations of traffic-related data processing workflows, using open-source Cloud simulation tools such as WorkflowSim[1] and IoTSim-Stream[2].

(B) Proposal of strategies for dynamic management of resources using available devices and clouds.

To address the limitations described above, in this project, resource management strategies are to be designed to take into account not only parameters referring to the quality of user experience, but also the challenges associated with the mobility of users in an urban environment, whilst minimising costs. It is envisaged that the profile of applications and data obtained in *(A)* will help inform the resource allocation process on how to better manage resources, as execution of data processing workflows progresses by taking and releasing resources.

[1] W. Chen and E. Deelman, "WorkflowSim: A toolkit for simulating scientific workflows in distributed environments," 2012 IEEE 8th International Conference on E-Science, 2012, pp. 1-8.

[2] M. Barika, S. Garg, A. Chan, R. N. Calheiros, R. Ranjan, "IoTSim-Stream: Modeling stream graph application in cloud simulation", Future Generation Computer Systems 99: 86-105 (2019).

3. Please provide a timeline for each specific exchange mission, considering the limit of missions and resources established in this Call:

Except when an extended visit to a third institution doing research in cognate areas is to be made, or in case of serious unforeseen circumstances (e.g., lockdowns), during each of the **four six-month periods** of project development, a visit by each partner to the other partner's institution is planned. The UoM Worksheet indicates the timeline for the UoM exchange missions, assuming that these will have USP as destination. The exchange missions shall focus on the following research activities: **Period 1**: *(A1)* investigation into existing resource management strategies, *(A2)* exploration of ITS data/applications for identification of target data sources and services, first publication planning/submission, delivery of seminars to UoM and USP students and academics; **Period 2**: *(B1)* establishment of target environment, *(B2)* further ITS data/application exploration and profiling, *(B3)* design, implementation and evaluation of proposed resource management strategies (1st Sprint), second publication planning/submission, guest lectures; **Period 3**: adjustments to allocation approaches to meet performance targets, *(B3)* (2nd Sprint), *(B5)* assessment of user-mobility impact on ITS data processing, *(B6)*, third publication planning/submission, reflection over topics for future research agenda and preparation of funding application, visit to another institution; **Period 4**: final adjustments to allocation approaches to meet performance targets, *(B3)* (final Sprint), *(B7)* fourth publication planning/submission, delivery of seminars in other institutions, design of academic post-graduate courses, funding application.

4. Please provide performance indicators for the planned activities:

Publication of research results in top-rated journals, such as Elsevier Journal of Computer Networks, Elsevier Journal of Computer Communications, Elsevier Journal of Ad Hoc Networks, Springer Journal of Wireless Networks, VLDB journal, as well as highly reputable proceedings of conferences such as ACM Mobiwac, ACM/IEEE MSWIM, IEEE ISCC, IEE LCN, IEEE NCA, SBRC, VLDB, EDBT, SIGMOD, CIKM, etc.; successful demonstration of deliverables in industry-related events as well as conference industrial tracks; ability to raise interest from industry in the project deliverables; establishment of further collaborations with industrial and academic partners; consolidation of a strong agenda for future research; successful application for funding future research; successful transfer of knowledge and skills to academics and students of both institutions via delivery of seminars, integration of material in academic courses, post-graduate degrees, project meetings, etc.

5. Please provide a description of each candidate's contribution to the mission, explaining the relevance of their expertise to proposed activities:

Rodolfo Ipolito Meneguette works with resource allocation and vehicular edge computing. He will mainly assist through his knowledge in the both areas of expertise by creating scenarios that combine resource allocation and vehicular edge computing, as well as, propose new allocation methods. He will also help in evaluating the inferred performance and overhead of proposed solutions. *Sandra Sampaio*'s expertise in data quality, preparation and analysis, as well as query processing and optimisation are particularly relevant to the missions associated with investigations into resource requirements of ITS applications, data and application profiling, impact of user mobility on data processing, and identification of requirements for and design of resource allocation mechanisms.

6. Please provide details of planned activities that will add to the impact of the exchange for Manchester and for the Host Institution in the State of Sao Paulo, for example: seminars, short courses, and visits to other institutions that carry out research activities in cognate areas.

Delivery of seminars to UoM and USP academics and students during the exchange missions; research collaborations with Professor Robson de Grande from the University of Brock in Canada and Professor Rizos Sakellariou from the University of Manchester, who will participate in a number of meetings; incorporation of research material/results in post-graduate courses; guest lectures; visits to academics from the John Moores University, UK (Rubem Pereira), Berlin University of Technology, Germany (Professor Odej Kao) to establish collaboration in the areas of resource allocation and evaluation in Cloud environments.

References

[1] B. Zhang, X. Mao, J. Yu, and Z. Han, "Resource allocation for 5g heterogeneous cloud radio access networks with d2d communication: A matching and coalition approach," IEEE Transactions on Vehicular Technology, vol. 67, pp. 5883–5894, July 2018.
[2] W. Li, J. Wang, G. Yang, Y. Zuo, Q. Shao, and S. Li, "Energy efficiency maximization oriented resource allocation in 5g ultra-dense network: Centralized and distributed algorithms," Computer Communications, vol. 130, pp. 10–19, 2018.
[3] L. Huo and D. Jiang, "Stackelberg game-based energy-efficient resource allocation for 5g cellular networks," Telecommunication Systems, pp. 1–12, 2019.
[4] Y. Hao, D. Tian, G. Fortino, J. Zhang, and I. Humar, "Network slicing technology in a 5g wearable network," IEEE Communications Standards Magazine, vol. 2, no. 1, pp. 66–71, 2018.
[5] Y. Hao, Y. Jiang, M. S. Hossain, A. Ghoneim, J. Yang, and I. Humar, "Data-driven resource management in a 5g wearable network using network slicing technology," IEEE Sensors Journal, 2018.
[6] D. M. Gutierrez-Estevez, M. Gramaglia, A. De Domenico, G. Dandachi, S. Khatibi, D. Tsolkas, I. Balan, A. Garcia-Saavedra, U. Elzur, and Y. Wang, "Artificial intelligence for elastic management and orchestration of 5g networks," IEEE Wireless Communications, 2019.