Department	School of Computing
Supervisors	Brian Davison, Amjad Ullah
Project Title	Sustainability and resilience through federated cloud services in the Internet of Things

PROJECT DESCRIPTION

Early reference architectures proposed for Internet of Things (IoT) applications assumed that the majority of processing would be performed by cloud services. However, the requirement for low-latency processing in certain use cases such as smart cities and autonomous vehicles highlight the need for processing to be performed closer to edge devices. The fog computing paradigm achieves this goal by providing cloud-like services using geographically situated resources. To resolve the inherent constraints on such resources, services can be federated so that unused resources on one node may be called upon by a neighbouring node to increase overall scalability.

The federated model opens up the possibility of an entirely decentralised cloud computing model in which the cloud platform itself is composed of a network of independent collaborative nodes. This introduces resilience into system architectures by ensuring that all nodes can function in isolation and that the removal of a single node does not affect the rest of the network. Beyond the digital domain, decentralisation can be used to build resilience into physical infrastructure where large-scale systems such as utility networks rely on embedded intelligence.

A further benefit of the decentralised strategy is the potential for local ownership of nodes. In contrast to the traditional model where the platform is owned by a single entity, the collaborative model distributes the benefits of ownership across communities thus enhancing their long-term sustainability at the same time as that of the technical services themselves. With this perspective in mind, this project targets three of the UN Sustainable Development Goals (SDGs):

- SDG9: Industry, infrastructure and innovation
- SDSG10: Reduced inequalities
- SDG11: Sustainable cities and communities

The aim of this project is to extend existing work on the federation and orchestration of cloud and fog services with a view to developing a framework for a fully-distributed cloud. The first phase of the project will be to conduct a thorough review of existing literature in this field. On the basis of the literature review, a manageable set of targets will be chosen for further development. Theoretical and conceptual work will be complemented by prototype development. Both of these streams of activity will be actively supported by the supervisory team and by access to appropriate resources provided by the University.

Prospective applicants are encouraged to contact the Supervisor before submitting their applications. Applications should make it clear the project you are applying for and the name of the supervisor(s).

Academic qualifications

A first degree (at least a 2.1) ideally in software engineering with a good fundamental knowledge of cloud computing and network protocols..

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental principles of software engineering
- Competent in software project management and Linux systems
- Knowledge of system architectures and network protocols

- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:
Any previous experience with IoT technologies would be highly beneficial. This could include projects from undergraduate or postgraduate study

Indicative Bibliography	Costa, B., Bachiega, J., De Carvalho, L. R., & Araujo, A. P. F. (2023). Orchestration in Fog Computing: A Comprehensive Survey. *ACM Computing Surveys*, *55*(2). https://doi.org/10.1145/3486221 Davison, B. (2022). IoT for Sustainability. In R. Buyya, L. Garg, G. Fortino, & S. Misra (Eds.), *New Frontiers in Cloud Computing and Internet of Things* (pp. 253–286). Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-031-05528-7 Tuli, S., Casale, G., & Jennings, N. R. (2022). CAROL: Confidence-Aware Resilience Model for Edge Federations. *Proceedings - 52nd Annual IEEE/IFIP International Conference on Dependable Systems and Networks, DSN 2022*, 28–40. https://doi.org/10.1109/DSN53405.2022.00016
Enquiries	For informal enquiries about this PhD project, please contact Dr Brian Davison (b.davison@napier.ac.uk)
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process