



## **School of Computing, Engineering, and the Built Environment Edinburgh Napier University**

### **PHD STUDENT PROJECT**

#### **Funding and application details**

**Funding status:** Self-funded students only

**Application instructions:**

Detailed instructions are available at <https://www.napier.ac.uk/research-and-innovation/research-degrees/how-to-apply>

*Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.*

#### **Project details**

**Supervisory Team:**

- DIRECTOR OF STUDY: Dr. Amjad Ullah (Email: [A.Ullah@napier.ac.uk](mailto:A.Ullah@napier.ac.uk))
- 2<sup>ND</sup> SUPERVISOR:

**Subject Group:** Computer science

**Research Areas:** Computer Science (Software engineering, Machine Learning, Internet of Things, Distributed systems)

**Project Title:** Towards a unified AI-driven approach of context handling to support reconfiguration decisions in Cloud-to-Edge orchestration for next-generation IoT systems

**Project description:**

The use of contextual information in computing systems (e.g., in desktop/web/mobile and pervasive/ubiquitous computing) and cloud computing were generally introduced, where it was necessary. However, since the emergence of the Cloud-to-Edge compute continuum, the use of context-based information has also become a fundamental and essential ingredient of IoT environments. This is due to the fact that the Cloud-to-Edge compute continuum model addresses the quintessential needs of next-generation IoT systems such as low latency analytics

closer to the source, privacy sensitivity, time awareness, location awareness, and simultaneous access to a geographically distributed array of sensors, remote localised heterogeneous computational resources as well as large-scale on-the-fly multi-cloud computational resource. In such an eco-system, real-world IoT applications work across multi-administrative resource domains where they combine heterogeneous and distributed computation, network communication, sensing, and actuators in many cases for the remote control of the environment; therefore, the use of contextual information can hugely assist the IoT operations in order to make informed run-time reconfiguration decisions to fulfil desirable objectives of the intelligent systems. Recent approaches to the use of contextualisation within the Cloud-to-Edge continuum are mostly ad hoc, where they focus on an individualistic aspect, e.g., context sharing among interdependent IoT applications, management of applications in mobile networks, distribution of computation between cloud and IoT gateways, etc.

The key aim of this project is to extend the popular “Five Ws” principle (who – characterises the identity of entity/user, where – indicates location-awareness, when – the notion of time-awareness, what – the real-time action/activity, and why – the circumstances leading to the activity) of context-awareness to the IoT environment. The project will investigate and consider the use of a wide range of contextual information most particularly in relation to systems, resources, applications and users, such as Resource state (current usage, such as CPU, memory etc.; availability); Networking aspects (e.g., congestion level, available bandwidth, communication overhead); Energy requirements (battery utilization, battery life); Environmental context (locality, time of the day, etc.); Non-cloud device context (computational capabilities, type of resource); Application context (low latency, QoS specification). The project will work towards the development of a context-proactive engine, where the aforementioned wide range of contextual information can be utilised to construct AI (Neural network and Deep-learning) based contextual models to proactively assist in making run-time system reconfiguration (deployment, offloading, and auto-scaling) decisions.

### **References:**

- [1] Ullah, A., Kiss, T., Kovács, J., Tusa, F., Deslauriers, J., Dagdeviren, H., Arjun, R. and Hamzeh, H., 2023. Orchestration in the Cloud-to-Things compute continuum: taxonomy, survey and future directions. *Journal of Cloud Computing*, 12(1), pp.1-29.
- [2] Ullah, A., Dagdeviren, H., Ariyattu, R. C., DesLauriers, J., Kiss, T., & Bowden, J. (2021). MiCADO-Edge: Towards an application-level Orchestrator for the Cloud-to-Edge Computing Continuum. *Journal of Grid Computing*, 19(4), 1-28.
- [3] Abowd, Gregory D., et al. "Towards a better understanding of context and context-awareness." *International symposium on handheld and ubiquitous computing*. Springer, Berlin, Heidelberg, 1999.
- [4] de Matos, Everton, et al. "Context information sharing for the Internet of Things: A survey." *Computer Networks* 166 (2020): 106988.
- [5] Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. (2013). Context aware computing for the internet of things: A survey. *IEEE communications surveys & tutorials*, 16(1), 414-454.

## **Candidate characteristics**

### **Education:**

A second class honour degree or equivalent qualification in computer science

**Subject knowledge:**

- Computer programming
- Cloud technologies
- Machine learning

**Essential attributes:**

- Experience in fundamental software engineering
- Competent in one (or some) programming languages
- Knowledge of Cloud, IoT and Microservices architecture
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

**Desirable attributes:**