PhD Studentship on Pervasive and Ubiquitous Computing

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Background

Mark Weiser (1991) introduced the concept of ubiquitous computing as the notion of computing devices embedded across all physical spaces, intermingling invisibly with our everyday activities, automating the most tedious, such as home lighting, and supporting the more complex such as driving. As such, these computing elements *"weave themselves into the fabric of everyday life until they are undistinguishable from it"* (Weiser, 1991) by leveraging technologies such as distributed systems, mobile computing, location systems, wireless networking, sensor networks, human–computer interaction, context-aware smart home technologies, and machine learning (Cook and Das, 2012; Souza et al., 2019).

The research community has embraced this paradigm as the Internet of Things, enabled by a wide range of devices: from simple passive objects (Smith and Konsynski, 2003), to *things* that actively engage with their environment, other *things*, and human users (Kortuem et al., 2010). From the simple Radio Frequency Identification (RFID) enabled objects used in the IoT's origins, *things* have evolved into complex objects imbued with agency, intelligence and autonomy (Fortino, 2016). Commercial and enterprise marketing promises that between the IoT and the mobile Apps ecosystem, objects would be connected to each other, allowing for seamless service composition, effectively creating a 'blanket of smartness' that would make common activities easier for the users (Bojanova et al., 2014). Market leaders, such as Intel, have promised ecosystems that would improve efficiency, safety, providing a richer experience to users, so that, devices

"*will become smart enough to function on their own, making real-time decisions, learning from their environment, and using that learning to improve performance*" (Intel, 2017).

Motivation

Weiser's vision implies a degree of 'smartness' in the environment, exemplified by the current iteration and roadmap established for the development of autonomous cars. In autonomous vehicles development, five stages of automation are defined, ranging from the most basic at level 1 to a fully autonomous operation at level 5 (Litman, 2014). Level 1 enables vehicle features such as cruise control, that is, only the speed of the vehicle is automatically controlled, whilst the operation of the vehicle is the driver's responsibility. At level 5, full decision making of the vehicle is expected in all possible terrain and driving conditions, with no user input in regards to vehicle operation. Parameters such as energy management and engine integrity are optimised, providing the system with a notion of self-well-being in order to maintain adequate operational standards. From a user's perspective it is expected that benefits such as safety, comfort and convenience are increased as a result of the device's autonomous operation (Atzori et al., 2014; Chi et al., 2007), and from a system wide point of view optimisation of infrastructure and resources is expected (Kamolov and Korneyeva, 2018).

The research topics proposed in this document aim to bridge the gap towards the realisation of a smart Internet of Things leveraged by the Pervasive and Ubiquitous computing (PUC) paradigm, in particular within the Urban Computing (Smart Cities) and Industrial Internet of Things (IIoT) use cases.

As such, some challenges have been identified towards the implementation and realisation of the pervasive and ubiquitous computing vision defined by Weiser over three decades ago, such as privacy and security, accessibility, energy management, interaction, context management and service discovery (Atzori et al., 2010; Stankovic, 2014; Ortiz et al., 2014; Gubbi et al., 2013; Aazam et al., 2014).

Proposed research

The proposed research looks the previously identified challenges, particularly standardization and interoperability between networks and devices, and their application to Urban Computing and Industrial IoT applications.

The main question this research posits is:

How to manage the non-uniform distribution of sensors and heterogeneity in Pervasive and Ubiquitous computing applications?

Pervasive and Ubiquitous Computing (PUC) often relies on readily available data sources for the implementation of its services. Notwithstanding, there is heterogeneity both in the type of available data sources and its distribution (physical and contextual location). This proposed project aims to research the impact of said distribution in PUC applications, postulating the sub-research question of how to provide alternatives to mitigate or leverage system heterogeneity towards the implementation of system to manage these data sources and their data with the use of data analytics techniques.

Potential impact

For the Faculty of CEBE's Research community, the wider ranging Pervasive and Ubiquitous Computing research fits within the Cloud Computing Centre's (centre's name TBD) focused research groups of Distributed computing and Urban computing. Moreover, this research would aim to look for support and collaboration from the Data Analytics group in the School of CDT.

The industrial applications enabled by this research would look to complement the current KTP led by the PI at Conway Packing Services focusing on Industrial IoT, and with the potential of be supported by the PhD Hub.

Finally, the EPSRC recognises Pervasive computing as a prioritised area of growth[1], allowing for the participation in research calls and bids ensuring its relevance and impact towards the University's REF strategy.

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[1] https://epsrc.ukri.org/research/ourportfolio/researchareas/puc/

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