Final Summary Report for project URBANMOB (322138)

Modelling Urban Mobility in City-Scale Ubiquitous Systems
(PCIG11-GA-2021-322138)
Reporting period: 1/1/2013 - 31/12/2016
Career Integration Grant
PI: Vassilis Kostakos, University of Oulu
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This report summarises the objectives and outcomes on the above named project. The grant awarded to the PI is a Career Integration Grant, aimed to help the PI consolidate his research with a long-term career perspective. The requested funding (100,000€, i.e. 25,000€ per year for 4 years) was be used by Kostakos to partly support a researcher working within the context of the broader project described here.

Summary of project objectives

The objective of the over-arching project is to utilise the data produced by Oulu's UPI (Urban Pervasive Infrastructure) and other sources for modelling and exploiting urban flows and networks. This data captures a rich subset of the everyday life and activities taking place in the City of Oulu (Figure 1).

Figure 1. (a) UBI-hotspot; (b) panOULU WLAN access point; (c) panOULU BT access point; (d) prototype smart traffic lights.

As interactive communication technologies play an increasing role in our everyday lives, the infrastructure that supports these activities can be in important source of understanding the type, frequency and characteristics of citizen's activities. Crucially, a characteristic of these technologies is mobility, and increasingly mobility has become an important aspect of technology usage and user needs. Hence, this project considers capturing and analysing various types of flows and networks of everyday life in the City of Oulu. By capturing and analysing these flows and networks, our project will develop services that better fulfil Oulu's stakeholders' needs. More specifically, the project has modelled and exploited:

- **Transport flows**: The project aims at modelling both vehicular and passenger transport flows. In transport modelling the origin-destination data is typically collected via expensive and time-consuming human surveys. The UPI allows passive and anonymous collection of information about vehicle's and people's trips across the city. This data will be used to generate an origin-destination matrix for transport, which is the cornerstone of designing effective transport.

- **Pedestrian flows**: Pedestrian flows are crucial in understanding the micro-economy of a city. There is a cyclic relationship between pedestrians and the local economy: pedestrians tend to go to shops, and shops tend to be established where pedestrians dwell. Typically, pedestrian flows are estimated via expensive and time-consuming human surveys. However, the UPI allows capturing pedestrian routes across the city, and these will be used to classify pedestrians in terms of their visiting patterns. This data

can be exploited to provide various personalised services to the individuals as well as to identify opportunities for the local economy.

- **Social networks**: An important reason why online social networking systems such as Facebook enjoy wide success is because they increase individual's *opportunities* for networking. Opportunities for networking have long been regarded as an important aspect of our society, with numerous events (both public and private) organised to bring people together and create new social ties. Oulu's UPI will be used to identify the social networking opportunities amongst Oulu's citizens by analysing the encounters between people. Encounters are a strong indication that individuals share interests because they are located both in space and time. Subsequently, these individuals will be given a digital "prompt" that will serve as an introductory cue.

Main results

- The PI has now established a new research center (http://ubicomp.oulu.fi).
- A number of publications have been made during this reporting period.
- Prototypes for Transport flows, Pedestrian flows, and Social Networks (via public displays) have been built.

Potential impact

The addition of Kostakos to the University of Oulu's research team is along the strategic investment and planning of the University and regional institutions. More specifically, there are three ways in which the addition of this new researcher will contribute to research excellence:

- Strategic research area: Internet and Information Technology.
  The conducted research has contributed to a reshaping of the definition of strategic research areas in the University of Oulu strategy for years 2016-2020. Specifically, the University of Oulu's 5 strategic research areas now includes "Digital solutions in sensing and interactions". A substantial investment has been made by the university on the topic, and the contribution by this project will allow for further synergies on this topic.

- Related research centre: Center for Ubiquitous Computing (http://ubicomp.oulu.fi).
  The project has enabled the PI to found and direct (during 2016) the Center for Ubiquitous Computing at the University of Oulu. It is located at the University of Oulu's Linnanmaa Campus, and housed in a modern purpose-built facility. With an annual budget of €2.6 million and world-class infrastructure, the center's mission is to conduct research on the next generation of interactive technologies. The scope of the research cuts across Ubiquitous Computing and Human-Computer Interaction, with a distinct focus on application-driven research. Its work spans the development of techniques for modelling human behaviour, augmenting physical spaces, and systems engineering to enable ubiquitous applications and services.

- Related research training centre: Infotech Oulu (http://www.infotech.oulu.fi)
  The research group hosting Kostakos (Initionally, MediaTeam Oulu research group, the Center for Ubiquitous Computng) is as full member of the Infotech Oulu research centre. Infotech Oulu is a research centre at the University of Oulu with the mission to promote ICT research and researcher training in the Oulu region. Infotech Oulu provides training to PhD students, organises courses and seminars, and provides administrative support.

In addition, the results will further be communicated to regional commerce institutions and organisations. The project will also approach regional redevelopment projects and will collaborate with them in order to apply our findings to real settings. In addition, software companies will be approached (including those in the UBI consortium, such as Nokia and other SME's), or possibly created as a spin-off, in order to develop new types of urban digital services enabled by the technology developed in this project. These services will enable local industries to engage with Oulu's citizens, and it is expected that these services will exemplify a new type of service sector in Finland's market

Finally, Work produced by the project has been presented at the following conferences:

- Conference on Security and Privacy in Wireless and Mobile Networks (WiSec) 2015
- International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp) 2015
- British Human Computer Interaction Conference (BCS-HCI) 2015
- Conference on Human Factors in Computing Systems (CHI) 2015
- International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp) 2016
- British Human Computer Interaction Conference (BCS-HCI) 2016
- Conference on Human Factors in Computing Systems (CHI) 2016