Ph.D. in Information Technology:

Afanasov, Nacci, Saidinejad and Veronese Final Dissertations

DEIB Seminar Room

January 25th, 2016

2.00 pm

First Ph.D. presentation and discussion:

Dr. Mikhail AFANASOV – XXVIII Cycle

"Software Level Adaptation in Cyber Physical Systems"

Supervisor: Prof. **Luca Mottola**

Abstract:

Cyberphysical systems (CPSs) are a category of engineered sys- tems that combines physical processes with computational control. The key property of these systems is that their functionality is emerging from the intense interactions between computational devices and the real world.

Consider a typical CPS application: a Wireless Sensor Network (WSN) for the environmental monitoring. The environment exhibits multiple dimensions that are changing continuously and independently. As the WSN monitors these changes, its functionality heavily depends on the environmental dynamics, which leads to the need for the WSN software to be adaptive.

Another large class of CPSs are Unmanned Aerial Vehicles (UAVs). These are representative of time-critical CPSs. The typical UAV control board also consists of a number of sensors that are used to calculate the modulation of the motors and to keep the flight stable. Similarly to WSNs, UAVs monitor the environment through sensors to control the flight. Crucially, UAVs rely on the sensoric input, and generate the control decisions in real-time.

In this thesis we focus on the adaptive software for such systems. Our goal is to provide language independent concepts that can help developers to design, verify and implement the adaptive software for time-critical systems. Unlike most existing work, we do not present the mechanisms or algorithms for adaptation. Our aim is to make the ways these mechanisms and/or algorithms are designed, programmed, and verified more effective.

In the first part of this thesis we introduce our language-independent design concepts to organize the WSN operating modes, decoupling the abstractions from their concrete implementation in a programming

language. Our language ConesC natively supports the dedicated adaptation mechanisms and allows developers to implement adaptive WSN software. To verify this software we provided a dedicated verification algorithm. The latter is integrated with our tool GrEVeCOM that delivers the seamless way to build the model of the software, to exhaustively verify it against the environmental evolutions, and to build the ConesC templates. Finally, ConesC sources are compiled with the dedicated translator yielding the binary that is ready to be deployed. The evaluation have shown that our concepts increase the ease of the developing and verifying of the adaptive WSNs software with a very little price, such as less than 2.5% memory overhead and less that 200ms verification time.

In the second part of the thesis we focus on the time aspect in enforcing adaptation decisions. Our concepts deliver different activation types for the CPS operation modes, trading off latency at run-time vs. programming efforts. Each activation type has also time boundaries that can be optionally enabled by the programmer. We show the usefulness of our concepts in a prototype built for the Cortex-M3 micro-controller. Our early evaluation has revealed that with the cost of a small MCU performance overhead, we provide an additional functionality and guaratees that do not exists in current approaches.

Second Ph.D. presentation and discussion:

Dr. Alessandro NACCI – XXVIII Cycle

"Methods and Tools for Effective Smart Buildings Deployment"

Supervisors: Prof. **Donatella Sciuto**, Ing. **Massimo Valla**

Abstract:

Nowadays, considering the continuous development of the sensor and actuator technologies - namely, the Internet-Of-Things - and the incessant growth of their applications in almost all the aspects of our everyday life, the realisation of the so-called smart spaces is something possible and many solutions for their actual implementation are finally available on the market. As defined by EIT ICT Labs, Smart spaces are environments such as apartments, offices, museums, hospitals, schools, university campuses, and outdoor areas that are enabled for the cooperation of different objects (e.g, sensors, actuators, devices and appliances) that have the capability to organize themselves with the goal of providing better services to customers and citizens, making living more comfortable and efficient. In particular, as it will be, the use of technology is intended to increment the user comfort, his safety and the energy efficiency of the smart spaces. The academia and the industry put a lot of effort during the last 30 years in the creation of the enabling hardware technology essential for the creation of the smart building concept. Several challenges

have been already addresses, especially from a technical point of view (low power sensors/actuators design, communication protocols, software interfaces design, etc.).

Anyway, this new technologies have also introduced new challenges: within this thesis work, some of the open challenges will be faced, proposing new theoretical frameworks, technologies and tools to move forward the actual implementation of smart buildings. In particular, after three decades of works on this topic, there are interesting topics that still to be faced to have smart buildings parts of our daily life: the Occupancy Detection Problem, the Building Programming Problem, Building Behaviour-Description Problem. Within this context, three technologies are proposed: an occupancy detection technology based on Bluetooth Low Energy, a building programming interface to let occupants express their own policies and a smart building simulation framework, as an essential tile for forecasting the building behaviour. These three technologies will be then used in two different case studies: in a run-time manager for the integration with the smart grid and an innovative building safety management system.

Third Ph.D. presentation and discussion:

Dr. Hassan SAIDINEJAD – XXVIII Cycle

"User Interface and Interaction in an Ambient Assisted Living System: Gestural and Vocal Interaction for the Inhabitant, Data Visualization for the Caregiver"

Supervisor: Prof. **Fabio Salice**

Abstract:

Ambient Assisted Living is a technological solution to the rising challenge of population ageing that augments the living environment of the elderly with ambient intelligence and assistive technology to support their independent life. This work presents BRIDGe, a modular, interoperable, and personalizable ambient assisted living system. User interface and interaction needs of BRIDGe users (the person, the family, and the caregivers) have been the motivation of this work. Three technological solutions have been proposed addressing the three needs identified by the social counterpart of BRIDGe. The two first needs concern the person, i.e. the user inside the house with the main interest of Home Control. Gestural interaction for a user (an elderly-disabled) with residual hand motor capability, and vocal interaction for a user (an elderly-disabled) with residual voice capability are the two corresponding solutions. The third need concerns the caregiver, i.e. the user outside the house with the main interest of understanding data collected from inside the house.

Fourth Ph.D. presentation and discussion:

Dr. Fabio VERONESE – XXVIII Cycle

"Collection, Processing and Analysis of Environmental Domotic Sensors Data for Behavior Drift Detection"

Supervisor: Prof. **Fabio Salice**

Abstract:

The world population is getting older resulting in socio-economic consequences due to ageing-related biological, psychological, and social fragilities. Rising care costs and the failure of traditional care models favor an independent ageing in place postponing institutionalization as far as possible. Ambient Assisted Living is a technological solution that improves the living environment of the elderly and fragile person with tools and the intelligence needed to support independent life. This Doctoral Thesis proposes four main intertwined focuses: the proficient collection of indoor human localization data, the HA (Home Automation) data processing to ensure dependability, the generation of synthetic HA datasets, and the analysis of data to create a correlation between HA status and Activities of Daily Living (ADLs). Finally, representing HA data through a proper image-like entity, it is possible to discover activities from sensors data, applying an unsupervised clustering.