

**Title of the doctoral program**

Computer and Control Engineering

**Title of the research activity**

High-Level End-User programming in the Internet of Things

**Short description of the research activity**

The objective of the research proposal is to enable end-users of future Internet of Things (IoT) systems to be able to effectively control and personalize the behavior of their surrounding technologies through high-level programming of desired results.

The current IoT systems are too often designed around “vertical” applications, with little or no programming, and too specific user interfaces, with not interoperability at all. Several “walled gardens” are being delimited, due to non-interoperable products, or to the jungle of proposed protocols, or to the emerging closed eco-systems. We will not try to fight this discomforting situation, but we will embrace it and try to build on top of it a comprehensive and pleasant user experience.

Even after a decade since the seminal papers in context-aware computing, the kind of programming and automation, both in smart homes and in mobile computing, still suffers from the same problems, since it's really designed for low-level device-to-device interactions.

Our project aims at **building the necessary interfaces, intelligence, infrastructure, and security, for enabling more advanced and user-friendly scenarios**, where the user is at the center of the interaction and may express his/her needs and desires in a user-centric and service-centric language, instead of device-centric.

The end-user-programmability of the Internet of Things, for enabling the above scenarios and similar user features, will therefore need to **tackle and solve**, with general and interoperable solutions, **the following issues**:

- Devising a suitable **representation for high-level and generalizable rules**, apt to represent the kind of programming scenarios that will emerge in the IoT. The Event-Condition-Action (ECA) patterns seems a well-grounded starting point, but needs to be extended to cope with a uniform way of representing multiple, variable, and ever increasing device types.
- The IoT world will consist of a continuous integration of services offered by **devices** and **cloud** services. Devices themselves may be associated to users (e.g., a smartphone or a wearable sensor) or to the environment (e.g., a presence sensor for pedestrian traffic lights). A suitable **open and comprehensive device and service representation** must be defined (in the form of an Ontology), able to represent the whole set of interacting systems.
- Each device or cloud service will offer different kinds of **capabilities** (information to be queried, actions to be asked, data to be stored, settings to be updated, ...). The set of capabilities needs to be modeled in the **device and service ontology**, to ensure that meaningful programming **rules may be defined according to specific capabilities**, in a **device-independent** and **service-independent** manner.
- Designing **easy-to-use User Interfaces**, suitable both for mobile devices and for the web, that will enable users to express their automation needs and to create high level rules to support them. The “**understandability**” of the programming **rule**, from the user point of view, will be the main concern, and will be attained through a user-driven methodology. Rules should also be easy to create depending on the current context (“more like this”-programming). The same process will be followed to **ensure understandability of user**

- policies**, to really empower users in the control of their data and their devices, avoiding the opaque “all or nothing” model adopted for mobile computing.
- Experimenting a **rule generator** based on the **historical data** gathered from the different devices. The goal of the generator is to **suggest new rules to the users** that can be interesting for them based on: existing rules created by themselves, data gathered from the devices, users activities (e.g. enable/disable rules, device handling such as change temperature set point...), and IoT ontology. The rule generator will be based on **machine learning** methods which will take advantage of the reasoning capabilities of the ontologies, particularly those formalized in description logics.

**Scientific responsible (name, surname, role, email)**

Fulvio, Corno, Associate Professor, [fulvio.corno@polito.it](mailto:fulvio.corno@polito.it)

**Number of vacancies for XXXI cycle (3 years program)**

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**Specific requirements (experiences, skills)**

Programming and software engineering skills

**Website of the research group (if any)**

<http://elite.polito.it/>