Technical Report

DUE

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Preamble

This document describes the basic guidelines for research, development and testing activities. The R&D activity regards a new solution devised for the planning and the management of complex distributed systems with parallel computing. This activity is bonded to a new languages that treats a new kind of sorted variables: the XML strings. The testing activity is focused on domotic system management.

Abstract

According to the vision of Ambient Intelligence (AmI), the most advanced technologies are those that disappear: computer technology should become invisible. All the objects around us must possess sufficient computing capacity to interact with users, the surroundings, each other and exhibit intelligent behavior. In home environments, Ambient Intelligence is the layer on top of the domotics. Its aim is to integrate isolated devices to achieve global, unified goals. Today, the lack of standard definition of application requirements for domotics has led to the development of a large number of ad hoc solutions which unfortunately are often limited and difficult to integrate. In order to make the advent of genuine AmI applications possible, there is a crucial need to define and develop a standard way forward.

The objective of this paper is to take steps in this direction by proposing an innovative intelligent system (DUE - Domus Universal System) based on: (1) a new universal distributed programming language (DUL - Domus Universal Language), (2) a sort type used to describe devices and device I/O (dXML - Domus XML), (3) an hardware abstraction layer (dHAL - Domus Hardware Abstraction

Layer) and (4) open source hardware/software philosophy. The aim of this system is provide an ad-hoc language able to implement coherence analysis of a domotic application at compile and at run time, and to easily describe the behaviour of domotic systems in relation to the events and contexts of users and devices. The sort type permits to DUL to be a modular language, this perfectly fits for home automation applications and permits a natural development of a text-based and/or graphical programming environment. Being an universal language, alongside to a middleware able to realize the fully interoperability among different and natively incompatible domotic systems and devices, this language can be used without taking care about the technologies of used devices. Being designed as distributed language, the system can share the computation loads according to the computing capabilities of the domotic network.

1.   Targeted breakthrough and long-term vision

The most significant breakthroughs that DUE wants to provide are:

> ➢ a new concept of programming language (DUL) with static componible types. It is an innovative solution in domotic programming that permits to verify at compilation time if the design of the domotic environment is coherent from a point of view of the programming language and of the domotic devices. This is obtained creating a new XML language called dXML that takes advantages of aspects of the functional programming paradigm. In particular, dXML models domotic devices and how they exchange message and DUL uses this models as types. Combining dXML with the functional paradigm, DUL specifies formal properties related to the interactions. In this way it is realized a strong static type check process and also the verification of the correctness of DUL code at run-time;

> ➢ the creation of an interoperability framework able to put in communication incompatible domotic sensors and actuators of different technologies uniformizing them using an high level abstraction language that makes them able to share data. This permits to choose devices for their functionalities and not for their belonging technology, overcoming a big issue in domotics, and to integrate old and new domotic systems;

> ➢ to describe how the domotic devices react when defined events happened in the environment and/or defined user parameter are measured. Taking advantage of the interoperability framework and of the domotic devices, DUL permits to control the environment to implement and to describe events, and to develop new AmI (Ambient Intelligent) oriented algorithm. Moreover, predefined AmI algorithms in DUE can can take as input a source created using DUL to verify when described events happens, to combine and elaborate data and to verify, as example, changes in user habits;

> ➢ a developing integrated environment using a common operating system technique based on levels of abstraction (usually represented using onion skin analogy);

This project conducts, for example, to this long-term vision:

➢ DUL introduces an high flexibility to the entire system permitting for example, in a AAL field, to medical staff to describe in DUL the signs that are typical to prevent emergency or dangerous situations for the health of elderly;

➢ DUE permits a quick and low-cost develop for specific problems such as systems for independence of elderly at home: exploiting domotic solutions implementing smart applications designed expressly for seniors, many daily activities can be automated to go beyond their physical limits and to improve their security and safety, making them more autonomous;

➢ dXML permits a modular description of the environment and a standard method to verify if the system is coherent.

This research project has surely a long term vision in terms of utility and in terms of research activities. In fact, the work can give a significant contribution, as example, to issues related elderly alone at home, to energy efficiency and so on. These examples are just some crucial issues for States and for EU. Moreover, as regard research activities, this project represents only a starting point that will permit the evolution of a new intelligent algorithms, the creation of new domotic devices and new smart solutions for the wellbeing of human being. Finally, DUL represents a real innovation in the field of the programming languages and it can be easily extended for specific applications such as Smart Cities and IoT; in a long-term vision it can became a general language for general purposes.

2.   Novelty and foundational character

During last years, the issue related interoperability among different domotic systems was faced in different ways. The literature [1-6, 10] offers many functioning and valid systems even if there is still not the definitive and standard solution. This is due principally because they do not provide enough innovation in programming method: to implement interoperability, most of the solutions in literature offer languages to solve specific purposes and they don't provide a coherence verification of all parts of the entire system. They are often based on XML and OWL, but almost none of them has developed an ad-hoc programming language for domotics with AmI capabilities.

Regard the current state of the art, DUE introduces:

➢ the innovative programming language DUL dedicated for domotics and an efficient and dependable system to design and to program domotic heterogeneous systems;

➢ the innovative componible sorted type [11] dXML;

➢ a modular approach in DUL that takes advantages of a new constructor called "parent-of". This constructor permits to extends the concepts of class and subclass that are typical of all object oriented programming languages, permitting to compose DUL functionalities and to create very malleable, flexible, type check verified system and highly reusable code;

➢ a domotic XML (dXML) able to describe and threat messages generated by a domotic system extending works such as [7-9]. dXML also takes advantages of the componible constructor [11-12];

➢ a simple guideline for devices and interfaces in order to have each device as a type (or module) of the DUL programming language;

➢ the possibility to write the entirely code on a single computer and see how it is executed over the domotic system. The domotic system is represented as a IoT network where each device plays its own role reading and writing messages, and performing actions such as operate relays, electrical motors, reading sensors and so on;

➢ to distinguish the code that runs and that doesn't run on domotic devices. The system is able to compile the code optimizing it according to the recipient's device;

➢ the creation of virtual devices. Devices that are not able to execute DUL distributed code or that are not natively DUE (e.g. belonging to KNX, UPnP, ZigBee and so on technologies), are virtualized;

3.   Implementation

This project represents an important innovation in the field of programming languages, domotics and modelling systems. During the year of activity will be designed, implemented and tested the core of the DUE system.

3.1 Description

The goal to be reached during the year of activities are to:

1. write dXML specifications and implementation. This task requires to write a grammar for the dXML syntax using the BNF formalism, and the semantics analyzed by CCS simulation/bisimulation processes. dXML realizes a sorted algebra;

2. write dHAL description and dHAL middleware implementation. This document provides a detailed description of the domotic Hardware Abstraction Layer (interoperability middleware) of DUE to use devices just by knowing their specifications. Specifications are written using dXML and are distinguished for each class of domotic devices. Moreover, it describes best practice to create new native DUE domotic devices.

3. write the DUL functional language: DUL will be written using Ocaml because it is a very flexible language and it combine both functional and imperative paradigms. In order to define DUL syntax and its operative semantic are used OcamlLex and OcamlYacc tools.

4.   References

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