An Evidence-Based Roadmap to Support the Internet of Things Software Systems Engineering

Rebeca Motta[12], Káthia de Oliveira[2], Guilherme Travassos[1]

[1] PESC/COPPE, Universidade Federal do Rio de Janeiro - Rio de Janeiro - Brasil

[2] Univ. Polytechnique Hauts-de-France, LAMIH, CNRS, UMR 8201 F-59313 Valenciennes - France

{rmotta, ght}@cos.ufrj.br, kathia.oliveira@uphf.fr

Abstract. *The Internet of Things (IoT) paradigm brings many expectations and challenges. It involves several knowledge areas that should be combined to develop more autonomous and smarter software systems. In this work, 117 recommendations distributed in 29 categories were organized in an IoT Roadmap, an instrument to support IoT development. The IoT Roadmap is an evidence-based artifact to comprise different expertise to deal with IoT in a multi-faceted way. The IoT Roadmap guides what to consider while specifying, designing, and implementing IoT systems, having its feasibility and applicability indicated by experimental studies. The IoT Roadmap can support researchers and practitioners in understanding IoT and provide a checklist to identify the applicable recommendations for IoT software systems.*

Resumo. *O paradigma da Internet das Coisas (IoT) traz muitas expectativas e desafios envolve várias áreas de conhecimento que devem ser combinadas para desenvolver sistemas de software mais autônomos e inteligentes. Neste trabalho, 117 recomendações distribuídas em 29 categorias foram organizadas em no IoT Roadmap, um instrumento para apoiar o desenvolvimento de IoT. O IoT Roadmap é um artefato baseado em evidências que abrange diferentes conhecimentos para lidar com a IoT de maneira multifacetada. O IoT Roadmap orienta o que considerar ao especificar, projetar e implementar sistemas de IoT tendo sua viabilidade e aplicabilidade indicadas por estudos experimentais. O IoT Roadmap pode apoiar pesquisadores e profissionais na compreensão da IoT e fornece um checklist para identificar as recomendações aplicáveis para sistemas de software IoT.*

1. Research Summary

The Internet of Things (IoT) is a paradigm with the idea of the pervasive presence around us of a variety of things that can interact with each other and cooperate with their neighbors to reach common goals [1]. For IoT, software systems are no longer limited to computers but can materialize into a great variety of different objects or specific users' goals and environments. Therefore, the development of IoT solutions is complex since it embodies physical, networked, software, and human-interactive systems characteristics. Moreover, physical and virtual components are intertwined, overlapping related engineering areas, and integrating different skills and technologies for their realization [2].

In this work, we researched the conceptualization, development, and evaluation of an evidence-based instrument named IoT Roadmap [3] to support specifying, designing, and implementing IoT software systems. The IoT Roadmap was organized based on evidence acquired through experimental studies and evolved with the primary studies conducted in its evaluation. The IoT Roadmap encompasses the IoT multidisciplinarity involving Facets regarding *Things*, Interactivity, Connectivity, Behavior, Smartness, Environment, and Data with individually designed recommendations for each one [4].

The seven Facets of the IoT Roadmap are directed by the problem domain, influencing the conceptualization and realization activities. The knowledge behind the IoT Roadmap shows that such projects should (1) define the problem domain highlighting the goal for IoT, (2) consider which components will be used to achieve such goal, and (3) define the identification, sensing, actuation and other behaviors to be performed by such components, (4) identify all the actors involved in the solution and their respective interaction methods, (5) establish an adequate medium to have everything connected, (6) define the intelligence and smartness necessary for such goal, (7) implement the strategies to deal with capturing, analyzing and processing data; and (8) consider the influence on and from the environment the solution is settled in.

The Facets are organized into categories, and each category is composed of items, providing recommendations that software organizations can use to support the engineering of IoT software systems. The current recommendations are straightforward and can be used in sequence or only in the desired facets, depending on the project goal and the team's skills. This organization enables a reasoning flow from project goals to output and results through discussions and decision-making. The recommendations suggested by the IoT Roadmap can provide a more precise direction for the project, providing directives from the problem domain to the materialized IoT solution.

Two experimental studies were carried out to observe the feasibility and use of the IoT Roadmap. First, a feasibility study was conducted as an online survey, from which participants stated the ease of use and usefulness of the IoT Roadmap. Then, an observational study was carried out with junior software engineers. The results indicate the feasibility of the IoT Roadmap with a practical application in two real IoT projects. Considering the research and results, the main outputs of this research are (1) the body of knowledge of IoT characteristics, challenges, and facets, (2) the set of recommendations to support IoT software systems engineering, and (3) the materialization of the research in an actionable instrument as the IoT Roadmap.

References

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