# Improving Semantics in Mobile Devices Profiling: A Model Conceptual Formalisation and Ontology Specification

Natasha Queiroz Lino, Austin Tate, Yun-Heh Chen-Burger

[1] Centre for Intelligent Systems and their Applications, School of Informatics, The University of Edinburgh, Appleton Tower, Crichton Street, Edinburgh, EH8 9LE, United Kingdom
{Natasha.Queiroz, a.tate}@ed.ac.uk, jessicac@inf.ed.ac.uk

**Abstract.** In this work we discuss and propose a new approach for semantic enhancement in mobile devices profiling. This work is motivated by the lack of semantic in existing profiling methods and is part of a broaden framework for visualisation of intelligent planning information in collaborative environments. In this paper, before the discussion of this new model, its knowledge representation and ontology specification concepts, we argue about problems in existing profiling methods.

## 1 Introduction

This paper introduces a new approach for mobile devices profiling motivated by the need of semantic enhancement. This work is part of a more broaden framework for visualisation of intelligent planning information in collaborative environments [1].

In the last decades, many advances have been made in intelligent planning systems. Significant improvements related to core problems, providing faster search algorithms and shorter plans have been proposed. However, there is a lack in researches allowing a better support for a proper use and interaction with planners, mainly in collaborative environments where, for instance, visualization can play an important role. We are investigating and proposing a new way to address the problem of visualization in collaborative intelligent planning systems via a more general approach. It consists in an integrated ontology set and reasoning mechanism for multi-modality visualisation destined to collaborative planning environments. This framework will permit organizing and modelling the domain from the visualization perspective, and give a tailored support for presentation of information based on reasoning.

The focus of this paper is in the proposition of a new model and ontology for mobile devices profiling based on semantic modelling. This device ontology is part of the integrated ontology set that composes the framework.

## 2 CC/PP Profiling: Reverse Engineering Analysis

Ubiquitous computing is an area that is growing very fast. Nevertheless, the diversity of devices, technologies and applications available are making software development a difficult task, where applications have to be tailored for the different devices characteristics and capabilities. In this scenario devices profiling plays an important role. Profiling is one of the technologies emerging concerned with delivering content. A device profile is a description of the device's characteristics in some way, which will permit to guide content presentation.

The World Wide Web Consortium (W3C) recommendation Composite Capability/Preference Profile (henceforth CC/PP) [2] is one effort developed to solve problems related to delivering content in devices. A CC/PP profile is a description of device capabilities and user preferences. Resource Description Framework (RDF) [3] is used as knowledge representation tool to describe user agent capabilities and preferences, where RDF classes discriminates different elements in a profile.

CC/PP was choose for grounding our investigation in devices profiling for several reasons. First because it has an approach that best suits our concepts of knowledge representation. Second because it is based on W3C standards and concepts for the construction of the Semantic Web [4], whose overall objective of enlarging the semantic web potential (reaching also mobile devices) is also part of our global objective. To conclude, it is due to its popularity among mobile software developers, and use as a real standard. Hence, further investigation on CC/PP was carried out with the objective of identifying its expressive power as a knowledge representation tool. For that, based on the CC/PP RDF schema for classes and core properties, a reverse engineering process was applied. The main result of the process was a detailed UML class diagram. The class diagram helped identifying the CC/PP expressiveness: its scope, granularity of information, etc. More details of the findings will be presented in future publication.

The approach of CC/PP has many positive aspects. First it can serve as a basis to guide adaptation and content presentation. Second, from the knowledge representation point of view, it is based in RDF, which is a good aspect because it is a real standard and also permits be integrated with the concepts of the Semantic Web construction. For our work, the Semantic Web concepts will also be considered. We envisage a Semantic Web extension that will not be treated in details here, put will appear in further publications. Third, another advantage of CC/PP is the resources for vocabulary extension, although extensibility is restricted.

On the other hand, CC/PP has some limitations for what we need. It has a limited expressiveness power, that doesn't permit a more broaden semantic expressiveness. Consequently it restricts reasoning possibilities. For example, using CC/PP it is possible to express that a particular device is Java enabled. However this knowledge only means that it is possible to run Java 2 Micro Edition (J2ME) in that device. But it can have e more broaden meaning if we question, for example, 'What really means be Java enabled?' or 'What is J2ME supporting?'. Having the answers for questions like that will permit a more powerful reasoning mechanism based on the knowledge available for the domain. For instance, if a device is Java enable, and if J2ME is supporting an API (Application Program Interface) for Java 3D, it is possible consider delivering information in a 3D model.

For that is necessary to develop a more complex model for devices profiling that will be semantically more powerful. It is necessary to incorporate in the model other elements that will permit enhance knowledge representation and semantic. In the next section we will be discussing an alternative for such a model.

## 3 A New Model Approach

This new model approach intends to enhance semantics and expressiveness of existing profiling methods for mobile and ubiquitous computing. Consequently, reasoning capabilities will also be enhanced. Semantics will be improved in many ways as we categorise and discuss in subsection 3.1. Additionally, in subsection 3.2 the ontology specification will be argued. For the development of this new model we first developed a general model of classes. Afterwards, an ontology specification was made that will permit reasoning about the problem of visualisation in planning systems, as part of a more broaden framework [1]. In the next subsections the approach will be explained in more details.

### 3.1 New Model and Semantic Enhancement Categorisation

In this new model being proposed, semantic improvement can be categorised as follows:

1. **Java Technology Semantic Enhancement:** In this category is intended to enhance semantic related to the Java world. It is not sufficient to know that a mobile device is Java (J2ME) enabled. On the other hand, providing more and detailed information about it can improve device's usability when reasoning about information presentation and visualisation on devices. For that, in this new model proposed is included semantic of information about features supported by J2ME, such as support to 3D graphics; J2ME APIs (Application Program Interface), for instance, the Location API, that intends to enable the development of location-based applications; and also J2ME plug-inns, such as any available Jabber [5] plug in that will add functionalities of instant messaging, exchange of presence or any other structured information based on XML.
2. **Display x Sound x Navigation Semantic Enhancement:** One of the most crucial things in development of mobile devices interfaces is the limited screen space to present information that makes it a difficult task. Two resources most used to by pass this problem are sound and navigation. Sound has been used instead of text or graphic to present information; for example, give sound alerts that indicate a specific message to the user. Indeed, it can be very useful in situation where the user on the move is not able to use hands and eyes depending on the task he/she is executing. In relation to navigation, this resource can be used sometimes to improve user interface usability, if

well designed. However, good navigation design has some complexity due to: devices diversity and because in some devices navigation is closely attached to the devices characteristics (special buttons, for example). So, this category intends to enhance semantic related to these aspects, that will permit a good coordination and reasoning through these resources when presenting planning information to mobile device's users participating in collaborative processes.

3. **Future New Technologies Semantic Enhancement:** This category of semantic enhancement is the more challenging one in this new model proposition. Mobile computing is an area that is developing very intensely. New devices and technologies are been created every day. In this way it's easy to create technologies that will be obsolete in few years time. Trying to overpass this problem, we envisage that will be possible to provide semantic to future new technologies in mobile computing via a general classes and vocabulary in the model and framework proposed.

### 3.2 Knowledge Representation: Ontology Specification and Reasoning

The knowledge representation approach that we are investigating for using in the framework is based on XML - Extensible Markup Language [6] and related technologies, following W3C standards. More specifically, the ontology specification is made in OWL that permits not only present information in a structured format, but also process it with semantic.

In a first phase, these technologies have been used as knowledge representation tools, however a Semantic Web application will not be aimed in future. These technologies filled a gap, providing first a syntax for structured documents (XML, XML Schema), and second a simple semantic for data models (RDF – Resource Description Framework), that evolved for more elaborated schemas (RDF Schema, OWL). RDF Schema permits semantics for generalization-hierarchies of properties and classes. OWL – Web Ontology Language, adds more vocabulary with a formal semantics, allowing more expressive power, permitting, for example, express relations between classes, cardinality, equality, and characteristics of properties, among others.

OWL [7] is an evolution of DAML+OIL [8] and is aimed for use when is necessary to process information, and not only present it, because facilitates machine interpretability via its additional vocabulary and formal semantics. OWL is divided in three sub-languages, with increasing expressiveness: OWL Lite, that provides classification hierarchy and simple constraints; OWL DL that has maximum expressiveness with computational completeness and decidability, founded by description logics; and OWL Full that allows maximum expressiveness and syntactic freedom of RFD, but without computational guarantees.

The OWL ability of processing the semantic of information seems to be appropriate technology to be used in the general framework being developed, to build the integrated ontology set, and reasoning mechanism in the problem domain. The resulting framework will considers the semantic of the information available, and it will be capable of reasoning based on real standards.

## 4 Conclusions

In this paper we introduced a new model approach for devices profiling. This new model is part of a more broaden framework for visualisation of intelligent planning information in collaborative environment. The approach presented in this paper is motivated by the need of semantic enhancement for mobile devices profiling. This work brings several contributions to the area. First it permits semantic improvement related to Java technology. This will allow reasoning considering Java aspects (resources, API's, plug ins, etc.) enabling the reasoning mechanism to propose tailored modalities of information visualisation. Second, is also being provided semantic enhancement related to display, sound and navigation aspects, motivated by the fact that a wise use of these resources can improve mobile devices usability. Additionally, the most challenging contribution is that the approach does not intend to be limited to current technologies, but is open and extensible to new technologies semantic formatting.

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