Applying Tropos modeling for Smart mobility applications based on the FIWARE platform

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Abstract. One of the main issues in current cities is mobility. The unprecedented growth in urban mobility has led to multiple open challenges to be considered in the design of smart cities that improve the citizens' quality of life. There are several factors involved in the development of urban mobility applications as pollution monitoring, traffic congestion, and environmental conditions. One of the most well-founded platforms to develop complex technological solutions for smart cities is FIWARE, which proposes open standard specifications using an open cloud infrastructure. In this context, modeling approaches are needed to represent, in a high abstraction level, the *to-be* view of a mobility application, with models that help the analysts to understand the semantic of the physical, human, and software actors involved in the application development. In this paper, we explore the use of Tropos framework for modeling in a high abstraction level, the requirements of a smart mobility application that will be developed with FIWARE. The paper discusses the issues found in using Tropos to represent the smart mobility solution.

Keywords: Tropos modeling, smart mobility, FIWARE platform

1   Introduction

Nowadays, the high density of vehicles in current cities has led to several complex issues, such as traffic congestion, pollution, longer trip time, decreasing public safety and increasing noise. For instance, in Mexico City, with 20 million people, there are 4 million vehicles on the road and a total of 22 million trips every day [1]. In this complex scenario, mobility concerns represent key challenges in smart cities design, where novel technologies such as Internet of Things (IoT) are required for developing systems that produce intelligent decisions based on data provided by objects connected to Internet. One of the most recognized platforms for smart city development is FIWARE [2], an open innovation ecosystem that allows creating new applications

and Internet services. Mexico has an instance of the FIWARE platform called Mexican FIWARE Lab Node hosted in the National Future Internet Laboratory (http://lanif.infotec.mx/), where we will deploy a smart mobility application taking the advantages provided by the platform. In this sense, more than 100 European cities are already using FIWARE, most of them for mobility solutions, however, one of the main issues of FIWARE, as well as of most of current smart city platforms, is that they are programming-based approaches, where solutions are generated starting from low design levels. In this paper, we present the use of the Tropos for modeling in a high abstraction level, the requirements of a smart mobility application based on FIWARE. A Release Planning (RP) approach will be used for developing application [4]. As a result, some challenges have been identified in the use of Tropos concepts to represent IoT components of technological solutions for smart mobility applications.

2 Objectives of the research

This paper has two main research objectives: a) to explore the use of Tropos to model the complex scenario of a smart mobility application to be developed, called *Green Route*, representing smart technology components as intentional actors since they have the ability to make decisions by themselves, and b) to make explicit the challenges to be faced in Tropos to appropriately represent smart technological components, specifically for mobility applications based on FIWARE.

3 Scientific contributions

We propose using the Tropos framework to model the scenario and the operational environment of *Green Route*. The objective of *Green Route* is to help the final user to determine the best route to follow to reach a destination, taking into account the user profile (e.g. age, health conditions, disabilities, etc.), and the user preferences, such as transport type. *Green Route* proposes the ideal route for the user, avoiding routes with high levels of pollution, floods or pollen, etc., allowing for instance, to obtain the preferred routes for people with respiratory diseases. *Green Route* obtains data from mobile and fixed sensors (based on the IoT approach) to get real time information. Additionally, *Green Route* obtains data from other sources, such as air conditions provided as open data and data generated through the concept of human-as-a-sensor to get the user feedback about specific conditions in its location (e.g., rain, pollution, etc.). *Green Route* is based on the cloud capabilities of FIWARE, which enables to connect sensors through standard specifications and provides software components to store sensors data, enabling data analysis and querying. It is important to point out that for developing the route system, we are considering to generate a series of releases among the requirement process, in order to satisfy the user needs obtaining early feedback and to satisfy important technical, resource, budget and risk constraints. Hence, we don't follow the conventional Tropos software development process.

Tropos modeling of a smart mobility application based on FIWARE

The goal of this phase is to present the generated Tropos models for *Green Route*[1], which mainly focuses on: a) the representation of all the elements that support *Green Route*: data acquisition and infrastructure and platform as a service for data storage, processing, analysis and consumption of data in the cloud, and b) the representation of all the required functionalities of *Green Route* to answer user needs. The actor concept has been used to represent the hardware and software involved in the solution, since they communicate among them without human intervention. Additionally, these components have skills to independently take decisions based on its context, making use of mechanisms of the artificial intelligence. For this reason these components were modeled as intentional elements.

The first model is the *as-is setting model* (Fig. 1) which describes, in a high level view, the current scenario to determine the best route to follow to reach a destination (without using a smart application), where the user needs to access to different data sources to consolidate the information. The second model is the *goal model* (Fig. 2) that represents the goal dependencies of the key actors of the *Green Route* in a high level view. This model was generated as a first approximation to automate the *as-is setting model.* In order to represent the sources to acquire environmental data, the model contains two units: *Mobile Data Acquisition Unit* (*Mobile Unit*) and *Fixed Data Acquisition Unit* (*Fixed Unit*). These units have been represented using the *technology module concept* [3], which allows to represent technology in a high abstraction level including information about functionalities, specific requirements and quality features. In our proposed scenario, the *technology module concept* allows to encapsulate all technology components related with data acquisition from several sensors, data local storing, wireless communication and data transmission.

The *Mobile Unit* represents the actor and dependencies involved in the process of acquiring environmental data from unit mounted on transport in movement, and the *Fixed Unit* represents the actor and dependencies involved in the process of acquiring environmental data from fixed monitoring stations. *FIWARE Lab* receives environmental data captured by sensors from *Mobile* and *Fixed Units*, also it receives environmental data obtained by a *crawler* from an *open data website*. The *PaaS consumer (*Platform as a Service*)* actor depends on *FIWARE Lab* to provide cloud resources on demand.
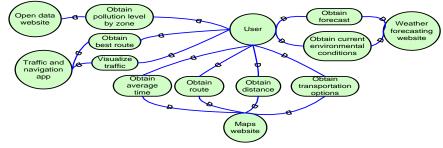

Fig. 1. The as-is setting model to reach a final destination manually

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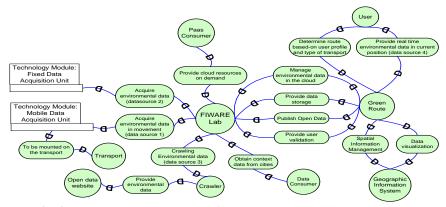[1] Models are available in: http://www.tagoon.semanticbuilder.com/Troposmodels/

Fig. 2. Goal dependency model of the smart city mobility application

The *Green Route* depends on the *FIWARE Lab* for storing, management, analysis and consumption of environmental data in the cloud. The *user* depends on *Green Route* to determine the ideal route to follow based-on user profile and type of transport, and provide real time environmental data in current position. The *Green Route* depends on *Geographic Information System* to perform historical analysis and to get data visualization through maps. In Fig. 3, a fragment of the third model (strategic rationale: SR) of the *Green Route* actor is presented. This model represents the social and intentional relationships mainly of IoT technologies and the final user.
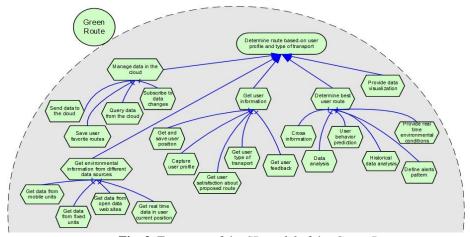

Fig. 3. Fragment of the *SR model* of the *Green Route* actor

In order to achieve the goal "*Determine route based-on user profile and type of transport*", the *Green Route* has to accomplish five main tasks: a) "*Manage data in the cloud*", which involves activities related with storage, security and data management; b) "*Get environmental information from different data sources*", which involves activities related with getting environmental data from sensor networks, open data websites and data provided by the user; c) "*Get user information*", which in-

volves activities related with collecting all the information from the user required to provide the best route; d) "*Determine best user route*", which involves activities related mainly with cross information and data analysis to generate the best route for the user, taking into account all the available information from the user and from the environment; and e) "*Provide data visualization*", which involves activities related with the visualization of available data through maps. At the present time, models have been used for analysis purposes. The next development phases will be incremental using technologies such as *DevOps* and *OpenShift*. Therefore, we have not used a specific Tropos tool for the modeling process.
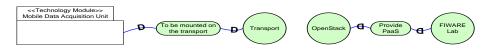
3.1 Experiences

In this section, we detail some of our experiences using Tropos while representing the IoT components of the smart mobility application. In general, Tropos enable analysts representing most of elements of smart mobility scenario: actors of different nature, technology, software and people, for instance, actors involved in cloud computing, sensor networks, crawling and user interfaces. Some issues identified are:

 - The *crawler* actor obtains environmental data directly from a *website* in an automatic way. In this case, there is not goal, task or resource delegation between actors, since the *website* is not aware of the *crawler*. This has been represented in the model as a goal dependency where the *crawler* is the *depender* and the *website* is the *dependee*, however, the *crawler* does not delegate the *website* the responsibility to provide the data.

 - Two examples of conflicts representing dependency between two actors have been identified, since the delegation is not about a task execution or a resource provisioning: a) The *Mobile Unit* depends on the *transport* to be mounted on it, b) The *FIWARE Lab* depends on *OpenStack* to provide Platform as a Service (PaaS). In these cases, a goal dependency has been used to indicate a physical dependency between two actors, however, these dependencies do not have the semantic of goal delegation.

4 Conclusions

The advantages of using Tropos for modeling smart mobility applications can be summarized in its effectiveness to cover a deeper understanding of a complex envi-

ronment, such as the smart mobility scenario, where both, software and hardware must take decisions independently based on its context.

We consider that representing a smart mobility scenario, without a formal language to present intentional social relations, will difficult to obtain a high level view of the system to be developed and to clarify the role of each actor in the fulfillment of the goals of the system. Moreover, it could not be determined the vulnerability level of the system if some actors fail to accomplish its goals. In this sense, we consider the effectiveness of using Tropos to enable the analysts to represent, in a high abstraction level, the complex IoT technologies involved in a smart mobility application. Tropos allows to obtain a deeper understanding of the environment where the application must operate, and the kind of interactions between components and the final users, considering that in the proposed scenario, there are complex relationships among actors of different nature, such as: smart software applications, cloud platforms, crawlers, sensor networks, human users, etc. It is important to point out that the development of mobility applications is highly dependent on technology. This technological dependency has been appropriately represented using the concept of module. Advantages and issues in using Tropos in modeling the to-be mobility application were identified.

5   Ongoing and future work

One of the conclusions of the modeling activity is the need to extend Tropos concepts for the representation and interaction of IoT technologies. We believe that the Tropos semantic (delegation of responsibilities, the vulnerability associated to dependency, the role of depender and dependee) does not comply the semantic of these new ways of interacting. For instance, some tasks are executed over on the information of an actor, without his permission. New modeling concepts are been developed to properly represent the needed semantics. As future work, we will use of the generated model as starting point of a semi-automatic process to develop the initial implementation of the system to-be. This is possible because the interaction with FIWARE components are standardized and they have well-defined functionalities.

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