Using Social Paradigms In Smart Cities Mobile Context-Aware Computing

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Context

Growing **cities pose** environmental, economic and social **challenges** amid attempts to provide sustainable livable conditions. **Tackling** these challenges **require** cutting-edge hardware and **software solutions** and business supported urban development given the **social** and **environmental sustainability**. The current urbanization scenario demands efficient solutions for public transportation, land use and high-quality urban services. Over the last decade the "smart city" concept has emerged as a technology-supported response to challenge these issues at city scale. While industry, education, participation and information technologies infrastructure compose the core four components of a smart city, we define a **smart city** as a collection of the **intelligent computing infrastructure**, such as a new generation of integrated hardware, software and network technologies that provide a real-time awareness of the real world [1].

Being a core component of urban strategies, **ubiquitous** information technologies provide the intelligent environment in smart cities computing [2]. Ubiquitous access to information, communication, and computing is enabled through the context-awareness. **Context-awareness** refers to an ability of a system to **adapt** its operations to the current context without explicit user intervention given certain contextual information. Given the ubiquity of mobile and wearable devices, their integration remains one of the open issues [3]. The present research proposes a **new ontology** model enabling a **dynamic integration** of **mobile devices** into a system supporting context-aware behavior.

! Challenges

The **dynamic integration** of a device into a context-aware computing system is one of the important contemporary research challenges. Another difficulty is to teach a computer to sense the environment and reason that would allow device to become proactive in offering services. Since the idea behind ubiquitous computing is a combination of large-scale mobility and pervasive computing capability, this concept inherently poses technical, social, and organizational challenges. These challenges include the design and implementation of computing architectures, and the rethinking of feasible ontologies, domain models, and a wide range of policy issues concerning social organization.

While the model proposed within the present research is unique and opens new horizons in designing systems with enabled context-aware behavior, there is a number of some imperfections and limitations associated with the approach:

- a mechanism for monitoring the tasks execution given a certain role;
- an algorithm to provide the information about a certain role to different devices;
- a testing functionality to check whether a device is able to perform task executions associated with a role;
- an algorithm to provide robust device management given several devices owning same Role;
- a communication schema and logic system.

Scaling Up

The model and the anticipated prototype can be used various domain where a dynamic integration of a mobile device is a requirement. As a result, one of our peer-reviewed publications is devoted to use-case scenarios describing the potential applications in detail. We envision that our research has a potential in healthcare to support people with special needs, in road pricing, as well as in a situation requiring personalized approach and context-aware services. The approach proposed can also find its application in road pricing, for example for different vehicle types and occupancy levels which can dynamically change.

Actions

The idea behind the research is inspired by the principles of organization theory and sociology and applies notions such as Role, Ownership and Responsibility. We argue that to support the dynamic integration of device into a context-enabled computing system a device needs to possess a certain amount of information or a predefined structure about the surrounding environment. This information includes: (i) the available roles existing in the environment, (ii) the roles that the device can own, and (iii) the information about other devices that own roles in that system. Sociology notions are utilized to represent knowledge about the system (Tables 1-3).

The important assumption in the model is the **competency principle** of a device which refers to its ability to execute all required functions to accomplish the tasks imposed by the role it owns. In this research we assume that when a device owns a role, the competency principle is satisfied. The ontology model and the relations of the introduced notions is demonstrated through the use-case scenario (Figure 1) where the main actors are people with special needs crossing a street regulated by traffic lights.

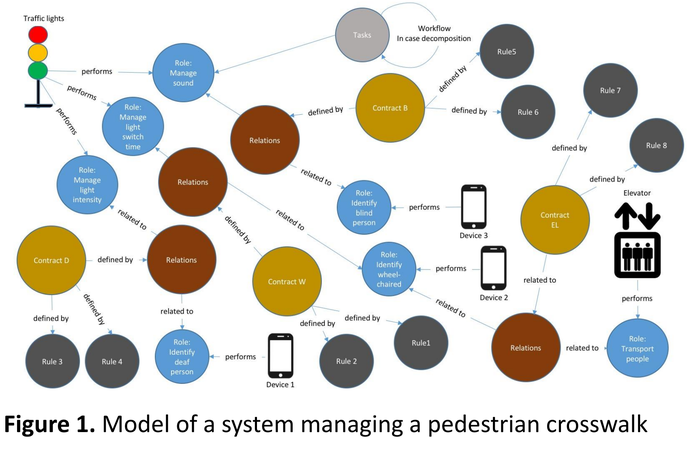

Figure 1. Model of a system managing a pedestrian crosswalk

Device	*Role*	*Context*
Traffic lights	Manage the lights switch time	Pedestrian traffic lights
Traffic lights	Manage sound	Pedestrian traffic lights
Traffic lights	Manage lights intensity	Pedestrian traffic lights
Mobile device of wheelchaired person	Identify wheelchaired person	Pedestrian traffic lights
Mobile device of blind person	Identify blind person	Pedestrian traffic lights
Mobile device of deaf person	Identify deaf person	Pedestrian traffic lights
Mobile device of wheelchaired person	Identify wheelchaired person	Elevator

Role	*Task*	*Context*
Manage the lights switch time	Change the lights switch time	Pedestrian traffic lights
Manage the lights intensity	Change the lights intensity	Pedestrian traffic lights
Manage sound	Connect beeps	Pedestrian traffic lights
Identify wheelchaired person	Submit wheelchaired ID	Pedestrian traffic lights
Identify blind person	Submit blind ID	Pedestrian traffic lights
Identify deaf person	Submit deaf ID	Pedestrian traffic lights
Identify wheelchaired person	Submit wheelchaired ID	Elevator

Relations			
Role	*Role*	*Contract*	*Context*
Identify wheelchaired person	Manage lights switch time	W	Pedestrian traffic lights
Identify blind person	Manage sound	B	Pedestrian traffic lights
Identify deaf person	Manage lights intensity	D	Pedestrian traffic lights
Identify wheelchaired person	Transport people	EL	Elevator

Tables 1-3. Structural knowledge of the model

Results

The present work applies the Design Science Research technique. Thus, the methodology for the research is twofold: a methodological construction of an **artefact**, and the development of the **experimental proof**. The artefact in the present research is a **conceptual model** of that allows a device to get integrated into a system and communicate with other devices given the contextual information. While the expected prototype serves as experimental proof.

Impact

Context-aware and ubiquitous computing is an essential element in building smart cities. This research proposes a novel approach to integrate mobile devices into a system with enabled context-aware behaviour. The idea behind the proposed approach is treating mobile devices as agents in multi-agent system. However, the novelty lies in having a **predefined structure** of the system available for mobile devices attempting to connect the system. In a nutshell, the predefined structure is represented by the **relations between components** in the system and **rules** regulating the relations.

Consortium

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