

# CONTEXT-ORIENTED KNOWLEDGE MANAGEMENT FOR INTELLIGENT USER ASSISTANCE IN SMART SPACE

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**Keywords:** Knowledge management, Ontology, Context, User profile, Smart space.

**Abstract:** Such topics as smart home, smart car have become widespread recently. The paper presents an innovative approach to context-oriented knowledge management in the smart space. The smart space consists of a set of devices that can interact with each other, exchange information and services. Knowledge management in such systems allows coordinating activities of a large amount of entities which can communicate within the smart space.

## 1 INTRODUCTION

Research efforts in the area of the smart spaces have become very popular recently. Such topics of research as smart home, smart car are widely discussed in modern computer science. In such systems all elements have to interact and coordinate their behavior without any user intervention.

Mobile phones have insensibly transformed from simple phones that allow users only to make calls and write SMS to multifunctional devices that allow them to connect to the Internet, take photos, use embedded GPS, and so on. Such capabilities make it possible for the user to use these devices as assistants. In case of occurrence of a certain situation (context), the device implements an automatic solution (or action) search. The context is formalization of a situation model embedding the specification of problems to be solved in this situation. The device takes into account the user preferences which are kept in the user profile.

A mobile phone in the modern world is always with its owner. This allows keeping and enlarging the user profile in the device. When the user finds him/herself in the smart space, it allows using this information to automatically interact with other mobile and fixed devices of the smart space.

Modern tendencies of information and telecommunication technologies require development of stable and reliable infrastructures to extract and keep different kinds of information and knowledge from various members of the smart space. The smart space assumes more than one

device that uses common resources and services. One of the most appropriate approaches to realize such infrastructure is knowledge management systems. This paper describes an innovative approach to context-oriented knowledge management for intelligent user assistance in the smart space.

## 2 RELATED WORKS

Different systems of mobile device use in the smart space have been examined. A brief description of the most essential approaches is presented below.

The authors of (Declan O., Vincent W., 2002) examine the problem of the semantic interoperability of several information systems. As a case study the authors take the smart space which is determined as a physical space rich in devices and software services that is capable of interacting with people, physical environment and external networked services. The authors introduce the smart space management as dynamic runtime adaptation of the smart space devices and software services to provide the necessary support for people's tasks and activities.

Paper (Cuno S. et al., 2008) describes the common architecture for a political management platform which provides access from different countries. This platform includes such technologies as web-services, XML, SSL.

The purpose of the project described in (Persist, 2009) is to study and develop a personal smart space

that provides a minimum set of functionalities which can be extended and enhanced as users encounter other smart spaces in their everyday activities. It is capable of learning and reasoning about users, their intentions, preferences and context. It is endowed with proactive behaviors which enable users to share context information with neighboring personal smart spaces, resolve conflicts between the preferences of multiple users, give recommendations and act according to them, prioritize, share and balance limited resources between users, services and devices, reason about trustworthiness to protect privacy and be sufficiently fault-tolerant to guarantee their own robustness and dependability.

In (Zhang D. et al., 2005) a context-based approach to the development of a future smart home is described. The authors argue that services in pervasive and mobile environments need to be context-aware so that they can adapt themselves to rapidly changing situations. The authors propose a generic five-layer model for guiding the design and implementation of context-aware systems. This model abstracts the functional elements of context-aware systems, i.e., context acquisition, context representation, context aggregation, context interpretation, and context utilization.

(CASCOM, 2007) is a Specific Targeted Research or Innovation Project supported by the European Union's IST program. The main objective is to implement, validate, and trial a value-added supportive infrastructure for Semantic Web based business application services across mobile and fixed networks. The project delivers a full proof-of-concept implementation of the generic CASCOM service coordination support infrastructure for mobile business application service coordination for mobile users and workers, and a field-trial CASCOM demonstrator for selected pervasive health care application services.

(Open, 2009) is a FP7 project which aims at developing an environment that provides people with the ability to continue performing their tasks when they move around and change their interaction device. The main goal of the OPEN project is to provide a general and open migratory service platform solution based on a sound and innovative scientific approach.

The purpose of the approach to the interoperability of different devices in network environment (Miko et al., 2006) is to offer the user the most appropriate terminal for handling incoming transmission according to the user's status and enable optimal handover between devices.

In (Kett et al., 2008) the authors discuss the problem of processes optimization in the sales

information system for a small and medium mercantile agency based on mobile devices. The authors present facts that most of such information systems are developed for large companies.

The purpose of the Italian innovation center Hewlett Packard (Mamelli A. et al., 2008) is to develop a mobile caregiver information platform. The authors developed an extensible set of services that allow patients staying at home to get permanent support. Mobile devices are used for the interaction with the user and for the monitoring of the patient environment.

The AMASE project (Kovacs E. et al., 1998) is adapting an existing mobile agent system to the requirements of a wireless computation environment. The project based on the Siemens SWARM platform in order to fit a wide range of heterogeneous mobile devices and to meet the requirements of wireless communication in an optimized manner.

Detailed analysis of this related research allows determining the following techniques for the user assistant systems in the smart space:

- semantic interoperability,
- web-based,
- client-server,
- scalability,
- real-time,
- monitoring,
- user profile,
- security,
- protocols.

### 3 KNOWLEDGE MANAGEMENT IN SMART SPACE

An approach presented here also relies on the ontological knowledge representation. The conceptual model of the proposed ontology-based knowledge management is based on the earlier developed ideas of knowledge logistics. Ontologies are used to describe knowledge in the smart space.

Different users and devices of the smart space interact in the knowledge management system. When the user registers in the system, his/her mobile device creates a user profile that allows specifying and enlarging user tasks in the smart space and personifying the information and knowledge flow from the system to the user.

The ontological approach to context-oriented knowledge management in the smart space is presented in Figure 1.

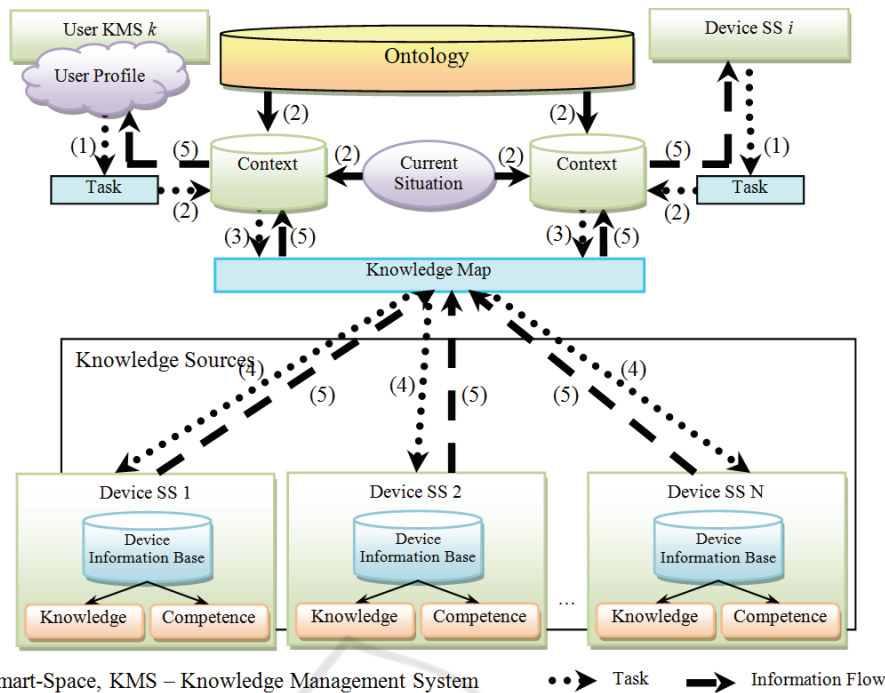


Figure 1: Ontological approach to context-oriented knowledge management in the smart space.

In accordance with the conceptual model, the context-oriented knowledge management system following a scenario for users and devices interaction support in the smart space is considered.

A user or device of the smart space generates a task (1). Based on this task, domain ontology, and current situation in the smart space context is built (2). Context is the description of the task in terms of ontology taking into consideration the current situation. The ontology in the knowledge management system describes the main terms used for the smart space description and relations between them. Then fragments of the ontology relevant to the task are extracted and unified. It contains abstract knowledge relevant to the task.

The knowledge map defines references between the ontological model (3) and knowledge sources (4). This makes it possible to use uncoordinated sources as a single distributed knowledge base. Based on the knowledge map and the formalized user task, the knowledge and information required for the user are acquired from appropriate sources (5).

If a user who is a smart space member serves as a knowledge source, it provides services for the system to access the owned knowledge. Information about the member is obtained from its user profile. Using this information the knowledge management system can provide it to other users and devices in the smart space.

For these purposes, a user profile has to contain personal information about the user, domain specific information, information that describes user preferences, feedback information and history that contains previous user activities in the system.

#### 4 USER PROFILE FOR MOBILE DEVICE IN SMART SPACE

Most of user profile models include such information as: first name, last name, gender, date of birth, languages, and contact information and user position. It is proposed to keep this information in the “Personal Information” module (Figure 2).

Since the knowledge management system is context-oriented, it is necessary to determine tasks that the user can solve at the moment, allow and deny access to the knowledge of the system, allow users to hide their profiles, track user location and time, status of user accessibility. For feedback estimations it is necessary to develop “System Information” and “Feedback” modules (Figure 2).

User preferences need to be formalized and kept in the user profile. Preferences include elements of the domain ontology preferred by the user (for example, in case of a presentation room that includes a big plasma screen and a projector the user prefers to make a presentation using the projector) and other

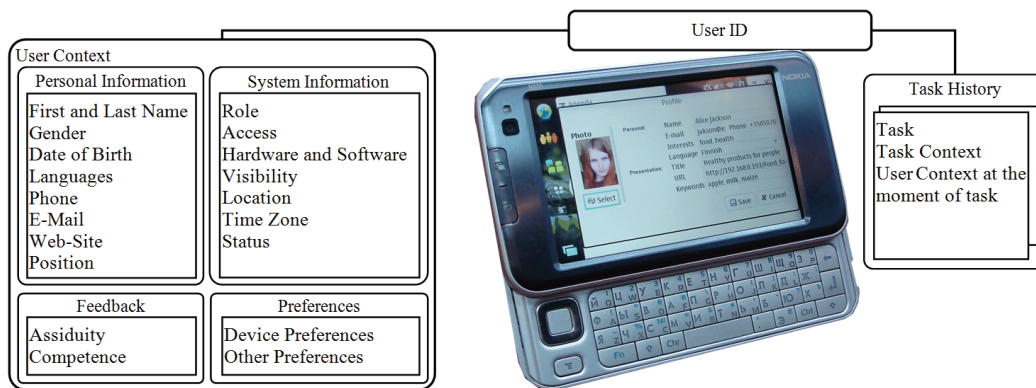


Figure 2: Conceptual model of user profile in the smart space.

preferences (for example, presentation time, amount of light in the presentation room, etc.).

For the purposes of keeping the history of interaction between the user and the knowledge management system and its further analysis, it is proposed to keep in the user profile his/her tasks, task contexts and user contexts at the moment of tasks generation. Based on this information, user preferences can be semi-automatically identified using ontology based clustering mechanisms described in (Smirnov A. et al., 2008).

User profile based on the presented model of the user profile has been implemented for mobile devices which interoperate in the smart-space (see Figure 2).

## 5 CONCLUSIONS

This paper presents an innovative approach to context-oriented knowledge management for intelligent user assistance in the smart space. This approach allows different devices in the smart space to interact with each other for the purpose of interoperability. User profiles allow keeping important information about the user and using it in the smart space.

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