Chapter 12
Ubiquitous Semantic Applications:
A Systematic Literature Review

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ABSTRACT

Recently practical approaches for development of ubiquitous semantic applications have made quite some progress. In particular in the area of the ubiquitous access to the semantic data the authors recently observed a large number of approaches, systems and applications being described in the literature. With this survey the authors aim to provide an overview on the rapidly emerging field of Ubiquitous Semantic Applications (UbiSA). The authors conducted a systematic literature review comprising a thorough analysis of 48 primary studies out of 172 initially retrieved papers. The authors obtained a comprehensive set of quality attributes for UbiSA together with corresponding application features suggested for their realization. The quality attributes include aspects such as mobility, usability, heterogeneity, collaboration, customizability and evolvability. The primary studies were surveyed in the light of these quality attributes and the authors performed a thorough analysis of five ubiquitous semantic applications, six frameworks for UbiSA, three UbiSA specific ontologies, five ubiquitous semantic systems and nine general approaches. The proposed quality attributes facilitate the evaluation of existing approaches and the development of novel, more effective and intuitive UbiSA.

INTRODUCTION

Recently practical approaches for the development of UbiSA that allow access to the Web of Data have made quite some progress. On the backend side, a variety of triple stores were developed and their performance and maturity improved steadily. With increasing power of ubiquitous devices it has become possible to use some of the triple stores on devices to allow offline access to the semantic data. Similarly tools and algorithms for processing and presenting data on ubiquitous devices are

progressing and approaches are deployed for the use on the emerging Web of Data. The quantity and quantity of semantic content being made available on the Data Web is rapidly increasing, mainly due to the use of automated knowledge extraction techniques or due to the semantic enrichment and transformation of existing structured data. Despite many interesting showcases (e.g. *Sindice¹*, *Parallax²* or *PowerAqua³*), we still lack more user friendly and scalable approaches for the exploration, browsing and search of semantic data. However, the currently *least* developed aspect of access to the semantic data is, from our point of view, the user-friendly *ubiquitous* applications that provide access to rich semantic content.

To define UbiSA, we must first specify what we mean by *ubiquitous* applications and *semantic* documents.

A guiding principle of ubiquitous applications is to break away from desktop computing to provide computational services to a user when and where required (Salber, Dey, & Abowd, 1998).

Ubiquitous applications are characterized by two main attributes (Weiser, 1991):

- **Ubiquity:** Interaction with the system is available wherever the user needs it;
- **Transparency:** The system is non-intrusive and is integrated into the everyday environment.

Semantic documents are documents that consist of semantic data and describe specific entities or collections of entities. Semantic data on the other hand is the data that is defined and linked in a way that it can be used by machines not just for display purposes, but for automation, integration, and reuse of data across various applications. Semantic data should provide a basis for coding, exchanging, and reusing structured metadata among applications exchanging *machine understandable* information on the Web.

Taking all of the above into account, we define *ubiquitous semantic application* as the computer software implemented specifically for ubiquitous devices and designed to help the user to perform specific tasks that satisfy the following requirements:

- The application is designed and developed specifically for (or with respect to) ubiquitous devices,
- The application utilizes semantic data during the work process in any way (e.g. executing SPARQL queries, reading or writing RDF triples).

A ubiquitous semantic application provides a human accessible interface with capabilities for reading, writing or modifying semantic documents.

Semantic documents facilitate a number of important aspects of information management:

- For *search* and *retrieval*, enriching documents with semantic representations helps to create more efficient and effective search interfaces, such as faceted search (e.g. in Ermilov, Heino, and Auer (2011)) or question answering. Ultimately, users are empowered to fight the increasing information overload and gain better access to relevant documents and answers related to their information needs.
- For *information presentation*, semantically enriched documents can be used to create more sophisticated ways of flexibly visualizing information, such as geospatial maps as described in Viana, Filho, Gensel, Oliver, and Martin (2007), Braun, Scherp, and Staab (2010), Wilson, Russell, Smith, Owens, and M. C. Schraefel (2005).
- For *information integration*, semantically enriched documents can be used to pro-

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