



Semantic-Based Bluetooth-RFID Interaction for Advanced Resource Discovery in Pervasive Contexts

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ABSTRACT

We propose a novel object discovery framework integrating the application layer of Bluetooth and RFID standards. The approach is motivated and illustrated in an innovative u-commerce setting. Given a request, it allows an advanced discovery process, exploiting semantically annotated descriptions of goods available in the u-marketplace. The RFID data exchange protocol and the Bluetooth service discovery protocol have been modified and enhanced to enable support for such semantic annotation of products. Modifications to the standards have been conceived to be backward compatible, thus allowing the smooth coexistence of the legacy discovery and/or identification features. Also noteworthy is the introduction of a dedicated compression tool to reduce storage/transmission problems due to the verbosity of XML-based semantic languages.

Keywords: knowledge-based systems; knowledge discovery; knowledge storage; mobile technologies; ontologies; semantic matchmaking; wireless technologies

INTRODUCTION AND MOTIVATION

Radio-frequency identification (RFID) is an increasingly widespread and promising wire-

less technology interconnecting via radio a transponder carrying data (*tag*) located on an object, and an interrogator (*reader*) able to receive the transmitted data. Tags usually contain a unique identification code, which can

be used by readers to identify the associated object. Since low-cost tags can be fastened to objects unobtrusively, preserving their common functions, RFID de facto increases the “pervasiveness” of a computing environment. Current RFID applications focus on retrieving relevant attributes of the object the tag is clung to, via a networked infrastructure from a fixed information server. This identification process involves the code associated to the transponder exploited as index key. Nowadays, tags with larger memory capacity and on-board sensors enable new scenarios and further applications, not yet explored.

We believe that in the era of semantic technologies and mobile computing, there is room for more advanced and significant applications of RFIDs extended with structured descriptions, so that a good equipped with an RFID can semantically describe itself along its whole life-cycle. We therefore conceived a unified framework where a semantic-enhanced RFID-based infrastructure and an advanced Bluetooth service discovery—also endowed of semantic-based discovery features—are virtually “interconnected” at the application layer permitting innovative services in u-environments. In our mobile framework, tagged objects expose to a reader not simply a string code but a semantically annotated description. Such objects may hence describe themselves in a variety of scenarios (e.g., during supply chain management, shipment, storing, sale and post-sale), without depending on a centralized database. The exploitation of these annotations calls for discovery/interaction protocols that are able to effectively deal with rich and articulated descriptions. Therefore, a novel multi-protocol and interactive discovery mechanism has been designed. In this effort, we borrowed from ideas and technologies devised for the semantic Web initiative. To simply illustrate our proposal, we set our stage in a *u-marketplace* context¹, where objects endowed with RFID tags are dipped into an enhanced Bluetooth framework.

In particular, building on previous works that enhanced the basic discovery features of Bluetooth with semantic-based discovery

capabilities (Ruta et al., 2006a), we propose an extension of EPCglobal specifications for RFID tag data standards, providing semantic-based value-added services. Coping with limited storage and computational capabilities of mobile and embedded devices, and with reduced bandwidth provided by wireless links, issues related to the verbosity of semantic annotation languages cannot be neglected. Compression techniques become essential to enable storage and transmission of semantically annotated information on mobile devices. We hence devised and exploited a novel efficient XML compression algorithm, specifically targeted for DIG 1.1 (Bechhofer et al., 2003) document instances. Benefits of compression apply to the whole ubiquitous computing environment, as decreasing data size means shorter communication delays, efficient usage of bandwidth and reduced battery drain for mobile devices in a Mobile ad hoc NETWORK (MANET).

The remainder of the article is structured as follows. In the next section, relevant technological bricks of the proposed framework are surveyed. Section 3 outlines the framework, explaining the discovery process as well as proposed semantic-based enhancements to RFID standards. The compression algorithm for semantic annotations is outlined in section 4. Section 5 exemplifies the approach in a u-commerce scenario. Results on key performance measures to assess the feasibility of the proposed approach, are provided in section 6. Conclusion closes the article.

Basics

In this section, we survey relevant aspects of languages, technologies and protocols we use and adapt, concentrating on key features our proposal is based on. We assume the reader is familiar with at least basic elements of Semantic Web and ontologies (Berners-Lee et al., 2001; Horrocks et al., 2001; Martin et al., 2002; McGuinness et al., 2002; Shadbolt et al., 2006), of OWL (<http://www.w3.org/TR/owl-features/>) and related languages, such as Description Logics (DLs) (Borgida, 1995; Donini et al., 1996).

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