Interoperable Semantic and Syntactic Service Discovery for Ambient Computing Environments

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ABSTRACT

The inherent heterogeneity of ambient computing environments and their constant evolution requires middleware platforms to manage networked components designed, developed, and deployed independently. Such management must also be efficient to cater for resource-constrained devices and highly dynamic situations due to the spontaneous appearance and disappearance of networked resources. For service discovery protocols (SDP), one of the main functions of service-oriented architectures (SOA), the efficiency of the matching of syntactic service descriptions is most often opposed to the fullness of the semantic approach. As part of the PLASTIC middleware, the authors present an interoperable discovery platform that features an efficient matching and ranking algorithm able to process service descriptions and discovery requests from both semantic and syntactic SDPs. To that end, the paper defines a generic, modular description language able to record service functional properties, potentially extended with semantic annotations. The proposed discovery platform leverages the advanced communication capabilities provided by the PLASTIC middleware to discover services in multi-network environments. An evaluation of the prototype implementation demonstrates that multi-protocols service matching supporting various levels of expressiveness can be achieved in ambient computing environments.

Keywords: Interoperability, Matching and Ranking, Semantic-Awareness, Service Discovery, Service-Oriented Ambient Computing

1. INTRODUCTION

Ambient computing envisions the unobtrusive diffusion of computing and networking resources in physical environments, enabling users to access information and computational resources anytime and anywhere, and this in a user-centric way, i.e., where user interaction with the system is intuitive, pleasant and natural. Mobile users take part in these ambient
computing environments by carrying around tiny personal devices that integrate seamlessly in the existing infrastructure. Such a setup is highly open and dynamic. Therefore, these environments must support ad hoc deployment and execution, integrating the available hardware and software resources at any given time and place. This dynamic merging is facilitated when organizing resources as autonomous, networked components. The Service-Oriented Architecture (SOA) computing paradigm is particularly appropriate for ambient computing systems. Indeed, in this architectural style, networked devices and their hosted applications are abstracted as loosely coupled services that can be integrated into larger systems. Service discovery (SD) is then an essential function within SOA, especially in the ambient computing environment, as it enables the runtime association to networked services. Three basic roles are identified for service discovery in SOA: (1) Service provider is the role assumed by a software entity offering a networked service; (2) Service requester is the role of an entity seeking to consume a specific service; (3) Service repository is the role of an entity maintaining information on available services and a way to access them. A service description formalism or language to describe the service functional properties complemented with a service discovery protocol enables service providers, requesters and repositories to interact with each other. A comprehensive service discovery solution for ambient computing environments must at once address a wide range of interoperability issues due to the environments’ heterogeneity, and the fact that ambient software services and potential software clients (assuming the role of service requester) are designed, developed and deployed independently.

Many research projects as presented in Section 2 have addressed some of the interoperability issues such as protocol interoperability, network interoperability, or semantics. In the context of the PLASTIC project, which aims to support the deployment and dynamic composition of mobile, adaptable applications in ambient computing environments, and in particular applications complying with Web-service standards, the PerSeSyn (Pervasive Semantic Syntactic) service discovery platform presented in Section 3 aims to address the above interoperability issues and provide a comprehensive SD solution for ambient computing environments. In this paper, we focus in particular on the challenges posed by enabling interoperable semantic-based discovery on top of heterogeneous, both syntactic and semantic-based SDPs. Towards this purpose, we introduce in Section 4 the PerSeSyn Service Description Model (PSDM), and, as its instantiation, the PerSeSyn Service Description Language (PDSL). PSDM is a conceptual model for enabling semantic mapping between heterogeneous service description languages. PSDL, which is an instantiation of PSDM, is not yet another service description language but a combination of emergent standards for service specification, namely SAWSDL and WS-BPEL. PSDL is then employed as the common representation for service descriptions and requests. Based on PSDM and PSDL, we define a set of conformance relations, as presented in Section 5, for matching heterogeneous service descriptions going from elementary syntactic service descriptions (e.g., given in SLP) to rich semantic service descriptions with associated conversations (e.g., given in OWL-S). Furthermore, we introduce a mechanism for ranking heterogeneous matching results towards efficient matching of service capabilities. We further evaluate in Section 6 the impact of introducing semantic based matching in addition to protocol interoperability realized through protocol translation. We finally summarize our contribution in Section 7.

2. RELATED WORK

Service discovery protocols enable services on a network to discover each other, express opportunities for collaboration, and compose themselves into larger collections that cooperate to meet an application’s needs. Many academic and industry-supported SDPs have already been
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