

Advanced Resource Discovery Protocol for Semantic-Enabled M-Commerce

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INTRODUCTION

New mobile architectures allow for stable networked links from almost everywhere, and more and more people make use of information resources for work and business purposes on mobile systems. Although technological improvements in the standardization processes proceed rapidly, many challenges, mostly aimed at the deployment of value-added services on mobile platforms, are still unsolved. In particular the evolution of wireless-enabled handheld devices and their capillary diffusion have increased the need for more sophisticated service discovery protocols (SDPs).

Here we present an approach, which improves Bluetooth SDP, to provide m-commerce resources to the users within a piconet, extending the basic service discovery with semantic capabilities. In particular we exploit and enhance the SDP in order to identify generic resources rather than only services.

We have integrated a “semantic layer” within the application level of the standard Bluetooth stack in order to enable a simple interchange of semantically annotated information between a mobile client performing a query and a server exposing available resources.

We adopt a simple piconet configuration where a stable networked zone server, equipped with a Bluetooth interface, collects requests from mobile clients and hosts a semantic facilitator to match requests with available resources. Both requests and resources are expressed as semantically annotated descriptions, so that a *semantic distance* can be computed as part of the ranking function, to choose the most promising resources for a given request.

STATE OF THE ART

Usually, resource discovery protocols involve a requester, a lookup or directory server and finally a resource provider. Most common SDPs, as service location protocol (SLP), Jini, UPnP (Universal Plug and Play), Salutation or UDDI (universal description discovery and integration), include registration and lookup of resources as well as matching mechanisms (Barbeau, 2000).

All these systems generally work in a similar manner. Basically a client issues a query to a directory server or to a specific resource provider. The request may explicitly contain a resource name with one or more attributes. The lookup server—or directly the resource provider—attempts to match the query pattern with resource descriptions stored in its database, then it replies to the client with discovered resources identification and location (Liu, Zhang, Li, Zhu, & Zhang, 2002).

These discovery architectures are based on some common assumptions about network infrastructure under the application layer in the protocol stack. In particular, current SDPs usually require a continuous and robust network connectivity, which may not be the case in wireless contexts, and especially in the ad-hoc ones. In fact in such environments, network consistence varies continuously and temporary disconnections occur frequently, so bringing to a substantial decrease traditional SDP performances (Chakraborty, Perich, Avancha, & Joshi, 2001).

Actually, there are several issues that restrain the expansion of advanced wireless applications, among them, the variability of scenarios. An ad-hoc environment is based on short-range, low power technologies like Bluetooth

(Bluetooth, 1999), which grant the peer-to-peer interaction among hosts. In such a mobile infrastructure there could be one or more devices providing and using resources but, as a MANET is a very unpredictable environment, a flexible resource search system is needed to overcome difficulties due to the host mobility. Furthermore, existing mobile resource discovery methods use simple string-matching, which is largely inefficient in advanced scenarios as the ones related to electronic commerce. In fact, in these cases there is the need to submit articulate requests to the system to obtain adequate responses (Chakraborty & Chen, 2000).

With specific reference to the SDP in the Bluetooth stack, it is based on a 128-bit universally unique identifier (UUID); each numeric ID is associated to a single service class. In other words, Bluetooth SDP is code-based and consequently it can handle only exact matches. Yet, if we want to search and retrieve resources whose description cannot be classified within a rigid schema (e.g., the description of goods in a shopping mall), a more powerful discovery architecture is needed (Avancha, Joshi, & Finin, 2002). SDP should be able to cope with non-exact matches (Chakraborty & Chen, 2000), and to provide a ranked list of discovered resources, computing a distance between each retrieved resource and the request after a matchmaking process.

To achieve these goals, we exploit both theoretical approach and technologies of semantic Web vision and adapt them to small ad-hoc networks based on the Bluetooth technology (Ruta, Di Noia, Di Sciascio, Donini, & Piscitelli, 2005).

In a semantic-enabled Web—what is known as the semantic Web vision—each available resource should be annotated using RDF (RDF Primer, 2004), with respect to an OWL ontology (Antoniou & van Harmelen, 2003). There is a close relation between the OWL-DL subset of OWL and description logics (DLs) (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2002) semantics, which allows the use of DLs-based reasoners in order to infer new information from the one available in the annotation itself.

In the rest of the article we will refer to DIG (Bechhofer, 2003) instead of OWL-DL because it is less verbose and more compact: a good characteristic in an ad-hoc scenario. DIG can be seen as a syntactic variant of OWL-DL.

THE PROPOSED APPROACH

In what follows we outline our framework and we sketch the rationale behind it. We adopt a mobile commerce context as reference scenario.

In our mobile environment, a user contacts via Bluetooth a zone resource provider (from now on *hotspot*) and submits her semantically annotated request in DIG formalism. We assume the zone server—which classifies resource contents by means of an OWL ontology—has previously identified

shopping malls willing to promote their goods and it has already collected semantically annotated descriptions of goods. Each resource in the m-marketplace owns an URI and exposes its OWL description.

The *hotspot* is endowed with a *MatchMaker* [in our system we adapt the MAMAS-tng reasoner (Di Noia, Di Sciascio, Donini, & Mongiello, 2004)], which carries out the matchmaking process between each compatible offered resource and the requested one measuring a “semantic distance.” The provided result is a list of discovered resources matching the user demand, ranked according to their degree of correspondence to the demand itself.

By integrating a semantic layer within the OSI Bluetooth stack at service discovery level, the management of both syntactic and semantic discovery of resources becomes possible. Hence, the Bluetooth standard is enriched by new functionalities, which allow to maintain a backward compatibility (handheld device connectivity), but also to add the support to matchmaking of semantically annotated resources. To implement matchmaking and ontology support features, we have introduced a *semantic service discovery* functionality into the stack, slightly modifying the existing Bluetooth discovery protocol.

Recall that SDP uses a simple request/response method for data exchange between SDP client and SDP server (Gryazin, 2002). We associated unused classes of 128-bit UUIDs in the original Bluetooth standard to mark each specific ontology and we call this identifier *OUUID* (*ontology universally unique identifier*). In this way, we can perform a preliminary exclusion of supply descriptions that do not refer to the same ontology of the request (Chakraborty, Perich, Avancha, & Joshi, 2001). With *OUUID* matching we do not identify a single service, but directly the context of resources we are looking for, which can be seen as a class of similar services. Each resource semantically annotated is stored within the *hotspot* as resource record. A 32-bit identifier is uniquely associated to a semantic resource record within the *hotspot*, which we call *SemanticResourceRecordHandle*. Each resource record contains general information about a single semantic enabled resource and it entirely consists of a list of resource attributes. In addition to the *OUUID* attribute, there are *ResourceName*, *ResourceDescription*, and a variable number of *ResourceUtilityAttr_i* attributes (in our current implementation 2 of them). *ResourceName* is a text string containing a human-readable name for the resource, the second one is a text string including the resource description expressed in DIG formalism and the last ones are numeric values used according to specific applications. In general, they can be associated to context-aware attributes of a resource (Lee & Helal, 2003), as for example its price or the physical distance it has from the *hotspot* (expressed in metres or in terms of needed time to get to the resource). We use them as parameters of the overall *utility function* that computes matchmaking results.

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