A Framework For Ubiquitous Web Service Discovery

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ABSTRACT

In this paper, we describe a framework for discovery of location-based ubiquitous Web services through physical tokens embedded in the real world. We developed a tool for submitting services to the UDDI registry and generating service tokens, and an interface for invoking services on a mobile device. We discuss our experiences in utilising the UDDI registry for resolving tokens to service invocation information, providing a powerful mechanism for discovery of ubiquitous Web services.

Keywords

Web services, discovery, tokens, UDDI, WSDL

INTRODUCTION AND MOTIVATION

The proliferation of computer-controlled devices into the physical environment and of electronic services into our everyday lives creates a demand for bridges between the physical world in which we live and work, and the virtual world of the computing services that assist us. The ubiquitous services that facilitate our actions in the real-world should then have tangible, physical anchors that provide a means of discovery, creating a link between the physical space and information space.

This project builds on the premise that the Web Services model should form a valuable basis for ubiquitous computing in a "dynamic environment where consumers of services bind dynamically and on-demand to a changing services back-end" [6]. A framework is developed for the real-world discovery and invocation of ubiquitous services through physical, detectable tokens and a Web services approach to service invocation. In particular, the project includes implementation of a tool for generating barcode-based Web service tokens and a working platform for invoking a Web service on detection of such tokens.

Scenario

Figure 1 illustrates a motivating example scenario, where a traveller arriving at a bus stop finds a barcode service token. Her mobile device reads the token through its in-built camera and decodes the service identifier. The service interface description is retrieved and she is presented with travel services relevant for her journey from that location, such as finding out the time until the next bus arrives, or a search for the bus routes taking her to a particular location.

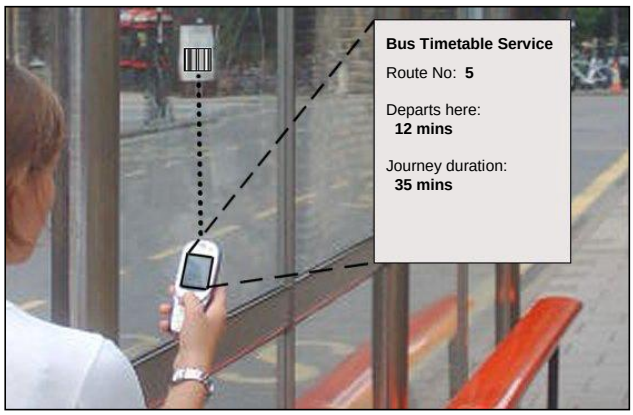

Figure 1 – A traveller accessing ubiquitous services at a bus stop

System Design

Web services provide lightweight, open standards for middleware functionality that are language and platform independent. The foundations of this model are XML-based messaging, a service description, and service discovery according to a publish, find and bind paradigm, where service providers publish descriptions to a central registry, from where they are independently retrieved by service consumers who then bind directly with the provider to invoke the service. The service description is a *Web Services Description Language* (WSDL) document [1] that specifies the service endpoints, protocols, operations and message formats. Service discovery involves the *Universal Description, Discovery and Integration* (UDDI) registry [7]. This is an open, industry-wide standard for distributed public registries exposing information about organisations and the Web services they provide.

We implemented a token authoring tool that accepts a WSDL file, such as that generated automatically by standard tools, and generates suitable UDDI structures to publish the service description to the registry according to the latest guidelines. A barcode is then returned that confers the unique UDDI service identifier in a standard encoding, and is distributed in the real-world – for example, on display at the bus stop. The crux is that the UDDI registry provides a powerful and flexible repository of Web services that is an open standard, well-documented and supported, with freely-available public replicated registries, and

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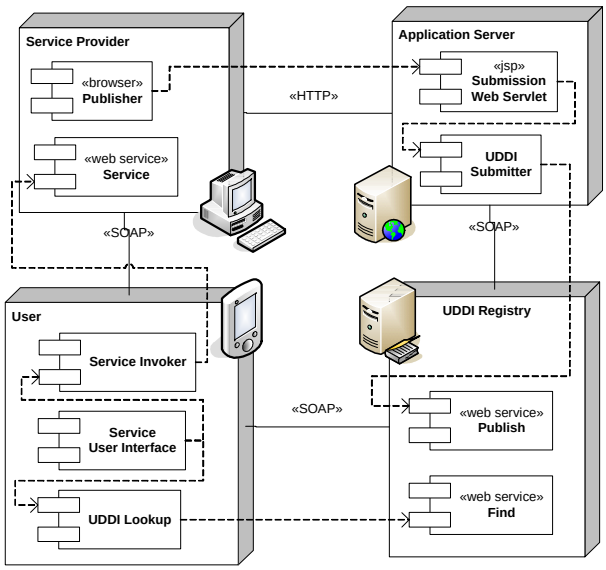

Figure 2 - Deployment diagram

suitable for discovery of Web services in a ubiquitous computing environment.

On sensing and decoding the barcode with a suitably-equipped mobile device, a look-up call to a UDDI registry node returns an up-to-date reference to the service description that is retrieved and invoked with a client interface that dynamically binds to the service endpoint according to the protocols and interfaces specified in the WSDL. Figure 2 illustrates the various interactions.

Experiences

The Web services model proved a powerful but lightweight framework for exposing service functionality in ubiquitous computing applications. Services can be deployed with ease and discovered in the physical environment via a barcode token and the UDDI registries. However, it is clear that elements of Web services technology are still developing; in particular, the UDDI standards still need to address issues of trust, security and best-practice.

In addition, with the WSDL service description a purely syntactic description, there is no established mechanism for inferring the semantics of the service. Consequently, a generic client for an arbitrary Web service is limited in its user interface, though may be sufficient for many straightforward ubiquitous services, such as that of the envisioned bus information service.

Related Work

The *CoolTown* project [4] ties computing resources to physical objects and places by enabling automated discovery of URLs from the surroundings. However, it operates on the premise that standard Web technologies, operating over HTTP with a lightweight Web browser front-end, provide a sound basis for ubiquitous computing. The dependence on a simple Web page and HTTP GET/POST style of invocation means this approach lacks the flexibility to support a broad range of services.

The *Entry Points* project at ETH Zurich [5] similarly embeds barcode tokens into physical objects in the environment. The ETHOC system is based on barcode tokens generated by a Web-based portal that manages the online content, and front-end software for wireless LAN-equipped devices. However, the functionality supported by the ETHOC system is limited to Web page content, contact and calendar entries, rather than arbitrary services.

The contribution of this project is a methodology for ubiquitous services based on WSDL service definitions and RPC calls rather than web pages and HTTP requests. The latter involves a further layer of complexity for defining the presentation of the service and only supports a limited style of invocation. The former involves a non-browser client with no prescribed interface, supports a richer style of invocation and furthermore, with greater semantic control is extensible to support service composition and interoperation.

Conclusions and Future Work

This project has explored the potential for a ubiquitous services model based on a Web services framework and highlighted the potential role of the UDDI registry in resolving ubiquitous service tokens to service invocation information.

Though barcode tokens have been implemented, it has been envisioned that other mechanisms for conferring a token could be used. In particular, RFID tags, infrared and even coordinate location systems might be utilised. In addition, a security model [3] may be implemented to establish support for commercial applications.

The DAML-S ontology [2] may be used to describe the semantics of Web services, making Web services computer-interpretable for the purposes for service discovery, invocation, interoperation, composition, verification and execution monitoring. Future work will involve investigating DAML-S for the purposes of Web service invocation in ubiquitous environments.

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