Replication Mechanisms Over a Set of Distributed UDDI Registries

Zakaria Maamar
Zayed University, UAE

INTRODUCTION

This paper presents a research initiative, which aims at developing replication mechanisms for the dynamic management of the content of several Universal Description, Discovery, and Integration (UDDI) registries (Curbera et al., 2003). These replication mechanisms are intended to be deployed in an environment of Web services (Papazoglou & Georgakopoulos, 2003). By content of an UDDI registry, we mean the announcements of Web services that providers post on the UDDI registry. Unlike other research initiatives in the field of Web services that essentially consider a single UDDI registry and assume a wired and stable communication infrastructure, the following aspects constitute the core of this research initiative:

• Several UDDI registries are spread across different regions. An UDDI registry is aware of the presence of other peers but does not perform any direct exchange of information on its content with them. The UDDI registries may belong to different businesses, have different usage policies, and pose various requirements on acceptable announcements and retrieval demands of Web services.

• There is no predefined communication infrastructure between the distributed UDDI registries. An infrastructure of type wired or wireless for direct interactions can be set up after assessing the importance of the exchange between the UDDI registries. In addition, an UDDI registry may be called to disappear if its owner decides to withdraw it.

• Absence of a centralized component that manages and coordinates the UDDI registries. It is noted that a central authority has always constituted a bottleneck in a system operation (Penserini et al., 2003). On the one hand, each UDDI registry is independent in defining the announcements of providers that it accepts and the retrieval demands of users that it satisfies. The definition of what to accept and what to satisfy is based on a set of UDDI registry-defined policies. On the other hand, each provider is independent in selecting the UDDI registries to which it will post its announcements of Web services. The selection of where to post is based on a set of provider-defined policies.

In a Web services scenario, an UDDI registry participates in two operations. The first operation consists of receiving the announcements of the description of Web services (also called services) from providers. After posting the announcements, the second operation consists of searching the registry content for the services that satisfy specific needs upon users’ needs. Examples of needs are multiple, varying from hotel booking and car rental to weather forecasts. The search consists of identifying the relevant services and indicating who offers them so that the identified services can be triggered after a potential composition (Casati et al., 2003). It is accepted that the advantages of Web services are highlighted by their capacity to be composed into high-level business processes referred to as composite services (Berardi et al., 2003). However, since the announcements of services are submitted to multiple UDDI registries, this results in a different content across the registries.

Targeting the dynamic management of multiple UDDI registries has some overlapping with the well-known problem of information total-replication over a set of distributed databases. An immediate solution to the UDDI-registry dynamic management is to flood the communication infrastructure with the new content of any UDDI registry that has been subject to changes. Changes in UDDI registries are expected to become frequent as the number of Web services of providers continues to grow. While the flooding seems to be a suitable solution for the context of a wired communication infrastructure, the lack of a reliable and permanent communication infrastructure is a major obstacle to this solution deployment. It was observed that the traditional database approaches for collecting, caching, and indexing data of interest in monolithic contexts become obsolete in global computing contexts (Karacasidis & Pitoura, 2002). In addition, unlike the case of a wired environment, the assumption of large bandwidth availability, low error rates, and always-on connectivity are invalidated in a wireless environment. Therefore, another alternative is required for the dynamic manage-
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The content of UDDI registries. It will be outlined throughout this article how mobile users constitute the vehicles of supporting the content exchange between the UDDI registries (i.e., content replication). It is important to strengthen that this support is done in a transparent way to users because of the use of software agents, which act on their behalf (Jennings, Sycara & Wooldridge, 1998).

Each UDDI registry is associated with a structure known as cluster of Web services. Several clusters exist across the communication infrastructure so that providers can connect to the most appropriate cluster according to various criteria such as proximity to and workload status of a cluster. The connection between providers and clusters is of type wired. For tracking purposes, a provider cannot be connected to more than one cluster, which means that a provider cannot post its announcements of Web services on the UDDI registries of multiple clusters. The cluster in which a provider declares its services for the first time is called master. Interesting is the situation where providers have similar Web services but respectively announce their Web services in separate UDDI registries. In Benatallah, Sheng, and Dumas (2003), service similarity is explained with the concept of service communities where alliances are formed among a potentially large number of services performing the same operation types. Unless some appropriate exchange mechanisms are made available, an UDDI registry would never be aware of the existence of similar services in other registry peers. Besides that, for a users wishing to satisfy their needs by triggering or composing Web services, users should be given the opportunity to consider all the existing services regardless of where they are announced. The two aforementioned scenarios (i.e., service similarity and users’ needs) shed light on the importance of supporting a content exchange between the UDDI registries. This content exchange requires deploying appropriate replication mechanisms.

A part of the solution of the dynamic management problem of UDDI registries relies on users who, first, are mobile and, second, have mobile devices (e.g., cell phones, personal digital assistants). The other part of the solution relies on software agents. It is accepted that software agents are suitable candidate for performing the composition operations of Web services on behalf of users (Huhs, 2002; Kuno & Sahai, 2002). The solution, which is outlined in this article, combines users and software agents to constitute what we refer to as messengers. Briefly about the operation of messengers, a software agent resides in the mobile device of a user. The agent caches a description of the list of Web services that were involved in the satisfaction of a user’s needs. On behalf of providers, users post services on various UDDI registries that are associated with clusters known as slaves. Because users have mobile devices, mobile support stations manage these devices when it comes to identifying their physical location and handling their incoming and outgoing messages/calls (Maamar, Ben-Younes & Al-Khatib, 2003). A mobile support station communicates with mobile users within its radio coverage area known as wireless cell. For the needs of this initiative, each cluster of Web services is attached to a mobile support station. Therefore, when a user enters a new cell (i.e., the user becomes under the coverage area of a new mobile support station), an exchange of information between the software agent of the user and the UDDI registry is conducted. This exchange enables updating this registry content. It is deemed appropriate to mention that users do not have to visit all the clusters. Their association with a mobile support station depends on their route to various places such as work, gym, and so forth.

Because a UDDI registry receives information on Web services from two independent sources, namely, providers of Web services and agents of users, the services are decomposed into two types: internal and external. Internal services are announced in an UDDI registry of a master cluster (the providers take care of the announcements). This registry has full control over the internal services by guaranteeing, for example, their QoS arguments. External services are always announced in an UDDI registry of a slave cluster (the agents of users take care of the announcements). This registry cannot, for example, guarantee the QoS arguments of the external services and their availability in their respective provider hosts for triggering purposes. Handling the features of external services constitutes one of the challenges of managing the content of several UDDI registries.

In this initiative, the exchange of the content of the UDDI registries does not target a total replication. Instead, a partial replication, which evolves over time to reach the level of a total replication, is aimed. A total replication between the UDDI registries might happen subject to the following factors:

- **The route of users**: users are not forced to visit all the clusters so that the UDDI registries are fed with new content. The involvement of users in the dynamic management of the UDDI registries does not have to be a burden on them. Because of the diversity of the routes of users, the update of an UDDI registry occurs each time these users are linked to a new support mobile station of a cluster, thus, in the vicinity of a new UDDI registry.
- **The different policies that exist such as provider-defined policies**: for instance, each regis-
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