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Towards an understanding of cloud services under uncertainty: A possibilistic approach ☆

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ABSTRACT

With the development of Web technologies and the increasing use of the Internet, more and more web services are being deployed. This gave birth to what called cloud services, which are widely used for building distributed cloud applications. With cloud-based service delivery, it seems hard for users to find the right service for their needs. However, if a single cloud service cannot meet all user requirements, a cloud service composition is required. With the rise of Web services on the Internet, the quality of response has been considered as an important criterion to choose the most relevant answer. The performance of web services may vary depending on the dynamic Internet environment, which makes the quality of service uncertain. Then, the need to deal with uncertainty in the operation of cloud services. Over the past decade, several approaches to service composition have been proposed to cope with this challenge. In this article, we provide a flexible and efficient cloud services composition framework that can respond to user queries and improve cloud services composition results by exploiting data uncertainty. We then introduce an effective strategy that allows modeling, invocation, and composition of services by dealing with data uncertainty. The experimental evaluation of a real case study demonstrates the effectiveness of our proposed strategy.

1. Introduction

Modern businesses are increasingly moving towards a service-oriented architecture for data sharing by placing their data sources behind services, providing an interoperable way to interact with their data. This class of services is known as cloud services. The Cloud Service enables users to automate service processes, simplify workflows, and find articles, help topics, and experts who can assist agents. Cloud Service Composition is a powerful solution for meeting complex user queries by combining primitive cloud services. As the data manipulated by services is becoming increasingly diverse, more complex and less structured, several works [46], [17] have addressed the different aspects of the Web service life-cycle, including service creation, invocation, discovery, selection, and composition [52] to face up to the problem of data volume, data heterogeneity or data evolution speed. However, there are still many other issues that need to be explored, namely,

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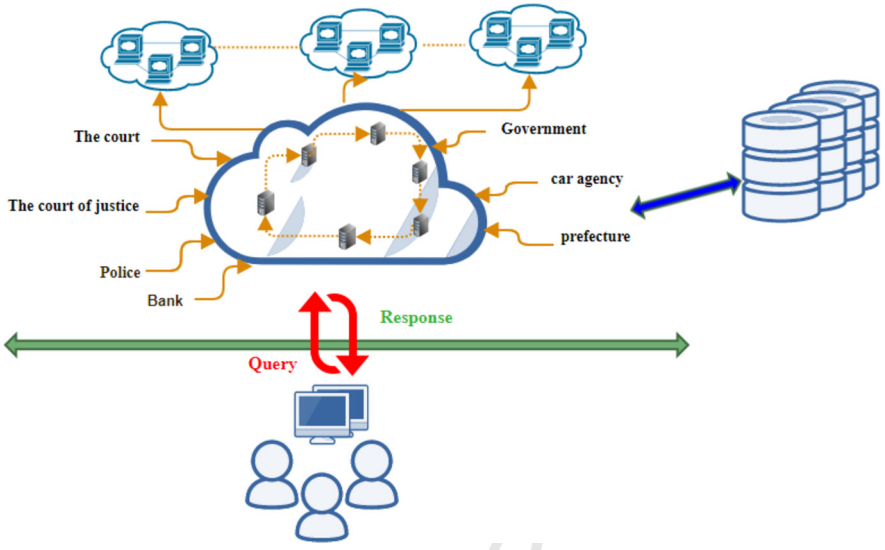

Fig. 1. Motivating example of a cloud service application.

Table 1
Examples of uncertain cloud services.

Services	Semantics
$S_1(\$witness, ?cars)$	Returns the cars seen by a given witness
$S_2(\$car, ?owners)$, $S_3(\$car, ?owners)$	Return the owners of a given car

uncertainty; since the data returned by a Cloud service is not always certain due to various raisons, e.g., the service accesses different data sources, privacy constraints, etc. [6]. Cloud services that return uncertain data are referred to as uncertain Cloud services [3]. Extensive research has led to a general understanding of the issues of uncertainty in various fields ranging from computational biology to economic decision-making. However, a study of uncertainty on large scale IT systems and cloud computing systems is limited. Most of the work examines the uncertainties in user perception of the qualities, intentions and actions of cloud providers. To the best of our knowledge, only few studies consider the uncertainty of services [3], [32], [36]. These approaches are based on a probabilistic model. However, in many real-life scenarios, a possibilistic model offers more suitable modeling [46].

1.1. Motivating example

Consider the example shown in Fig. 1 that describes a cloud service application. The following figure presents a typical scenario that clearly shows the different actors involved in the search for cloud services composition to answer a user request. It refers to the storage and access to data via Cloud. It allows all users such as banks, police, court, ... to quickly access these flexible and economical computing resources, so as to quickly resize any application. These users can edit, access, or insert data into the same database that is shared between them. And in this way the data used become uncertain. Consider a cloud user "police" checks a case of a fatal accident. He wants to know the person responsible for this accident and the car that caused this harm. He therefore needs to check the words of the witnesses, to look for cars and their owners. He also needs to connect to this cloud application to retrieve the necessary information by accessing the shared database.

Consider a set of Cloud services in Table 1. The symbols "$" and "?" denote inputs and outputs of cloud services, respectively. Services providing the same functionality belong to the same service class. For instance, service S1 returns the cars seen by a given witness, while services S2 and S3 return the owners of a given car

The uncertainty of these cloud services could have different origins. For example, the uncertainty of service S1 can be caused by the imprecision of the witnesses, while that of services S2 and S3 may be due to the fact that they integrate different data sources. The uncertainty associated to services must be explicitly modeled and described so that the user understands and interprets correctly the results returned by these services, and uses them in a correct way. The importance of uncertainty process of results returned by cloud services gets clearer when the outputs include several results or when the largest value of possibility does not appear first. The need for a clear uncertainty model for uncertain services is further exacerbated when they are composed to provide value-added services. For example, assume that an investigator Bob wants to find the owner of the car seen by the witness Alice. The answer Bob's query, there is a need to compose service S1 with service S2, S3 or both of them. In other words, one has to invoke first service S1 to retrieve the cars seen by Alice. Then,

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