Recently, building reliable web services compositions has triggered extensive research efforts. Considering that web services tend to be frequently updated or even to disappear unexpectedly, composition may fail easily causing reliability decrease. To challenge reliability, in this paper we propose WS-SAGAS, a transaction model for a reliable specification of web services composition. A composition is modeled as a hierarchy of arbitrary nested transactions, executed in a distributed architecture, with proper failure detection and recovery mechanisms.

1. Introduction

Nowadays business processes are typically running within a collection of largely distributed and loosely coupled computing environments. Generally, such business processes need to be continually reconsidered to fit to process changes. To cope with such environment requirements, wide range of solutions were proposed. Unfortunately, many of them have several limitations. They mainly lack appropriate supports for correctness and reliability enhancement in the presence of failure. Addressing those issues is difficult because of the absence of standards application.

Later on, with the emergence of XML-based standards, followed by web services, researchers realized that those standards are strong enough to support such requirements. As a consequence, the trend is towards deploying business processes by connecting elementary web services. As an example of such trends, Open Grid Services Architecture (OGSA) is proposed [5]. Despite these standards help considerably to enhance interoperability, reliability is not yet well addressed. In fact, with web services environment volatility and dynamism, it is most likely to happen that a component service is updated or moreover it disappears suddenly. In such situation, it is necessary to provide proper failures detection and recovery mechanisms. This is fundamental to avoid overall composition consistency review.

To achieve these requirements, augmenting web services composition specification with the transaction concept, as already revealed in other areas, seems to be adequate. Nevertheless, considering that web services are naturally distributed i.e. hosted by different web services providers, relying on these providers to support transactions is not feasible. Thus, it becomes obvious that defining an accurate transaction model valid for the whole composition is essential.

However there are many advanced transaction models [2]. Applying directly already proposed models is not acceptable because of web services particularity, compared with usual software components.

Motivated with these concerns, in this paper we propose WS-SAGAS, a new transaction model. Specifically WS-SAGAS extends nested-sagas model [1] and enriches it with “State” feature. State capturing allows coordinating primarily autonomous web services in a composition and helps to inform about web services composition potential execution progress. Moreover, in case of potential failure occurrence, it will allow to detect it and indeed to recover. Besides, in WS-SAGAS, we inherit also the “vitality degree” from other models such as ConTract and Open Nested [2]. We expect the vitality degree to reduce considerably failure possibilities and indeed increase composition availability. We justify this as follow. Since originally a transaction succeeds only if all its components are successful, with vitality degree introduction, only vital components success is required.

The remainder of the paper is organized as follows: Section 2 gives an overview of WS-SAGAS transaction model. Section 3 discusses the execution model of WS-SAGAS in a distributed architecture, and explains it in an illustrative example. Finally, Section 4 concludes the paper and provides some remarks concerning future works.

2. WS-Sagas Transaction Model

2.1 Transaction Paradigm Applicability

Considering that web services tend to be frequently updated or even to disappear unexpectedly, composition may fail easily, causing reliability significant decrease. This makes web services rather different from usual software components. Consequently, web services warrant a particular transaction support especially shaped for them. We discuss in what follow what kind of properties a transaction needs to satisfy to fit to web services context.

A traditional transaction is supposed to support fully ACID properties, which is not acceptable for web services. Our justifications are as follow. First, “Atomicity” property full support is not required. Instead of deducing a whole composition failure when one of its components fails, it is more profitable to soften "Atomicity", in other words, to take advantage of the transaction support that services might formerly encompass e.g. compensation. Moreover, it would be more efficient to choose another service, which supports the same semantic. Actually, there is a wide range of semantically equivalent web services enabled to provide same functionalities in different ways. Second, similarly "Isolation" and "Consistency" properties should be relaxed because none of them is relevant. Since compositions might be long running, enforcing "Isolation" affects negatively execution progress. This is because parallel transactions communication is required in web services context, since cooperation among transactions is an essential feature. Besides, ensuring “Consistency” enforcement means first, monitoring each web service invocation and later, identifying the service(s), component
In what follows, we investigate the applicability of the nested-transaction model proposed [2]. Seeing web services context requirements, we propose to enrich it with state capturing feature that we will describe in the following subsection.

2.2 Nested-Sagas Transaction Model

There are several advanced transaction models proposed [2]. Seeing web services context requirements, we investigated the applicability of the nested-transaction model [3], sagas model and finally nested-sagas model [1]. In what follows, we compare these three models:

1. Nested-sagas transactions can be recursively defined. Thus they support an arbitrary level of nesting contrary to the original sagas transactions, where nesting is limited to two levels;
2. The original nested transaction model of [3] ensures atomicity and isolation of the whole transaction. A sub-transaction failure is reflected on its parent. This is not conceivable because considerable amount of already executed works would be lost;
3. Nested-sagas transaction model considers about communication mechanisms, an essential feature in web service context. Each saga specifies input and output ports bound at run time to mailboxes i.e., messages queue.
4. Nested-sagas with already specified input and output ports can be more practically mapped to web services since structures are somehow identical;
5. Finally, compensating transaction provides much more flexibility. Since it was primarily proposed in sagas transaction model, it is worthy to build on nested-sagas instead of the nested-transaction model.

Guided by this comparison, we propose to inherit features of interest from the nested-sagas model. Specifically, arbitrary nesting level, relaxed ACID properties and transaction compensation. We also inherit the vitality degree feature, proposed in several advanced transaction models [2]. Moreover, in order to satisfy properly the transaction support described in 2.1, we also propose to enrich it with state capturing feature that we will describe in the following subsection.

2.3 WS-Saga Description

A ws-composition WSC is a collection of n elements from a composition \{E_1, E_2, E_3, ..., E_n\}. As depicted in Figure 1, a composition is specified as an orchestration of elements. Depending on the considered nesting level, the same element E_i is either assimilated to an atomic element or to a ws-composition e.g. E_3 is assimilated to an atomic element in WSC1 specification while in WSC2 specification, it is composed of two elements E_{3.1} and E_{3.2}.

An atomic element has a state S_i and a vitality degree where "v" in E_i^v stands for Vital element and "nv" in E_i^nv stands for Not Vital element.

Definition I Element state S_i

An atomic element is exclusively in one of the following states:

1. Waiting: If element E_i^v is not yet submitted for execution and is waiting to;
2. Executing: If element E_i^v is executing;
3. Aborted: If element E_i^v encounters a failure;
4. Committed: If element E_i^v has successfully terminated and was committed and
5. Compensated: If element E_i^v has been compensated.

An element execution is actually the execution of a web service providing functionalities of interest. This service execution control is delegated to an engine e, already allocated to the considered element. State change, as described in Figure 2, is performed by that engine e. The state concept introduction is motivated with the following concerns:

1. Since web services are originally without state, when they are executing as component of the same composition, without the state concept introduction, it will not be possible to know the execution progress.
2. In order to decide how to go forward in a WSC execution i.e. decide to which element(s) to delegate the execution control or whether to resume the execution, it is essential to know the execution progress of elements being executed.

Definition II Element Vitality Degree

We introduce the vitality degree of an element E_i^v in order to add flexibility in the way ws-composition failure is cascaded. We distinguish a vital element E_i^v from a
3.1 THROWS Distributed Architecture Overview

In this section we describe how web services composition, specified as WS-SAGAS transactions, will be executed in a distributed architecture that we already proposed and named THROWS. More details about THROWS architecture are available in [4].

THROWS stands for “a Transaction Hierarchy for Route Organization of Web Services”. Specifically THROWS is a distributed architecture for web services composition reliable execution where the control is hierarchically delegated among distributed engines dynamically discovered during the composition execution. These distributed engines interact in a peer-to-peer way.

Each engine $e_i$ is responsible of the successful execution of an element $E_i$ that is, the execution of an available web service $WS_i$. $WS_i$ is offering the same functionalities, as element $E_i$ requires.

THROWS achieves failure capturing and recovery from failure by the “Candidate Engines List (CEL)” concept and the “Current Execution Progress (CEP)” concept. CEP and CEL are to be available on each engine side. CEL is relative to an element from a composition. It is the list of candidate engines enabled to execute it i.e.

Figure 2. Element State Transition Diagram

not-vital element $E_{nv}$ as follow:

1. Aborting a vital element component of a ws-composition will induce aborting the whole ws-composition, if there is no alternative web service to execute the same element.
2. Aborting a not-vital element will not be reflected on its parent, thus a ws-composition can complete successfully even though not all its components elements were committed.
3. Initially the vitality degree of all elements is by default set to vital.

3.2 Illustrative Example

To ensure a better understanding of how web services compositions are depicted as WS-SAGAS transactions, we describe in what follow the case of a trip reservation business process. To reserve a trip, a customer needs to submit an itinerary that indicates desired destination, departure and arrival time and date. Airplane ticket and hotel reservation are crucial for the whole process success. Car rental is considered as optional. By using WS-SAGAS transaction model description, the trip reservation business process will be specified as in Figure 3. Initially, all the elements state is set to “waiting”, with no engine allocated. The CEP of WSC$_1$ is indicated as follow:

- CEP (WSC$_1$)$_{initial} = \{E_1^{\downarrow}, waiting, null\}, \{E_2^{\downarrow}, waiting, null\}, \{E_3^{\downarrow}, waiting, null\}\}$

The order of execution is $E_1^{\downarrow}\langle E_2^{\downarrow} ; E_3^{\downarrow} \rangle\langle E_4^{\downarrow}$. i.e. when element $E_1$ is committed successfully, elements $E_2$ and $E_3$ executions are concurrently launched. To start executing element $E_4^{\downarrow}$, $E_2^{\downarrow}$ and $E_3^{\downarrow}$ successful completions are necessary because both of them are vital. Contrary to $E_4^{\downarrow}$ considered as not vital i.e. if airplane ticket and hotel reservation were successful but car rental failed, the whole composition success can be deduced.

Suppose $e_{11}$ is allocated to execute $E_1^{\downarrow}$, i.e. to execute a web service $WS_1^{\downarrow}$ providing the same semantic required by $E_1$. If engine $e_{11}$ executed successfully $WS_1^{\downarrow}$, $E_1^{\downarrow}$ state is updated to “committed”, $e_{11}$ will check in CEP whether there is following elements, it will generate CEL of $E_2^{\downarrow}$ and $E_3^{\downarrow}$, as successors that need to be executed in parallel, and allocate $e_{21}$ and $e_{31}$ to execute respectively web services $WS_2^{\downarrow}$ and $WS_3^{\downarrow}$. Finally it will update CEP as follows, and communicate it to $e_{21}$ and $e_{31}$.
As future work, we are currently investigating implementation issues and specifically the feasibility of web services composition implementation using WS-SAGAS transaction model.

\[\text{References}\]


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