A CONCEPTUAL FRAMEWORK FOR AUTOMATED SERVICE TRADING

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Palabras clave: None

Resumen. Automating the creation and management of SLAs in electronic commerce scenarios brings many advantages, such as increasing the speed in the contracting process or allowing providers to deploy an automated provision of services based on those SLAs. We focus on the service trading process, which is the process of locating, selecting, negotiating, and creating SLAs. In this article, we propose a conceptual framework that can be used to analyse existing efforts in order to develop concrete architectures that effectively address the problem of the automated service trading. The novel contributions of this paper are threefold: we identify the roles and interactions that are necessary to carry out this automated service trading, we motivate and introduce the idea of trading protocols, and we define the elements that are necessary to support an automated decision-making in service trading.

1 Introduction

In recent years, we have witnessed how new technologies are enabling the emergence of a new age of enterprises that quickly adapt to their ever-changing business environments but keep their costs under control. This is the main characteristic of what has been called real-time enterprises. Two elements are the key to achieve this vision: the management and analysis of the information collected by the enterprises related to their business environment, and the ability to use products or services offered by other enterprises as components for further innovation.

The service-oriented computing paradigm [2] and the service-oriented architectures based on web services are the mechanisms used to support this idea of using services offered by other companies as pieces of our systems. In this context, SLAs (Service Level Agreements) are a key point because they grant guarantees about how a service will be provided or consumed by establishing both functional and non-functional requirements that must be fulfilled by both parties during the service execution. Additionally, SLAs allow providers to deploy an automated provision of services based on the SLAs agreed with their customers [7].
We define service trading as the process of locating, selecting, negotiating, and creating SLAs. The service trading is a subprocess of a more general contracting process that was already defined in [6]. Although there are infrastructures to provision SLAs and services [7] that agree with them automatically, there is little support, to the best of our knowledge, to tackle the service trading process, which is still mostly a human-centric process. However, automating the service trading process is a key characteristic of a real-time enterprise.

In this paper, we take the ideas exposed in [6] as a starting point and propose a conceptual framework for automated service trading. The framework is divided into six organisations\(^1\) (discovery, information, selection, agreement making, binding, and trading), and each one cares for a specific subgoal in the whole service trading process. Our goal is not to implement a concrete architecture but to develop a conceptual framework that can be used to define, compare and analyse the interoperability of different service trading architectures.

Our work advances the state of the art in service trading in the following. First, we clearly identify the roles that are necessary to carry out this service trading as well as the relationships between them. Second, we motivate and introduce the trading protocols, which are a specification of the global behaviour of the trading system from a temporal point of view. And third, we define the elements that are necessary for an automated decision-making in the service trading process. This bridges the two key elements of a real-time enterprise mentioned before: the management and analysis of the information collected by the enterprises as the basis of the decision-making, and the ability to use services offered by other enterprises through the automated creation of SLAs.

The structure of this article is the following. Next, in Section 2, we briefly introduce the organisational metaphor and we describe the conceptual framework. Section 3 compares our framework with other proposals developed by both the industry and the academy, and we conclude and enumerate future work in Section 4.

## 2 Conceptual Framework

Several phases have been identified on the contracting process [6] (as it is shown in the left part of Figure 1): The conceptual framework proposed in this article is focused on the information and negotiation phases. Therefore, on the one hand, input to the framework consists in the requirements gathered during preparation phase. We call user preferences to this set of information developed in the preparation phase; additionally, it is worth pointing out that our idea of user is independent of the nature of the stakeholder, i.e. whether user stands for a service consumer or a service provider. On the other hand, the output of the framework is a established SLA. This SLA can be used to drive the further deployment and fulfilment phases.

In order to deal with the complexity of the service trading problem, we use the organi-

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\(^1\)We borrow this term from the GAIA methodology[14]. An organisation does not amount to a company or a department but to a number of agents that work together
sational metaphor [14] where organisations are outlined developing a general architectural characterisation of the problem. In so doing, our model is composed of six organisations (depicted in the central-right part of Figure 1) that interact amongst each other.

As an introduction to the conceptual framework, we can sketch the global behaviour of organisations as following: The discovery organisation performs the process of locating a set of potential providers or consumers according to a number of functional and non-functional requirements; candidates discovered, are then passed to the information organisation in order to gather detailed information about the characteristics and preferences of each potential party. This information is subsequently used by the selection organisation to create and select a set of promising agreement proposals with other parties. Proposal selected are also analysed to decide whether we would start a negotiation process with other parties or produce a take-it-or-leave-it offer. This instructions are delegated to the agreement making organisation responsible to actually negotiate or propose the agreement to other party. During this procedure, agreement making organisation interact with the binding organisation by asking for approval to make or accept binding offers. In so doing, the responsibility of the binding organisation can be seen as to determine when an offer may be accepted.

Finally, the main goal of the trading organisation is to specify a choreography that will regulate how the whole process is carried out, that is, it cares of starting the search for parties, submitting offers, waiting for responses, starting negotiations or sending binding offers. Additionally, trading organisation monitors the market (making use of the discovery organisation) in order to decide when the agreement search should be started.

The remainder of this section describes each organisation detailing their goals and the roles that can be identify on them.
2.1 Trading

In general, service trading is a process whose details change from scenario to scenario depending on the type of parties involved and the temporal requirements to be met. Particularly, it is necessary an orchestration of the different stages in the trading process.

The trading organisation focuses on the global behaviour from a temporal point of view. Its goal is the coordination of the remain layers so as to implement a trading protocol. To understand what a Trading Protocol is, we use a simple real-life example: A public bidding where an institution looks for a service provider and devises a trading protocol that consists of the following stages: the announce of the bidding, a deadline for the submission of proposals, a period of resolution and, finally, the communication of results. The trading protocol also states temporal constraints for each stages. This organisation is composed of the following roles:

- The Trading Protocol Selector role analyses user preferences to decide which of the trading protocols suit better to the temporal constraints specified on them.
- The Customer Manager role is in charge of interacting with the environment in order to handle user preferences. Consequently, this role transmit the appropriate part of these preferences to the rest of the roles. Additionally, this role is the responsible for trigger the search based on market status and knowledge harvested from pervious searches. Once a given search is about to start, this role is assisted by the Trading Protocol Selector to invoke the appropriate actors that would develop the trading protocol used on the search.

2.2 Discovery

In the discovery organisation the main aim consist in locating potential parties demanding (or supplying) a service that other party provides (or needs). Roles in this organisation include:

- The Discovery Service role represents an abstraction of the discovery infrastructure that should be refined in further concrete models. Different infrastructures can be selected from a range of models: from a centralised paradigm to a distributed one.
- The Market Mediator role is in charge of adapting local knowledge model in a given party to the appropriate discovery infrastructure. This adaptation make independent the characteristics of market model to the rest of organisations.
- The Tracker role is the active part that make use of the discovery service to search for some particular trading event.
- The Advertiser role is the complementary role for Tracker generating trading events to be searched. This trading events, should be parameterised with the most significative user preferences that can be made public.
2.3 Information

The goal of this organisation is to manage the public information about the user preferences and the potential candidates found by the discovery organisation. The amount and type of information collected from each candidate may be different; however, at a conceptual level the information should include, at least, the public features about the service demanded/supplied. In addition, some information can be harvested from external sources, e. g., information about the reputation of the candidate. Roles in this organisation include:

- The Inquirer role poll the different Informants located by the Discovery organisations. In so doing, this role can select a strategy of querying, depending on the interaction standard and the type of information needed to match user preferences.

- The Informant role is the responsible for publish all the public user preferences that can be useful to other parties in order to evaluate the possibilities to become a business partner.

Both Inquirer and Informant must implement a compatible specification of a format to express functional and non-functional features of services and a procedure to query and to inspect services. In addition, the Inquirer must provide an integration of the service features format with the taxonomy of the discovery layer.

2.4 Selection

The aim of the selection organisation is to choose a set of candidate parties with whom a negotiation process can be started or to whom an agreement proposal can be submitted. The selection starts with a set of information about potential parties coming from several sources: information provided by the information organisation after an active search, agreement proposals received from other parties, and non-successful offers coming from the binding organisation, so that they can be processed again. The selection process is carried out by the following roles:

- The Proposal builder role creates agreement proposals based on the information gathered by the information organisation. Then it sends these agreements proposals to the Proposal collector.

- The Proposal collector receives the agreement proposals generated by the Proposal builder as well as the agreement proposals coming from other parties through the Proponent role and submits them to the Proposal filter. Optionally, it can keep them until an event occurs. For instance, they can be kept until the negotiation phase finishes.

These offers are non-successful because either they were not good enough for us or the other party rejected them.
• The Proponent role represents the party that is submitting us a proposal.

• The Proposal filter role is in charge of filtering the agreement proposals collected by the Proposal collector and the non-successful offers coming from the binding organisation. The filter criteria are not unique but, in most cases, they depend on the preferences given by the user and the status of the whole service trading process. After this process, several proposals are rejected and the others are sent to the Proposal dispatcher role.

• The Proposal dispatcher sends the proposal to the most appropriate Agreement Maker. One system may have several Agreement Makers with different characteristics and one of them may be better than the others for certain conditions. For instance, one Agreement Maker can implement auction protocols, another one can implement bilateral negotiation protocols, and another one can implement just a take-it-or-leave-it protocol.

2.5 Agreement Making

The goal of the agreement making organisation is to provide a mechanism to create agreements, possibly through an automated negotiation process, that are acceptable to all the parties involved in them. Therefore, the result of this organisation is an agreement that specifies the terms under which the service shall be executed. This may include both functional and non-functional terms.

The process to create agreements can range from a very simple form of communication such as the submission of an offer by one party and its acceptance or rejection by the other one, to a more complex form based on negotiation protocols. A negotiation protocol establishes the rules that govern the negotiation and the way the communication amongst the parties involved in the negotiation is carried out. The most common negotiation protocols are based on the submission of offers and can be categorised into auctions \[11\] (e.g., English, Dutch or Vickrey) and bilateral negotiations. Bilateral negotiations involve the exchanging offers and counteroffers between the two parties carrying out the negotiation \[10\].

The decision-making mechanisms determine the way the parties involved in the negotiation process behave. There are four parts that should be implemented in these decision-making mechanisms: (i) an offer evaluation, usually carried out through the definition of utility functions to each term of the agreement; (ii) a decision on which response shall be sent to the counterpart; (iii) a construction of a counteroffer if necessary \[3\], and (iv) a model of the world and of our opponents in order to improve our negotiation capabilities \[15\]. We have identified three roles in this organisation:

• The Agreement Maker is the role that implements our agreement creation mechanism. Therefore, it must understand an agreement format and support at least one protocol to create agreements. This role can act almost as a proxy if it just

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implements a take-it-or-leave-it agreement creation protocol. However, it can be very complex if it understand several negotiation protocols and has to create bids or counteroffers. There is no restriction on the number of Counter-parties that the Agreement Maker can be negotiating simultaneously.

- The Counter-party role represents the party that we are trying to reach an agreement with. This role must implement the same communication protocol and agreement format as the Agreement Maker.

- The Notary role must guarantee that the agreement created between the two parties is reliable and non-repudiable.

2.6 Binding

The goal of the binding organisation is to determine when a binding offer must be submitted and whether a binding offer that has been received should be accepted. In addition, this organisation must establish when these decisions are going to be made. For example, one option is to make the decision as the offers are received; another possibility is to make the decisions at some points in time that has been previously set. These points may be dynamically selected, depending on changing conditions of the environment such as the frequency of arrival of offers, or statically determined based on temporal constraints imposed by the trading protocol, or a combination of them both. Therefore, the responsibilities of this organisation are not only to determine whether a binding offer must be accepted or submitted but to establish when these decisions shall be made as well. This organisation is composed of two roles:

- The Commit Handler role has the final decision on whether to bind to an offer or not and it is also in charge of determining when these decision are made. To make these decisions it takes into account the user preferences about the contents of the agreement and the agreement process and it consults other roles about the feasibility of committing to an agreement.

- The Capacity Planner role analyses the provider’s capability to provision a certain agreement and recommends the Commit Handler to commit or not to that agreement. This role is specific to the concrete deployment of the service provider.

3 Related Work

In this section, we analyse related proposals from two points of view: First, we focus on different conceptual architectures or frameworks that address the interoperability of web services. Second, we give an overview of current technologies that can be used to develop different parts of the organisations identified in our framework.

Since web services and service-oriented computing paradigm were introduced, some architectural research has been developed. The comparative analysis carried out amongst
them focuses on automating the service trading; in Table 1 we study how the organisational goals identified in our conceptual framework are addressed in each proposal.

Web Service Architecture (WSA)[12] is the reference architecture built by W3C. Due to the abstraction level of this conceptual architecture, SLAs automation creation is marginally dealt and the only issues directly handled are discovery ones. However, in the last couple of years, an extended web service architecture [13] have addressed Information problem in terms of standards for metadata interchange.

In the area of integration and virtual organisations, an evolved grid paradigm has emerged in the last years: the service grid. There is a wide range of on-going standardising work in this context. As part of this work, a conceptual architecture has been developed: the Open Grid Service Architecture (OGSA)[4]. This approach tries to address a highly distributed scenario of collaborative stakeholders. Concerning our organisational goals, OGSA deals with all organisations that involves some kind of interaction (Discovery, Information and Agreement Making) in an explicit way. Nevertheless, organisations centred in decision-making mechanisms (Selection and Binding) are not well defined and the needed elements have not been identified. However, in OGSA there are some references to the capacity planning issues.

The Semantic Web has influenced several research fields; particularly, semantic approaches have boosted several open research efforts in the web services field. One of the most active is the Web Service Modeling Ontology (WSMO) that comprises a group of specifications and systems for dealing with semantic web services. In particular, there is a conceptual architecture called WSMO-Full that describes the abstract background of WSMO. In this approach, interactions related to the information organisation are not clearly isolated and no further architectural element is outlined. However, there are some subtle references to additional information needs after a discovery phase. WSMO-Full[8] is more centred on decision making than other architectures and they explicitly propose a selection after the discovery of potential candidates. Nevertheless, it does not identify the issues related to the decision-making in the binding organisation. WSMO-Full supports the creation of agreements and defines contract agreement choreographies that are protocols for message interactions between at least one service requestor and at least one service provider. However, unlike our trading protocols they do not cover all phases of

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Table 1: Comparative analysis of conceptual frameworks
service trading but only the creation of agreements, and they are more focused on the messages exchanged rather than the temporal behaviour of the system.

Following the idea of semantic web services, a joint effort of several research groups in the area have developed a more general and abstract conceptual framework called Semantic Web Service Architecture (SWSA)[1]. SWSA completely covers discovery and agreement making. However, information issues are not addressed in an explicit architectural concept, although some highly related requirements are defined. Additionally, some matchmaking mechanisms are stated as part of their discovery phase. Nonetheless, this matchmaking is only about the advertised information of the service, while in our proposal, there is an additional selection carried out by the selection organisation that chooses amongst concrete agreement proposals instead of just advertised information.

We have analysed how different approaches differ based on the organisational outlining of our framework. Additionally, another significative difference amongst frameworks is the way they integrate the behaviour of service consumer and service provider into the overall architecture: on the one hand, WSMO-Full is aligned with our approach and the elements of its architecture are independent of the nature of the stakeholders, i.e. whether the are service consumers or service providers. On the other hand, SWSA strongly links the behaviour of active roles to the service consumer side while the more passive roles correspond to the service provider.

4 Conclusions and Future Work

This paper focuses on the problem of service trading. In this context, our main aim is to achieve an effective background for the development of automated discovering, selection and negotiation of SLAs. To this end, a conceptual framework is developed and compared with related conceptual approaches.

The main contributions of this article are:

- A decomposition of the automated service trading problem outlining a set of abstract roles and organisations. Unlike other proposals, which are centred in the interactions between parties, we also identify the necessary elements for the automated decision making.

- The conceptual framework presented aims to define and compare different trading architectures. Furthermore, the conceptual background developed can be used to analyse potential interoperability amongst architectures.

- We introduce the concept of Trading Protocol as a method for defining the temporal features and behavioural stages of trading scenarios. These protocols drive the choreography of the different elements and allow a temporal match procedure among SLA demands/offers of stakeholders.

Additionally, it is worth pointing out that an automation of the service trading process, shall benefit not only a cross-organisational scenario but also an intra-organisational (in-
integration) one: SLAs have been associated traditionally with cross-organisational transactions where a company must enforce a certain level of service to their partners; however, real-time enterprises paradigm, in most cases, is built upon the integration of a complex organisation; in this context SLAs are starting to be an important issue to be addressed amongst the subsystems involved. In this integration scenario, the rationalisation of the usage of resources inside the organisation argues for SLAs to be managed as automatically as possible. In so doing, new promising fields such as the Service Grid [4] are aligned with an hybrid scenario cross/intra-organisational where SLAs are comparatively important.

Further work to be done in this field is to develop a reference architecture making use of the conceptual framework presented. This architecture has been outlined in [9] although some refinement and implementation must still be developed.

REFERENCES


