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Management Summary

In this deliverable we present models and techniques for Business Aware Transaction Management in Services Network.

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- Inaugurating a Europe-wide common program of education and training for researchers and industry thereby creating a common culture that will have a profound impact on the future of the field.
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1. Introduction

Service oriented architecture (SOA) is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. By making resources in a distributed and open system available as independent composable services, SOAs reduce complexity and increase flexibility. Composability of services allows organizations to create (new) applications within their enterprise information systems just by aligning existing services.

A service often encapsulates a set of related business functions. Due to the inherent autonomy and heterogeneity of Web services, ensuring composite services reliability remains a challenging problem. Therefore, using a service assembly requires major efforts in order to deliver a coordinated collective result. Such coordination efforts may be addressed solely in the process logic that assembles the services. However, according to [1, 8] transaction processing concepts are a superior option. By managing only a group of services, transaction processing concepts guarantee that the group of services achieves a coordinated common, consistent, and mutually agreed outcome. **Business-aware** transactions research aims at providing the right segmentation and support of knowledge, data, actions and events to render Business Process Management capable of bridging the gap between transactional system level events and Business transaction concerns. For tightly-coupled systems, transactional coordination is common and ubiquitous. However, in open and very evolving **Services Networks**, Checking, Analyzing and Reusing systematically business-aware transactions lead to new issues in the following domains:

- Modeling: What language for Business aware transaction tackling Reliability, flexibility and Reuse? How to define business data, events and service end-points correlations?

- Design Time Analysis: How to provide/check automatically compliant/ce (of) composite web services with business level requirements? How to help non computer science expert to debug a Conflicting Business Aware Specification?

- Run time: How to ensure the correctness of a business level design or an implementation in open system? According to runtime business aware checking, how to promptly deviate and adapt the behavior of the composition of services?

- Service Network analysis: What impact gets Business transaction over the bottom-up Service Network analysis?

In this deliverable, we report on our works regarding modeling business transactions in a particular setting, checking of consistent behaviours of services described at different levels of abstraction and by using different abstraction formalisms. We summarize the different contributions and we provide the papers that describe in more details the different facets of the contributions.

2. Modeling/Service Networks Analysis

- ***Modeling Business Transactions across Service Supply Chain Networks***: This work is concerned with understanding the complex nature of service network environments with particular attention on exploring business transactions across supply chains. Although business transactions have been traditionally well documented throughout literature, what becomes apparent is that these approaches fail to capture the dynamic complexity of modern service supply chains. To address the problem, this work introduces a method to model supply chain behavior which is of particular interest at the network design time and offers a conceptual view of extracting network analysis and process metrics. We introduce a business transaction language (BTL) to gain insight into the business transactions while we also explore the application of social network analysis (SNA) to model the dynamism of service networks. In doing so, the research sets out to generate greater service network intelligence and extend the service network ontology while visualizing the transactional interaction landscape. The detailed work is reported in [2].

- ***Towards Business Transaction Management in Smart Service Networks***: In order to ensure proactive and real time monitoring of processes that live within service networks, it is necessary to have a transaction model that is able to accommodate business-level events and situations. Paper [2-1] introduces a business transaction model for processes that live within service networks. The model is designed in such a way that correlation of business-level events is made possible.

3. Design time analysis

- ***Service composition by accommodating business rules and preferences***: We investigated a novel three-stage approach to compose Web services. Given a user query and a set of service descriptions, we rely on query rewriting to find services that implement the functionalities expressed in the user query. Then, we rely on configuration to capture dependencies between services, and to generate a set of composed Web services described as a directed acyclic graph, while maintaining validity with respect to ***business rules*** (orchestration stage). We also proposed a semantic ranking algorithm to rank results according to ***user references*** (classification stage). We provided a formal framework and a complete implementation of the proposed approach, together with experiments on Web services from different application domains. The approach can be summarized as follows: Firstly, we propose a language for describing abstract services, while remaining independent from any underlying service ontology that providers could use for describing services at the concrete level (OWL-S or others). Secondly, we propose a three-stage approach to automatically generate Web service composition template. We rely on configuration and query rewriting techniques. The stages can be described as follows: (1) finding the

services that implement the functionality of each goal in the query (discovery stage), (2) orchestrating the interactions between selected Web services in order to achieve the composition and to fulfill user's requirements (such as constraints) (orchestration stage) and (3) ranking candidate solutions according to users' preferences (classification stage). In this approach, we use the semantic annotation of services to generate automatically, without user intervention or logs analysis, composition template from the user requirements (such as preferences and constraints). The detailed work is reported in [3].

- ***Analysis of compliance rules*****:** Providing adequate tools to tackle the problem of inconsistent compliance rules is a critical research topic. However, few tools fully analyze conflicts over underpinning logics of a natural language (eg. temporal logic, deontic logic...). Such early and declarative specifications can be critical for ***specifying policies*** and ***transactional requirements*** in agile and distributed environments. Thus, formal languages for compliance requirements and their ***analysis*** have become critical in many computer science domains (e.g., business process management, service oriented computing, e-commerce). An ongoing research topic is the analysis of a conflicting set of temporal logic compliance rules. This problem is critical for debugging declarative specifications, handling conflicting contracts, debugging transactional specifications, or tackling unrealizable service compositions. There exist several formalisms to deal with time such as LTL, MSO, TLTL , MTL. These logics underpin many of modern ***compliance languages*** and their associated theories and tools are used to address problems related to verification, service composition, goal oriented requirement analysis, graphical design of property patterns. We investigated the problem of efficiently extracting temporal logic unsatisfiable cores for debugging ***compliance rules***. Intuitively, an unsatisfiable core is a conflicting subset of rules. We restrict ourselves to LTL for which many results and efficient model checking methods exist. However, the problem of efficiently detecting a small LTL unsatisfiable core is still open. Conflict driven methods exist for SAT-solver algorithms. They provide quite efficient extraction of conflicting rules written in propositional logic. SAT-solvers have been extended (e.g.,Unbounded Model Checking (UMC) SAT-solvers) to deal with the more expressive LTL. In our work, we propose a new conflict-driven depth-first-search solver inspired by SAT-based ones, DFS for tableau and resolution for temporal logic. Furthermore, we show how it is possible to extract a small unsatisfiable cores. The details of this work are reported in [4].

- ***Compatibility analysis in presence of security policies*****:** Web services choreography is used in the design phase of complex peer-to-peer applications in which each peer can be implemented by a Web service. Therefore, selecting Web services for ***choreography implementation*** using the ***compatibility*** checking approach with access control is one of the objectives of our research. In this work, the business protocol models of the Web service are extended by adding information to the message on each transition about the service in which this message will be sent to or received from. We define and verify Web service compatibility in order to see if (and how) several

services can have ***interactions based on their protocols***. This approach will help the designers to select Web services in an easy way and verify if they can implement the required choreography or not by checking the compatibly using our approach. In addition to access control, time has a crucial role in many of Web services behavior. Therefore, ***modeling and analyzing*** Web services based on error free compatibility and replaceability checking with time constraints is one of our major contributions in this work.

The more the Web service is complex, the more it has parameters that affect the behavior of this service. Enriching the Web service behavior by certain parameters such as time and access control policies can be generalized to include any other parameter such as privacy information, message meaning, etc. In this context, one of our contributions is to provide a general model for Web service business protocol annotated by message specifications. Each message specification contains the constraints and the information that are required or provided by the service.

To conclude, this work is about checking the compliance of Web services after including a set of constraints such as the access control policy and time. The formalism of timed automata and constraints are used to represent the services specification for which the compliance of the services must be verified. Compatibility and replaceability analyses between Web services using their business protocols are performed in the presence of these constraints. Algorithms are then developed for the verification of compliance with the aim of ensuring compliance with these high level specifications. The detailed work is reported in [5].

- ***Adaptation of Web Service Interactions using Complex Event Processing Patterns***: Usually, Web Services are developed independently and follow different standards or approaches in constructing their interfaces. Web Service compositions will often use services in ways that were not foreseen in their original design and construction. As a consequence, most of Web Services will be incompatible since many services will not support the same interface. To solve this problem, one needs to generate adapters that can make two Web services collaborate even if they were not designed in that a way. The generation of adapters requires the elicitation of mismatches between services. The research report [5-1] describes an approach that makes use of complex event processing to resolve both signature and protocol incompatibility problems that may exist between Web Service interfaces. The approach is oriented towards the use of a set of operators that can be applied to incoming messages individually or in combination to modify the structure, type and number of messages sent to the destination.

4. Runtime analysis

- ***Business protocol based monitoring***: Nowadays, software systems allow more automation of tasks and complex interconnections within the same system and across different systems, which is particularly facilitated by the emergence of Service Oriented Architecture (SOA). In this context, the need to insure compliance to

regulations in force is more necessary than ever. However the tasks of specifying, and checking compliance of software systems at run-time become particularly challenging. In this work, we propose a view based monitoring approach and framework that target the monitoring of business process compliance at runtime, and supports monitoring of different levels, including internal business process monitoring, business protocol monitoring, and services choreography monitoring, and offers the ability to perform monitoring over a specific view of a business process or choreography. The detailed work is reported in [6].

- ***Ad-hoc monitoring and management capabilities*****:** Advanced business transactions involve collaborations of multiple business partners and therefore benefit from transparency and visibility of the status of such business process networks. Besides monitoring the execution of distributed processes, this demand requires flexible management capabilities in order to dynamically react to relevant situations. However, current business process management systems mostly consider monitoring and controlling of single centralized process executions, are often heterogeneous and do not provide standardized runtime monitoring or management APIs. This work therefore aims at a concept and supporting infrastructure to flexibly collect information about the execution of process parts running on a remote system, to automatically process this information and to predefine and execute timely reactions to detected complex situations where ever necessary. The approach utilizes a two-tier architecture, consisting of a service-based common management interface and an additional (optional) management component which executes user-defined management rules and actions using complex event processing. The detailed work is reported in [7].

5. Relation to other BPM deliverables

Deliverable JRA-2.1.1 showed the lack of languages and methods to support Business Aware Transaction in the context of Agile Service Networks. Deliverable JRA-2.1.2 provided support for analyzing correlations between KPIs and SLAs metrics in Service Networks. Deliverable JRA-2.1.3 provided a preliminary language for Business Aware Transaction Management and succinctly explored Business Transaction regarding Process Fragments. The deliverable also proposed how current formal methods can provide tools for checking and supporting a business transaction language but in a rather static (at most a predefined adaptation/deviation is possible) way. JRA-2.1.4 continued modeling and analysis of Service Networks. It proposed a framework for service network simulation, isolated critical concepts for relevant service network management, and discussed value-based and performance-based analyses of service networks. The present deliverable aims at consolidating the approaches of precedent deliverables technically and formally (e.g., monitoring, composition, checking, realisability analysis, adaptation). It continues also to study interaction between business Transaction and Service Networks and still proposes refined model and concepts for business transaction language. Overall it heads toward more agile-oriented conceptual, technical and formal methods.

6. Conclusion

In these works, we proposed methods and concepts to define and support the features of business aware transactions in Service Network at any level of the BPM lifecycle. However, some challenging issues remain open. First issue is to propose sound method to support non monotonic specification (typical in contract or transaction) and analysis. The link between such deontic logic and transactional behavior is actually critical while deviating a transaction to a secondary goal. Second issue is the necessity of paradigm/logic/calculi to tackle business aware on-the-fly adaptation and also to integrate human handling (e.g., Runtime monitoring and then human directed re composition of service but keeping compliant). Finally, analysing and executing business transaction process fragment at the reuse step is still an open issue.

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