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Management Summary

This deliverable presents the final research outcomes and an overview of the main research results produced in the scope of the WP-JRA-2.1 during the S-Cube project. The first section introduces the research area and consolidates the research work carried out by the S-cube partners in terms of the main research questions and challenges that have driven the research in this workpackage. It presents the progression of work through the project. The second part of the deliverable introduces the new research results with respect to service networks, business transactions in service networks and business transaction management. Research methodologies cover several aspects such as modeling & analyzing service networks, transformation rules for correlating service networks models to choreography models, recent developments to the Business Transaction Language (CD-JRA-2.1.3), a set of approaches enabling business transaction monitoring in distributed environments such as service networks and a set of frameworks for supporting and ensuring compliance, adaptability and reusability in end-to-end processes of service networks. We also present the approaches used to evaluate and validate the research findings. The research results are presented through the summaries of papers of the project partners.

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Vision and Objectives of S-Cube

The Software Services and Systems Network (S-Cube) will establish a unified, multidisciplinary, vibrant research community which will enable Europe to lead the software-services revolution, helping shape the software-service based Internet which is the backbone of our future interactive society.

By integrating diverse research communities, S-Cube intends to achieve world-wide scientific excellence in a field that is critical for European competitiveness. S-Cube will accomplish its aims by meeting the following objectives:

- Re-aligning, re-shaping and integrating research agendas of key European players from diverse research areas and by synthesizing and integrating diversified knowledge, thereby establishing a long-lasting foundation for steering research and for achieving innovation at the highest level.
- 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.
- Establishing a pro-active mobility plan to enable cross-fertilisation and thereby fostering the integration of research communities and the establishment of a common software services research culture.
- Establishing trust relationships with industry via European Technology Platforms (specifically NESSI) to achieve a catalytic effect in shaping European research, strengthening industrial competitiveness and addressing main societal challenges.
- Defining a broader research vision and perspective that will shape the software-service based Internet of the future and will accelerate economic growth and improve the living conditions of European citizens.

S-Cube will produce an integrated research community of international reputation and acclaim that will help define the future shape of the field of software services which is of critical for European competitiveness. S-Cube will provide service engineering methodologies which facilitate the development, deployment and adjustment of sophisticated hybrid service-based systems that cannot be addressed with today’s limited software engineering approaches. S-Cube will further introduce an advanced training program for researchers and practitioners. Finally, S-Cube intends to bring strategic added value to European industry by using industry best-practice models and by implementing research results into pilot business cases and prototype systems.

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List of Acronyms

ACID	Atomicity, Consistency, Isolation, Durability
B2B	Business-to-Business
BPEL	Business Process Execution Language
BPM	Business Process Management
BPMN	Business Process Modeling Notation
BPMS	Business Process Management System
BT	Business Transaction
BTF	Business Transaction Framework
BTL	Business Transaction Language
CEP	Complex Event Processing
CRL	Compliance Request Language
IRF	Integrated Research Framework
KPI	Key Performance Indicators
KPO	Key Performance Objective
QoS	Quality of Service
SBA	Service-based Application
SLA	Service Level Agreement
SN	Service Network
XML	Extensible Markup Language

Chapter 1

1 Introduction

In recent years, the shift towards the service economy combined with the rapid evolution of information technology, forced service companies to join their competences resulting in the formation of service networks because of the economic globalization and the pressure for innovation. In this way, service companies focus on their core competences and sustain their competitive advantage through organizing and capitalizing over the advantage of collaboration. Flexibility, quality, cost effectiveness and competitiveness are some of the reasons underpinning the change of horizontal or vertical industries to networks of collaboration [1,2,3,4].

Hence, in a service network, various interdependent service providers or enterprises cooperate with each other by employing their social and technical resources with the aim of delivering a value-added service to the market. Service networks have been proposed as a methodology and tool for analyzing the structure and performance of these networks [5]. They usually offer a graph-based approach to model, analyze and optimize business interactions inside complex business networks. Typically, nodes represent the business partners (service providers), while the edges indicate the interactions between the partners in terms of services and service offerings.

Service networks reside in at the business level [6] and are supported by partners' business processes in order to fulfill business goals of the network as a whole, and consequently, the business goals of each partner in the network. Each service offering in the service network wraps a set of complex and concrete interactions between partners in terms of business processes running on their back-end systems. Thus, the end-to-end process of the service network is subdivided into composite service processes connecting service provisions of several service providers. Software and human services can be routinely mapped to atomic services, and can be selected, customized and combined into aggregated service-based applications (SBAs). In the case of using SOA as the service network's enactment platform, software service applications are (very often) implemented with web service technologies. The software service may be deployed on a software service infrastructure, which may for example be a distributed cloud environment, providing the capabilities required for enabling the development, delivery, maintenance and provisioning of services as well as capabilities that monitor, manage, and maintain QoS such as security, performance, and availability [7].

Interactions among business partners are governed by a set of business rules, policies, constraints, business events, local or aggregated QoS requirements and associated KPIs, which are defined in negotiated agreements, also known as contracts or service-level agreements (SLAs). Until now, these business- or application-level requirements were buried into the execution code of services realizing the end-to-end process of the service network and they were not treated in an isolated manner. This approach complicated and even prohibited any effort of customization of processes in critical situations such as adapting service networks structure upon the entrance or the exit of a participant in the network or when optimization of the network's performance is needed.

This has given rise to the concept of Business Transactions (BTs). A business transaction is defined as a series of collaborative business activities, involving multiple business entities, which co-operate to achieve the agreed-upon business objective of the SN [8]. Business transactions reflect the business-level requirements and isolate them from the implementation logic, while treating them as a logical unit of work that under certain conditions succeed or fail. The core purpose of business transactions is to properly align the SN's partners' systems and business processes by enforcing SLAs and other business-level requirements compliance through their choreography/orchestration behavior. Therefore, an end-to-end process realizing a service network can be considered as a set of business transactions, some of them defined as conventional short-lived actions consistent with ACID properties, while others follow a more relaxed version of transactional properties.

On one hand, existing methodologies regarding service networks have grown in a fragmented manner and the research work conducted mainly concentrated on SNs from two different perspectives; the business perspective and the IT perspective. The business perspective provides conceptual modeling and analysis techniques studying service systems in a high abstraction layer depicting the entities participating in the network while also analyzing network's vitality and the strategic decisions of each participant and the network as a whole. In this category, various business models have been proposed, which were evolved mainly from the value chain model, and they are also known as value network models.

On the other hand, the IT perspective deals with the alignment and coordination of the participants' business processes and information systems in order to achieve the agreed-upon business outcome. Business process modeling is considered to be the most important task in the development, engineering and re-engineering of business processes and various business process modeling languages, techniques and specifications have been proposed coming from both academia and industry including Web services technology (e.g., BPMN, UML Activity Diagrams, Petri Nets, EPCs, ebXML specifications family, RosettaNet, WS-CDL, BPEL4Chor, etc).

Traditional economic and strategy analysis methodologies, which have been used to evaluate business performance, have been proved inadequate when it comes to designing and deploying service-based applications (SBA). Moreover, Business Process Management (BPM), which has been grown through years to become a discipline and technological platform for managing enterprise's business processes including both IT-oriented and human-centric processes [9], has been restrictively applied within enterprise's boundaries just for the improvement of its existing business processes excluding support for applications that are characterized by wide-scale and complex dynamic interactions like those found in service networks [5]. BPM systems are composed of tightly coupled business application and integration technology components, making hard to accommodate business process changes with the underlying infrastructure and vice versa. This restricts the core pursue of enterprises: business agility.

Thus, there is a need for providing new concepts for driving the service implementation from business models accommodating the networked form of service providers and the delivery of service-based applications. This has been one of the major goals of this workpackage.

Furthermore, there is a need for interconnecting the concept of business transactions from the business process level with service networks, and enable proper correlation of business objectives and SLAs to Key Performance Indicators (KPIs) in the underlying business processes. This interconnection will become the basis of measuring business performance in terms of the agreed SLAs and KPIs. With this vision, an SBA is viewed as a collection of transactional and not-transactional services. Current transaction standards such as UMM, Open EDI and ebXML, focus only on the business document exchanges between partners without taking into account the aforementioned concepts, while transactional properties are enabled through Web services standards like WS-Transaction and WS-Coordination. Therefore, the aim of this workpackage has been the definition of a business-aware transactional model and support mechanisms to express business transactions based on common business functions (e.g., payment) governed by conditions stipulated in SLAs to preserve compliance of business partners and their business processes. This work allows business transaction management and monitoring with respect to business events coming from either real-time and historical data to detect changes in the operational behavior, or from user specified conditions (e.g., orders that exceed a certain size) or constraint (rule) the execution of business transactions.

1.1 Structure of the deliverable

This deliverable includes both a consolidation part of the research results, which were produced during the S-cube project and included in previous deliverables, and the research outcomes that have been attained during Y4.

In this context, Section 1.2 introduces the research challenges of the WP-JRA-2.1 based on the gaps identified in the area of interest described in the introductory part, while Section 1.3 summarizes over the research work carried out in respect of these challenges. Section 1.4 outlines the current research results and the areas of coverage and finally, Section 1.5 discusses about the linkage between the new proposed research results with other S-Cube work-packages' challenges.

In Chapter 2, we present current research outcomes of partners in the following areas of coverage; service networks and business transaction management including both design-time approaches as well as runtime monitoring of business transactions in terms of the underlying composition models (choreographies and orchestrations). Also, research on adaptation of service networks, reusability of services and privacy-aspect of business protocols is included. This chapter provides a summary of each contribution to briefly introduce the main achievements with respect to overall S-Cube's challenges and to describe the evaluation methods used to verify the approaches.

Chapter 0 concludes this deliverable with a short summary of the results and outlines future research orientation. Finally, Appendix A includes the original papers for further analysis and assessment.

1.2 Key Research Challenges and Results

The following two research challenges are defined in the S-Cube Integrated Research Framework (IRF) for the workpackage JRA-2.1:

End-to-End Processes in Service Networks: This research challenge focuses on design-time concepts, mechanisms and languages for specifying, analyzing, and simulating end-to-end processes in service networks. Approaches also, explore business protocols, both bi-lateral and multi-lateral agreements and support business protocols in service networks through developing and designing business transaction aware concepts and mechanisms.

Business Transactions in Service Networks: This research challenge focuses on concepts, mechanisms, and languages for run-time monitoring of business transactions. A better understanding is required of existing monitoring approaches, techniques and solutions. Existing transaction monitors limit themselves to sniffing and aggregating system-level events. An integrated approach that realizes mechanisms and concepts for monitoring business-aware transactions is needed. A formal foundation underpinning business transactions is also needed for the purpose of determining their correctness and consistency, considering also performance analysis concepts techniques for business transactions. Research supports monitoring service-enabled business processes through a proposed business-aware transaction model.

IRF contains the detailed description of challenges, research questions and research results. This deliverable covers both challenges and consolidates over the outcomes for year 4 of the project. For each contribution, the corresponding research challenge is presented to indicate where it fits.

1.3 Consolidation of previous Research Results

During S-cube project, the research work performed in this workpackage deal with the two major goals as described in the introductory section, including the definition and development techniques for business-aware transactions. Initially, the research was driven by the need to address the existing gap between service networks and business processes implemented based on service-oriented architecture. To this purpose, the deliverable CD-JRA-2.1.2 presented a novel architecture that links service networks and BPM by means of an enhanced BPM layering and lifecycle, placing a service network layer on top of the BPM layer [6]. The service network layer included the service network models, which represent participants and interactions, while the BPM layer included the composition models. The proposed architecture covered both functional and non-functional perspectives. The functional perspective included a service network meta-model for modeling service networks and then, transforming these models to business process models skeletons, and vice-versa. The non-functional perspective covered the description of some set of non-functional properties (e.g., KPIs, process metrics, QoS) relevant to each layer and correlated them with the functional artifacts with the aim of enabling monitoring of these properties across the network. In addition, an initial quantitative analysis methodology was also proposed in order to evaluate the strategies followed by each partner and the overall strategy of the network in terms of value maximization. The contribution of CD-JRA-2.1.2 was to two-fold: (1) it simplified the modeling of strategic business processes, and (2) lowered the bars in terms of technical expertise on modeling notations for business processes, while allowing analysts to concentrate on strategic goals without being directly involved with BPM.

In terms of the second research challenge, the deliverable CD-JRA-2.1.3 focused on the concept of business transactions and the need for application level-management technologies that can ensure highly reliable application- and system-level transactions [8]. Thus, business transactions were heavily investigated in order to provide a holistic definition based on existing literature. In this scope, process fragments and particularly, transactional process fragments were explored and a business transaction model was proposed. The initial version of the Business Transaction Language (BTL) was presented that encompasses several concepts and standard primitives to be utilized in order to develop complex SBAs involving transactional process fragments, while defining and enforcing transactional QoS and SLA stipulations into SBAs. The foundation of BTL lies between the combination of concepts from application integration, transaction-based and business process management technologies. The deliverable also included the formal underpinnings of the BTL to ascertain the construct and internal validity of the BTL with the aim of enabling the automatic verification between business process specification and transactional properties on the other side.

Work continued regarding service networks modeling and analysis techniques. In the deliverable CD-JRA-2.1.4, we provided a more refined modeling approach for SNs by proposing different views on SN; the offering-centric and global views. The offering-centric focused on a particular participant in an SN, while the global view shows the totality of information[7]. Also, a lifecycle of SNs was presented that breaks down the creation, implementation, enactment, monitoring and optimization of a network into five distinct phases. SN analysis methodologies were also proposed covering both simulation-based approaches on estimating value and performance on both views, and a hybrid approach to predict performance at the level of software services as well as end-to-end processes in service networks was also presented. Finally, social network analysis techniques were presented in order to model and simulate the performance of each participant, with the clear goal of increasing the manageability of SNs.

The deliverable JRA-2.1.5 [10] dealt with modeling business transactions in SNs in respect of the BPM lifecycle and analysis techniques of business transactions. A set of monitoring approaches was proposed focusing on both design-time and run-time analysis of business transactions. For design-time analysis, the following approaches were proposed. Firstly, a novel three-stage approach was presented to derive service compositions out of Web Services, which provide the desired functionality (discovery stage), by accommodating business rules (orchestration stage) and user references (classification stage). Secondly, a conflict-driven Tableau depth-first-search solver for LTL was presented. This work focused on detecting conflicting compliance rules. Thirdly, an approach was presented that checks and verifies the compliance of Web services in respect of a set of constraints. Lastly, an approach was described that makes use of complex event processing to resolve both signature and protocol incompatibility problems that may exist between Web Service interfaces. In respect of run-time analysis, we proposed a view based monitoring approach and framework that target the monitoring of business process compliance, 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. A two-tier architecture was also proposed that consists 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,. This approach allows for collecting information about the execution of process parts running on a remote system.

1.4 Overview of Contributions

This deliverable includes the following contributions:

- *A Multi-layer Approach for Customizing Business Services* [11]
- *Service Network Analysis and Prediction Tool* [12]
- *Adaptation of Web Service Interactions using Complex Event Processing Patterns* [13]
- *Service Science: Exploring Complex Agile Service Networks through Organisational Network Analysis* [14]
- *Modeling Business Transactions across Service Supply Chain Networks* [15]
- *Business Transaction Framework* [16]
- *An Event Model for WS-BPEL 2.0* [17]
- *Migratability of BPMN 2.0 Process Instances* [18]
- *Service-based Business Transactions: Modeling, Adaptation and State propagation-based Monitoring* [19]
- *A Framework for Management and Control of Service Granular Properties in Service-based Applications* [20]
- *Business Process Compliance Management: An integrated Proactive Approach* [21]
- *Timed Privacy-aware Business Protocols* [22]

The contributions will be further described in the Chapter 2 in terms of their research context, the methodology proposition, including also the evaluation method used. In the following paragraphs, we present a categorization of these research results based on the research topics addressed by them. In the end, two frameworks are presented which provide a consolidation aspect over business transactions and service networks.

Modeling, Analysis and Adaptation of Service Networks

In this category, the contributions are oriented towards modeling and analysis techniques of end-to-end processes in service networks including reusability of business services and adaptation of networks. The contributions focus on the workpackage's first key challenge. Specifically, authors in [14] examines how organisational network analysis (ONA) can be applied as a novel approach to model agile service interaction. The purpose of this work is placed on the identification of SNA and ONA's concepts as an instrument allowing for monitoring the impact of service relational structures on performance and explains how SNA present service metrics to model service behavior. In [12], a generic service network meta-model for modeling service networks is presented, taking into account concepts from both business and IT perspective, and contributes to the offering-centric view on service networks that was described in CD-JRA-2.1.4. This meta-model enables visualization of graph-based service network models focusing on the focal actor's network of collaborations and depicting business entities and their interactions as service offerings, and a prototype tool, entitled Service Network Analysis and Prediction Tool (SNAPT), is described. SNAPT supports the visualization of service networks based on the proposed meta-model and serves as a hub between existing business process modeling tools (Eclipse BPMN and IBM WebSphere Business Modeler) and simulations tools (Vensim). In [11], a service customization reference model is proposed for enabling customization of services at different levels in order to be reused in different contexts. This reference model allows decomposition of reusability requirements into two layers and then, into separate views allowing customization of business policies, quality of service, tasks and controls parameters. This approach eliminates the complexities of this process and allows non IT experts to customize services. Finally, authors in [13] make use of the complex event processing (CEP) technique to solve signature and protocol incompatibility problems between Web services 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. This contribution aims at providing efficient adaptability mechanisms that may deal with (unanticipated) changes to service-enabled processes such as restructuring of the service network upon entrance or exit of participants

Design Issues on Business Transactions

In this category, the research work includes design-time issues on business transactions including the refinements on Business Transaction Language and a business transaction conceptual framework. The research work included in this category deals with the workpackage's second challenge. In particular, authors in [15] present the recent development of the BTL, which was presented in CD-JRA-2.1.3. In this work, BTL encompasses three main perspectives: the business, the functional and the protocol perspectives. The business perspective includes business elements like SLAs, policies and QoS, while the functional perspective entails business functions (composite services or processes) which are composed of events and activities, including BTL's contingency and compensating activity. The protocol perspective focuses on the business protocols (ordering of business functions) specification, which determines the order of business transactions. Moreover, current contribution provides a refinement over the classical transactional properties such as atomicity and isolation and identifies the flexible behavior of a business transaction as the most viable solution to deal with uncertain and dynamic events. The second contribution in this category proposes a consolidated version of a business transaction framework which integrates and relates transaction management mechanisms from databases and contractual obligations between business partners in order to enable the specification and execution of reliable inter-organizational business processes [16]. This framework consists of a uniform business transaction model (BTL) and a reference architecture.

Monitoring and Adaptation of Business Transactions

This category includes the contributions that deal with the monitoring aspect of business transactions both at design-time and runtime, and focus specifically on the workpackage's second challenge. To this extent, a generic event model for WS-BPEL 2.0 is presented in [17], which can support both passive monitoring and control of process execution by external applications. The event model consists of a set of event models for different types of BPEL entities that change their state, such as process instances, general and scope activities, invoke activities, loops and so on. Authors in [18] investigates the "migratability" of business transactions, that is the ability to partition and transfer a business transaction within a specific control flow structure in order to allow adaptation of business transactions. This approach is oriented towards the flexible distribution of business transactions at runtime to deal with dynamic changes during execution in terms of their functional and non-functional requirements as well as their environment. Thus, authors present a generic migration model, which allows the representation of language-independent process instance data, as a supplement to process models. Also, special focus is placed on event processing and a respective classification of events with respect to a process instance migration. In [19], a framework is proposed accommodating a state model and a graphical notation for business transactions and for the corresponding SLAs. The proposed methodology discusses the correlations (relationships) that exist among business transactions and choreographies and it proposes a set of propagation rules that map the state of a choreography to the state of business transactions.

Compliance and Verification of Business Transactions in Service Networks

This category includes three contributions that consolidates and integrates business transactions in service networks. The contributions, which fall into this category, respond to both research challenges for this workpackage in contrast to the ones included in the previous category. Firstly, a framework is proposed for the management and control of the non-functional characteristics of a SBA regarding management of the global QoS constraints of a business transaction [20]. In this context, the approach aims at enabling better collaboration of changing QoS properties and other service granules in service networks, allowing the substitution of web-services in terms of failure or unavailability of a service at run-time. Secondly, authors in [21] present a compliance management framework that integrates and complements design-time and run-time compliance verification and monitoring approaches. It proposes the Compliance Request Language (CRL) for specifying compliance requirements using a set of abstract domain-specific (compliance) patterns, and their automatic transformation into formal statements/query expressions. These formal statements are used for automated verification of business processes both at design-time and runtime through their executing instances. Finally, authors in [22] investigate an extension to the business protocols in order to accommodate privacy aspects and time-related properties. They propose a Timed Privacy-aware Business Protocols (TPBPs) model as a state machine which encompasses privacy requirements and specifically, the time-related properties, and describes the verification of SLA compliance through monitoring of the non-functional QoS in a business protocol.

1.5 Relationship to Other Workpackages

The research papers presented in this deliverable are closely related to the research challenges of other workpackages in S-Cube. In particular, service networks' modeling and analysis techniques depend on and influence JRA-1.3: End-to-End Quality Provision & SLA Conformance and JRA-2.2: Adaptable Coordinated Service Compositions. Service networks are analyzed based on their corresponding composition models in terms of defined business metrics and goals to be achieved. Modeling business transactions in SNs and monitoring their execution depends on proper transformation rules to map to service composition models (JRA-2.2) for their enactment and simulations. Conformance to business contracts and SLAs is also an integral part of the vitality and future of service networks.

In addition, service networks' end-to-end processes rely on the service engineering principles and techniques introduced in JRA-1.1 in terms of service integration and reusability of services. To this extent, constructing end-to-end business processes requires proper customization of the reusable services in order to fit in the underlying composition models, and provide the desired business solution eliminating the need to develop from scratch these parts of a business process. The customization process contributes to current approaches by providing a policy-based requirements customization to service fragments.

Business transaction monitoring depends on and contributes to the techniques introduced by JRA-1.2: Adaptation & Monitoring, in order to enable the flexible execution distribution of processes, and to monitor metrics of underlying services (JRA-2.3). Furthermore, JRA-1.2's adaptation techniques contribute to the adaptation of service networks that may be required for satisfying business metrics or when the structure of a service network changes due to the entrance or exit of business partners and existing service-enabled processes suffer from incompatibility at the level of the end-to-end processes and associated web services. Also, this deliverable influences the JRA-1.3 objectives through providing a framework to ensure QoS of end-to-end processes in evolving environments which is vital for the successful completion of business transactions under specific QoS stipulations and through the proposition of a business protocol model accommodating privacy requirements and time-related properties.

Chapter 2

2 Overview of Research Results

This section summarizes the research methodologies proposed in this workpackage. Each contribution is described by the following concepts in order to provide a better understanding regarding the approach followed and the evaluation which took place for justifying the findings:

– *Background*: Describes the context and background of the problem being addressed.
– *Problem Statement*: Describes the particular problem addressed by the contribution.
– *Relevance of the Problem and Progress from the State of the Art*: Describes why this problem worth to be solved, how it contributes to the solution of the stated problem and the progress from existing work.
– *Contribution Summary*: Provides an overview of the main objectives achieved by the presented paper.
– *Evaluation*: Describes the method used to evaluate and/or validate the approach presented in the contribution, including experiments, simulations, prototype, etc.
– *Relation to Research Framework*: State how the contribution is aligned with S-Cube's conceptual research framework and the research challenges addressed.
– *Conclusion*: Discuss key concepts, current gaps and shortcomings of the solution as well as addresses future work

2.1 A Multi-layer Approach for Customizing Business Services

Contributed by: Tilburg, Lero

Keywords: Service, Reusability, Customization, Service Oriented Computing (SOC), Service Based Application (SBA).

2.1.1 Background

The reusability of services is a cornerstone of Service-Oriented Architectures as it allows for linking together services in order to solve an end-to-end business problem or process and to create a Service-Based Application (SBA). For instance, services such as order processing, and shipment processing can be reused to build an order management application. Reusability can be deemed as one of the most significant qualities of services within the domain of SBAs for several reasons. In particular, reusability facilitates Just-in-time (JIT) service integration that plays vital role in meeting other important service qualities such as customer satisfaction. For example, if a client purchases goods from a provider who does not provide an insurance service for their delivery and the client asks for shipping insurance, the provider should be able to provide this service to promote customer satisfaction, which in turn maximizes the return for provider. In such situations, the provider can integrate a (reusable) insurance service with the running business application, just in time, instead of developing the service from scratch, reducing in this way the up-front costs for the service provider.

2.1.2 Problem Statement

Although reusability has many merits, it has two limitations: generalization and over-specification. Generalization facilitates designing services from generic point of view; for example, a generic order management application can be designed to meet most requirements by abstracting away its specificity. This means generic services cannot be used in a specific context since they lack the ability to satisfy the specific requirements of any context. Over-specification is the opposite of over-abstraction. An over-specified service has attributes that are highly-specific in a certain context. Unlike generic services, over-specified services may be reused in a specific context, but the target context has to match exactly the source context in terms of requirements. In practice, this is impractical because the requirements between contexts cannot be symmetric. As an example, payment service developed for a business organization operating in the United States cannot be reused directly by any organization in Europe. This example covers wider area; in fact, it is highly unlikely the service could be reused by any other organization in the US. This implies neither generic nor over-specified (reusable) services can be reused to build SBAs directly.

2.1.3 Relevance of the Problem and Progress from the State of the Art

This research revolves around two concepts: reusability and customization. Both these concepts are heavily documented throughout various bodies of literature [23,24]. These concepts are substantial within service engineering domain. To-date, a list of interesting solutions around service customization has been proposed [25,26,27]. These solutions are meant to facilitate fragmenting a complex business process into different parts that are intended to be reusable and customizable for target business process model. The idea of customizing processes through fragmentation is interesting but the solution they proposed is limited to technical aspect and missing technique that facilitates customizing policy related requirements of services.

A collection of reference models that are used for developing business applications, widely known as SAP reference model, was proposed [28]. These models are being used in many application services that are developed using technologies from SAP (http://www.sap.com/) and this work has been cited heavily. According to the state-of-art study, a considerable number of SAP reference models is structurally incorrect. Thus, they proposed configurable EPCs within the light of customization concept. Configurable EPCs were investigated by researchers in order to identify and model the service variability. They produced interesting results such as configuration gateways that support customizing the functional aspects of reusable processes. Noticeably, these works are limited within EPCs and SAP reference model. This means it is not clear whether the proposed solution is applicable to other process model. To solve such a problem, a framework with guidelines to transform a process model to SAP reference model has been proposed. Now, this framework can map a process model (ignoring the model type) to SAP reference model with customization support. From our perspective, these solutions are too technical for analysts who do not possess solid understanding on different types of technologies (e.g., SAP, ARIS, etc). Some relatively simple customization solutions have been also proposed, but like many other earlier ones, they ignored the non-functional aspects of services. As we have already mentioned, the non-functional aspects and in particular, those of security, policy, and quality, are critical importance for modern day business environment and thus service engineering.

Our multi-layer solution approach is an initiative to simplify service customization through parameterizing both business and technical requirements of services. Some of the earlier solutions also allow parameterizing services but they do not consider business level parameters. Parameterization is relatively simple technique that helps non IT-experts to customize services. Additionally, the segmentation of views helps analyzing the requirements of services especially what customization parameters should be used for the target context.

2.1.4 Contribution summary

In this paper, we propose a multi-layered approach to building SBAs that supports the customization of component services at different layers. The goal of this research is to ease the complexities of service customization and allow non-IT experts without a background in service related technologies (e.g., business analysts) to customize services. The proposed solution provides guidelines for the non-IT expert to allow them to customize services with respect to the specific context.

2.1.5 Evaluation

As described in the paper, we have partially validated the framework in a case study involving industry companies. A simple and user-friendly tool implementation is the subject of an ongoing work. We are also developing the tool that will provide step-by-step customization guidelines to the users to ease the customization complexity for non-IT experts. Additionally, we plan to build a repository of parameters which will be integrated with the tool in future. Therefore, we will continue enriching the repository of parameters.

2.1.6 Relation to Research Framework

The research results that are reported in this paper fit with the research challenge "End-to-End Processes in Service Networks" that revolves around modeling and analysis of service networks. In particular, this article contributes to modeling of service networks with generic and reusable business services by customizing them.

2.1.7 Conclusion

The multi-layer customization solution described in this article aims at supporting non IT experts for customizing services. The proposed solution helps in the customization of services by providing several necessary aspects, including the provision of a service customization reference model (the foundation of the proposed multi-layered solution approach), a comprehensive understanding of services and their customization requirements through service views and a list of parameters and operators that can be used in the customization of services.

2.2 Service Network Analysis and Prediction Tool

Contributed by: UoC

Keywords: Service Networks, Service Systems, Visualization of service network models, BPMN, Business Processes

2.2.1 Background

Nowadays, organizations operate in an extremely evolving and challenging environment, where increased competition, the pressure for innovation and the constant change of customers' demands, have forced them to focus primarily on their core competences. Businesses have outsourced some of their business activities resulting in the formation of complex economic networks. Typically, enterprises rely on Business Process Management Suites (BPMS) to model and manage the lifecycle of their business processes, including both IT-based and human-centric processes, eliminating the need to develop or re-develop custom software [7]. However, BPM has been restrictively applied within enterprise's boundaries just for the improvement of its existing business processes excluding support for applications that are characterized by wide-scale and complex dynamic interactions like those found in SNs. BPM systems are composed of tight coupled business application and integration technology components, making hard to accommodate business process changes with the underlying infrastructure and vice versa. Through years, the proliferation of the Internet of services and the growth of ICT has brought new opportunities in the business environment. Concepts like service-oriented architecture (SOA) and service-oriented computing have dominated in systems design. SOA has introduced a new way of creating loosely coupled components as software services, while allowing the composition of them into new business processes, decoupling processes from application implementation. The advantages of combining BPM and SOA can be summarized in the following: promoting business agility, promoting reusable business functionality, enabling cross-platform compatibility and cost-efficiency.

2.2.2 Problem Statement

Service networks have been analyzed from two perspectives: the business perspective and the IT perspective. The business perspective provides conceptual modeling and analysis techniques studying service systems in a high abstraction layer depicting the entities participating in the network while analyzing network vitality and calculating value created for each participant and for the network as a whole. Methodologies, belonging in the business perspective, have evolved from the value chain model and value chain system and several business models and value models have been proposed thereafter. On the other hand, the IT perspective deals with the information systems supporting the network ,which coordinate the activities and business processes among the entities. BPM provides the technological platform to enable business processes. Business process modeling is maybe the most important aspect of BPM and various business process modeling languages, techniques and specifications have been proposed coming from both academia and industry including Web services technology.

Moreover, the business processes realizing the SN exhibit a dynamic, cross-functional and cross-organizational nature involving many external partners. In such environments, creating, executing and monitoring of cross-enterprise collaborative business processes are mandatory to achieve connection of entire business value chains. Supporting such processes requires inclusion of heterogeneous systems, message exchange patterns either synchronous or asynchronous, flow coordination, exception and change management and so on. Business processes that take place in SNs need to be structured, modularized, reused, coordinated and synchronized with other relevant activities within the service network in order to improve or optimize their operation and ensuring that they will perform within specified timeframes and under right conditions.

2.2.3 Relevance of the Problem and Progress from the State of the Art

Service businesses, which exploit service-oriented architecture, in conjunction with the current paradigm of cloud computing require new modeling and analysis methodologies in order to deliver complex, reusable and reliable services. Traditional economic and strategy analysis methodologies, which have been used to evaluate business performance, have been proved inadequate when it comes to designing and deploying service-based applications (SBA). In this context, service networks have been proposed as the proper tool for modeling and analyzing service businesses and service-based applications because they offer the required level of abstraction. Currently, there is a little understanding of the BPM lifecycle over SNs and current BPM systems do not take into consideration the adaptive aspect of processes as well as the collaborative nature exhibited by processes involved in the service networks. Moreover, BPMSs provided limited support in redesigning and monitoring of collaborative processes. Thus, there is a need to capture and analyze the adaptive business processes spreading multiple enterprises along with the SN's contracts (SLAs), policies and each business partner's goals.

Thus, there is a need for a holistic approach combining the concepts underpinning BPM and SOA in order to support enterprises in service systems prevailing in the networked economy. The research work contributes towards a unified modeling methodology combining concepts from the business perspective and the IT perspective. The business perspective of SNs focuses on analyzing the business strategy in terms of profitability, network vitality and so on. The IT perspective focuses on defining business process models describing tasks, control and data flows, etc. that contribute to the final outcome of a business process.

2.2.4 Contribution Summary

We aim at providing a service network-centric framework for modeling, studying, developing, and monitoring services in complex service ecosystems where all involved stakeholders can provide and extract information to facilitate their needs. We also envision that the framework will promote and enforce a collaborative process between service network's partners in respect of the policies, contracts and objectives from both in the level of the network as a whole and in the member's level individually.

In this context, we propose a service network meta-model for constructing service network models representing the business entities and their interactions in terms of service offerings. This approach contributes to the offering-centric view, which was presented in CD-JRA-2.1.3, and provides a simplistic and more concrete view of the key participant's final strategic service offering. Our approach towards service networks combines concepts from both the economic and the business perspective and it is consistent with the principles introduced by the S-D Logic proposed by Vargo and Lusch ([29], [30]). Thus, the first tenant is the service which forms the basis of economic exchanges. In general, we view a service network as a set of business entities and services and it is depicted as a graph composed of nodes corresponding to the participating business entities and edges corresponding to services. The edge implies an economic exchange; the origin point is the business entity which offers the service, while the end point refers to the business entity that consumes the offered service. The term “business entity” is used to refer to any economic entity that provides and/or consumes services in a service network. Services' in our meta-model refer to both goods and services, tangible and intangible in nature, and denote what is exchanged in the context of service network model. The meta-model also includes the concept of Key Performance Objectives (KPOs) in order to model business and performance objectives. KPOs are like Key Performance Indicators (KPIs) but they reflect the expected value as declared by a business analyst. Hence, KPIs contains the measured value of a business metric in contrast to the expected value declared by a KPO. The concept of KPOs is included in the service network modeling phase to describe the expected performance of the underlying business processes from both the source and target business entities. The vision of this meta-model is to provide a common language that economists, business analysts and ICT developers will be able to understand and thus, serving as an intermediate between traditional Value Network analysis and service-oriented ICT systems and models.

Furthermore, a set of transformation rules have been defined to enable mapping service network constructs to business process modeling constructs defined in BPMN standard and the free-form language defined by the IBM WebSphere Business Modeler [31]. Moreover, we propose an approach to transform service networks to Verna Allee's value networks [12] and generate a report to depict the results of the Value Network Analysis (VNA) applied to the transformed value network. By conducting this approach the business analysts using SNAPT can discover the capabilities and the bottlenecks of the network through powerful business performance indicators. Also, a simple cost-revenue model is supported to enable further analysis of service networks.

2.2.5 Evaluation

To support the proposed methodology, a prototype tool has been developed that enables Service Network modeling and analysis, entitled “Service Network Analysis & Prediction Tool” (SNAPT). SNAPT follows the Model-driven approach (MDA) rather than a traditional monolithic application approach. The Eclipse platform has been utilized for the development process taking advantage of the plug-ins extension mechanisms in order to allow future extensions or modifications to the tool. The tool targets business analysts who need to study existing service networks or explore the vitality of emerging ones. In addition to modeling and studying service networks, SNAPT users are also allowed to develop their own KPI Library and map business goals to the Service Network model. SNAPT also provides a set of KPIs based on the APQC Framework [32].

Furthermore, a set of transformation rules have been defined to enable mapping service network constructs to business process modeling constructs defined in BPMN standard and the free-form language supported by the IBM WebSphere Business Modeler [31]. These transformation rules automate the process of mapping service network models to business process models. To implement and illustrate these mappings, we have enabled the interaction of SNAPT with two different software tools. The SNAPT user can convert a service network model into its corresponding abstract business processes supported by either the Eclipse-based BPMN modeler or IBM's WebSphere Business Modeler Advanced.

The tool also supports the value network analysis approach proposed by Verna Allee by exporting a report to summarize the results. Furthermore, we utilize the Vensim tool for simulation purposes [27]. Vensim is a software tool which is used for developing, analyzing, and packaging high quality dynamic feedback models. We have implemented a SNAPT extension in order to transform service network models to dynamic systems modeled in Vensim (SNAPT2Vensim plug-in). A system dynamics model in Vensim tool consists of variables and arrows that represent the relations and specifically the dependencies among the variables. Actually, the main functionality of SNAPT2Vensim plugin is based on the automatic conversion of a service network model that is designed in SNAPT to a system dynamics model that is compatible in Vensim tool. SNAPT is delivered as a standalone application and a demo is available at:

http://downloads.tsl.gr/SNAPT/demo/snapt2.htm.

2.2.6 Relation to Research Framework

The presented contribution fits in the Business Process Management domain and meets the research challenge "End-to-end processes in Service Networks".

2.2.7 Conclusion

This contribution describes SNAPT, a tool developed with the vision of serving as an intermediate tool bridging the existing gap between business analysts and IT professionals, combining concepts from both the IT and business perspective on service systems. SNAPT supports the virtualization of service networks based on a service network meta-model designing for this purpose. SNAPT serves as a hub providing appropriate outputs to both simulation tools that analyze the vitality of these networks as well as to BPM suites, for supporting the underlying business processes which connect the systems of the involved participants. To this extent, SNAPT models are extracted into an initial form of collaborative business processes based on the BPMN format and the IBM's WebSphere Business Modeler's business process model format. Future work on SNAPT includes the integration of a library of business protocols in order to ease transition from service network models to business process models, such as RosettaNet PIPs [39] from the supply chain domain. As cloud computing has become a trend and hot topic in the IT, service network modeling techniques should be used to provide models for cloud computing ecosystems. Notation and actors' roles should suit the needs of this ecosystem. In the bottom line, service networks encompasses many common features found also in business perspective of cloud computing.

2.3 *Adaptation of Web Service Interactions using Complex Event Processing Patterns*

Contributed by: Tilburg

Keywords: Web service, process adaptation

2.3.1 Background

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 enable two Web services to collaborate even if they have not been designed in that a way. The generation of these adapters requires the elicitation of mismatches between services.

2.3.2 Problem Statement

Incompatibilities between Web Service protocols can be classified as either signature incompatibilities or protocol incompatibilities. The signature incompatibilities arise due to the differences between services in terms of message structure, content and semantics. In Web services, XML schema provides a set of `built-in' types to allow the construction of complex input and output message types from these primitives. This extensibility in constructing message types in XML often means that a message from one Web Service will not be recognized by another and, therefore, there is a requirement to provide some function that maps the schema of one message to another. The protocol incompatibilities exist when Web services wish to interact but are incompatible because they support different message exchange sequences. For example, if two services perform the same function, e.g., accept purchase orders, but Service A requires a single order containing one or more items while Service B expects an order message for each item, there is a mismatch in their communication protocols that must be resolved in order to interoperate. To solve these incompatibilities, two approaches can be followed: either force one of the parties to support the other's interface, or build an adapter that receives messages, converts them to the correct sequence and/or maps them into a desired format and sends them to their destination. However, both of these solutions are unsatisfactory; imposing the development of an interface for each target service can lead to an organization having to maintain a different client for each service it uses, and the implementation of bespoke ad-hoc point-to-point adapters is costly and not-scalable.

2.3.3 Relevance of the Problem and Progress from the State of the Art

Active research is also being performed into the adaptation of web service protocols, although all work we have surveyed does not tackle both problems of signature and protocol incompatibility and all use different approaches to the presented CEP-based technique. Our chosen approach solves both signature and protocol incompatibilities.

2.3.4 Contribution summary

The paper 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.

2.3.5 Evaluation

To evaluate our proposal, a prototype implementation has been developed. It illustrates the practical generation and deployment of CEP-based adapters using model transformation. It has two stages: the design phase that models the adapter using operator automata through the use of an incompatibility detection process to produce a platform independent model, whilst the transformation phase takes the platform independent model to produce the adapter as a continuous computation queries for a CEP engine, i.e., a platform specific model. A live demonstration of the system is available at: http://www.youtube.com/watch?v=g05ciEPZ_Zc

2.3.6 Relation to Research Framework

This work relates to the research challenge "End-to-End Processes in Service Networks". In particular, it contributes both to the formation and adaptation of service networks where partners can be added or replaced with that the existing service-enabled processes suffer from incompatibility at the level of the end-to-end processes and associated web-services.

2.3.7 Conclusion

Web service incompatibilities are found in either their message signatures or protocols. This paper presents a CEP approach to adapt Web service interactions and resolve these conflicts. Using predefined operators, which are represented as configurable automata, allows us to automatically CEP generate adapters capable of intercepting incoming messages exchanged between services and adapting their structure, type and number into the desired output message(s). Our future work will be in two areas: (i) performing extensive testing on real services, and (ii) developing tools to assist service designers to generate adapters.

2.4 *Service Science: Exploring Complex Agile Service Networks through Organisational Network Analysis*

Contributed by: LERO

Keywords: Service Science, Agile Service Networks, Social Network Analysis, Service Network Performance Analytics

2.4.1 Background

Promoting software engineering methodologies is one of the key challenges for Ireland, yet a vital one to sustain our economic competitiveness [33]. Agile software engineering is a methodology which continues to gain increasing levels of academic and industrial attention. Agile software development is a collaborative approach which supports iterative and incremental methods within software engineering teams [34]. The key factors which foster the value of agile software development include human interactions, developing improved software solution, customer collaborations, and responding to change [35]. Thus, the composition and organisation of agile teams has a direct influence on the functionality of agile software development.

2.4.2 Problem Statement

The software industry is currently undergoing a fundamental change with the transition to agile and lean methods. However, there is a lack of integrated research efforts towards understanding the dynamics of agile and lean methods in an effort to optimize agile capabilities [36]. One of the key issues within agile software is to understand how the dynamics of team collaboration impacts on service performance. The aim of this contribution is to examine how we can apply social network analysis (SNA) as an agile software engineering modeling method which improves the visualisation of team dynamics. This will allow managers to monitor the impact of service relational structures on performance through a service network performance analytics framework [37]. The output of employing SNA is to develop a theoretical and practical approach to monitor and measure how collaborative efforts across teams can be structured to optimize agile software development outcomes. It also provides a theoretical foundation to develop an audit framework with associated metrics of agile practice. This research is also grounded in the emergence of service science developments to examine value co-creation across agile teams.

2.4.3 Relevance of the Problem and Progress from the State of the Art

Information exchanges are a vital resource to support decision-making within agile software service teams [34]. In short, there is a need for more sophisticated methods in data management and usage by agile software development teams to facilitate higher quality decision-making ([34], [36], [38]). Therefore, this research addresses this gap by introducing a novel method which assists teams through targeted and focused decision support mechanisms by mapping service behavior. This research is closely related to the work conducted in JRA-1.1 regarding ASN for Global Service Engineering (GSE) [39]. Supporting service actions through cross-organisational organisations and teams may be described through ASN. ASN rely on message flows that typically transcend several organisations and span geographical locations ([40], [41], [42]). Understanding how information is disseminated across teams and geographical locations is considered problematic, especially across agile service developments [43,44]. From a management perspective, it would be more practical to understand the service characteristics [45], such as structural, compositional, and behavior to identify [37]. For example, it would be useful to identify where bottlenecks or structural holes exist across the network. Agility has therefore become an important service factor to respond to the dynamic business environment particularly to sustain innovation within the software industry. Therefore, the design, management and delivery of complex service systems suggest that we need to develop a scientific understanding regarding the configuration of resources to deliver service excellence. In order to extend our understanding on service delivery, particularly within an agile environment, there is a need to establish alternative methods to examine service formation and the value propositions which connects them.

2.4.4 Contribution Summary

Agile software development is a collaborative approach which supports iterative and incremental methods within software engineering teams. The key factors which foster the value of agile software development include human interactions, developing improved software solutions, frequent customer collaborations, and the ability to rapidly respond to change. Thus, the composition and organisation of agile teams has a direct influence on the functionality of agile software development. Decision-making plays a critical role within a complex service environment in order to stabilize software development teams. Thus, information exchanges are a vital resource to support decision-making within service teams. The material used to guide decisions on service actions is influenced by socio-technical factors. Understanding how information is disseminated across teams is considered problematic, especially across agile service developments. Technology is often implemented to enhance service efficiency and enhance performance. However, in many cases, managers have little insights as to 'how' technology influences service relational structures. This work introduces an agile software engineering modeling method which improves the visualization of team dynamics. This method allows managers to monitor the impact of service relational structures on performance through a service network performance analytics framework and through the application of social network analysis (SNA) as a novel approach to model interaction and visualize the agile service infrastructure. This chapter discusses the importance of developing greater insights into ASN and examining alternative methods to visualize the relational structure which stabilizes networks. The scenario highlights that the SNA method of studying service patterns is critical to examining service systems. We explain how SNA offers a fitting technique to study relational patterns which support ASN infrastructures. This chapter provides a significant platform to extend theoretical developments on ASN and to develop additional methods to map agility within the service environment.

2.4.5 Evaluation

SNA focuses on pairs or groups of individuals who share some kind of relational tie such as within ASN. SNA typically begins with one specific community and examines the relational infrastructure which stabilizes the network (e.g., an organization). Adopting SNA is a significant contribution within the agile research domain. There are many difficulties in modeling the intertwining complexity and dynamic service configuration of people, knowledge, activities, interactions, and decisions which creates and delivers value [46]. This presents a starting point upon which the research explores how to model an ASN. This supports how we describe an ASN as 'the exchange of resources or competencies'. There is a large body of literature which suggests that SNA can present us with a unique method to model and monitor the dynamics of ASN (for example, [47], [48], [49], [50], [51], [52], [53], [54], [37]). It is claimed that managers have ignored the "dynamic characteristics of networks and the ways that dynamic qualities of networks affect organisations' flexibility and change" [55]. This has unavoidably led to organisations failing to capture the 'health' of their service networks dynamics and performance (for example, behavioral, functional, compositional, and structural) and the overall contributory value of service linkages (relational structures). SNA focuses on exchange patterns of relations among actors [56] and presents an opportunity to model the relational ties between each node to model service network behavior. To understand the dynamic nature of ASN and its impact on service performance, it is critical to explore the underlying principles in service behavior and analyze how and why services perform in a specific manner from socio-technical viewpoint. This is necessary as Spohrer et al. [1] posit that the success of service science will be achieved through the introduction of general theories of service interaction and co-creation of value. Mapping representation of an ASN is important as managers realize that the key to continued success is within their understanding of how workflows and business processes can be optimized [57].

This section summarizes the main concepts which may be used as service network analytics framework (Table 1), while the ASN scenario that follows examines a sample of these. This demonstrates their application and suitability of SNA as a platform to develop an audit framework. Table 1 identifies the metrics and provides a brief explanation of the various service network analytics.

Table 1 Example of Service Network Analytics

Metric	Explanation of it Measure
Betweenness	Examines the connectivity of node between two other nodes in a network and determines the number of actors a particular node connects other nodes indirectly.
Bridge	Is the link which, if it was removed, it would move the nodes to an alternative structural position in the sociogram/graph.
Centrality	Provides an indication of the 'power' of actors based on their overall connection with other actors.

Centralisation	Identifies the difference between all of links for each nodes divided by maximum available links.
Closeness	Determines how resources may flow from one actor to another, i.e. it measures how close actors are to one another in a network.
Clustering coefficient	Examines the likelihood that two associates of an actor are associates themselves. The higher the value the greater the clique.
Cohesion	Measures the degree to which actors are connected to one another, for example, the strength of cliques.
Degree	Counts the number of ties to other actors across a network.
Eigenvector centrality	Measures the importance of actors within a network based on their connectivity.
Path length	Measures the distance between two nodes in the network.
Radiality	Examines the degree of an actor 'reach' into the network which is informs and influences.
Reach	Measures the degree in which an actor within the network can reach another actor in the network.
Structural equivalence	Examine which nodes have a common set of link/connections to other actors within the network.
Structural hole	Identifies network holes which may be strategically filled by connecting one or more actors. This may, for example, improve communication within a network.

The following scenario examines the impact of service technology on the relational infrastructure of a SN. From this research, we examine how we could develop an audit framework with associated metrics and training materials which will have significant contributions towards software engineering performance. The scenario presents a fictitious agile organisation, Agile Inc., which wishes to examine its ASN in the hope to gain a better understanding of the relational structure supporting the agile activities. Agile Inc. is interested in learning about the ASN characteristics in order to gain a deeper understanding of how the performance may be improved. They also want to examine how technological innovation may influence the service structure and consequently, the teams' performance. This scenario examines how Agile Inc. may examine how performance is influenced by relational structure of the agile team. Agile Inc. wishes to foster an interactive agile environment between the national software engineering teams and are interested in learning how agile leaders across a national network interact with other team leaders across the team. Management is particularly interested in understanding the exchange of resources and competencies.

An ASN typically comprises of numerous entities in the form of organisations, groups, or teams. The actors distributed across Agile Inc are represented as nodes within a network. Between each node, interaction is facilitated by the exchange of resources and/or competencies in various agile practices. These exchanges are represented as edges or links within the graph. This links are vital as they represent the value of the relational infrastructure which supports the co-creation of service 'value'. It is critical to understand that each node in the network is not fixed, but rather, represents its position within a given time (i.e. a snapshot). Interaction involves at least two nodes within any exchange which represents their reaction to specific business process. These exchanges may comprise of a number of factors, for example, knowledge diffusion through various ASN partners in a decision-making problem. Modeling the ASN may highlight who is the greatest influence or who emerges as a leader within the ASN or where 'structural holes' exist across the network. Therefore, SNA concepts and measures (table 1) allow us to examine the relational structure of the ASN to uncover truths of service interactions (i.e. compare the differences between Figure 1 and Figure 2). For the purpose of this study, we provide an abstract representation of the ASN. Node identifications have been removed from both figures as this example scenario is employed for demonstrative purposes.

Figure 1 SNA Map of ASN (before IT-innovation)

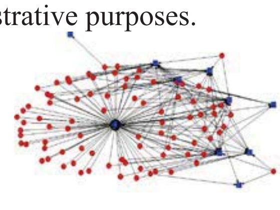

Figure 2 SNA Map of ASN (after Web-based system)

Figure 1 illustrates the relational structure of ten main agile teams which interact on a regular basis during various software engineering practices. These teams are dispersed across Europe in various locations. The blue nodes represent the managers of each organisation while the red nodes represent the software developers. The links illustrate the connection or relationship each actor has with other team members within the environment. This data was gathered through the distribution of a survey to all staff members within this ASN. Each staff member was asked to indicate their level of interaction with employees across the ASN for various tasks and the findings presented in Figure 1 summarize their responses.

Upon further inspection, Agile Inc. notices that there is a lack of network cohesion across the ASN. They suspect that this may hamper agile practices, for example; loss of information, threaten service quality, impact on service reputation, and ultimately, prevents them from optimising performance. Agile Inc also identify that there are 13 nodes which appear to be dominant within the centered of the network as they occupy a powerful position (i.e., a bridge or a broker between service providers). Agile Inc. are considering innovative methods to centralize agile practice through a more united application of agile practices. Agile Inc. implement a central communication forum which allows actors exchange resources and competencies with other actors. While the implementation of service innovation is often considered to be beneficial, Agile Inc. wish to employ a method which would examine how service relations have altered as a result of the service communication forum. Figure 2 demonstrates the impact of the technology on the service structure and highlights how the service has become more centralized and removes service bottlenecks through the service. This approach supports the diffusion of innovation across the network and enhances the exchange of information to support decision-making tasks.

To examine how this change impacts on the ASN, Table 2 lists some of the SNA concepts and summarizes the impact of implementing technology on a service network relational structure. This examines the impact of service technology on the relational infrastructure of the service network. This demonstrates how SNA concepts may be introduced as service network analytics to examine change to service dynamics within an ASN and develop service network performance analytics for technological innovation.

Table 2 Example of Service Network Analytics Metrics

Concept	Old ASN	New ASN	Difference explained
No. of Ties	254	208	Reduced number of structural ties to deliver a service.
Density	0.061	0.072	Increased density of network making the network more connected.
Distance	Average: 1.97 Cohesion: 0.514 Fragmentation: 0.49	Average: 1.13 Cohesion: 0.73 Fragmentation: 0.28	Distance reduced as a result of technological innovation and improved the cohesiveness of the actor-network.
Krackhardt GTD Measures	Connectedness: 1.00 Hierarchy: 0.00 Efficiency: 0.97 LUB: 1.00	Connectedness: 1.00 Hierarchy: 0.38 Efficiency: 0.10 LUB: 0.95	The “horizontal differentiation” of the service structure have reduces to improve ‘connectivity’.
Hybrid Reciprocity:	0.0031	0.00	The reciprocity of ties has reduced which suggests greater service efficiency.
Degree (Centralisation)	Outdegree: 0.54% Indegree: 25.34%	Outdegree: 5.48% Indegree: 94.88%	IT service innovation introduces greater cohesion and efficiency and is less dependent on other individuals.
Eigenvector Centrality	55.02%	8.31%	IT innovation provides more equal service structures as it adopts the central position.
Distance-Weighted Fragmentation	0.486	0.28	Reduces the distance between all nodes of a service through increased cohesion.
2-Mode Cohesion Measures	Density: 0.03 Avg Dist: 2.48 Radius: 3.00 Diameter: 4.00	Density: 0.68 Avg Dist: 1.62 Radius: 2.00 Diameter: 4.00	Service IT innovation increases the service density, and transitivity, while it reduces the average distance, radius, diameter, fragmentation, and normalised distance across the network.

	Fragmenta: 0.00 Transitiv: 0.56 Norm Dist: 0.60	Fragmenta:0.23 Transitiv: 0.98 Norm Dist: 1.18	Interestingly, the diameter remains the same in both networks suggesting that there was no significant impact on the actor-network boundary.

While Table 2 list some of the metrics we may incorporate to examine the impact of technological innovation on ASN, we can also incorporate the use of key performance indicators in agile software development through predefined service performance targets. There are many measures (see Table 1) which a manager may apply to an ASN to examine various factors of a service network. The example provided here generates many measures to inform management of the service structure and how SNA provides insights on the ASN dynamics. From such insights, it becomes evident that ASN are not engineered and but rather become the emerging product of collaboration to co-create and co-stabilize an ASN. Although, the purpose of this scenario is to provide an example of how one might demonstrate the application SNA to model ASN, while using large data sets it becomes more obvious as to the power of SNA as an analytics method.

2.4.6 Relation to Research Framework

The contribution of this research server Business Process Management layer and explains how SNA present service metrics to model service behavior. It also supports service design capabilities.

2.4.7 Conclusion

As part of our future work, we will build on this approach from both a theoretical and practical approach through numerous case studies in agile software development. We anticipate that this fork will lead to the construction of an audit framework which will assist monitor ASN and provide significant contributions to the emergence of Service Science, with particular attention on performance analytics of service networks. We will also continue to test the application of SNA in developing ASN performance indicators within the audit framework. We anticipate that this approach will harness more open innovation within agile software engineering developments.

2.5 Modeling Business Transactions across Service Supply Chain Networks.

Contributed by: LERO

Keywords: Business Transaction, Service Network, Business Transaction Language, Social Network Analysis, Supply Chain, Service Infrastructure

2.5.1 Background

Modeling business transaction denotes specifying the structural and behavioral aspects of transactions that underpin the applications and particularly Service Based Applications (SBA). The structural aspect deals with the construction of a transaction and several transactional models have been defined, such as distributed transactions [58] and open nested transaction model [59], which are structurally rich enough to be used for defining business transactions in a SN environment. On the other hand, the business perspective of business transactions entails real-world business element and deals with the operations including process level operations (e.g., refund) and system level operations (e.g., commit). This element refers to the *agreements* between SN partners and *declaration* of a set of obligations. Obligations in terms of QoS may promote the atomic behavior of transactions, while obligations, in terms of actions, are a set of rules that impose constraints and must be satisfied by the SN's participants' business processes. Moreover, the vitality attribute of services in SBAs influence the behavior and the final outcome of the transaction as a whole. Vital services are those services that must commit successfully in order to commit the business transaction.

In general, the behavior of a transaction behavior is determined by the well-known ACID properties (atomicity, consistency, isolation, and durability) [60]. But, these properties are not suitable for complex applications such as SBAs ([58], [61]). Thus, the transaction models (e.g., Nested, Multilevel, and Flat), which are built on them, lack the efficiency when used for new applications such as SBAs ([61] & [62]). The strictness of these properties is the primary reason for inefficiency. More specifically, atomicity does not allow any failure in transaction and isolation uses two-phase locking protocol, which degrade the performance of business transaction [58]. Nonetheless flexibility is an important metric to measure efficiency in business transaction. In a word, flexible behavior is highly desired in business transaction for service network.

2.5.2 Problem Statement

Business transaction models should (i) incorporate business elements (ii) facilitate the design of flexible business transactions. Traditional transaction models are efficient in designing short-lived transactions that are viewed mainly from database perspective but the business perspective has been ignored almost completely in those models. However, traditional models do not provide adequate support for designing business transaction model by incorporating business elements in particular, service level agreements that are crucial to today's service oriented business applications. Traditional models are too restrictive due to the strict principles such as atomicity and isolation. Atomicity forces a transaction to fail if any of its cohorts fails. Nevertheless, isolation, which is better known as serialization, does not allow concurrency. Consequently, operations consume more time than expected and the isolation property is not suitable for long-running business transactions.

2.5.3 Relevance of the Problem and Progress from the State of the Art

Service Based Applications (SBAs) that support end-to-end business processes in SNs typically involve well-defined standard sub-processes s (e.g., payment processing, shipping and tracking, determining new product offerings, granting/extending credit, managing market risk), which can be applied to a variety of application scenarios. Such standard processes or process fragments are associated by business elements such as service level agreement that contains business policies and quality of services. This implies transactions of SBAs are driven by business elements. Therefore, business transaction model must correlate these business elements.

Our analysis suggests that uncertainty (e.g., disappearance of goods) and requirement dynamism (e.g., demand arbitrariness) are the predominant challenging factors in business. Although uncertain events do not happen commonly, dynamic ones are quite common and foster enormous challenges for the organizations to survive modern day's highly competitive business environment. Both dynamic and uncertain events are hard to perceive in advance because they mostly happen without any historical record. These events affect business transaction heavily; in particular, they cause failure. According to our analysis on various business scenarios, flexible behavior of a business transaction is the most viable solution to deal with uncertain and dynamic events. Thus, a business transaction model must be built on techniques that help to define flexible transaction behavior.

BPMN standard provides constructs for business transactions, such as transaction, cancel event and compensate activity elements, but the notation is very basic and does not allow specifying business-oriented transactional attributes or correlating business elements with transactional business processes. In [63], the authors extend BPMN to facilitate annotating transactional attributes in a business process by introduced a flow type subsuming control and message flow in order to link two or more participants within the same scope. While this new artifact enables reconfiguring (re-modeling) business transaction dynamically, the core business elements (e.g. QoS), are still ignored.

Furthermore, to increase flexibility, a constraint based recovery mechanism for business transaction is introduced in [64]. The authors propose a set of actions that entail either ignore, retry, and substitution to support forward recovery of business transaction. Upon failure of a component transaction, either of these actions is performed depending on the condition. The same business transaction recovery mode (forward) with different mechanism is suggested in [65] to increase flexibility in business transaction. The authors propose a framework based on abstract service, which acts as a mediator for compensation transaction adopting forward recovery. Unlike the traditional compensation action, this framework offers strategic compensation actions within business transaction. In this work, we refine the BTL, the XML language proposed in a previous deliverable, to include the transactional properties, such as flex-atomicity and relaxed-isolation.

2.5.4 Contribution Summary

Our contribution in this research is two-fold: (a) to propose a business transaction language to design a business transaction model taking into account the business elements and (b) to define relaxed properties for flexible business transaction. In an earlier phase, we proposed a design-time declarative language, the Business Transaction Language (BTL), for modeling business transactions in service networks. This contribution presents the recent development of BTL. In general, BTL describes what (transactional elements) should be defined in a business transaction model but not how they should be implemented. BTL comprises of three main perspectives: the business perspective, the functional perspective, and the protocol perspective. BTL captures business, functional, and protocol related elements through these perspectives.

The business perspective encompasses the concept of service level agreement (SLA), which influences the behavior of business transactions in service network. An SLA is formal agreement between two to many partners and contains a set of obligations (policy) and service guarantees (QoS) that that must be satisfied while performing business transactions. The functional perspective of BTL entails business functions (which are in fact composite services or processes). Business functions are composed of events and activities. An activity is an abstraction of a piece of work that's has to be performed within a process whereas an event denotes an occurrence or something has happened in a process [66]. Since flex-atomicity is a desired property of business transaction in service network, BTL allows specifying contingency activity and compensating activity. The key purpose of these activities is to prevent the total failure of business transactions. The protocol perspective allows specifying the business protocol governing interactions in SNs. This protocol specifies the order of business functions, which consequently determines the order of business transactions, defines the ordering of message exchanges, and captures all behavior aspects that have cross-enterprise business significance [67]. This is because, business transactions are realized through execution of business functions in an ordered manner. For instance, a purchase order business transaction may follow the execution order of business functions in following sequence: order registration, payment and delivery. In contrast, the delivery transaction may happen before payment or payment can be split into before and after delivery. The execution order is important to the business transactions in service network since they ensure correctness of the business transactions. This order is maintained using business protocols.

Additionally, for flexible transaction behavior, we refine the classical transaction properties such as atomicity and isolation, and we propose relaxed variants for then. We do not consider consistency and durability within the scope. Table 3 shows these properties with a brief description of each.

Table 3 List of business transaction properties

Transactional Properties		Description
Behavioral	Flex-Atomicity	Atomicity cannot be fully compromised due to the fact that complete non-atomicity may increase the transaction failure rate exponentially. But flexibility guarantees that a failure of a transaction can be repaired using contingent transaction. We also call this flex- atomicity as *eventual failure atomicity* which denotes a transaction is failed entirely

		only when it is beyond to be repaired.
	Relaxed-Isolation	Relaxed-isolation determines the visibility of outcomes. The classical isolation property do not allows externalizing the outcome of a child transaction until the parent transaction commits. Relaxed-Isolation ensures the externalization of every change that happens after operation. For instance, the transition of the state of transactional activity is notified to all of its collaborating partners at once. Relaxed-isolation is prone to inconsistency. In fact, it is the trade-off between consistency and performance. In service network environment, performance is a primary factor to gain customer satisfaction. Thus, relaxed-isolation may be more suitable than the classical isolation by tolerating inconsistency at lower extent.

2.5.5 Evaluation

We analyze business transactions using a supply chain scenario of Auto Inc. described in [68]. The AutoInc network spans across wide territories and we develop a SN scenario including bank and insurance as service partners as additional business partners. Figure 3 depicts the service network scenario of Auto Inc.

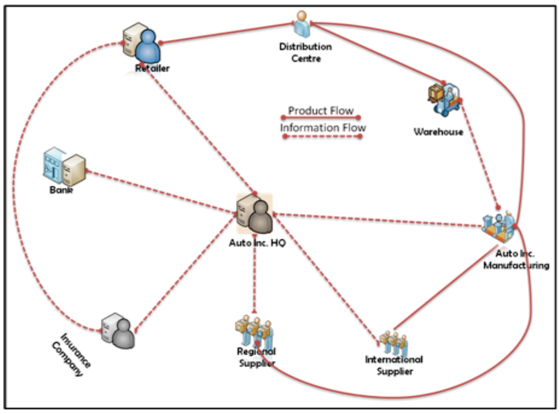

Figure 3 Auto Inc. service network scenario

Auto Inc. supply chain network embodies suppliers from different regions and continents in particular, from Europe. Auto Inc. does not have logistics partner because the suppliers provides logistics support. In addition, the distribution centre is responsible for the transportation of tangible service (product) to the retailers. This setting manifests that the inter-organisational SN structure is highly complex since it connects many disparate and spatial service nodes that fire up numerous interactions among them. The SBA that supports the end-to-end processes of the Auto Inc.'s network includes order processing, delivery and payment services. These are composite services encapsulating operations that perform the requests triggered by the partners across the network. The transactional properties are blended with these services, for which they are treated as transactional services. For this scenario, we consider that BTL has been used to define the transactional properties of these services at design-time in order to determine the behavior of the business transactions. In this scenario, we investigate over business behavioral consistency, flex-atomicity and reflexivity, which are the properties used for analyzing transactions' behaviors at runtime.

Business transactions are said to be consistent if and only if they satisfy the obligations and guarantees, such as response time, processing lead-time, delivery lead-time, and data privacy. We name this consistency as business behavioral consistency. The obligations and guarantees that determine business behavioral consistency are stipulated in SLA (the business perspective of BTL) and a transaction monitor is employed to monitor it at runtime. The monitor flags the transactions as inconsistent if they fail to satisfy SLA during and after the execution. The business behavioral inconsistency may denote the failure of a transaction. For instance, if a delivery from international supplier is delayed, it is the behavioral inconsistency of the supplier. It affects the transaction in several ways such as Auto Inc. may cancel the order which fails the transaction between Auto Inc. and the supplier. The effect of this failure may propagate throughout the network if Auto Inc. fails to deliver the cars ordered by retailers. The retailer cancels the order, which fails the transaction entirely for this particular instance (purchase order). Furthermore, if a regional supplier fails to deliver the raw materials (e.g., CD player), the transaction between regional supplier and Auto Inc. fails. According to the notion of classical atomicity, the transactions that are linked to this failed transaction, for instance the transaction between retailer and Auto Inc., should be aborted immediately. This atomicity has been relaxed in business transaction in Auto Inc. service network by invoking the compensation activity as well as contingent activity that are supplied by BTL (note that, the transaction manager integrates BTL). We call it flex-atomicity. The compensation activity undoes the results of the transaction between regional supplier and Auto Inc. and contingent activity initiate an alternative transaction which repairs the failed transaction. This resists the failure of business transaction entirely.

Business in the given scenario is collaborative. Thus, it is important that any change in end-to-end process in Auto Inc. SN should be externalized immediately to the other partners that are part of the collaboration. This is relaxed-isolation property of business transaction. Note that relaxed-isolation allows exceptions. In particular, the failure of a transaction may not always be broadcasted across the partners in the service networks to resist the total failure of transactions. We suggest masking these failures using some techniques.

2.5.6 Relation to Research Framework

The contribution of this research serves *Business Process Management* and *Service Composition & Coordination* layers. In the BPM layer, business processes are modeled using BTL. In the SCC layer, transactions of business processes are composed together to build end-to-end business transactions process and the BTs' attributes are enforced during execution (execution specification based on BPEL).

2.5.7 Conclusion

This research is the result of the first phase of our research work on business transaction language and service network modeling analysis. BTL, as described above, is a specification containing expected details of transaction and as part of our future work; we are currently working on mapping the transaction properties (defined using BTL) to the runtime language which will realize them. We believe that there is a list of works to be carried to successfully complete the BTL. This contribution emphasizes the need for BTL to enhance performance reporting mechanisms. From our perspective, the requirement of a language must be well-justified before the development of the language; otherwise, it can be obsolete like many other languages. Additionally, the current version of BTL does not facilitate defining relaxed-isolation property. This work is in progress which we will add in the next version of BTL.

2.6 Business Transaction Framework

Contributed by: Tilburg

Keywords: BPM, Transactions, Logics

2.6.1 Background

In e-business, business transactions are trading interactions between possibly multiple business partners that strive to accomplish an explicitly shared business objective, which extend over a possibly long period of time and which are terminated successfully only upon recognition of the agreed contractual agreements between the collaborating parties. To conduct e-business successfully, business partners' distributed information and support systems must be seamlessly integrated in a highly dynamic fashion and on-demand basis. Service orientation is the current predominant architectural style that facilitates such integration from a technological perspective. Service orientation, however, only provides very rudimentary support for the creation and coordination of meaningful, reliable and business-driven e-business transactions.

2.6.2 Problem Statement

Inspired by the current gap between the worlds of business transactions and IT transactions, the following research questions have been formalized in order to be investigated in this research:

- What is the state of art with respect to transactions, in particular related to the modeling, specification and execution of transactions, in relevant research fields, both from a technology and business perspective?
- What are the requirements and essential building blocks of a BTF to provide business execution semantics and overall reliability and flexibility to inter-organizational business processes?
- How can transactional semantics of complex composite business processes be specified formally and in a uniform manner?
- What is a suitable reference architecture allowing the use of the BTF on top of a standard web services architecture also incorporating current industry standards?
- How can the proposed solution be validated practically?

2.6.3 Relevance of the Problem and Progress from the State of the Art

To address the above problem statement, we bridge the gap between two independent fields of research; transactions from the IT world and transaction as used in by the business community. IT transactions have been around since the Seventies to provide reliable information processing in automated information systems. Originally developed for simple “debit-credit” style database operations in centralized systems, they have moved into much more complex application domains including aspects like distribution, process-orientation and loose coupling in Web service environments. In contrast to IT transactions, which are driven by purely technical requirements such as coordination, data consistency and recovery, business transactions are driven by economic needs and their objective is accomplished only when the agreed upon conclusion among trading parties is reached, e.g., payment in exchange for goods or services. Thus, the aim of this research it the design and development of a comprehensive yet flexible Business-aware Transaction Framework (BTF), that is not restricted to a specific application domain or application environment and that supports explicitly specified reliability aspects of complex, contract-driven, and service-oriented business processes.

2.6.4 Contribution summary

This work is a consolidation of the previous research activities in S-Cube, notably on the requirements for the business transaction language, the BTL meta-model itself, and its formalization [8]. We identify the following set of research results with respect to the currents state of the art in business and IT transactions:

- We propose a comprehensive and consolidated version of the business transaction framework (BTF), as the basic conceptual structure underpinning the concept of business-aware transactions. This framework integrates and relates transaction management mechanisms from databases and contractual obligations between business partners in order to enable the specification and execution of reliable inter-organizational business processes and it consists of the following elements:
    - The uniform model, referred to as the Business Transaction Model (BTM), that underpins the BTF and provides the context for the Business Transaction Language (BTL).
    - The BTL as the XML-based language to specify inter-organizational business transactions. This is the major contribution of our work, as we have designed and formalized the language in detail both from a structural as well as behavioral perspective.
    - A reference architecture and possible implementation direction with relationships to existing industry standards.
- We have identified the limitations of existing specifications and technologies with respect to Web service and business transactions.

2.6.5 Evaluation

The evaluation of this work is threefold: (1) We formalized the language by means of a state machine model and temporal logic, (2) we proofed the correctness by providing a formal validation of our language by a model-checker (Uppaal), verifying that it exhibits transactional properties like recovery and vitality as intended, and (3) we implemented and simulated a set of business transaction scenarios extracted from the S-Cube automotive case study, using the model-checker, thereby indicating the feasibility of our framework.

2.6.6 Relation to Research Framework

This work relates to WP-JRA-2.1's research challenge " Business Transactions in Service Networks ". In particular, this PhD thesis provides a consolidated and integrative description of a business transaction framework, transaction language and formal underpinnings, fusing intermediate results in S-Cube from previous deliverables. In particular, the focus is on modeling and analysis of business transactions.

2.6.7 Conclusion

With the business transaction framework, we provide a comprehensive and validated set of concepts and several standard primitives and conventions that can be utilized to develop complex Service-Based Applications (SBAs) that allow to handle contextual changes and exceptions in service-enabled processes. We thereby realized a core element in direct support of the main objective of WP-JRA-2.1.

2.7 An Event Model for WS-BPEL 2.0

Contributed by: USTUTT

Keywords: BPEL, Events, State Model

2.7.1 Background

The Web Service Business Process Execution Language 2.0 (WS-BPEL 2.0 [20], BPEL for short) is one option for workflow execution in the Web service platform, which realizes a SOA. A BPEL process model defines a process by orchestrating Web services and it is exposed as a Web service itself. The process model contains different types of entities for defining the process logic, such as partner links for linking the Web services involved in the service orchestration, variables holding process data, basic activities for interacting with Web services and data handling, structured activities for defining the control flow of the process and enabling compensation-based recovery. The process model is deployed on a BPEL engine which executes process instances based on the process model.

2.7.2 Problem Statement

The execution of a process causes changes to the state of the underlying BPEL entities. For example, a process instance is first instantiated, is then running for a while, and at some point will either be completed successfully, faulted, or exited purposely using a BPEL *exit* activity. The transitions between states are signaled using events. These state transitions and the respective states can be considered part of a state model, or alternatively, of an event model. Although, state models for the different BPEL entities can be derived from the operation semantics of the BPEL specification, they are not explicitly defined in it, and in particular, the specification does not prescribe which events the BPEL engine has to expose to the outside for monitoring purposes. Thus, BPEL engine implementations differ in the event models they support.

2.7.3 Relevance of the Problem and Progress from the State of the Art

An event-model for BPEL4WS 1.1 has been presented by Karastoyanova et al.[69]. WSBPEL 2.0 is the successor of BPEL4WS 1.1 and introduced new activities. This work adapts the event-model by Karastoyanova et al. to reflect these changes and also honored the experiences matured by applying the BPEL4WS 1.1 event-model in cross-partner transaction [70] and cross-process monitoring [71].

2.7.4 Contribution Summary

This report presents an engine-independent WS-BPEL 2.0 event model. It supports both passive monitoring and active control of process execution by external applications. Some of the assumptions in the presented event model are inspired by a particular implementation, e.g. fault handling and compensation; however they are kept as general as possible, so that they can be mapped on other engine-specific approaches to tackle faults and support compensation. In addition, the report draws on the experience of some of the authors in business process management and software development. The overall BPEL event model consists of a set of event models for the different types of BPEL entities that change their states: processes, process instances, general activities, scope activities, invoke activities, loops, links, variables, partner links, and correlation sets. The event model is used by the authors of the report in several projects, all utilizing process life cycle events in different scenarios.

2.7.5 Evaluation

This event model has been implemented in the Apache ODE engine v1.3.4 and is available at http://www.iaas.uni-stuttgart.de/forschung/projects/ODE-PGF/. A detailed description of the implementation is provided by Steinmetz [72].

2.7.6 Relation to Research Framework

The event model presented in this work serves as a foundation for the monitoring of BPEL processes (IRF Challenge: “Monitoring of Process Performance Metrics in Service Composition”). Moreover, the event model represents a foundation for the Business Transactions language pursued in JRA-2.1 (IRF Challenge: “Business Transactions in Service Network”).

2.7.7 Conclusion

This report has presented a generic event model for WS-BPEL 2.0 that can be used to monitor running processes. The event model enables clients to change the behavior of the process according to their needs. The event model has been implemented using the open source Apache ODE engine. Also, a monitoring-only event model can be derived from the event model but the drawback of this is that they cannot be used in conjunction as the proposed event model allows for skipping events being mandatory in the monitoring-only event model.

2.8 Migratability of BPMN 2.0 Process Instances

Contributed by: UniHH

Keywords: BPMN, Process Instance Migration

2.8.1 Background

In today's dynamic environments, business transactions are often subject to changes related to the content and the structure of the business case. In consequence, flexibility of supporting information and communication systems is one of the most driving factors. Considering that a business transaction is not always executed by a single organization or, more technically, by a single process engine, also the requirements for the distributed execution of individual process instances can change dynamically. A typical example is the spontaneous shift of a selected process partition to a mobile device in order to allow for its offline execution in a different location. Other examples include the dynamic distribution of process instances due to load balancing strategies for process engines or the runtime exchange of business partners in order to quickly react to market changes or to individual demands of customers.

2.8.2 Problem Statement

In situations where requirements for a distributed execution of individual process instances of business transactions can change dynamically, a flexible distribution mechanism is needed. In addition to the distribution at design time, such a flexible mechanism therefore has to support the ad-hoc change of the process’ distribution at runtime – depending on the current situation of the business transaction. Furthermore, changing the distribution of a transaction may affect several aspects of the execution, including the current state of respective process instances and events which are driving the execution of the business transaction. A solution has to incorporate these issues and – at the same time – it has to be suitable for existing and future business transaction models with no additional efforts.

2.8.3 Relevance of the Problem and Progress from the State of the Art

Many existing approaches focus on the physical fragmentation of processes at design time which is not sufficient for the execution of business transactions in dynamic environments. During runtime, decisions must be taken regarding each process instance's distribution parameters in order to transfer both the process model and its instance data to another process engine. Most of the approaches regarding distributed workflow management either encompass a migration specific extension of a standard process description language such a XPDL or WS-BPEL [73,74] or use a completely proprietary specification [75,76,77,78]. In contrast to WS-BPEL processes, BPMN processes are able to combine interactive user-centric tasks and automatic application tasks such as web services on both a specific and abstract level. Furthermore, they can already specify descriptions about a distributed execution and BPMN includes a strong event concept allowing event-based control flow constructs. But, the migration of BPMN 2.0 process instances has not been considered yet. BPMN processes have inherently different characteristics and this implies new challenges for migration. In order to address these challenges, we focus on the BPMN control flow elements with respect to a potential migration of a process. This contribution therefore aims at a consolidation of the research results developed in the work package WP-JRA-2.2 regarding a flexible execution of service compositions into the work package WP-JRA-2.1.

2.8.4 Contribution Summary

In order to allow a flexible distribution of business transactions, the concept of process instance migration allows for deciding about most distribution parameters at the runtime of each process instance. The procedure used here basically involves stopping the execution of a running process instance of a business transaction, capturing its current status, and transferring both the process model and its instance data to another process engine where the execution of the process is continued. Using this strategy, a business process can be distributed at nearly any time with an arbitrary granularity of process partitions and open number of potentially participating process engines.

As such dynamic distribution requires a common understanding of the business case as well as a standardized specification including an execution semantic, the applicability of process instance migration is dependent on the underlying process description language. Since respective standards do not include the standardization of process instance data, the actual contribution is based on a technology-independent migration model, which is used to supplement the original process model.

In particular, the contribution investigates the migratability of BPMN 2.0 process instances, i.e. the ability to partition and transfer the business transaction within a specific control flow structure. Therefore, the most important control flow constructs are studied and discussed. Since the execution of business transactions is often driven by events, a special focus is on event processing and a respective classification of events with respect to a process instance migration.

2.8.5 Evaluation

The approach was evaluated by means of a prototype implementation. Therefore, the open source BPMN 2.0 process engine Activiti was extended with an additional support for process instance migration. The experiences with the prototype show, that, dependent on the process engine's architecture, deep intrusions in the engine's code may be necessary. However, the engineering effort for extending an existing process engine has to be performed only once in order to migrate arbitrary process instances automatically. Compared to a physical fragmentation which requires modification and deployment of each individual process model, this engineering effort is feasible – especially if many process instances have to be distributed individually.

2.8.6 Relation to Research Framework

The contribution is settled between the elements Business Process Management and Service Composition & Coordination of the conceptual research framework, i.e. it contributes to the challenge Business Transactions in Service Networks. It therefore affects the steps Deployment & provisioning, Operation & management and Enact adaptation in the reference life-cycle by providing an approach in order to flexible distribute the execution of business transaction, both at design time and at runtime.

2.8.7 Conclusion

Business transactions are inherently distributed and are subject to dynamic changes of both, their functional and non-functional requirements as well as their environment. In case of service networks, which are governed by a set of contracts and agreements, changes in their terms require quick reactions and their adoption from the underlying process instances. This contribution aims at a flexible distribution at runtime due to a changing situation. The proposed approach utilizes the concept of process instance migration in order to adapt the distribution of a business transaction with respect to the current situation and execution state. It shows that migration of BPMN process instances is – in general – possible and therefore usable in the context of business transactions. However, information about the point of time when to adapt the distribution of a business transaction was not subject to this contribution and, therefore, has to be provided by the Adaptation and Monitoring infrastructure.

2.9 Service-based Business Transactions: Modeling, Adaptation and State propagation-based Monitoring

Contributed by: USTUTT

Keywords: Business Transaction, Service Choreographies, Cross-Process Monitoring, Process View, State Abstraction

2.9.1 Background

Business-centric requirements can be captured with business transactions as they describe the interactions of multiple companies in the form of exchanged goods, service level agreements, and common business objectives. Business objectives are long-term goals whose achievement cannot be verified automatically, but must instead be agreed upon by collaborating partners. To execute business transactions, they can be implemented by choreographies that model the interactions of the business processes of the involved partners. The choreographies may have to be rearranged, e.g. process models have to be split or merged in order to efficiently distribute the choreography on different infrastructures that meet the SLAs defined in the business transaction.

2.9.2 Problem Statement

Business transactions currently miss a graphical representation of their structure and possible states. To support the monitoring of choreographies that realize parts of a business transaction, their states have to be mapped to those of the business transaction. As choreographies might need to be rearranged to meet changes in the functional and non-functional requirements, the mappings between choreography and business transaction states must likewise be aligned.

2.9.3 Relevance of the Problem and Progress from the State of the Art

Business transactions are a relatively new research area. As they were invented for mainly monitoring purposes, a visualization and state models are required. Since business transactions are not executable, tracking the enactment of the business transaction relies upon the alignment with the state of the implementing choreography.

2.9.4 Contribution Summary

The paper proposes an approach to the monitoring of business transactions. It introduces a state model and a graphical notation for business transactions and for the corresponding SLAs. It is shown how the states of the implementing choreography can be mapped to the states of the business transaction and of the SLAs. Moreover, it is discussed how the states can be propagated upon choreography rearrangement. Additionally, the work also proposes the architecture for a framework that enables business transaction monitoring.

2.9.5 Evaluation

The proposed graphical notation is evaluated with a case study from a fictional film studio, the *Mastermovies*. The business transaction example found in [19] depicts the business activities that form the BT and the corresponding business objects and SLAs. In addition, a system architecture is presented enabling the design and monitoring of business transactions and their implementation artifacts. The proposed architecture provides also components to rearrange choreographies and to propagate the states of the rearranged choreographies to the business activities.

2.9.6 Relation to Research Framework

Advancing the design of the Business Transaction language and its relationship with monitoring (IRF Challenge: “Business Transactions in Service Networks”) and the understanding of the relationship between business transactions and choreographies (IRF Challenge: “Linkage between Business Transactions and Service Compositions”).

2.9.7 Conclusion

This contribution presented an approach to monitor business transactions that are implemented in BPEL4Chor choreographies. To do so state propagation rules were introduced that map the state of the executed choreography to the state of the business transactions. The definition of this state propagation rules can be done in a semi-automatic fashion. State propagation rules from the choreography to the business transaction are created automatically, while state propagation rules to map the state from the choreography and its execution environment to the SLA have to be defined manually, as the SLAs are domain-specific.

2.10 A Framework for Management and Control of Service Granular Properties in Service-Based Applications (SBAs)

Contributed by: Tilburg

Keywords: Regulatory compliance, Compliance patterns, Design-time compliance management, runtime compliance monitoring, runtime statistical queries, compliance request language.

2.10.1 Background

Today, the Web Service framework has reached the evolutionary phase that enables it to become the software foundation for SBAs and for the next generation e-business. The quality of business transactions is measured in terms of end-to-end qualities, rather than the qualities of any individual service. This definition sets out the need for a mechanism to ensure that the end-to-end qualities of a business process are reached.

In recent years, different architectures and tools for managing service granular properties, which range from business data to business activities of transactional nature, have been developed. Several architectures focus on a transaction's business data (e.g., delivery times, quantities, prices, discounts, local and aggregated QoSs), in order to ensure a continuous, cohesive information flow and correlation of end-to-end process properties. Since, the dynamic selection of services is an important issue in Web services composition, the majority of architectures provides services to specify quality parameters of a single task (e.g., a transmission task) in an application and mechanisms for managing a single resource (e.g., network bandwidth). Other QoS management frameworks support the characterization of pre-defined fixed end-to-end quality levels and provide services to request fixed quality levels or resource allocation from the environment. There is also QoS management middleware to support the QoS management of diverse real-time applications that execute in distributed environments. Their architectures are designed to facilitate the specification of quality of services of diverse application components and the specification and management of quality levels of individual components within a complex application to maintain the end-to-end quality. In particular, they can maintain the end-to-end quality of service (e.g., response times) of interdependent tasks that execute on different resources while trying to focus on the quality of services of individual tasks. However, none of the above solutions consider end-to-end quality of business transactions and how exceptions affect it.

2.10.2 Problem Statement

The consequence of an exception (e.g., service failed, unavailability of a component service), occurring after an execution plan has been built and while it is being executed, could result in the unsuccessful completion of a business transaction. The end-to-end QoS requirements pre-specified at the start of the business transaction would not be fulfilled. This could result in cancelation, delays, non-completion of the payment in time, unsatisfied clients and increased cost of the final product as a result of increased costs of the business transaction, etc. Moreover, it could directly affect the organization and its loyal customers.

These raise the need for a framework that deals with unexpected event occurring during composite service execution. This research makes use of knowledge, architectures and tools developed so far in order to provide a solution that guarantees a successful completion of a business transaction. We aim to find a solution that will guarantee a successful completion of a business transaction within the QoS requirements predefined at the beginning of the business process.

2.10.3 Relevance of the Problem and Progress from the State of the Art

The management of application information and procedures, deeply buried in Service-Based Application (SBA) code, renders the potential reuse, customization and monitoring of application management capabilities impossible. It also introduces intrinsic discontinuities between end-to-end business processes as the flow of information may be disrupted. This leads to the imperative need for explicitly managing fine-grained tenets-service granular properties of SBAs.

Until now, research has focused on models and frameworks that deal with the management of the non-functional requirements of the business transactions. However, there are unresolved aspects related to the management of end-to-end business processes. As described in the Background section, none of the previous works and architectures has provided support for exception handling during composite service execution. Taking this gap into consideration, we extend the previous work in [79] and we analyze different cases with discontinuities in non-functional requirements between end-to-end business processes.

2.10.4 Contribution summary

We propose a framework to manage and control the non-functional characteristics of a SBA with the purpose to improve the management of the global QoS constraints of a business transaction. An algorithm is also proposed for the computation, estimation, and comparison of end-to-end QoS. The proposed approach allows the substitution of web-services in case of the failure or unavailability of a service at run-time. The aim is to provide the end-to-end business processes within the terms of the SLA agreed between the service provider and the service client. The order management business transaction described in the work provides the abstract services required for the composite service. The abstract services are role descriptions that correspond to a concrete specific function. During run-time, this description is used to find a concrete service that meets the local QoS for that abstract service and then to select and use it in the composite service. By doing so, we can guarantee an achievement of the global QoS requirements of the business transaction.
This approach has the following characteristics:

- A multi-dimensional QoS approach. The approach defines QoS properties that can be divided into two groups: quantitative properties, such as time and cost, and qualitative properties like reliability and availability. The approach can be extended with other properties depending on the domain of the service-based application. The algorithm implemented will take into consideration only qualitative properties.
- QoS driven service selection. The service selection during run-time is based on global requirements leading to an optimal overall QoS.
- A simple workflow engine simulator. The engine uses the algorithm in order to react to events occurring during the execution of the workflow by rescheduling the execution in order to ensure that the overall QoS will be achieved.

2.10.5 Evaluation

The goals of this research are realized using a workflow engine containing an algorithm for the computation, estimation, and comparison of end-to-end QoS. The relevant service dimensions necessary to correctly characterize workflows will be investigated. In workflows, quality metrics are associated with tasks, and tasks, in turn, compose workflows. The computation of workflow QoS is done based on the QoS of the tasks that compose a workflow.

Different workflow constructions mechanisms are used by the algorithm for treating events that could cause a deviation from the QoS constraints. The algorithm has to work on the workflow slice that still need to be executed. At every node during the execution of the workflow, the actual QoS has to be measured and then compared with the value of the estimated QoS. If there is a difference between them than the workflow execution plan should be adapted.

This work has been validated through a prototype implementation using the complex event processing technology (CEP) to put in practice the proposed algorithm. Here is a link to a live demonstration: http://dl.dropbox.com/u/13869335/demo.avi

2.10.6 Relation to Research Framework

The work contributed to both research challenges defined for this JRA-2.1. In particular, management of process granules serves as the foundation of management of business transactions. This contribution provides a framework and prototypical implementation to ensure QoS of end-to-end processes in changing environments; a prerequisite for any business transaction to successfully complete (under specific QoS stipulations).

2.10.7 Conclusion

On the basis of a critical review of the existing composite service technologies, we have shown that the current situation does not offer a solution to the problem of management of the non-functional characteristics of the composite service. Particularly, the failure of a service would cause the failure of the service composition which ultimately is the failure of the business transaction in terms of it not meeting the agreed non-functional requirements.

Through this work, we conducted an empirical study, and analyzed the different scenarios that could cause the failure of meeting the global QoS constraints of an end-to-end business transaction. To address this problem, we propose a framework to manage and control the non-functional characteristics of a Service-Based Application with the purpose to improve the management of the global QoS constraints of a business transaction. Our proposal has been validated through a prototype implementation using the complex event processing technology.

2.11 Business Process Compliance Management: An Integrated Proactive Approach

Contributed by: Tilburg, UCBL

Keywords: Regulatory compliance, Compliance patterns, Design-time compliance management, runtime compliance monitoring, runtime statistical queries, compliance request language.

2.11.1 Background

Service-oriented architecture (SOA) is an integration framework for connecting loosely coupled software modules into on-demand business processes. Business processes form the foundation for SOAs and require that multiple steps occur between physically independent yet logically dependent software services. Where business processes stretch across many cooperating and coordinated systems, possibly crossing organizational boundaries, technologies like XML and Web services are making system-to-system interactions commonplace. Ensuring the compliance of service-enabled business processes with applicable laws and regulations is a key concern that has been paid much interest particularly after some high-profile business failures and scandals, such as Enron and WorldCom. These incidents resulted in the enactment of a broad body of strict legislations, e.g. Sarbanes-Oxley act. These laws extend the long-standing requirement for public companies to maintain systems of internal controls, requiring management to certify and the independent auditor to attest to the effectiveness of those systems. Subsequently, organizations are left struggling and spending billions of dollars on compliance, mainly to avoid the risks of bankruptcy, loss of reputation and even criminal penalties. Executives and analysts of diverse industry sectors identified regulations and compliance as one of the top business risks. Compliance is the process of ascertaining the adherence of business processes and enterprise systems to relevant laws and regulations, which may emerge from legislation and regulatory bodies, standards and code of practices (such as, ISO 9001), internal policies and business partner contracts, e.g. service level agreements (SLA).

2.11.2 Problem Statement

With respect to the business process lifecycle, compliance assurance activities can take place in three forms: Design-time compliance verification, Runtime compliance monitoring and Offline compliance monitoring. Design-time and runtime compliance management are preventive by nature, which means that violations are detected and mostly avoided, and in case they occur, recovery actions may semi-automatically be invoked to mitigate their impacts. Offline monitoring, on the other hand, is typically detective, such that violations are discovered after they occur. Efforts in managing compliance commonly focus on one of these compliance assurance forms. However, today's fast and ever-changing business environment requires both design-time and runtime compliance management approaches to be integrated in accord to pursue a preventive and proactive focus.

2.11.3 Relevance of the Problem and Progress from the State of the Art

Current literature lacks of a comprehensive compliance management framework that combines the approaches discussed above in order to ensure a lifetime compliance support. In this paper, we consider compliance management as an integral part of the BP management and thus, a comprehensive business process compliance management framework is introduced integrating design-time compliance verification with the subsequence runtime monitoring.

2.11.4 Contribution summary

In this paper, we propose an integrated compliance management framework that complements and integrates the design-time and runtime compliance verification & monitoring approaches. At the heart of this framework lies a high-level pattern-based compliance specification language - Compliance Request Language (CRL)- that enables compliance requirements to be specified using abstract domain-specific patterns. Expressions that are designed using CRL can be automatically transformed into formal statements/query expressions, thereby facilitating automated verification and monitoring approaches to be used. The CRL provides significant support for the specification of compliance requirements as the business and compliance experts are not required to go into the details of complex formalisms. The generated formal statements (rules) are used for automated design-time verification and runtime monitoring. That is, the business processes are verified against these statements (rules) at design-time and their executing instances are monitored at runtime.

2.11.5 Evaluation

The approach proposed in the paper is validated in three ways: firstly, the internal and construct validity of the approach are verified by formalizing its underpinnings to validate its logical consistency. Secondly, the implementability of the approach is ascertained with an experimental integrated tool-suite (prototype). Lastly, we have explored and tested our approach with case studies (non-S-cube) drawn from industrial partners in the COMPAS EU project in which we participated.

2.11.6 Relation to Research Framework

The contribution of this research serves Business Process Management layer in the S-Cube's conceptual research framework and addresses "End-to-end processes in Service Networks" and "Business Transactions in Service Networks" research challenges.

2.11.7 Conclusion

Compliance management should be one of the integral parts of BP management, such that compliance requirements should be based on a formal foundation of a logical language to enable automated future reasoning techniques for verifying and ensuring BP compliance starting from the early stages of business process management. To ensure continuous guaranteed compliance, a preventive focus should be adopted, such that design-time compliance verification should be complemented and integrated with the subsequent runtime monitoring. In this paper, we introduce the basic building blocks of a comprehensive business process compliance management framework as a major step towards a lifetime compliance support. Compliance Request Language (CRL) is central to this framework. It allows abstract specification of compliance requirements using a rich and novel set of compliance patterns, which are synthesized from a comprehensive analysis we performed in our previous work. It enables capturing diverse types of compliance requirements that span the control-flow, data and employed resources structural perspectives of business processes. From abstract CRL expressions, design-time rules (as LTL formulas) and runtime queries (as BPath expressions) are automatically generated. This significantly facilitates the adoption of the framework in business practice, as it shields the complexity of learning and using multiple low-level languages from the users. Generated LTL rules are then verified against relevant BP models following a model-checking approach for design-time verification. Generated BPath queries are evaluated against the running instances of the statically compliant BP model via an XML evaluation engine, for runtime compliance monitoring. As a future work, the validation of the proposed concepts, and the usability and efficacy of the tools should further be intensified by their application on various case studies and empirical tests on prospective users.

2.12 *Timed Privacy-aware Business Protocols*

Contributed by: UCBL/UPD, USTUTT

Keywords: Non functional quality of service, Privacy, Web services, Business Protocols, Timed automata

2.12.1 Background

Over the past years, there has been a widespread increase in the use of web-based services supporting different business applications. Such popularity is accompanied by an exponential amount of data exchanged and collected by interacting entities, and a number of pressing issues that should be resolved, especially the issues related to consumers' Personal Identifiable Information (PII). In fact, most of the time, web-based service providers require some personal information or financial information from their consumers. Such information might be used for a number of purposes, from access to their online services (authentication, authorization) to billing (accounting), to service maintenance and so on. Hence, today, the individuals are becoming more and more concerned about the privacy of their personal data which are considered as non functional QoS that a service should respect while performing its functionalities.

2.12.2 Problem Statement

In general, privacy policies describe an organization's data practices: what information they collect from individuals (e.g., consumers) and what (e.g. purposes) they do with it. To enable privacy protection for Web service consumers across multiple domains and services, the World Wide Web Consortium (W3C) published a document called Web Services Architecture (WSA) Requirements that define some specific privacy requirements for Web services as a future research topic. At this moment, there is still no standardized Web services privacy technology. That is, no current Web service modeling technology offers a simple way to state privacy requirements. Policies specified as rules under which conditions the private data can be collected have been proposed as a solution to this problem. Moreover, services descriptions include the interface definitions on transport level defined in WSDL and the business protocol definitions. WS-BPEL can be used to specify such protocols. However, in order to facilitate service development and to allow automated analysis of service descriptions, a formal model is needed. In the literature, it has been developed an expressive business protocol model based on state machines. The proposed approach provides contributions to protocol analysis for functional aspects. However, to the best of our knowledge, no similar work has been done in the context of privacy.

2.12.3 Relevance of the Problem and Progress from the State of the Art

No similar work has been conducted in the context of business protocol. In fact, the current works in business protocols address functional aspects of business process behavior, but even functional QoS are not addressed. In addition, one of the essential ingredients in the completeness of behavioral analysis is quantitative properties such as time. Little work has been conducted in this direction. Time-related properties are relevant in this setting particularly for privacy handling. Indeed, in many scenarios we expect that Web services satisfy some timed constraints regarding the collected personal data of a client. It is important to check whether the timed privacy properties are satisfied specifically for distributed business protocols. In this work, we investigate privacy issues in the context of business protocols. Moreover, we emphasize the time related properties of privacy management. Indeed, to fulfill these objectives and address the privacy shortcoming discussed so far, we propose a formal framework for specifying and verifying time-related properties in privacy-aware Web service protocols. Thus, in this work we introduce non functional QoS in the business protocol model.

2.12.4 Contribution summary

Web services privacy issues have been attracting more and more attention in the past years. Since the number of Web services-based business applications is increasing the demands for privacy enhancing technologies for Web services will also be increasing in the future. In this paper, we investigate an extension of business protocols, i.e., the specification of which message exchange sequences are supported by the web service, in order to accommodate privacy aspects and time-related properties. For this purpose we introduce the notion of Timed Privacy-aware Business Protocols (TPBPs). We also discuss TPBP properties can be checked and we describe their verification process.

2.12.5 Evaluation:

A prototype of handling the timed properties of non functional QoS in business protocol is ongoing.

2.12.6 Relation to Research Framework

The contribution of this research serves Business Process Management layer and monitoring layer in the S-Cube's conceptual research framework and addresses "End-to-end processes in Service Networks" and "Business Transactions in Service Networks" research challenges.

2.12.7 Conclusion:

In the past few years, Web services privacy issues have been attracting more and more attention from the industry and research community. Since the number of Web services-based business applications is increasing, one can imagine that the demands for privacy enhancing technologies for Web services will also be increasing in the future. It is known that a service description should not only include the service interfaces as in conventional middleware, but also the business protocol i.e., the specification of which message exchange sequences are supported by the service. To automate the analysis of service descriptions, a simple and expressive business protocol model based on state machines is proposed in the literature, which supports rich timing constraints handling the service functionalities. In this paper, we investigated an extension of business protocols in order to accommodate privacy aspects and time-related properties, leading to what we call Timed Privacy-aware Business Protocols (TPBPs). The proposed model was described as a state machine, emphasizing the privacy requirements and in particular the time-related properties. We also discussed the properties to be checked and described the verification process. We currently are working on the following issues:

- Definition of fine-grained timed properties. For instance, we would like to investigate the combination of time related properties of behaviors with those of privacy.
- What Web services need to know is not only user preferences but also the user context, which includes any information that can be used to characterize the user and her situation. Hence user context should include user's local data as well as any data stored about the user such as those stored in customer relationship management (CRM) systems to make effective use of Web services

Chapter 3

3 Conclusions

This deliverable provided an overview of the main research goals that have driven the research work in this workpackage and the research results achieved through the S-Cube project. Initially, the main research areas were introduced to present the research gaps identified by the project. Then, the research results throughout this workpackage were outlined covering both areas of interest: Service Networks and Business Transactions. The various papers included in this deliverable reveals the progression of work beyond previous those included in previous deliverables. Each contribution was summarized with its objectives and their relation to the workpackage's research challenges, the progress regarding state of the art, the approach followed and the validation methodology used to evaluate the findings.

Concerning the research challenge "End-to-End Processes in Service Networks", the following research results were included. A prototype tool, entitled SNAPT, was presented which allows to visualize and model service networks based on a proposed meta-model and serves as a central hub between BPMSs and simulation tools. Also, it supports the transformation process of service network models into collaborative process models and both qualitative and quantitative analysis on SNs models. Then, an agile software engineering modeling methodology was introduced applying social network analysis to model service behavior and to monitor the impact of service relational structures on performance. Moreover, a multi-layered approach, allowing modeling of SNs with generic and reusable business services through the customization of both business and technical requirements of services, was presented. Also, a complex event processing (CEP) approach was introduced which resolves signature and protocol incompatibility among Web services interfaces and contributes both to the formation and adaptation of SNs where partners can be added or replaced.

Concerning business transactions management, recent developments in the BTL, the design-time language of BTs in SNs, were presented. Then, a consolidated version of a Business Transaction Framework (BTF) was analyzed, which integrates transaction management mechanisms and contractual obligations in order to enable the specification and execution of reliable inter-organizational business processes. The framework includes a business transaction model, the XML language (BTL) and a reference architecture. In regard to SNs and BTs monitoring, a set of methodologies were also presented. Firstly, a framework was presented for monitoring BPEL4Chor choreographies corresponding to BTs through proper mapping of choreography states to the BT's states. This framework also includes a graphical notation for BTs and SLAs, and a state model for capturing the correlations among BTs and choreographies. Secondly, an event model for WS-BPEL2.0 was described serving as a foundation for the BTL and it includes of a set of event models for different types of BPEL entities enabling monitoring of BPEL processes. Thirdly, an approach to flexible distribution of BTs at runtime based on a changing situation was introduced. Particularly, the migratibility of BPMN 2.0 process instances was investigated focusing on the event processing and a respective classification of events with respect to a process instance migration.

Some research works consolidates over both work-packages challenges. In this scope, a framework was described, which manages and controls the non-functional characteristics of SBAs with the aim of improving the management of the global QoS constraints of a BT predefined at the beginning of the business process. The proposed approach deals with unexpected events occurring during composite service execution and enable better collaboration at the level of changing QoS properties and other service granules of end-to-end processes in SNs. Furthermore, an integrated compliance management framework was presented that complements and integrates the design-time and runtime compliance verification & monitoring approaches contributing towards a lifetime compliance support. Finally, a business protocol model based on state machines was presented. This model, entitled "Timed Privacy-aware Business Protocols (TPBPs)" emphasizes on the privacy requirements and in particular on the time-related properties and also the verification processes are described.

Although this deliverable is the last one in the series of deliverables which have been produced during S-Cube project, it is obvious that partners will continue their work in the respective areas of interest. Collaborations among partners, which have come into existence due to S-cube, will continue after the end of the project as the foundations over service networks and business transactions have been set and new research challenges have become apparent.

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