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Management Summary

In this deliverable we introduce the revised version of the S-Cube Integrated Research Framework (IRF). Based on the internal validation presented in the deliverable CD-IA-3.2.2 as well on the improvements implemented by the planned readjustment of S-Cube's Joint Programme of Activities, the research challenges and research questions included in the first version of the IRF (see CD-IA-3.1.3) had been updated with respect to the research focus of the Joint Research Activities. This effort aims at reducing the complexity of the IRF and also to ensure its consistency. In addition, a first attempt to identify the relationship between the research challenges and questions in the IRF and the Future of Internet vision is discussed.

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City University London	U.K.
Consiglio Nazionale delle Ricerche	Italy
Center for Scientific and Technological Research	Italy
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The S-Cube Deliverable Series

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.

S-Cube materials are available from URL: http://www.s-cube-network.eu/

Contents

1 Introduction

The goal of this deliverable is to produce a consolidated version of the Integrated Research Framework (IRF) by revising the IRF published in the on-line annex of CD-IA-3.1.3 [1] according to the internal verification results coming from the CD-IA-3.2.2 [2] as well as by incorporating the changes to readjust S-Cube's Joint Programme of Activities as identified in CD-Mgt-1.3.1, which ensure that S-Cube continues to address highly relevant research challenges and objectives.

The *internal verification* ensures that the IRF is useful for guiding integrative research in S-Cube. Three issues can be distinguished regarding this internal verification:

- *Consistency check:* An internal verification of the IRF consistency ensures the overall quality and integrity of the integration framework. E.g., it will be analysed whether the structure of the IRF is consistent or whether the IRF is consistent with the knowledge model (WP-IA-1.1). For instance, the consistency would be violated if the IRF links to terms in the knowledge model, which do not exist (any more).

  The output of this verification is used to *correct* the integration framework.

- *Gap Analysis:* Together with the verification of the IRF consistency, a gap analysis is performed by analysing the IRF elements themselves. This gap analysis ensures the completeness of the IRF. E. g., this verification will reveal research questions without research results This gap shows that important research results are still missing in the IRF. As a consequence, there are different ways to eliminate this gap – the modification of the research framework itself (as part of the work in WP-IA-3.1), to stimulate mobility in order to close this gap (as part of the work in WP-IA-2.1), or even to set up new collaborations with external bodies.

  The output of this verification is used to *initiate a modification of the IRF* or *to trigger mobility activities*.

- *Scenario-based Evaluation of the IRF*: The IRF will be verified with a SBA development scenario, e. g., with one concrete path through the IRF's life cycle. This verification ensures the consistency between the entire IRF and its elements or in other words, the compatibility of the S-Cube research results. For instance, this scenario-based verification will reveal whether the outputs of a requirements engineering technique (research result) can be used as inputs for a design technique later on.

  The output of this verification is used to *initiate a modification of the IRF* or *to trigger mobility activities*.

The goals related to the internal verification are the following ones:

- G1 *IRF Complexity*: with this goal we control the complexity of the IRF, especially whether it grows substantially over time. This goal is important since a low IRF complexity bears the risk not to cover important aspects of SBAs while a too complex IRF comes at the risk of low understandability of the IRF.
- G2 *Consistency*: The consistency check ensures the integrity of the IRF. Since the IRF is implemented as relational database [2], the consistency checks ensure the formal integrity of the IRF database. The consistency is important since an inconsistent IRF will lead to unpredictable and wrong results when working with the IRF.
- G3 *Gap Analysis*: The gap analysis aims to reveal potential incompleteness of the IRF. It identifies elements, which are "left alone" in the IRF such as research challenges that are not refined into research questions. The gap analysis ensures that the unnecessary elements are removed from the IRF and missing elements are added (e. g. by means of research activities).
- G5 *Integration Status*: To demonstrate the interactions between the work packages, the two joint research activities and to show the integration achieved in S-Cube, the integration status of the IRF is measured.

1.1 Overview of IRF

The main goal of the IRF is to define a coherent holistic framework of the scientific activities of the project, which integrates the principles, techniques, methods and mechanisms provided by the joint research activities JRA-1 and JRA-2, and the results of the validation and empirical evaluation obtained from WP-IA-3.2. Since the sources of this information are the S-Cube partners, the definition, evolution and consolidation of this IRF is a collective effort that includes the whole network. The resulting framework takes into account all the elements able to describe the on-going research in the project, as well as the research issues that will be considered in the future.

In order to better interpret and implement this goal of the IRF, both the content of the IRF and the methodology to define it have changed during the project.

- During the initial phases of the project (see CD-IA-3.1.1 ”Integration Framework Baseline”), the IRF Baseline has been defined as a first attempt to give a coherent view of the research efforts that are covered by S-Cube, and to identify relations, overlaps and gaps among the different research work packages . This has been achieved through four Views on the S-Cube research, defining respectively the reference “Conceptual Research Framework”, the “Reference Life-Cycle”, the ”Logical Run-Time Architecture”, and the ”Logical Design Environment” for the project.
- In a second phase (see CD-IA-3.1.3 “First Version of Integration Framework”), the IRF has been exploited to collect and organize all the research challenges, questions, and results, considered in the project, to define relations among them and with the IRF Views, and to define a strict connection to the Industrial Case Studies and to the Validation Framework. This has been an important effort where all the S-Cube partners have been asked to contribute research challenges, questions and results they are working on, to make these elements consistent to the Validation Framework and the Industrial Case Studies, and to participate to a continuous update of the elements in the framework. The most important outcomes have been a shared view and a common understanding of the different investigations undertaken in the project, and has facilitated the establishment of collaborations and synergies among work packages and partners.
- Given the good level of integration that has been achieved in the previous phases, during the 3rd year of the project, whose achievements are described in this deliverable, the decision has been taken to reduce the effort and coordination costs of producing and maintaining a complete and updated version of the IRF (also see CD-Mgt-1.3.1). For this reason, we have revised the approach adopted in this work package to guarantee the coherence of the research undertaken by S-Cube. More precisely, the IRF will be maintained and updated along the whole life-cycle of the project, but only for internal purposes, and focusing only on those aspects that are most relevant to guarantee the synergy and alignment of the research work packages, namely research challenges and research questions. Moreover, even if the IRF will be available to all partners, the main users of the IRF will be the leaders of JRA work packages, which will guarantee its update and will exploit it to assess and guarantee the coherence and consistency of the research activities.

1.2 Limitation of last version of IRF

According to the results of the first validation (see the CD-IA-3.2.2) we put the following recommendations:

- Goal G1 – IRF Complexity: The IRF is already quite complex. In the future the project should strive not to add more elements to the IRF but rather to add relations between those elements since these relations indicate that the project produced integrated results.
- Goal G2 – Consistency Check: The results of the consistency check indicate that the relations between elements, challenges, research questions and research results should be carefully reviewed.
- Goal G3 – Gap Analysis: From the gap analysis we can deduce that the challenges are well related to the four different views while these relations are missing for research questions and research

results. Especially the "Logical Design Environment" view is not widely used in the project, so it should be considered to remove this view from the IRF. In addition, we found challenges with no associated research questions and research questions without results. The relevant workpackages should review these challenges and questions to decide whether they are still relevant.

- Goal G5 – Integration: The integration metrics shows that the elements in the IRF are generally well connected. Isolated elements should be investigated in the futures. However, the cross-JRA metrics indicate that effort was made to plan the cooperation between the two JRAs (reflected in cross-JRA challenges and research questions) but the results of this effort are still pending.

1.3 How the IRF is refined

Taking into account the result of the internal verification, the IRF is refined in terms of research challenges and questions. For this reason, we mainly concentrated on the work done in the JRA work packages that reflect, by definition, the research issues studied in the project. Operatively, each JRA-WP leader was in charge to analyse the research work done in the last year in order to identify the relevant areas of study (for more details on the updated research focus of the JRA WPs also see CD-Mgt-1.3.1). At the same time, research challenges and questions that they do not consider relevant due to lacks of work on that or difficulties to really deal with them, are candidates to be dropped from the IRF. In some other case, the research challenges and questions are only refocused according to the results obtained in the last period.

1.4 Structure of the deliverable

The remainder of this deliverable is structured as follows: in Chapter 2 we present in detail the added, updated, and removed research challenges and questions. In particular, for each updated and removed elements, a description about how these modifications affect the Goals G1, G2, G3, and G5 is included.

To improve the relevance of the IRF with respect to the research in the Service Oriented area, in Chapter 3 we propose an additional classification of the research challenges and questions. In particular, we aim with this classification to identify how the Future of Internet vision (including Internet of Services, Internet of Things, and so on) is considered in the current IRF and if the IRF can be extended to consider that area of study.

Finally, concluding remarks in the Chapter 4 concludes the deliverable.

2 IRF refinement

2.1 Research challenges

In the next paragraphs, for each JRA, the list of new, modified, and updated research challenges is presented. In particular, for each removed and updated challenge we describe how the modifications affect the goals discussed in Chapter 1.

2.1.1 New research challenges

2.1.1.1 JRA-1.1

Name	Identify best practices for SOA migration
Synopsis	Migration from legacy software to SOA is nowadays an important topic. Industry, in fact, has a large quantity of software to be modernized and made available as added-value services. Therefore, the identification of best practices and migration strategies for service engineering is critical for both SOA adoption in industrial setting, successful migration of legacies, and ROI.
Authors	VUA
Description	Migration from legacy software to SOA is nowadays an important topic. Industry, in fact, has a large quantity of software to be modernized and made available as added-value services. Migration approaches from legacy systems to SOA mainly differ in the way they provide solutions for two challenging problems of what can be migrated (i.e. the legacy elements) and how the migration is performed (i.e. the migration process). Furthermore, there are many differences between academic and industrial approaches. For example, while scientific approaches mainly take a reverse engineering perspective, industrial practitioners developed best practices in forward engineering from requirements to SOA technologies, where legacy code is not transformed but used as a reference. Therefore, the identification of best practices and migration strategies for service engineering is critical for both SOA adoption in industrial setting, successful migration of legacies, and ROI.
IRF elements	Reference lifecycle: all elements
Related challenges	Evolution of Services Lifecycle of service compositions The identification of process-oriented SOA viewpoints
References	• Razavian, M. & Lago, P., A Frame of Reference for SOA Migration, In: Di Nitto, E. & Yahyapour, R. (eds.) Towards a Service-Based Internet, Springer Berlin / Heidelberg, 2010, 6481, 150-162. • Razavian, M.; Nguyen, D. K.; Lago, P. & van den Heuvel, W.-J. The SAPIENSA Approach for Service-enabling Pre-existing Enterprise Assets International Workshop on SOA Migration

	and Evolution (SOAME), OFFIS, 2010, 10. • Razavian, M. & Lago, P. Towards a Conceptual Framework for Legacy to SOA Migration 5th International Workshop on Engineering Service Oriented Applications (WESOA) at ICSOC, Springer, 2009, 6275, 445-455
Glossary	S-Cube lifecycle, Migration
Keywords	Software evolution, migration of legacy systems

Name	Support Agile Service Networks with context modelling
Synopsis	An emerging paradigm in service engineering is associated with Agile Service Networks (ASNs) that link together services collaborating to provide some added value. ASNs can be applied to various types of situations involving modern organizations and organizational social structures (OSSs), a.o. social networks like communities of practice and working groups; partnerships dynamically managed as collaborating services; global or distributed teams of developers within and across organizations. Such situations can be modeled as specific contexts. Hence, by using context modeling techniques we can reason about the requirements for supporting them with ASNs, and hence identify the mechanisms that ASNs should offer to be applied in practice.
Authors	VUA
Description	Analysis and Identification of how social networks in organizations can be supported by service networks. Types of social networks will be identified from both research and industrial case studies. Their characteristics will be mapped on service networks. Scenarios about each typology will be defined to show how service oriented techniques like adaptation and composition can support this paradigm.
IRF elements	Reference lifecycle: all elements
Related challenges	Lifecycle of service compositions
References	S-Cube Deliverables: CD-JRA-2.1.3, PO-JRA-2.1.1, CD-JRA-2.1.2
Glossary	S-Cube lifecycle, Adaptable Service-Based Applications, Context
Keywords	Context modelling, Agile Services Networks, Context Adaptation

2.1.1.1 JRA-1.2

None

2.1.1.2 JRA-1.3

None

2.1.1.3 JRA-2.1

None

2.1.1.4 JRA-2.2

None

2.1.1.5 JRA-2.3

None

2.1.2 Modified research challenges

2.1.2.1 JRA-1.1

None

2.1.2.2 JRA-1.2

None

2.1.2.3 JRA-1.3

None

2.1.2.4 JRA-2.1

Name	Business Transactions in Service Networks
Synopsis	How to develop and validate concepts, mechanism and languages for run-time monitoring of business transactions?
Authors	
Description	*Motivation*: Business transactions are the heart-and-soul of agile service networks, and as such need to be better understood. *Challenge*: To overcome this challenge, a better understanding is required of existing monitoring approaches, techniques and solutions, which are further scrutinized in both WP-JRA-1.2, as well as existing (automatic) approaches for quality assurance as discussed in WP-JRA-1.3. This challenge involves resolving the following two deficiencies of existing techniques and solutions: • Existing transaction monitors typically limit themselves to sniffing and aggregating system-level events. An integrated approach that realizes mechanisms and concepts for monitoring business-aware transactions is currently lacking. This sub-challenge will particularly benefit from ongoing research with regarding to system monitors and business activity monitors in WP-JRA-1.2. • A formal foundation underpinning business transactions is currently lacking. A modelling and formalization approach is

	required for the purpose of determining their correctness and consistency. Such an approach will also consider performance analysis concepts and techniques for business transactions.
IRF elements	*Framework*: BPM, SCC, SAM, SQDNA *Life Cycle*: requirements engineering and design; operation and management; *Infrastructure*: N/A
Related challenges	
References	PO-JRA-2.1.1/2.1.2/2.1.3
Glossary	business process management, end-to-end processes, business transactions, transaction models, long-running transactions, ACID, composition, business activity monitoring
Keywords	

This research challenge is slightly modified to better reflect the focus of the work package in its updated description. In particular, the (new) emphasis of T-JRA-2.1.2 is put on monitoring service-enabled processes, proposing for this purpose a business-aware transaction model and support mechanisms driven by comment business functions. To this effect, the description of this challenge was modified accordingly (supporting objectives G1 and G2).

2.1.2.5 JRA-2.2

None

2.1.2.6 JRA-2.3

None

2.1.3 Removed research challenges

None

2.2 Research questions

In the next paragraphs, for each JRA, the list of new, modified, and updated research questions is presented. In particular, for each removed and updated question we described how the modifications affect the goals discussed in the Chapter 1.

2.2.1 New research questions

2.2.1.1 JRA-1.1

Name	How to incorporate in the C-Cube lifecycle the techniques developed by all JRAs?
Synopsis	The S-Cube lifecycle aims at integrating all design and service management techniques defined by the various WPs in a coherent engineering framework.
Authors	POLIMI

Type	Methodology
Description	S-Cube lifecycle proposes a set of phases involving all the activities starting from the early requirement engineering till the deployment and operation of the service based applications (SBA). Beside the phases typical of the classical software systems, it tries to address the phases that are specific for the adaptable service based applications. It is composed by two circles (each of them characterized by a sequence of activities) managing evolution and adaptation of adaptable SBA. Thanks to this, since the whole development and operation process is covered, all the techniques and methodologies developed by all the research work-packages could find a place in at least one of the phases of the lifecycle. Different approaches are developed by each WP addressing different aspects of service engineering. Service Engineering, Adaptation and Monitoring and Quality assurance approaches are developed focusing on different layers (BPM, Service Composition and Service Infrastructure). Each approach could be analyzed in order to find a place in the proposed lifecycle and it would be interesting define how all the techniques could be integrated among them. Such question could be seen strictly related to the definition of the high level scenarios in JRA-1.2 and IA-3.2. Three distinct research pillars were identified and three different scenarios were defined (Context-aware adaptation and monitoring scenario, Assumption-based multi-layer monitoring and adaptation scenario and QoS-driven multi-layer adaptation scenario). All of the scenarios were analyzed highlighting the mapping of the various contributions on the S-Cube lifecycle.
Challenges	Definition of a coherent life cycle for adaptable and evolvable SBA
IRF elements	Reference lifecycle: all elements Reference framework • Service adaptation and monitoring • Service engineering and design • Service composition and coordination
Related questions	Define in the life cycle phases to enable adaptation and evolution of SBA Associate adaptation strategies to the adaptation triggers How context information could be exploited during the lifecycle Design for adaptation Design for monitoring How can we measure, control, evaluate and improve the adaptation cycle? Evolution of Services Lifecycle of service compositions Continuous requirements engineering of service-based applications Integrating self-optimisation and proactive adaptation The identification of process-oriented SOA viewpoints Service composition driven by dynamic service selection
References	Deliverable "CD-IA-3.2.4, Results of the Second Validation" to be due at M36
Glossary	S-Cube lifecycle

Keywords	S-Cube lifecycle, Service Based Applications

Name	Can SBAs development be framed into the broader service design area?
Synopsis	Over the past decades, service design has emerged as an important discipline in the design field. One question now is whether SBA development fits within the general frame of reference of service design – and if so, how it relates to this field.
Authors	CITY
Type	Methodology
Description	Following the rise in the service economy, the past few decades have seen a rise in service design as an important discipline in its own right within the design field. Unlike services in the SOA sense of the term, the definition of services in the broader sense is still the subject of an open debate. Increasingly however, both manners of services are thought to be correlated, with SOA often enabling the provision of business services, and software services being incorporated as elements of business service that have to integrate into an overarching service design. The relation between both service areas will be explored in terms of their general concepts, design activities and core stakeholders. The mapping of concepts from both domains and their similarities (e.g. SOA roles of developer, composer, assembler, provider, consumer vs SD product designer, service designer, provider, consumer, service staff) as well as differences (e.g. SOA specific management, adaptation and decommissioning vs SD's more direct human factors impact and consumption model) will be researched, with their respective tools and processes likely more challenging to contrast as service design does not yet offer stable/standard processes to develop, monitor and evolve services (indeed much of the design used to be conducted on an ad-hoc basis and/or in a fragmented manner by people not specialised in the matter rather than as a cohesive process).
Challenges	comparing and correlating both type of services' lifecycles in the absence of an agreed established service design process
IRF elements	Reference Life cycle: Early requirements engineering; Requirements Engineering and Design; Deployment and Provisioning; Operation and Management; Identify Adaptation Strategy; Identify Adaptation Need (i.e. all except “construction” and “enact adaptation”) Conceptual research Framework: Service adaptation and monitoring; Service engineering and design; Service composition and coordination; Business process Management; Quality definition, negotiation and assurance Infrastructure: N/A
Related questions	Definition of a life cycle phases to enable adaptation and evolution of SBA Lifecycle of service compositions Design for adaptation How to measure, control, evaluate and improve the adaptation cycle Evolution of services KPI monitoring for SBA

References	CD-JRA-1.1.4 Coordinated design knowledge models for software engineering and service-based computing
Glossary	Service, service-based application, service life cycle model
Keywords	Life cycle model, service-based application

Name	How can we validate the adaptation processes of the S-Cube lifecycle?
Synopsis	The adaptation related processes of S-Cube life-cycle have been developed with input from relevant literature and industrial inquiries. It is now necessary to validate these processes so that they can be applied generally in the field.
Authors	Lero
Type	Method
Description	
Challenges	Definition of a coherent life cycle for adaptable and evolvable SBA
IRF elements	Service Engineering and Design Service Adaptation and Monitoring
Related questions	Define in the life cycle phases to enable adaptation and evolution of SBA Associate adaptation strategies to the adaptation triggers How context information could be exploited during the lifecycle Design for adaptation How can we measure, control, evaluate and improve the adaptation cycle? Integrating self-optimisation and proactive adaptation Service composition driven by dynamic service selection
References	S. Lane, Q. Gu, P. Lago, I. Richardson, Adaptation of Service-Based Applications: A Maintenance Process?, Tech. Rep. Lero-TR-2010-08, Lero, the Irish Software Engineering Research Centre, University of Limerick, 2010
Glossary	
Keywords	Adaptation, Software process

Name	How to categorize and characterize SOA migration strategies?
Synopsis	Given many differences among SOA migration approaches it is hard to achieve a general understanding of ‘How to perform SOA migration’ and consequently it is hard to determine the SOA migration strategy. To define a migration strategy, various aspects such as what activities are needed for such migration, what are the available knowledge assets, and what should drive the whole migration, needs to be considered. Accordingly, to select a migration approach, to be used in the strategy, it is essential to know how those aspects are addressed in that specific approach. A reference that categorizes and characterizes different approaches using the mentioned aspects facilitates systematically determining the migration path to take.
Authors	VUA
Type	Methodology

Description	To obtain SOA Migration categorization, a systematic review that extracts migration categories existing in the field will be conducted. The strength of systematic reviews in minimizing the bias in the review process will enhance the extraction of sound and meaningful categorization of the migration approaches. Such categorization will bring order on the existing SOA migration approaches and provides insight on 'how to perform SOA migration'.
Challenges	Identify best practices for SOA migration
IRF elements	Reference lifecycle: all elements
Related questions	What types of activities are covered? What types of knowledge drives SOA migration? How is the overall migration process organized?
References	
Glossary	S-Cube lifecycle, Migration
Keywords	Software evolution, migration of legacy systems

Name	How do practitioners carry out SOA migration from legacy systems?
Synopsis	Industry, nowadays, has a large number of software products that need to be modernized and made available as added-value services. These services draw on the functionality of pre-existing systems. Some of these may be legacy systems while others may still be technically-healthy and value-adding enterprise applications. To support the modernization, enterprises spend a significant amount of time and effort on devising migration strategies. Furthermore, the migration strategies employed in industrial practice are significantly different from the academic ones. Such differences root in the discrepancies in their requirements and goals as well as their perspective on 'what SOA migration entails'. Therefore, the identification of best practices and migration strategies for service engineering is of critical importance.
Authors	VUA
Type	Methodology
Description	In order to gain an understanding of 'how migration is perfomed in industrial practice' and further identify the best practices, we will conduct a emprecial qualitative study in a set of SOA solution provider companies. This emperical study will use semi-structured interview technique. To aid decision-making concerning the SOA migration strategies, we will categorize the migration strategies in industry considering the following axes a) migration context (organization type, available resources, business domain properties and constraints), b) the migration process and c) the available best practices.
Challenges	Identify best practices for SOA migration
IRF elements	S-Cube lifecycle, Migration
Related questions	What are the SOA migration strategies used in industry? What are industrial best practices?
References	
Glossary	S-Cube lifecycle, Migration
Keywords	Software evolution, migration of legacy systems

Name	What Context information is relevant to model Organizational Social Structures?
Synopsis	Enterprises are organizational social structures. The information to describe OSSs in terms of context models for enterprises can be first obtained via Systematic Literature Reviews of Social Structures with the goal of describing them in terms of their types and attributes.
Authors	VUA
Type	Methodology
Description	Enterprises are complex organizations, their existence being heavily influenced by technical and social issues alike. Agile Service Networks are a promising mechanism to tackle the increasing complexity and scale of such organizations. To be successful, ASNs should be based on a sound scientific basis and engineered around industrial needs. To model an industrial setting as an ASN, contextual information is needed. Since an organization can be seen as an social context as well as a social organization, a survey of the literature concerning such social structures has the potential to provide the needed contextual data. An SLR (Systematic Literature Review) is a sound way to carry out such an investigation.
Challenges	- Envisioning Industrial contexts as social and technological contexts - Understanding Contextual Relations and hierarchical typing of Organizational Social Structures
IRF elements	Reference lifecycle: all elements
Related questions	- Are there standard attributes and types in organizational social structures that apply to industrial organizations? - Can a typing hierarchy be defined for organizational social structure? - Can Context information be used to deploy context-aware Agile Service Networks?
References	S-Cube Deliverables: CD-JRA-2.1.3, PO-JRA-2.1.1, CD-JRA-2.1.2
Glossary	Globalization
Keywords	Industrial Context, Industrial Social Network

2.2.1.2 JRA-1.2

None

2.2.1.3 JRA-1.3

Name	Predictable factors for Pro-active SLA negotiation
Synopsis	Investigate the range of predictable factors that can affect the utility of pro-active SLA negotiation.
Authors	CITY
Type	Technique
Description	Proactive SLA negotiation reduces the time required for runtime

	replacement of services but may also lead to a waste of system resources due to negotiation of SLA with service providers whose services might never be used. Hence, the process of selecting the services/providers for proactive SLA negotiation needs to be integrated with prediction capabilities for different factors that affect the chances of using pre-negotiated SLA (e.g. the potential for needing to replace the service for which a particular provider offers an alternative, the potential of ending up with a successfully pre-negotiated SLA with a particular provider etc). City will investigate the range of predictable factors that can affect the utility of pro-active SLA negotiation.
Challenges	Proactive SLA negotiation and agreement Quality prediction techniques to support proactive adaptation End-to-End Quality Reference Model
IRF elements	Framework:,SAM,QDNA, SCCLife Cycle: deployment and provisioning, operation & management , enact adaptation Infrastructure: Monitoring engine - Discovery and registry infrastructure - Negotiation engine - Adaptation engine
Related questions	Proactive SLA negotiation and agreement Integration of prediction mechanisms with proactive SLA negotiation Agent-based technology and chemical programming for proactive SLA negotiation
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	SLA, proactive SLA negotiation, predictable factors

Name	Integration of prediction mechanisms with proactive SLA negotiation
Synopsis	Investigate ways of integrating related prediction mechanisms with the proactive SLA negotiation framework
Authors	CITY
Type	Technique
Description	Proactive SLA negotiation reduces the time required for runtime replacement of services but may also lead to a waste of system resources due to negotiation of SLA with service providers whose services might never be used. Hence, the process of selecting the services/providers for proactive SLA negotiation needs to be integrated with prediction capabilities for different factors that affect the chances of using pre-negotiated SLA (e.g. the potential for needing to replace the service for which a particular provider offers an alternative, the potential of ending up with a successfully pre-

	negotiated SLA with a particular provider etc). City will investigate the ways of integrating related prediction mechanisms with the proactive SLA negotiation framework that it has developed in S-Cube.
Challenges	Proactive SLA negotiation and agreement Quality prediction techniques to support proactive adaptation End-to-End Quality Reference Model
IRF elements	Framework: - SAM - SQDNA - SCC Life Cycle: - deployment and provisioning - operation & management - enact adaptation Infrastructure: - Monitoring engine - Discovery and registry infrastructure - Negotiation engine - Adaptation engine
Related questions	Proactive SLA negotiation and agreement Predictable factors for Pro-active SLA negotiation Agent-based technology and chemical programming for proactive SLA negotiation
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	SLA, proactive SLA negotiation, quality prediction

Name	Agent-based technology and chemical programming for proactive SLA negotiation
Synopsis	Using agent-based technology exploiting chemical programming methods to devise effective negotiation mechanism, to proactively fire negotiations before possible failures arise.
Authors	CNR
Type	Technique
Description	Proactiveness is deemed an important feature of service-based systems. Research mostly focuses on prediction of quality and related quality assurance techniques (see TJRA-1.3.3). However, negotiation (due to considerable time and resource requirements) can become an obstacle to achieving proactiveness. Thus, CNR will study the use of agent-based technology exploiting chemical programming methods to devise effective negotiation mechanisms. In particular, CNR wants to study the possibility of proactively fire negotiations before possible failures arise.
Challenges	End-to-End Quality Reference Model

	Proactive SLA negotiation and agreement Quality prediction techniques to support proactive adaptation
IRF elements	Framework: - SAM - SQDNA - SCC Life Cycle: - deployment and provisioning - operation & management - enact adaptation Infrastructure: - Monitoring engine - Discovery and registry infrastructure - Negotiation engine - Adaptation engine
Related questions	Proactive SLA negotiation and agreement Predictable factors for Pro-active SLA negotiation
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	Agent-based technology, chemical programming, proactive SLA negotiation

Name	Data mining techniques to support proactive adaptation
Synopsis	Exploiting data mining techniques to predict the need for proactive adaption
Authors	CNR
Type	Technique
Description	Observations of the current trends in service research and exchange with the S-Cube associate members have shown a very strong relevance and interest in work on run-time quality assurance for service-based systems, especially considering quality prediction to trigger pro-active adaptation. Thus, CNR will investigate into exploiting data mining techniques to predict the need for proactive adaption
Challenges	Proactive SLA negotiation and agreement Quality prediction techniques to support proactive adaptation Proactive Adaptation and Predictive Monitoring End-to-End Quality Reference Model
IRF elements	Framework: - SQDNA - BPM - SCC - SI Life Cycle:

	- deployment & provisioning - operation & management - identify adaptation need - identify adaptation strategy Infrastructure: - Monitoring engine - Run-time QA engine - Negotiation engine - Adaptation engine
Related questions	Runtime Prediction of KPIs and SLA Violations Based on Machine Learning Techniques Process Mining for Quality Prediction
References	T-JRA-1.3.3 (Assuring and Monitoring End-to- End Quality Provision and SLA Conformance)
Glossary	Monitoring, Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	Data mining, proactive adaptation

Name	Framework for automating SLA negotiation
Synopsis	Definition of a framework for automating the negotiation of service level agreements
Authors	Polimi
Type	Technique
Description	Proactiveness is deemed an important feature of service-based systems. Research mostly focuses on prediction of quality and related quality assurance techniques (see TJRA-1.3.3). However, negotiation (due to considerable time and resource requirements) can become an obstacle to achieving proactiveness. Thus, Polimi aims at defining a framework for automating the service level agreements negotiation.
Challenges	End-to-End Quality Reference Model Proactive SLA negotiation and agreement Exploiting user and task models for automatic quality contract establishment
IRF elements	Framework: - SQDNA - SAM - SED - SCC Life Cycle: - deployment and provisioning - operation & management - enact adaptation Infrastructure: - Negotiation engine
Related questions	SLA Negotiation for non functional QoS Automated quality negotiation and agreement in diverse service

	infrastructures
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	Automated SLA negotiation

Name	Support for Negotiation Models
Synopsis	Enhancing support for SLA negotiation models
Authors	SZTAKI
Type	Technique
Description	Proactiveness is deemed an important feature of service-based systems. Research mostly focuses on prediction of quality and related quality assurance techniques (see TJRA-1.3.3). However, negotiation (due to considerable time and resource requirements) can become an obstacle to achieving proactiveness. Thus, SZTAKI will investigate into enhancing support for negotiation models of service level agreement
Challenges	Proactive SLA negotiation and agreement Exploiting user and task models for automatic quality contract establishment End-to-End Quality Reference Model
IRF elements	Framework: - SAM - SQDNA - SED - SCC Life Cycle: - deployment and provisioning - operation & management - enact adaptation Infrastructure: - Negotiation engine
Related questions	Proactive SLA negotiation and agreement SLA Negotiation for non functional QoS Automated quality negotiation and agreement in diverse service infrastructures Framework for automating SLA negotiation
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	SLA, negotiation models

Name	Process Mining for Quality Prediction
Synopsis	Quality predictions based on process mining techniques
Authors	SZTAKI
Type	Technique
Description	Observations of the current trends in service research and exchange with the S-Cube associate members have shown a very strong relevance and interest in work on run-time quality assurance for service-based systems, especially considering quality prediction to trigger pro-active adaptation. Thus, CNR will investigate into exploiting process mining techniques to predict quality of the business process.
Challenges	Quality prediction techniques to support proactive adaptation Proactive Adaptation and Predictive Monitoring End-to-End Quality Reference Model
IRF elements	Framework: - SQDNA - BPM - SCC Life Cycle: - deployment & provisioning - operation & management - identify adaptation need - identify adaptation strategy Infrastructure: - Monitoring engine - Run-time QA engine - Negotiation engine - Adaptation engine
Related questions	Runtime Prediction of KPIs and SLA Violations Based on Machine Learning Techniques Data mining techniques to support proactive adaptation
References	T-JRA-1.3.3 (Assuring and Monitoring End-to- End Quality Provision and SLA Conformance)
Glossary	Monitoring, Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	process mining, quality prediction

Name	The impact of data-related characteristics on the accuracy of QoS predictions
Synopsis	Investigate how data-related characteristics can impact the accuracy of predictions of QoS in realistic systems
Authors	UPM
Type	Technique
Description	Observations of the current trends in service research and exchange

	with the S-Cube associate members have shown a very strong relevance and interest in work on run-time quality assurance for service-based systems, especially considering quality prediction to trigger pro-active adaptation. Thus, UPM will continue working on studying how taking into account data-related characteristics can impact the accuracy of predictions of QoS in realistic systems. UPM's thesis (shared by other members of the consortium) is that in reality the concrete data plays an important role on the behavior of service-based systems and cannot be ignored when making predictions. In this line, UPM wants to compare their approach with that generated based on data-mining approaches and find out what is the best combination based on the type of services and services compositions involved in a computation.
Challenges	Quality prediction techniques to support proactive adaptation Proactive Adaptation and Predictive Monitoring End-to-End Quality Reference Model
IRF elements	Framework: - SQDNA - BPM - SCC Life Cycle: - construction - deployment & provisioning - operation & management - identify adaptation need - identify adaptation strategy Infrastructure: - Monitoring engine - Run-time QA engine - Negotiation engine - Adaptation engine
Related questions	How can cost-based derivation of data-aware QoS for a service composition be used for predictive monitoring?
References	T-JRA-1.3.3 (Assuring and Monitoring End-to- End Quality Provision and SLA Conformance)
Glossary	Monitoring, Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Level Agreement, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service, Data-Aware QoS
Keywords	Data-related characteristics, accuracy of QoS prediction, data mining

Name	Synergies between proactive negotiation and run-time QA
Synopsis	Investigating into the synergies between proactive negotiation and run-time QA
Authors	UniDue
Type	Technique
Description	Proactiveness is deemed an important feature of service-based

	systems. Research mostly focuses on prediction of quality and related quality assurance techniques (see TJRA-1.3.3). However, negotiation (due to considerable time and resource requirements) can become an obstacle to achieving proactiveness. Thus, UniDue will investigate into synergies between proactive negotiation and run-time QA
Challenges	Proactive SLA negotiation and agreement Run-time Quality Assurance Techniques Quality prediction techniques to support proactive adaptation Proactive Adaptation and Predictive Monitoring End-to-End Quality Reference Model
IRF elements	Framework: - SAM - SQDNA - SCC Life Cycle: - operation & management - identify adaptation need - identify adaptation strategy Infrastructure: - Monitoring engine - Run-time QA engine - Negotiation engine - Adaptation engine
Related questions	Proactive SLA negotiation and agreement Online Testing for Quality Prediction Online QA Approaches
References	T-JRA-1.3.2 (Specifying and Negotiating End-to-End Quality and SLAs)
Glossary	Analytical Quality Assurance, Failure, Failure Semantics, Fault, Monitoring, Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Fault, Service Level Agreement, Software Quality Assurance, Static Analysis, Testing, User Error, Validation, Verification, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	run-time QA

Name	Usage-based online testing for proactive adaptation
Synopsis	Exploration of usage-based online testing for proactiveness
Authors	UniDue
Type	Technique
Description	Observations of the current trends in service research and exchange with the S-Cube associate members have shown a very strong relevance and interest in work on run-time quality assurance for service-based systems, especially considering quality prediction to trigger pro-active adaptation. Thus, UniDue will investigate (together with the associate members UPC and CERTH) into the use of usage-based online testing to

	support proactive adaptation.
Challenges	Run-time Quality Assurance Techniques Quality prediction techniques to support proactive adaptation Proactive Adaptation and Predictive Monitoring End-to-End Quality Reference Model
IRF elements	Framework: - SQDNA - SCC - SAM Life Cycle: - operation & management - identify adaptation need - identify adaptation strategy Infrastructure: - Monitoring engine - Run-time QA engine - Negotiation engine - Adaptation engine
Related questions	Online Testing for Quality Prediction Online QA Approaches Run-time Verification for Quality Prediction
References	T-JRA-1.3.3 (Assuring and Monitoring End-to- End Quality Provision and SLA Conformance)
Glossary	Analytical Quality Assurance, Failure, Failure Semantics, Fault, Monitoring, Proactive Adaptation, Quality Attribute, Quality of Service Characteristic, Quality of Service Constraint, Quality of Service Dimension, Quality of Service Level, Quality of Service-Based Adaptation, Reactive Adaptation, Service Fault, Service Level Agreement, Software Quality Assurance, Static Analysis, Testing, User Error, Validation, Verification, Quality of Service Negotiation, Service Level Agreement Negotiation, Level of Service
Keywords	Online testing, usage-based testing, quality prediction, proactive adaptation

2.2.1.4 JRA-2.1

Name	Understanding the Implications of Service Network Relational Structures on Service Performance Analytics.
Synopsis	Through the lens of actor network theory (ANT) and the application of social network analysis (SNA), we explore service network performance within the public sector.
Authors	LERO
Type	Technique, Model
Description	Nowadays, organisations are becoming increasingly interested in understanding the operations of service networks as a means to adapt to the ever-changing environment. In order to deliver effective services, providers are being advised to 'innovate' their service delivery systems. Innovation in this context often refers to technology, technique or restructuring improvements. There is a growing body of evidence which supports that actor network

	theory (ANT) allows us to gain a greater understanding of networks within the IS discipline. Specifically, we examine the effectiveness of a technique called 'social network analysis' (SNA) in extending business process management to enhance the manageability of service networks.
Challenges	- Understand IT-enabled business process measurement in the public sector. - Develop a systematic view to consider the infrastructure which supports service networks - Explore service networks through an ANT research lens. - Apply SNA theory in the context of service network process relations and visualisation. - Develop a Service Network Performance Analytics framework within the public sector
IRF elements	Framework: BPM Life Cycle: analysis/design
Related questions	- How can we measure key performance indicators (KPIs) of IT-enable business processes across service networks? - How much does a business process contribute to the success of the service network? - What are the implications of relational structures (characteristics, etc) on service network performance? - How can we visualise service network interactions and their impact on the nature of a service network?
References	JRA 2.1.4
Glossary	- business process management, optimization, end-to-end processes, analysis
Keywords	Service network, performance analytics, actor network theory, social network analysis, business process management, Service Network Performance Analytics, key performance indicators.

Name	Formal verification and validation of business transactions specification
Synopsis	Propose formal concepts and techniques for design-time verification and validation of business transactions.
Authors	UCBL
Type	Design-time verification technique
Description	The formal verification and validation concepts and techniques will be designed for formally ascertaining consistency and correctness of business transactions. Formal logic families that will be considered include-but are not restricted to: temporal logic, deontic logic, and, defeasible and transactional logic. The approach to logically underpin business transactions will be highly iterative, driving each iteration closer toward
Challenges	formalizing the business transaction language relying on a combination of formal languages. mapping informal (e.g., graphical) representations of BTL into its formal counterpart

	developing and validating formal verification concepts and techniques, possibly against S-Cube case studies.
IRF elements	*Conceptual model*: Design and deployment of business transactions concepts
Related questions	Business Transactions in Service Networks
References	The deliverable CD JRA 2.1.3, CD JRA 2.1.4
Glossary	
Keywords	Formalization, Verification, Correctness, Consistency

Name	Modelling of the Agile Service Networks
Synopsis	Develop modelling notation for description of Service Networks
Authors	USTUTT
Type	Language/notation
Description	The variety of available modeling approaches for Agile Service Network originate either in the business or the technical domains. The approaches coming from the business domain lack the necessary linkage to the BPM stack. Technically-oriented approaches typically consider only a subset of necessary elements to represent the business nature of the Service Networks. We will answer this research question by investigating the requirements for a modelling notation of Agile Service Networks that bridges effectively the business and technical aspects of SOA by (1) reusing the knowledge on service/business networks from the business domain and (2) providing mappings from the ASN notation to Business Processes and Service Compositions.
Challenges	End-to-end processes in Service Networks;
IRF elements	Business Process Management; Service Composition and Coordination
References	http://bibadmin.s-cube-network.eu/show.php?id=42 http://bibadmin.s-cube-network.eu/show.php?id=63
Glossary	Agile Service Networks
Keywords	List of keywords to facilitate search.

Name	Linkage between Business Transactions and Service Compositions
Synopsis	Mechanisms for mapping of Business Transactions to the Service Compositions
Authors	USTUTT
Type	Mechanism
Description	Develop the mapping between the Business Transactions and Service Compositions and its fragments. The service composition fragments are annotated with different QoS and have diverse transactional properties. The information about the fragments together with the definition of a business transaction will serve as the basis of the linkage mechanisms. We will answer this question by introducing (1) models of reusable service composition fragments annotated with QoS properties, and (2) mechanisms to map a business transaction into a set of QoS-

	annotated service composition fragments. Further on this line of work, we will investigate how the changes applied to a business transaction propagate to the underpinning service compositions, triggering their adaptation, e.g. through the replacement of fragments with others.
Challenges	QoS Aware Adaptation of Service Compositions; Business Transactions in Service Networks
IRF elements	Agile Service Networks, BPM, Service Composition
Glossary	Service Composition, Business Transaction, Process Fragment
Keywords	BPM, Service Composition, Business Transaction, Process Fragment

Name	Monitoring of Business Transactions
Synopsis	Providing high level information about the status of the distributed and decentralized execution of Business Transactions.
Authors	UniHH
Type	Mechanism
Description	Involved participants of Business-aware Transactions should be able to obtain information about the current status of its execution. However, due to the inherently distributed and decentralized nature of Business Transactions, interested parties have no direct access to the required data. Hence, there is a need for a mechanism which is able to collect status information from involved participants, aggregate the data and provide high level information about business data. This involves, e.g., information about business objects which are processed by the Business Transaction, and business events which appear during the execution of business processes. This research question is strongly related to the mapping of Business Transactions to Service Compositions.
Challenges	Business Transactions in Service Networks
IRF elements	Framework: BPM, SCC Lifecycle: operation & management
Related questions	Business Transactions in Service Networks, Linkage between Business Transactions and Service Compositions
References	None
Glossary	Business Aware-Transaction, Business Activity Monitoring, Service Composition, Business Process, Business Transaction, Process Fragment
Keywords	Business Object, Business Events

2.2.1.5 JRA-2.2

Name	Specification of Non-functional Parameters for Runtime Decomposition
Synopsis	A dynamic decomposition and evaluation of non-functional constraints for the execution of (distributed) processes requires an appropriate description language which facilitates runtime decomposition.

Authors	UniHH
Type	Language
Description	The distribution and execution of service compositions should be adapted to relevant changes in the underlying service infrastructure, e.g. considering classical non-functional aspects such as availability and price, but also advanced context requirements such as location and security issues. Especially in dynamic environments (e.g. in mobile ad-hoc networks), service providers enter and leave the system spontaneously and quality-of-service parameters change very often. In consequence, non-functional characteristics of services cannot be determined before the actual execution of each single activity of a process instance. Thus, *temporarily* most suitable participants must be selected -- which means in particular, that it is not possible to calculate an optimal configuration of service assignment for the entire process, but that each local service selection has to comply to a suitable global solution at any time. In order to respect the original interests and intentions of the process modeler and/or initiator in face of such necessary adaptations, non-functional requirements have to be expressed in a way which supports an expressive description as well as an efficient runtime decomposition and evaluation of non-functional characteristics. Based on these observations, existing languages for specification of QoS parameters have to be evaluated and an appropriate language and service selection algorithm have to be proposed.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Framework: Service Composition and Coordination Life Cycle: Operation and Management
Related questions	Algorithm for Runtime Decomposition of Non-functional Requirements, Context-Aware Execution of Distributed Processes.
References	S-Cube Deliverable CD-JRA-2.2.5
Glossary	Process Fragmentation, Service Orchestration
Keywords	Adaptation, Context, Decomposition, QoS, Service Orchestration

Name	Algorithm for Runtime Decomposition of Non-functional Requirements
Synopsis	A runtime decomposition and evaluation of non-functional constraints for the execution of (distributed) processes requires an appropriate algorithm which considers the special characteristics of service selection in dynamic environments.
Authors	UniHH
Type	Algorithm
Description	The distribution and execution of service compositions should be adapted to relevant changes in the underlying service infrastructure, e.g. considering classical non-functional aspects such as availability and price, but also advanced context requirements such as location and security issues. Especially in dynamic environments (e.g. in mobile ad-hoc networks), service providers enter and leave the system spontaneously and quality-of-service parameters change very

	often. In consequence, non-functional characteristics of services cannot be determined before the actual execution of each single activity of a process instance. Thus, *temporarily* most suitable participants must be selected -- which means in particular, that it is not possible to calculate an optimal configuration of service assignment for the entire process, but that each local service selection has to comply to a suitable global solution at any time. Based on an appropriate description of non-functional characteristics and requirements, an efficient algorithm is needed in order to select a temporarily adequate solution based on a runtime decomposition of global requirements on process level into local requirements on service level. As runtime execution of the algorithm and quick reactions are required, especially heuristic approaches should be considered.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Framework: Service Composition and Coordination Life Cycle: Operation and Management
Related questions	Specification of Non-functional Parameters for Runtime Decomposition, Context-Aware Execution of Distributed Processes.
References	S-Cube Deliverable CD-JRA-2.2.5
Glossary	Process Fragmentation, Service Orchestration
Keywords	Adaptation, Context, Decomposition, QoS, Service Orchestration

Name	Automatic derivation of composite service specifications
Synopsis	Synthesize specifications for service compositions, given the composition schema and the specifications of the participating services.
Authors	UPM
Type	Method
Description	While existing service description frameworks attempt to describe service compositions using a variety of composition models, no framework attempts to handle the problem of automatically producing specifications for a composite service, based on the specifications of participating services. Such composite specifications are of crucial importance for the verification of compositions, providing the ability to check whether a composition satisfies given requirements, or whether changes to the participating services lead to composition with the same or less requirements and/or results. The main objective is to calculate the preconditions and postconditions for each fundamental control construct (sequential execution, different flavors of parallel execution and so on). This will lead to generic specification templates which can be combined for more complex compositions. A further step would be to attempt to simplify the resulting composite specifications using simple syntactical equivalences or by exploiting logical equivalences between conditions in order to weaken preconditions or strengthen postconditions.
Challenges	Formal Models and Languages for QoS-aware service compositions

IRF elements	Requirements Engineering and Design Service Composition and Coordination
Related questions	-
References	-
Glossary	Formal Specification, Service Description, Service Composition, Service Specification, Composition Schema
Keywords	-

Name	QoS-Aware Optimization of Service Compositions with Transactional Properties
Synopsis	Optimization of service compositions with transactional properties in order to optimally fragment or merge the service compositions regarding chosen QoS and cost criteria.
Authors	USTUTT
Type	Method, technique
Description	The performance of applications is influenced by the way its operations are grouped into global transactions. This in turns influences the performance of business processes which utilize these applications as implementations of process activities/steps. Stratified transactions, as produced by the stratification approach is a way to manage a global transaction by combining the more elemental transactions coordinated using the two-phase commit protocol and queued transactions. The stratification approach should be applied on process-based service compositions with transactional properties in order to optimally fragment/merge the service compositions regarding chosen QoS and cost criteria. The research question requires both (1) definition of appropriate model and evaluation criteria (2) application of different optimization methods to discover optimized solution.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Framework: Service Composition and Coordination Life Cycle: Enact Adaptation, Identify Adaptation Strategy Logical Run-Time Architecture: Adaptation Engine
Related questions	-
References	S-Cube Deliverable CD-JRA-2.2.3
Glossary	Quality of Service-Based Adaptation
Keywords	Fragmentation, Service Composition, Split and Merge of Service Compositions, Stratification of Transactions

Name	Monitoring of Process Performance Metrics in Service Compositions
Synopsis	Process performance on service composition level is assessed in terms of process performance metrics (PPMs). We will investigate how to model and monitor PPMs in service orchestrations.
Authors	USTUTT

Type	Method, technique
Description	Process performance on service composition level is assessed in terms of process performance metrics (PPMs). We will investigate how to model and monitor PPMs in service orchestrations. This involves creating a language for modeling different types of PPMs (such as time, quality, and cost related) based on service orchestration models (in particular WS-BPEL), deployment of monitoring models and runtime monitoring.
Challenges	Monitoring of Quality Characteristics of Service Orchestrations and Service Choreographies
IRF elements	Framework: Service Composition and Coordination Life Cycle: Operation and Management. Logical Run-Time Architecture: Montoring Engine
Related questions	Cross-Partner Process Monitoring based on Service Choreographies
References	S-Cube Deliverable CD-JRA-2.2.2
Glossary	Service Orchestration, Business Activity Monitoring, Process Performance Metric
Keywords	-

Name	Context-Aware Execution of Distributed Processes.
Synopsis	The main goal here is to enable a flexible, context-based adaptation of the responsibilities for the execution of a business process (in whole or in part) to dynamically changing situations at runtime.
Authors	UniHH
Type	Method, technique
Description	Service-based applications should be able to adapt to changes in the system's overall context, e.g. considering aspects such as business partners, locations, technological differences, security issues and classical non-functional aspects such as availability and workload. This is especially relevant for the execution of long-running or ad-hoc business processes which are initiated in environments where potential process participants can enter and leave the system dynamically or where quality-of-service parameters change very often. Therefore, the ability to split a given process instance based on current context data is a vital characteristic in order to allow for outsourcing process parts to (temporarily) most suitable participants at runtime - while respecting the original interests and intentions of the process modeler and/or initiator.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Framework: Service Composition and Coordination Life Cycle: Operation and Management, Identify Adaptation Need, Identify Adaptation Strategy, Enact Adaptation.
Related questions	Execution of Parallel Paths within Distributed Processes
References	S-Cube Deliverable CD-JRA-2.2.3
Glossary	Adaptation, Context, Process Fragmentation, Service Orchestration
Keywords	Context-Awareness, Distribution, Runtime Adaptation, Process

Name	Execution of Parallel Paths within Distributed Processes
Synopsis	The execution of a business process can be distributed to different participants which are each responsible for the execution of one of the parallel paths of the process. An efficient and flexible synchronization of control flow and data requires advanced synchronization and coordination mechanisms.
Authors	UniHH
Type	Mechanism
Description	As part of a flexible outsourcing, fragmentation or decentralization mechanism, process execution often involve the distribution of tasks which have to be run in parallel. However, if parts of such a parallel section of a process are distributed to several different parties, advanced synchronization and coordination mechanisms are required. If furthermore shared data objects are used in more than one of these parallel fragments, a separate execution could lead to undesired or even wrong results. Therefore, adequate concepts have to be developed in order to ensure a flexible distributed execution of parallel process paths as intended by the process modeller while avoiding as much coordination overhead as possible.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Framework: Service Composition and Coordination Life Cycle: Operation and Management
Related questions	Context-Aware Execution of Distributed Processes.
References	S-Cube Deliverable CD-JRA-2.2.3
Glossary	Process Fragmentation, Service Orchestration
Keywords	Distribution, Process, Parallelism, Data dependencies, Correctness, Synchronisation

Name	Addressing the frame problem in service specifications
Synopsis	Solving the frame problem in the domain of Web services
Authors	UoC
Type	Technique
Description	Preparing formal service specifications comes with a great deal of issues, one of which is the frame problem. The frame problem stems from the fact that including clauses that state only what is changed when preparing formal specifications is inadequate. Instead, one should also include clauses, called frame axioms, that explicitly state that apart from the changes declared in the rest of the specification, nothing else changes. Solving the frame problem essentially means finding a way to state frame axioms concisely without resulting in extremely lengthy, complex, possibly inconsistent, obscure specifications and at the same time retaining the ability of proving formal properties of the specifications. This solution should take into account both atomic services and service compositions.
Challenges	Formal Models and Languages for QoS-Aware Service Compositions
IRF elements	Conceptual Research Framework: Service Engineering and Design, Service Composition and Coordination

	Reference life-cycle: Requirements Engineering and Design
Related questions	Addressing the frame problem in service specifications
References	- http://bibadmin.s-cube-network.eu/show.php?id=141
Glossary	Formal Specification, Service Composition, Service Description, Service Specification
Keywords	Frame Problem

Name	Addressing the ramification and qualification problems in service specifications
Synopsis	Application of the ramification and qualification problems in the domain of Web services
Authors	UoC
Type	Method
Description	Apart from the frame problem, which deals with expressing what remains unchanged in a formal specification, there are two other problems (sometimes described as facets of the frame problem), the ramification and qualification problems. The ramification problem concerns the adequate representation and inference of information about the indirect effects (ramifications) that might accompany the direct effects of an action or an event. The qualification problem deals with the circumstances and conditions that must be met prior to the execution of an action and how to update such qualifications when new knowledge is acquired. It would be interesting to examine the application of these problems in the domain of Web services (both for atomic and composite service specifications), the effects they may have and how existing solutions can be adapted to the services domain. This research directionmay lead to the definition and formalization of a specification language for Web service and service compositions that offers robust solutions to all facets of the frame problem based on its foundations.
Challenges	Formal Models and Languages for QoS-Aware Service Compositions
IRF elements	Conceptual Research Framework: Service Engineering and Design, Service Composition and Coordination Reference life-cycle: Requirements Engineering and Design
Related questions	Addressing the frame problem in service specifications
References	R. Miller, Three problems in logic-based knowledge representation, Aslib Proceedings: New Information Perspectives, Vol. 58, Issue 1/2, pp. 140-151, 2006
Glossary	Formal Specification, Service Composition, Service Description, Service Specification
Keywords	Qualification Problem, Ramification Problem

Name	Determining whether two service specifications are equivalent
Synopsis	The problem of equivalence involves proving that two different

	services have the same effect in the world state and produce semantically equivalent outputs. The general problem is undecidable but it should be interesting to explore restrictions that make the problem decidable.
Authors	UoC
Type	Method
Description	The problem of equivalence involves proving that two different services have the same effect in the world state and produce semantically equivalent outputs, if given semantically equivalent inputs. This is of particular importance in the case of substituting one service with another in a composition, since one would need to guarantee that the substitution is transparent to the end user. Equivalence between two services can be expressed using the notion of containment, where the first service contains the second and vice-versa. The general problem is undecidable but it should be interesting to explore restrictions (e.g. to the number and form of inputs and outputs, preconditions and effects) that make the problem decidable.
Challenges	Formal Models and Languages for QoS-aware service compositions
IRF elements	Requirements Engineering and Design
Related questions	-
References	- Fan, W., Geerts, F., Gelade, W., Neven, F., and Poggi, A. 2008. Complexity and composition of synthesized web services. In Proceedings of the Twenty-Seventh ACM SIGMOD-SIGACT-SIGART Symposium on Principles of Database Systems (Vancouver, Canada, June 09 - 12, 2008). PODS '08. ACM, New York, NY, 231-240
Glossary	Adaptation, Formal Specification, Service Composition, Service Specification
Keywords	Containment, Equivalence

Name	Service composition run-time validation of non-functional requirements
Synopsis	How to ensure a proper selection of services able to satisfy non-functional constraints
Authors	POLIMI
Type	Methodology
Description	Specifying functional and non-functional properties only at the level of interfaces is required to support lifelong validation of dynamically evolvable compositions, which massively use late-binding mechanisms. Indeed, at design time a service refers to externally invoked services through their required interface. At run time, the service will resolve its bindings with external services that provide a matching interface, i.e., their provided QoS conforms to the one defined at design time.
Challenges	End-to-End Quality Reference Model Run-time Quality Assurance Techniques Monitoring of Quality Characteristics of Service Orchestrations and Service Choreographies

IRF elements	Operation & Management; Monitoring Engine
Related questions	
References	Luciano Baresi, Elisabetta Di Nitto, Carlo Ghezzi, "Toward Open-World Software: Issue and Challenges," Computer, vol. 39, no. 10, pp. 36-43, Oct. 2006.
Glossary	Validation, Service Composition
Keywords	

Name	KPI monitoring with incomplete information
Synopsis	Understand how the lack of information due to the involvement of external services affects the KPI monitoring
Authors	POLIMI,USTUTT
Type	Method
Description	Performance measurement of business processes is typically performed in terms of Key Performance Indicators (KPIs), which are key metrics for evaluating the processes in terms of time, cost, and quality dimensions. The evaluation of KPIs is based on measurement data obtained by monitoring process activities. The provision of needed measurement data is often costly, in particular for non-IT based process activities, or KPIs measurement is simply not possible, for example, if some parts of the process are performed as a service by an external organization. For these reasons, the KPI evaluation is hampered.
Challenges	End-to-End Quality Reference Model Run-time Quality Assurance Techniques Monitoring of Quality Characteristics of Service Orchestrations and Service Choreographies
IRF elements	Operation & Management; Monitoring Engine
Related questions	Cross-Partner Process Monitoring based on Service Choreographies
References	-
Glossary	Key Performance Indicator
Keywords	-

Name	Foundations of Analysis for Service-Based Systems
Synopsis	What could be the common denominator which would make it possible to effectively analyze large, heterogenous systems to discover hidden properties?
Authors	UPM
Type	Principle
Description	Automatically and statically inferring emerging properties at design time is very advantageous as it makes it possible to detect some regularities and misbehaviors ahead of time - before the system in being executed. The range of inferred properties can be very wide, as well as their application: from forecasting resource usage to detecting system-wide invariants to ensure coherence under e.g.

	aborted transactions or transformations (adaptations or whatever) of the compositions. Analysis, in this sense, has to be distinguished from verification in the sense that the latter checks provided properties, while the former infers existing properties. Deriving properties in a safe way requires the analysis to work on a representation of the system with a perfectly defined semantics. In order for the whole range of interconnected systems to be automatically analyzed as a whole, a unified semantics and representation syntax has to be created.
Challenges	QoS Aware Adaptation of Service Compositions; Adaptation of Service Compositions; Formal Models and Languages for QoS-Aware Service Compositions; Quality Prediction Techniques to Support Proactive Adaptation; End-to-End Quality Reference Model; Analysis and Prediction of Quality Characteristics of Service Compositions
IRF elements	Logical Design Environment: Modelling Techniques, Verification Techniques Conceptual Research Framework: Design Capabilities Reference life-cycle: Early Requirements Engineering
Related questions	Quality estimation using service invocations How can cost-based derivation of data-aware QoS for a service composition be used for predictive monitoring? Adaptation of QoS-aware Service Compositions based on Influential Factor Analysis and Prediction How can end-to-end quality be assured through extension Software Development Quality Assurance Processes? Business Transactions in Service Networks
References	
Glossary	Analytical Quality Assurance, Verification
Keywords	Analytical Quality Assurance, Verification

Name	Foundations for data semantics in service-based systems
Synopsis	Data needs to be taken into account for many fine-grained analyses gearing towards ensuring / verifying QoS and semantical compliance. This aspect of SOC has probably not been paid attention enough.
Authors	UPM
Type	Principle
Description	Data flowing through a service-based system can indeed impact its behavior: it is not always the case that channels / compositions do not have knowledge of the data which flows through them. Therefore, having information about the data (e.g., data invariants) can help in shaping the semantics of the system as a whole (e.g., deduce system invariants). More sophisticated languages than e.g. XML schemata are necessary to capture in a richer way he relationships between different data pieces, expected invariants, etc., the problem being not so much the syntax as the formal semantics and the tools to work with these semantic descriptions.
Challenges	Formal Models and Languages for QoS-Aware Service

	Compositions
IRF elements	Logical Design Environment: Verification Techniques Conceptual Research Framework: Service Composition and Coordination; Service Quality Definition, Negotiation and Assurance
Related questions	How can cost-based derivation of data-aware QoS for a service composition be used for predictive monitoring? End-to-End Quality definition Language
References	
Glossary	Data-Related Quality, Data-Aware QoS, Data Reliability, Data Accuracy, Data Completeness, Data Validity, Data Integrity
Keywords	Data-Related Quality, Data-Aware QoS, Data Reliability, Data Accuracy, Data Completeness, Data Validity, Data Integrity

Name	Describe behavior and semantics uniformly
Synopsis	Finding a formalism to uniformly describe semantics and behavior of service compositions.
Authors	UPM
Type	Principle
Description	Behavior and semantics have usually been described under different perspectives and using a different set of tools. An all-encompassing theory needs to bridge this gap, either by finding strong connections between these two areas or by finding a formalism to uniformly describe semantics and behavior. This is relevant not only to describe services in themselves, but also to be able to describe both what is expected from a service compositions and (if possible automatically) to derive what service composition gives.
Challenges	Formal Models and Languages for QoS-Aware Service Compositions
IRF elements	Logical Design Environment: Modelling Techniques Conceptual Research Framework: Service Composition and Coordination Reference life-cycle: Requirements Engineering and Design
Related questions	Foundations for data semantics in service-based systems
References	
Glossary	Semantic Web Services Composition, Semantic Web Services
Keywords	Behavior, semantics, description logics, petri net

Name	Applying the sharing-based analysis to the problem of service composition fragmentation
Synopsis	Applying the general concept of sharing to model and analyze both the control structures of a composition and its data flow.
Authors	UPM
Type	Method
Description	Composition notations and languages, such as BPMN [17], and WS-BPEL [16], allow process modelers and designers to view a composition from the point of business logic and processing

	requirements related to parallelism and data flow. The now fashionable service mash-ups are also tools for building (usually simplified) customized workflows from known service components in a user-centric way. Finally, com- positions can be programmed in any common programming language, such as Java, with infrastructure that provides the necessary constructs and libraries for establishing client connections to, and exposing Web services. This calls for a neutral, language independent notion of fragmentation and fragmentation possibilities. The notion of sharing-based fragmentation is based on the very general notion of independence between parts of a composition. The underlying idea is that workflows have a certain degree of freedom in (re-)arranging their activities, without violating the overall inter-process business protocol, and while preserving their essential prop- erties, such as correctness and transactional integrity. The question is how to apply the general concept of sharing to model and analyze both the control structures of a composition (usually already presented at the level of workflow design), and its data flow, which is usually not present in many workflow designs, but which may induce dependencies between parts of the composition thay may disrecommend treating them as fragments.
Challenges	QoS Aware Adaptation of Service Compositions
IRF elements	Logical Design Environment: Transformation and Generation Techniques Conceptual Research Framework: Service Composition and Coordination Reference life-cycle: Construction, Identify Adaptation Need
Related questions	
References	- S-Cube Deliverable CD-JRA-2.2.3
Glossary	Adaptation Mechanism, Service Composition
Keywords	Fragmentation, Service Composition, Split and Merge

2.2.1.6 JRA-2.3

None

2.2.2 Modified research questions

2.2.2.1 JRA-1.1

None

2.2.2.2 JRA-1.2

Name	Process Mining to devise complex monitoring and adaptation mechanisms and tools

Synopsis	Use of process mining techniques to support the monitoring and adaptation of SBAs
Authors	CNR
Type	Mechanism
Description	Process Mining joins ideas of process modeling and analysis on the one hand and data mining and machine learning on the other. This approach provides means to extract from the previously collected data an additional knowledge not explicitly modeled before. In this way, it is possible to reveal the patterns and relations in the SBA behavior that are different from those expected by the SBA designer. These patterns and relations may characterize the deviations that are critical for the SBA functioning and adaptation, thus enabling prediction and smarter adaptation decisions in the application management.
Challenges	Proactive adaptation and predictive monitoring
IRF elements	Conceptual Research Framework: SAM; BPM; Integrated A&M Capabilities; Reference Life-Cycle: Identify adaptation need; Operation and Management; Identify Adaptation Strategy; Logical run-time environment: Adaptation Engine; Monitoring Engine;
Related questions	• Analysis of Influential Factors of KPIs and SLA Violations Based on Machine Learning techniques • Runtime Prediction of KPIs and SLA Violations Based on Machine Learning Techniques
References	CD-JRA-1.2.2 Taxonomy of Adaptation Principles and Mechanisms
Glossary	Process Mining; Predictive Monitoring; Machine Learning;
Keywords	-

This research question is modified in order to reflect better the objectives of the research line with respect to the SBA monitoring and adaptation and to differentiate from the related research questions in JRA-1.3 and JRA-2.2, where the machine learning techniques are studied for the purpose of prediction and process analysis. That is, the consistency (G2) and integration (G5) objectives are targeted. In relation to the integration objective, new relations (also cross JRA) are added in order to reflect the use of the mining techniques as the common basis for the problems studied in those work packages.

Name	Using models and aspect to design and adapt SBS
Synopsis	Use of the combination of model-driven design, aspect-oriented approaches, and variability modeling as the way to address the problem of dynamic self-adaptation of complex SBA systems.
Authors	INRIA
Type	Method
Description	High-variability of features in Dynamic Adaptive Systems (DAS) introduces an explosion of possible runtime system configurations (often called modes) and mode transitions. Designing these configurations and their transitions is tedious and error-prone, making the system feature evolution difficult. For self-adaptation of

	services, we want to adapt quickly because 1) the evolution of the context of the application (services) is dynamic and changes can appear in a short laps of time and 2) the evolution of SBA itself should be reflected on the fly. Uniform modeling with the automated adaptation support are required in these settings. This research question aims to study the use of Model-Driven Design and Aspect-Oriented Modeling (AOM) to tame the combinatorial explosion of DAS modes. Using AOM techniques, one could derive a wide range of modes by weaving aspects into an explicit model reflecting the runtime system and to use these generated modes to automatically adapt the system. Model representation can help to detect adaptation needs before they appear thus enabling proactive SBA adaptation.
Challenges	• Proactive adaptation and predictive monitoring; • Quality Prediction Techniques to Support Proactive Adaptation • Comprehensive and integrated adaptation and monitoring principles, techniques, and methodologies
IRF elements	Conceptual Research Framework: SAM; SQDNA; SCC; SI; Integrated A&M Capabilities; QA Capabilities Reference Life-Cycle: Requirements Engineering and Design; Identify Adaptation Need; Identify Adaptation Strategy Logical Run-Time Architecture: Monitoring Engine; Adaptation Engine; Run-Time QA Engine Logical Design Environment: Modelling Techniques
Related questions	• Cross-layer monitoring mechanisms • Predictive SBA monitoring techniques • Design for adaptation • Associate adaptation strategies to the adaptation triggers
References	• B. Morin, T. Ledoux, M. Ben Hassine, F. Chauvel, O. Barais, J.M. Jezequel. "Unifying Runtime Adaptation and Design Evolution". In CIT 2009
Glossary	Evolution, self-adaptation
Keywords	Model-driven design, aspect-oriented programming, models@runtime

This research question is changed in order to also integrate other fine-grained research questions defined separately in this WP (thus reducing the complexity of IRF – objective G1). To the moment, those research questions had very fragmented and detailed solutions, while following a similar paradigm that enters into the model-/aspect-based approach for the design and provisioning of adaptive SBAs. Besides, the relations to research challenges and other questions are unified. Additional related research questions are added in order to increase the consistency of IRF elements (G2) as well as the integration (G5) as some of the new relations are cross-WP.

Name	Cross-layer integrated monitoring mechanisms
Synopsis	In order to enable the analysis the effects and dependencies across different SBA layers, it is necessary to propagate and correlate different monitoring events across layers.

Authors	FBK
Type	technique, mechanism
Description	Different SBA layers generate and are bound to different types of activities and events. These events, however, are often not isolated but depend on or reflect the situations at other layers. To be able to properly analyze the failures or changes in a holistic way, as well as to properly react to those changes, it is critical to be able to propagate and correlate events at different layers to have a complete picture.
Challenges	Comprehensive and integrated adaptation and monitoring principles, techniques, and methodologies
IRF elements	Conceptual Research Framework: SAM; A&M Capabilities; Integrated A&M capabilities; Reference Life-Cycle: Identify adaptation needs; Logical run-time environment: Monitoring Engine;
Related questions	• Means to identify adaptation needs across layers • Cross-layer integrated and coordinated SBA adaptation mechanisms • Means to identify adaptation strategies across layers • Process Monitoring in Service Choreographies • Monitoring of Process Performance Metrics in Service Compositions • Business Process Management Monitoring and Adaptation: Managing key performance indicators (KPIs) within Agile Service Networks (ASN) • Non-intrusive QoS monitoring of services and service compositions
References	http://bibadmin.s-cube-network.eu/show.php?id=250 http://bibadmin.s-cube-network.eu/show.php?id=26 http://bibadmin.s-cube-network.eu/show.php?id=269 http://bibadmin.s-cube-network.eu/show.php?id=270
Glossary	Monitored Event, Monitoring Mechanisms
Keywords	-

In this research questions additional relations are added in order to ensure consistency of the IRF with respect to the relations between the research challenges (G2), and to guarantee integration of IRF (G5) as the added related questions define the cross-JRA links. In particular, the research questions from JRA-2.1 (Business Process Management Monitoring and Adaptation) and from JRA-2.2 (Process Monitoring in Service Choreographies and Monitoring of Process Performance Metrics in Service Compositions) are added.

Name	Monitoring and adaptation for autonomous SBA components
Synopsis	Monitoring and adaptation approaches that support the creation and sustainable usage of autonomous components covering the full lifecycle of a SBA
Authors	SZTAKI,TUW
Type	Methodology
Description	Autonomous behaviour of the different SBA components requires

	the identification of those adaptation strategies that could be applied on a single component of the SBA. This single component should autonomously fire these strategies based on the monitoring events describing the actual behaviour of the component. The identification of the strategies excludes those adaptation strategies that would affect the environment of the autonomous component.
Challenges	Comprehensive and integrated adaptation and monitoring principles, techniques, and methodologies Mixed initiative SBA adaptation
IRF elements	Conceptual Research Framework: A&M capabilities Reference Life-Cycle: identify adaptation strategy, enact adaptation Logical run-time environment: Service Infrastructure
Related questions	• Self-optimization and self-healing of a single service • On-demand, dynamic service provisioning
References	http://bibadmin.s-cube-network.eu/show.php?id=135
Glossary	Self-adaptation, autonomic resource virtualization, autonomic system
Keywords	-

Consistency check revealed some problems with the definition of this research questions. To resolve them we

- Added knowledge model terms relevant for this research
- Added related research questions from JRA-2.3.

In this way the objectives G2 and G5 (ass the added research questions are cross-JRA) are achieved.

Name	Means to identify adaptation strategies across layers
Synopsis	Understand how to identify, filter, validate, and compose adaptation actions into a coherent adaptation strategy
Authors	FBK
Type	Technique
Description	To address the problems of the adaptation compatibility and integrity, the mechanisms for the identification and selection of the adaptation strategies should be able to (i) validate the adaptation strategies against the whole model of the application; (ii) foresee whether the adaptation strategies are sufficient to achieve the corresponding requirements; (iii) to identify search appropriate adaptation strategies when the previously selected strategies are insufficient or may in turn trigger some other adaptations.
Challenges	Comprehensive and integrated adaptation and monitoring principles, techniques, and methodologies
IRF elements	SAM; A&M Capabilities; Identify Adaptation Need
Related questions	• Means to identify adaptation needs across layers • Cross-layer integrated monitoring mechanisms • Cross-layer integrated and coordinated SBA adaptation mechanisms

	• Adaptation of QoS-aware Service Compositions based on Influential Factor Analysis and Prediction • How can cost-based derivation of data-aware QoS for a service composition be used to drive adaptation? • QoS-Aware Optimization of Service Compositions with Transactional Properties
References	http://bibadmin.s-cube-network.eu/show.php?id=250 http://bibadmin.s-cube-network.eu/show.php?id=269 R. Kazhamiakin, B. Wetzstein, D. Karastoyanova, M. Pistore, and F. Leymann: "Adaptation of Service-Based Applications Based on Process Quality Factor Analysis". In Proc. 2nd Intl. Workshop on Monitoring, Adaptation, and Beyond (MONA+), 2009.
Glossary	-
Keywords	-

In this research question we have added related research questions where cross-cutting aspects such as non-functional properties are used to drive the SBA adaptation at different SBA layers. In this way, the objectives of integration (G5) are achieved.

2.2.2.3 JRA-1.3

2.2.2.4 JRA-2.1

None

2.2.2.5 JRA-2.2

None

2.2.2.6 JRA-2.3

None

2.2.3 Removed research questions

2.2.3.1 JRA-1.1

None

2.2.3.2 JRA-1.2

- **Models@Runtime to check and optimize the adaptation plan**. This research activity appeared to be too-fine grained, and as a consequence very limited results have been obtained. To reduce complexity of IRF (G1), and to ensure better research integration, the objectives of this research questions are incorporated into the research question "Using models and aspect to design and adapt SBS", which is very relevant as it is based on a similar model-driven approach for self-adaptation.

- **Unifying Runtime Adaptation and Design Evolution.** As in previous case, this research question is very specific. As the question proposes model-driven approach for monitoring it has been integrated with the research question "Using models and aspect to design and adapt SBS". Note that also the relations with other questions and elements are integrated. In this way, the change addresses the complexity objective (G1).
- **Monitoring non functional QoS in SLA**. The specific objectives of this research questions concern on the one hand traversal aspect of QoS monitoring in SBA and on the other hand the specific technology solutions for SLA monitoring. As for the second objective, several research questions address the problem of quality monitoring at different SBA layers. As for the first objective, it is reflected in the cross-layer SBA monitoring mechanisms. To minimize the complexity of IRF (G1), we propose to remove this question. On the other hand, the research question "Cross-layer integrated monitoring mechanisms" is extended with additional relations concerning research questions of monitoring non-functional SLA aspects.
- **Relaxing QoS in SBA and techniques**. This research question aims to study the problem of driving SBA adaptation by quality properties. In this way the research question is strongly related to the research question "Means to identify adaptation strategies across layers" while using specific techniques for doing that. For the sake of IRF simplicity (G1) we propose to merge this objective with the "Means to identify adaptation strategies across layers" question. To ensure the IRF consistency and integration (G3 and G5 respectively) we propose to add to the latter additional relevant research questions.

2.2.3.3 JRA-1.3

None

2.2.3.4 JRA-2.1

- **Can we develop measures for the value of IT, thus allowing us to exploit network structuring and prediction within agile service networks (ASNs)?** and **Business Process Management Monitoring and Adaptation: Managing key performance indicators (KPIs) within Agile Service Networks (ASN).** These two research questions did not result into any concrete result activities due to their too fine-grained nature. For this purpose, and following objective G1, they were removed from the IRF and subsumed under a new research question 'Understanding the Implications of Service Network Relational Structures on Service Performance Analytics' (see 3.1.1.1).
- **Formal model for concepts of business transactions**. Given the fact that this question failed objective G2 and it overlapped with the more fine-grained research question 'Formal verification and validation of business transactions specification' (see 3.1.1.), we decided to remove it from the IRF to promote objective G1.

2.2.3.5 JRA-2.2

None

2.2.3.6 JRA-2.3

None

3 Additional classification

In this chapter we investigate how the research goals identified within IRF are aligned with the ideas and objectives of the Internet of Services. Specifically, we classify the research challenges and research questions, specifying how much that particular challenge or question is relevant for the Future Internet vision. This classification will be important in the 4th year of the project to better correlate the research work of the network with the new initiatives launched by the European Commission on the topic of Future Internet.

The vision of the Future Internet [3] foresees a novel global system that enables openness, trustworthiness, dynamicity and proactiveness, absence of central control, and partial predictability in serving the everyday life activities of citizens and organizations. The objectives posed by this vision in order to move towards the Internet of Services include

- The ability to interact with services in permanent, seamless, transparent, trustworthy, and adaptable way, thus requiring services to be always and reliably available through all means of communications, hiding the technology details, and usable in different applications.
- The ability to manage services in open, decentralized, dynamic, and often unpredictable settings.

These challenges require further evolution of the research activities applied to more “classical” service research and goes far beyond the vision of enterprise SOA. To understand how much the research framework addressed in S-Cube is aligned with this new vision we aim at classifying the research challenges and research questions with respect to their contribution to the requirements of the “Internet of Services”.

3.1 Classification of Research Challenges

Challenge	**JRA**	**YES**	**POSSIBLE**	**NO**
Definition of a coherent life cycle for adaptable and evolvable SBA	1.1		X	
Measuring, controlling, evaluating and improving the life cycle and the related processes.	1.1		X	
HCI and context aspects in the development of service based applications	1.1	X		
Understand when an adaptation requirement should be selected	1.1		X	
Exploiting the concept of service-based applications in the internet of things setting	1.1	X		
Comprehensive and integrated adaptation and monitoring principles, techniques, and methodologies	1.2		X	
Proactive Adaptation and Predictive Monitoring	1.2		X	
Context- and HCI-aware SBA monitoring and adaptation	1.2		X	
Mixed initiative SBA adaptation	1.2	X		
End-to-End Quality Reference Model	1.3		X	
Rich and Extensible Quality Definition Language	1.3		X	
Exploiting user and task models for automatic quality contract establishment	1.3		X	

Proactive SLA negotiation and agreement	1.3		X	
Run-time Quality Assurance Techniques	1.3		X	
Quality Prediction Techniques to Support Proactive Adaptation	1.3		X	
End-to-end processes in Service Networks	2.1		X	
Business Transactions in Service Networks	2.1		X	
Formal Models and Languages for QoS-Aware Service Compositions	2.2		X	
Monitoring of Quality Characteristics of Service Orchestrations and Service Choreographies	2.2		X	
Analysis and Prediction of Quality Characteristics of Service Compositions	2.2		X	
QoS Aware Adaptation of Service Compositions	2.2		X	
Multi-level and self-adaptation	2.3	X		
Deployment and execution management	2.3	X		
Process mining for service discovery	2.3		X	

The classification shows that a few challenges already explicitly refer to the problems of the Internet of Services. In addition, all the other challenges address issues that play substantial role in the definition and objectives of the Internet of Services, and could embrace research activities that target specifically the Internet of Services. This classification is however very high-level, due to the fact that the challenges are rather generic. More refined information is obtained from the classification of research questions discussed in the next section.

3.2 Classification of Research Questions

Question	JRA	YES	POSSIBLE	NO
Define in the life cycle phases to enable adaptation and evolution of SBA	1.1		X	
Associate adaptation strategies to the adaptation triggers	1.1		X	
How can we improve Business Process Management in Service Network?	1.1			X
How context information could be exploited during the lifecycle	1.1		X	
Identifying relevant HCI knowledge to inform SBA engineering	1.1		X	
Identifying human stakeholders in SBA engineering	1.1		X	
Exploiting user model knowledge in SBA engineering	1.1	X		
Exploiting user error knowledge to inform SBA engineering	1.1		X	
Design for adaptation	1.1		X	
Built-in adaptation	1.1		X	
Design for monitoring	1.1		X	
How can we measure, control, evaluate and	1.1		X	

improve the adaptation cycle?				
Service Protocol Engineering for Service Networks	1.1		X	
Evolution of Services	1.1		X	
Lifecycle of service compositions	1.1			X
Continuous requirements engineering of service-based applications	1.1		X	
Integrating self-optimisation and proactive adaptation	1.1		X	
The identification of process-oriented SOA viewpoints	1.1			X
The identification of automation viewpoints of SBA adaptation	1.1		X	
Service composition driven by dynamic service selection	1.1		X	
How to incorporate in the S-Cube lifecycle the techniques developed by all JRAs?	1.1			X
Can SBAs development be framed into the broader service design area?	1.1	X		
How can we validate the adaptation processes of the S-Cube lifecycle?	1.1		X	
Cross-layer SBA monitoring	1.2		X	
Cross-layer identification of adaptation needs	1.2		X	
Cross-layer SBA adaptation	1.2		X	
Predictive SBA monitoring techniques	1.2		X	
Context-driven adaptation based on requirements models and techniques	1.2		X	
Monitoring and adaptation for autonomous SBA components	1.2		X	
Context and HCI aware adaptation of SBA monitors	1.2	X		
Using models and aspect to design and adapt SBS	1.2		X	
Process Mining to devise complex monitoring and adaptation mechanisms and tools.	1.2		X	
How to obtain self-supervising BPEL processes?	1.2			X
Service evolution	1.2		X	
End-to-End Quality definition Language	1.3		X	
KPI monitoring for SBA	1.3		X	
Negotiation capabilities under the open-world assumption	1.3	X		
Service composition run-time validation of non-functional requirements	1.3		X	
Automated quality negotiation and agreement in diverse service infrastructures	1.3		X	
Runtime Prediction of KPIs and SLA Violations Based on Machine Learning Techniques	1.3		X	
Online Testing for Quality Prediction	1.3		X	
Run-time Verification for Quality Prediction	1.3		X	

Advantages of non-intrusive QoS monitoring of services and service compositions	1.3			X
Lifecycle of service compositions	1.3		X	
Online QA approaches	1.3	X		
Adaptation quality framework	1.3		X	
Automatic identification of relevant concepts to model QoS evolution	1.3		X	
Generation of test scenario to stress QoS of SBS	1.3			X
Models@Runtime to check and optimize the adaptation plan	1.3		X	
Proactive SLA negotiation and agreement	1.3		X	
Design, Specification & Verification of a Negotiation & Contract Agreement Protocol	1.3		X	
Optimisation of Business Processes	1.3			X
Validation of service behaviour	1.3		X	
SLA Negotiation for non functional QoS	1.3		X	
Relaxing QoS in SBA and techniques	1.3		X	
How can cost-based derivation of data-aware QoS for a service composition be used to drive adaptation?	1.3		X	
How can cost-based derivation of data-aware QoS for a service composition be used for predictive monitoring?	1.3			X
Quality estimation using service invocations	1.3		X	
How can end-to-end quality be assured through extension Software Development Quality Assurance Processes?	1.3			X
Predictable factors for Pro-active SLA negotiation	1.3		X	
Integration of prediction mechanisms with proactive SLA negotiation	1.3			X
Agent-based technology and chemical programming for proactive SLA negotiation	1.3			X
Data mining techniques to support proactive adaptation	1.3		X	
Framework for automating SLA negotiation	1.3		X	
Support for Negotiation Models	1.3		X	
Process Mining for Quality Prediction	1.3		X	
The impact of data-related characteristics on the accuracy of QoS predictions	1.3			X
Synergies between proactive negotiation and run-time QA	1.3		X	
Usage-based online testing for proactive adaptation	1.3		X	
End-to-end processes in Service Networks	2.1	X		
Business Process Management Monitoring and Adaptation: Managing key performance indicators (KPIs) within Agile Service Networks (ASN)	2.1		X	
Business Transactions in Service Networks	2.1		X	

Understanding the Implications of Service Network Relational Structures on Service Performance Analytics.	2.1			X
Formal verification and validation of business transactions specification	2.1			X
Modelling of the Agile Service Networks	2.1		X	
Monitoring of Business Transactions	2.1		X	
Linkage between Business Transactions and Service Compositions	2.2			X
Analysis of Influential Factors of KPIs and SLA Violations Based on Machine Learning techniques	2.2		X	
Runtime Prediction of KPIs and SLA Violations Based on Machine Learning Techniques	2.2		X	
Adaptation of QoS-aware Service Compositions based on Influential Factor Analysis and Prediction	2.2		X	
Cross-Partner Process Monitoring based on Service Choreographies	2.2		X	
Specification of Non-functional Parameters for Runtime Decomposition	2.2			X
Algorithm for Runtime Decomposition of Non-functional Requirements	2.2			X
Automatic derivation of composite service specifications	2.2		X	
QoS-Aware Optimization of Service Compositions with Transactional Properties	2.2		X	
Monitoring of Process Performance Metrics in Service Compositions	2.2		X	
Context-Aware Execution of Distributed Processes.	2.2		X	
Execution of Parallel Paths within Distributed Processes	2.2			X
Addressing the frame problem in service specifications	2.2			X
Addressing the ramification and qualification problems in service specifications	2.2			X
Determining whether two service specifications are equivalent	2.2			X
Service composition run-time validation of non-functional requirements	2.2		X	
KPI monitoring with incomplete information	2.2		X	
Foundations of Analysis for Service-Based Systems	2.2			X
Foundations for data semantics in service-based systems	2.2		X	
Describe behavior and semantics uniformly	2.2		X	
Applying the sharing-based analysis to the problem of service composition fragmentation	2.2		X	
Scalable and fault tolerant techniques for	2.3		X	

service discovery				
Self-optimization and self-healing of a single service	2.3		X	
Supporting adaptation of service-based applications	2.3		X	
On-demand, dynamic service provisioning	2.3	X		
Selecting Web Services Based on Structured and Unstructured User Feedback	2.3	X		
Light-weight Service Metadata for Service Registries	2.3	X		
Runtime SLA Violation Prevention	2.3		X	
Cost-Based Optimization of Adaptations	2.3		X	

The classification of research questions confirms that, in few cases, there is already an explicitly refer to the problems of the Internet of Services. In most of the cases, such a reference in not explicit yet, but the research questions cover issues that play substantial role in the Internet of Services. Finally, there are some research questions that are not directly related to the problems of the Internet of Services. This is particular true for a range of research questions raised in the technological work packages (i.e., JRA-2.1, JRA-2.2, and JRA-2.3) as well as for some of very specific questions in cross-cutting work packages (JRA-1.3 and JRA-1.2). In the former case this happens due to the fact that the questions address the issues related to specific technologies or mechanisms that are much more relevant for the enterprise SOA settings. In the latter case those research questions actually refer to the intersection of the cross-cutting aspect with the specific technological area and thus inherits the previous concern. It has to be remarked that, while these research questions are not directly related to specific issues of the Internet of Services, most often they provide technologies and mechanisms that are at the foundation of service-based applications and that define the baseline of the Internet of Services vision.

In general, the research trends studied in S-Cube are aligned with the goals and objectives of the IoS. To improve the synergy between the two agendas, we will maintain this classification during the 4th year of the project, will continue monitoring its evaluation, and will pass the information on possible synergies to the research work-packages.

4 Conclusion

In this deliverable we presented the new version of the IRF that had been revised according to the results of the first internal validation discussed in the CD-IA-3.2.2. This new version took into account the research work done in the last year in the Joint Research Activities Work Packages. Most of the update focused on the research questions. This means that the general objectives of the research on Service Based Applications remain unchanged, whereas the topic to be analysed had been updated with respect to the current state of the art. According to this streamline, the deliverable also started considering the relationship between the IRF and the Future Internet vision.

References

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