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| *Authors* | *CITY, LERO, POLIMI, VUA* |
| *Editor:* | *Andreas Gehlert (UniDue)* |
| *Reviewers:* | *Branimir Wetzstein (UStutt)* |
| | *Mohand-Said Hacid (UCBL)* |
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## Management Summary

Deliverable CD-JRA-1.1.5 is a paper-based deliverable comprised of seven research papers. All papers deal with the exploitation of codified context knowledge. It can clearly be seen that on the one hand the different research communities interpret “context” differently ranging from HCI aspects to engineering aspects relevant for SBAs. On the other hand our analysis of the relation of the approaches to the life cycle model shows that the approaches try to integrate different phases of the life-cycle and, thus, S-Cube is now focussing more on integrated research, which covers more than one phase of the life-cycle of SBAs.



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# Contents

# 1 Introduction

Service-based Applications (SBAs) are developed for constantly changing environments, e. g. it is expected that these applications adapt and evolve over time to satisfy new requirements and new contexts. Under context we understand all elements outside the boundaries of a SBA including the user of the SBA, other systems interacting with the SBA, the physical environment on which the SBA is executed as well as rules and regulations applying for the SBA. To structure the before-mentioned elements we group them to so called context factors. So far, S-Cube considered the following categories of context factors [11]:

- *Technical context factors*: Technical context factors may include the device on which the SBA is executed, its computational resources such as CPU speed and memory etc.
- *Environmental context factors*: These include location as the most prominent context factor but also temperature, lighting conditions and time.
- *HCI context factors*: Human-computer interaction (HCI) context factors include the human, e. g. the users or developers of a SBA including their tasks, competencies and skills. We even showed that an organizational culture may have an impact on SBAs.

We found another context factor of interest to the S-Cube project, which was not considered so far:

- *Service Engineering Context*: With service engineering context we mean context factors such as design decisions, rationale and stakeholders concerns. In this deliverable we especially examine how the rationale of the decision whether to automate a service influences the service engineering process. The inclusion of the service engineering context is important because according to industrial experience problems are encountered when only technical, environmental and HCI context factors are documented and more service-engineering context factors are disregarded. Here, we illustrate service engineering context factors for those service aspects that are of specific importance in the construction of SBAs.

Based on this introduction, this paper-based deliverable is structured as follows: In the remaining paragraphs of this section, we explain how the deliverable is related to the overall strategy and challenges of WP-JRA-1.1 and which method was used to collect and document the papers on which this deliverable is based. In Section 2 we present the seven papers in more detail. Finally, we draw some conclusions in Section 3. The papers themselves are documented as confidential annex to this deliverable.

## *1.1 Deliverable CD-JRA-1.1.5*

According to the Description of work, deliverable CD-JRA-1.1.5 deals with the "Analysis on how to exploit codified HCI and codified context knowledge for SBA engineering". With "codified" we mean that the knowledge is written in a way that can be interpreted both by a human and by a machine. By "exploiting" we mean that the knowledge should be useful for engineering SBAs in its broadest sense. Given the life-cycle model introduced in [12], the codified HCI and context knowledge may influence the different phases of the life cycle. To illustrate the exploitation of codified context knowledge, consider the following example:

> *A car uses a service-based navigation system, which uses the global positioning system (GPS). The car drives into a tunnel where no GPS information is available. However, the tunnel provides a positioning service to overcome this problem. The car navigation system may adapt itself to use the positioning service instead of the GPS service.*

This example illustrates two context factors: location and service provisioning – location to detect that the car enters a tunnel and service provisioning describing that different services may be available at

different locations and times. It also shows how these context factors influence the life cycle: While the car drives into the tunnel, monitoring may detect that the GPS service is not available anymore (or the navigation service infers this information from the current location and a map; context factor location). Given this monitoring event, the SBA needs to adapt itself, e. g. by searching for newly available positioning services (context factor service provisioning). In addition, the example also provides a rationale for considering context factors during the design of the SBA – without this consideration the SBA would have never monitored for location and available services and would, therefore, not been able to adapt to the new situation.

This deliverable directly contributes to the challenge CH1: "HCI and context aspects in the development of service-based applications", which is described as follows (cf. [13]):

> *"Humans are involved in service-oriented computing as end users and consumers, but also as service designers and providers (e.g. Human-Provided Services). A foreseen change in the use and distribution of services, as exemplified in the vision of an upcoming Internet of Services, is expected to further draw humans within the "service loop" and to promote human-to-application interaction as well as application to-application interaction. However, to this day, there has been little intersection between research in service-centric systems and Human-Computer Interaction. Human specificities, diversity and tasks characteristics are currently not taken into account in SBA design and delivery - despite being properties that could be powerful drivers for SBAs configuration and personalization. Thus, an integration of HCI knowledge in the engineering of SBAs is necessary to address the need for SBAs to be designed and delivered in ways fitting to human use wherever appropriate. Such integration is also required for the exploration of new opportunities afforded by the exploitation of HCI knowledge - for the enhancement of SBAs' existing capabilities, and for the delivery of new capabilities. It needs the identification of HCI knowledge that delivers enhanced or new capabilities for SBAs; moreover the codification of this knowledge for its application to the development and use of SBAs is required. Another important issue is represented by the characterization of the context of SBA in order to enable the identification of the adaptation requirements; the observation of the context could guide the adaptation process."*

The deliverable also contributes to the following other challenges:

CH2 "*Definition of a coherent life cycle for adaptable and evolvable SBA*" as it refines the S-Cube life cycle by introducing practices to be performed in each phase.

CH3 "*Measuring, controlling, evaluating and improving the life cycle and the related processes*" as in [6] it offers an approach for the estimation of the overall value of a service network;

CH4 "*Understanding when an adaptation requirement should be selected*", "*Run-time Quality Assurance Techniques, Multi-level and self-adaptation*", and "*Context and HCI -aware SBA monitoring and adaptation*" since in [6],[7] and [8] the discussion is about when and how to improve a service network and a SBA depending on context factors.

## *1.2 Method of Collecting and Analyzing Partner Contributions*

This deliverable is based on ten papers. These papers were produced as joint research efforts of workpackage WP-JRA-1.1 in year 2. All papers were summarized using the following template in order to enhance readability of the document and comparability of the approaches:

- *Context and Background*: Initially, the context and background of the problem being addressed in the paper is provided.
- *Problem Statement*: Based on the background, the problem that is addressed (i.e., the research question which is answered) is motivated and explained.

- *Relevance of the Problem and Progress from State of the Art*: The explanation on why the problem is relevant is important to understand why the problem (i.e., research question) is worth pursuing. In addition, the relation of the work to the state of the helps understanding the novelty of the contribution and its progress from existing work.
- *Solution Idea and/or Solution and/or Research Method*: Either the (innovative) solution (idea) to the problem is stated or the research method employed (e.g., empirical study) is described.
- *Benefits and Evaluation*: The benefits and utility of the solution when applied to the problem is stated, and, if applicable, it is described how those benefits have been demonstrated by means of an evaluation (method of evaluation and results).
- *Discussion and Future Work*: Critical discussion on what are the current gaps and shortcomings of the solution and which future research activities are planned. This will allow shaping the future research roadmap for the WP.
- *Relation to WP Challenges*: The contribution to the WP research challenges is described to understand the contribution of the paper to the overall aims of the deliverable and the WP.
- *Relation to Research Framework*: The approaches presented in the various papers are related to the Integrated Research Framework and in particular to the Conceptual Research Framework View (e.g. Engineering & Design, Monitoring and Adaptation, Quality definition and assurance, BPM, Service Composition and Coordination, Service Infrastructure), to the life cycle, to the infrastructure and to the logical design environment view. See deliverable IA-3.1.3 for more information.

## *1.3 Overview of the Contributions*

In total seven papers were collected for this deliverable. The collected contributions can be classified according to the following categories:

- *Users as Context Factors*: Papers [1] - [5] focus on the end-user of the SBA as context factor when engineering SBAs and, therefore, contribute to challenge CH1. In [1] the authors start with the observation that system faults can be traced back to a large extend to user errors. Therefore, the authors argue that it is important to choose services at design time, which are already capable of dealing with user errors. In addition, service selection at runtime could find services to adapt the system once the user error occurred and lead to a faulty system. The authors use error taxonomies as basis for their work.

  In [2] and [3] the authors argue that services bound in a SBA should support the task the user is carrying out and the services should be according to the user's skills and preferences. Therefore the authors of [2] and [3] describe how user model information (skills and preferences) as well as user task models influence the way in which services should be selected for the SBA.

  In [4] the authors propose an approach, which empowers the SBA user to customize the SBA according to his/her needs. The variation points describing how the system can be customized are described with variability modelling techniques. At customization time, the user is asked to choose between the different variants by asking questions regarding the context of the user.

  Paper [5] approaches the influence of the user on service selection from a technical point of view. The starting point of the paper is the observation that users will increasingly use web services to carry out their daily tasks. In order to find suitable web services, search engines need to implement new search strategies, which take the users' tasks into consideration. Paper [5] describes the first step in this direction, e. g. it proposes an algorithm to cluster user queries. These clusters will eventually be used to derive the users' tasks behind the queries and to build a knowledge base, which in turn will be used to derive the new search strategies described above.

- *Context Factors as Design Rationale*: The second category deals with the design rationale describing why the SBA was designed in a particular way (contribution to challenge CH1). In [10] the authors focus on the aspect of automation of services during the design of the SBA. The authors argue that although service automation is specifically important for SBAs to maximize their capability of being agile and dynamically adapting to business changes, completely automating services is in practice not always technically possible or is often restricted by some domain-specific factors. Therefore, the decision on whether to automate a service or carrying it out manually is clearly 1) a design rationale and 2) a decision depending on the context of the SBA. The authors showed in two case studies that—depending on the context—different concerns may affect the decision of realizing a service as software.
- *Exploiting Context Factors to support design for adaptation*: Papers [7] - [9] exploit context factors to allow the system to adapt to changes. In paper [8] the authors propose a process for engineering context-sensitive SBAs (contribution to challenge CH4). The engineering process contains the following phases: modelling the SBAs context, modelling adaptation triggers, which decide in which cases an adaptation is needed, construct context monitors, which are needed to detect changes in the context and construct adaptation mechanisms called strategies. The approach foresees a dependency between adaptation mechanisms and context factors.

  In [7] the authors deal with the question of dependability and contribute to challenge CH4. The starting point is the observation that a SBA is basically a network of services, which are not under the control of the SBA operator. Thus, once a service fails, the system may stop operating. Various strategies such as adaptation at runtime once a service failure occurs can be applied to solve this problem. The approach presented by the authors support SBA designers with preventive and corrective improvement actions that may enhance dependability. These strategies depend not only on the services that may fail but also on context factors. In this paper, the inevitable changes of the context (service availability) lead to a new design method.

  Paper [9] investigates one particular context factor – the qualities of a provided service (contribution to challenge CH1). The authors provide an architecture for deciding whether a deviation of the current service quality from a defined service quality leads to an overall violation of the SBA's requirements. The authors argue that their approach avoid unnecessary adaptations (because an adaptation is only triggered in case a requirement is violated) and allows to detect the root cause of the problem, e. g. in case multiple quality attributes were violated.
- *Exploiting Context-dependent design patterns to optimize the business value network*: Paper [6] aims at applying software engineering techniques to support evolution of a service value network at the business level and, therefore contributes to challenges CH3 and CH4. The main idea is that it is possible to find particular structural configurations in the business service networks and apply some transformation rules to optimize the value of such network. Context information of the environment in which the network is operating is used to take decisions whether to apply or not a transformation. Finally, through simulation, the approach has shown to increase the performances of the network.

## *1.4 Relation to the Integrated Research Framework*

The major mean to demonstrate integration in the S-Cube project is the integrated research framework (IRF). By aligning the approaches described in this deliverable we show the interaction between the different workpackages and the coverage of the framework elements. Given the fact that the project developed isolated approaches, e. g. approaches belonging to one element in the IRF in Y1, we would expect that the approaches in this deliverable are overspanning more than one element in the IRF.

To demonstrate integration, we align the approaches to the Conceptual Research Framework and Life Cycle Views. The relation to the Conceptual Research Framework view demonstrates the interaction between the different Joint Research Activities (cf. Figure 1) and to the life cycle as major outcome of WP-JRA-1.1 documented in PO-JRA-1.1.1 [12] (cf. Figure 2). Since WP-JRA-1.1 is concerned with

engineering activities, the Infrastructure and Logical Design Environment Views are disregarded in this analysis.

Figure 1 shows the relation of the approaches to the Conceptual Research Framework view. Not surprisingly all approaches are related to the Engineering and Design Element. As already described in Section 1.3, most approaches are concerned with the impact of engineering techniques on monitoring and adaptation. Therefore, the relation between the Engineering and Design and Adaptation and Monitoring elements is well covered. In addition, the relation with the Quality Definition, Negotiation and Assurance, Business Process Management and Service Composition and Coordination elements is also covered by this deliverable.

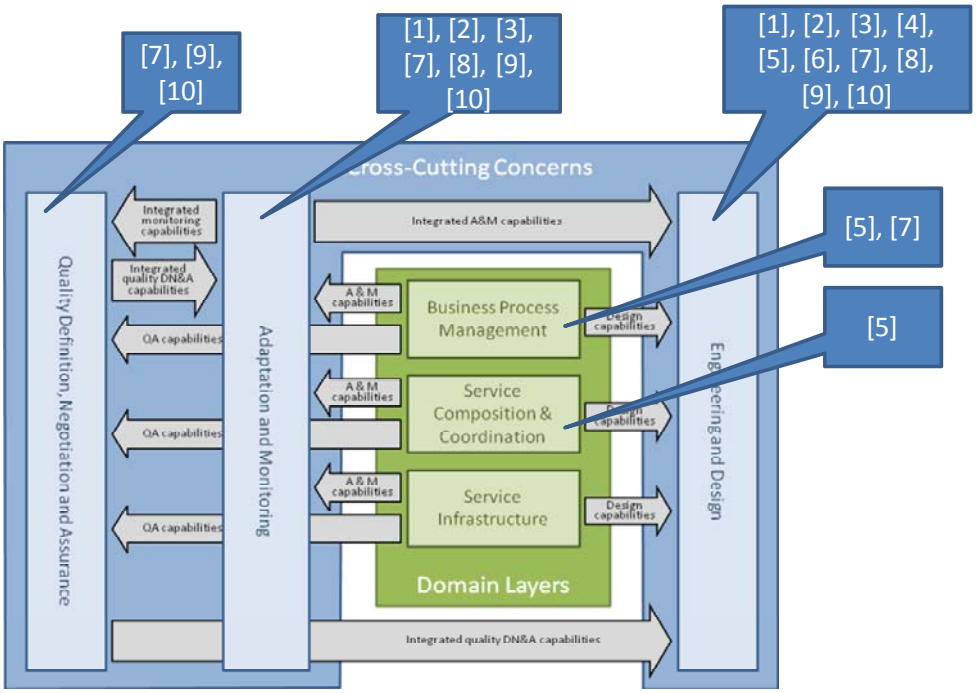


*Figure 1: Relation of the approaches to the Conceptual Architecture*

Figure 2 shows clearly that nearly the entire life cycle has been covered by the research results presented here. Especially paper [8] (not depicted in Figure 2) covers all phases of the life-cycle and, therewith, demonstrate the feasibility of approaches overspanning multiple phases of that life cycle.

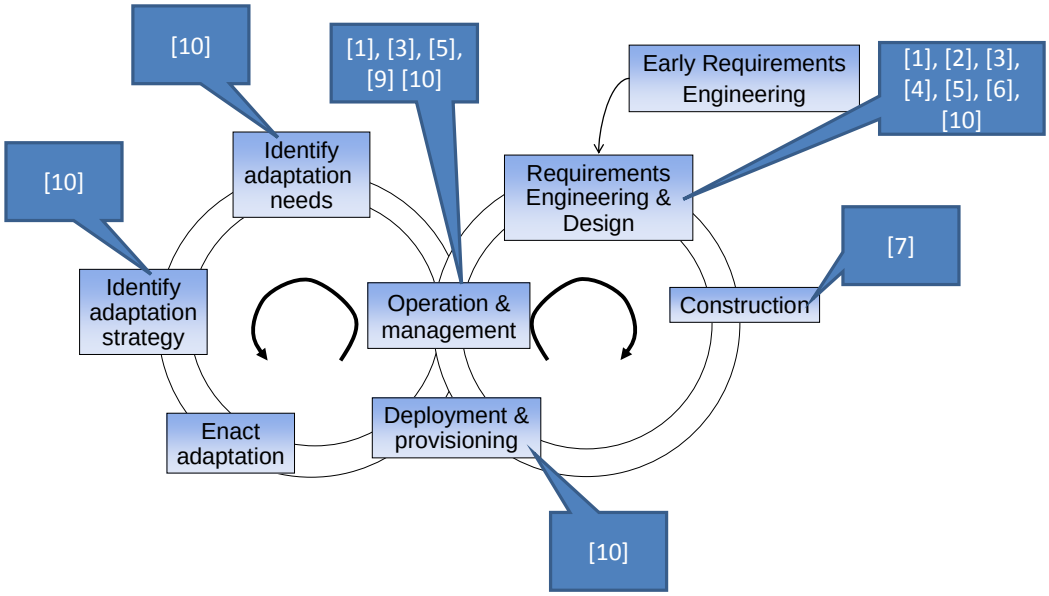


*Figure 2: Relation of the Research Results to the Life Cycle*

Finally, this deliverable directly contributes to the IRF as the approaches presented in the following represent new research results and/or research questions. Consequently, these research results and/or research questions represent an important input to the IRF and are, therefore, documented in Appendix A.

# 2 Detailed Description of the Contributions

The following Subsections contain the documentation of the provided papers in form of the template explained in Section 1.2.

## *2.1 User Error for SBA Engineering [1]*

**Context and Background**: Software services are increasingly being used in enterprise settings as well as in mainstream, day-to-day computing. As services' application ranges and end user base augment, so will the need for robustness in Service Based Applications (SBAs) so that they continue to provide good service in anomalous situations, hence preventing possible productivity loss, reduced user satisfaction, and even accidents in safety-critical systems.

**Problem Statement**: Fault-tolerance for services and SBAs does not exploit knowledge on the human sources of faults occurring in SBAs; it is however well-documented in HCI that most system faults find their roots in errors committed by the human stakeholders - as end users inputting erroneous data causing system faults for instance, but also as designers and programmers introducing architectural errors and bugs in the software - and that knowledge about user error is useful in the design of more robust, fault-tolerant systems.

**Relevance of Problem and Progress from State of the Art**: The interoperability and reuse capabilities associated with services are distinct advantages for dynamically building heterogeneous, loosely-coupled SBAs; they do however introduce robustness issues. SBAs have to integrate services that are often developed using differing technologies, and which implement different approaches for error-handling. For instance, some services may implement a "throw and catch" approach where an error is internally handled while others might stop at outputting runtime errors for handling by an external human or automated component. Further, the granularity, format and content of these errors might differ from service to service, with some error codes being specific to a particular service and

others being natural language, human-readable messages. By and large, current research on fault-tolerance focuses on these interoperability issues and on mechanisms addressing fault detection, handling and recovery at various levels of the SBAs' technical infrastructure. However end users are increasingly involved in Service-Oriented Computing and the errors they may commit using the systems must be prevented, handled or mitigated to ensure SBAs continued good service. To the best of our knowledge, no approaches integrating this knowledge are applied to SBA engineering.

**Solution Idea**: User errors are common feature of interactions between users and computer-based systems; they have been extensively studied in the field of HCI. A number of taxonomies exist to identify and classify them, providing a reference to the different, broad categories of errors users make. Established interaction models describing users' interactions with systems have also been proposed in HCI literature. We leveraged knowledge from both of these areas to identify possible mappings between the user error types described in existing taxonomies and specific stages of a user's interaction with an SBA. We further investigated their possible causes and the recommendations that may be derived for the discovery and selection of services handling these causes. For instance, consider the "Action sequence execution" stage of a user interaction with a system (here, an SBA – see Figure x below). During this physical, actionable interaction with services at run-time, the end-user may commit mistakes triggered by a poor accessibility and/or visibility of the SBA controls (which may be solved by selecting services compliant with relevant accessibility standards), or by incorrect data entry (in which case it is recommended that SBAs requiring data input also perform data validation checks).
Overall, insights were gained into the user errors that were likely for each interaction stage - including those anterior and posterior to direct action on the SBA, where errors in how the user comprehends the system and forms an intention to use it are formed. These insights informed the development of simple heuristics for the selection and discovery of services that avoid or mitigate common user errors for:

- design time service discovery , to inform the service discovery process and specifically seek to select services handling the common or likely errors a user could make.
- runtime service discovery , to enact adaptation as a reaction to SBA faults possibly introduced by user errors.

The heuristics derived from this exercise pertained to the following areas: data input validation; availability of help functionality; availability of feedback on action; accessibility; completeness of specification; and usability. These heuristics are being implemented as selection rules for design time service discovery, and were codified as constraint queries for runtime service discovery to specify additional constraints that a candidate service's specification must match (additionally to the structural and behavioural properties of the service to be replaced).

**Benefits and Evaluation**:
The constraint queries for RSD allow the specification of selection heuristics and rules for the run-time discovery of services implementing specific user-error avoidance or handling strategies. Similarly, it is expected that the codified user error heuristics will provide additional criteria and filters for the discovery of services preventing or handling common user errors. The empirical evaluation of the constraint queries for RSD and the implementation of the user error heuristics as discovery rules for a service discovery platform are both ongoing.

**Discussion and Future Work**:
The increasing diversity of SBAs users and services' rising use in mission-critical systems motivates the research into services fault-tolerance and robustness, this to ensure that the design and execution of SBAs strives towards minimizing the occurrence and impact of errors. This paper reported on approaches applied to codify knowledge about user errors:

- For service discovery at design time, to inform the service discovery process and specifically seek to select services handling the common or likely errors a user is susceptible to make.
- For service discovery at runtime, to enact adaptation as a reaction to SBA faults possibly introduced by user errors.

User error taxonomies and interaction models were drawn upon to frame the common user error types liable to occur at various stages of a user interaction with SBAs. These were then used to derive service selection rules for the discovery of services with functionalities addressing these error types. Constraint queries were further derived for performing runtime adaptation via RSD, which we expect will be refined after the first round of empirical testing is complete. Following implementation and evaluation in the Service Centric Systems Engineering's (SeCSE) Use Case and Requirements (UCaRE) tool, the refinement of the selection rules and possibly the creation of new rules tailored to particular application domains is also expected. Several research directions will further research into the application of user errors for SBA engineering. The exploration and integration of factors affecting user errors, possibly by interlinking discovery rules, models about the users and their context, and the tasks performed is another promising research direction, possibly leading to the development of task models' associated common user errors for instance. Finally, novel ways for services to describe their error handling capabilities and the development of possible "user error service design patterns" encapsulating HCI recommendations for user-appropriate handling of errors are being considered.

**Relation to WP Challenges**: HCI and context aspects in the development of service based applications

**Relation to Research Framework**: Service engineering and Design, Adaptation and Monitoring

## *2.2 Exploiting User Model Information for Service Discovery [2]*

**Context and Background**: Service-based application users are shifting from a small, often technically-minded user base to a much more inclusive, broader audience whose varied characteristics and needs must be accommodated. Although extensive research exists on the topic of user-adaptive software systems, the particular case of SBAs has not as widely been investigated as of yet. In this paper, we propose to exploit user model information to develop additional criteria and filters for selecting services based on user's characteristics, this to permit the discovery of services whose specifications match user requirements better.

**Problem Statement**: SBAs are composed of services which are developed to be reusable rather than for exclusive use in specific, well-scoped applications. Their range of operations and end users are potentially too diverse to be foreseen: *"the eventual consumers of the service may not be known to the service provider and may demonstrate uses of the service beyond the scope originally conceived by the provider"*. Consequently, individual SBA design often cannot take into account anything but the most generic considerations about their hypothetical end user population where appropriate.

**Relevance of Problem and Progress from State of the Art**: It is widely acknowledged that user-tailored interactive systems support users in their tasks better than more generic, "one size fits all" systems as also evidenced by the extensive research in the fields of personalisation and adaptation of software systems that have been carried out, and the uptake of user-centred design methods in software engineering. Approaches to the design and implementation of SBAs, however, are often business-driven and seldom leave space to the integration of knowledge about the end users in the engineering process. As a result, SBAs cannot yet deliver their functionalities in a truly user-centric way, which we argue is obstructive to a good user experience and adoption by the wider audience, but also to their effectiveness in performing their functions.

**Solution Idea**:
User Models - knowledge structures encapsulating information about users – can be a means to integrate end user knowledge in the SBA engineering process, more specifically at the stage of service discovery. We developed a user model as a faceted representation of aspects of the user; then a set of these facets was codified into XML-based templates and added to the UCaRE module, to provide information about the user. Plain-text heuristics expressing the alterations or qualities a SBA would

ideally make or have (respectively) to best match a user's requirements were developed, then codified to be added as user model rules to the repository of SeCSE service queries. They were formalised to: specify the relevant user model facet and providing the path to its relevant node; link to the relevant service description facet by providing its path node for the verification of the rule; specify the type of verification to be performed (e.g. existence of a criterion, ranges the criterion had to be within); and suggest keywords for the query expansion for each of these rules.

**Benefits and Evaluation**:
Overall, the codified user model heuristics and the availability of the user model information provide additional criteria and filters for the selection of services based on user's characteristics, this to permit the discovery of candidate services in the registry whose specifications match the user model requirements. The empirical evaluation of this approach to using user model information is currently ongoing; a preliminary appraisal however suggests it will be proven to have a beneficial impact on service discovery, this by permitting a better match between the user requirements and the discovered services' functions.

**Discussion and Future Work**:
Along with empirical evaluation, further lines of research are either ongoing or being considered. Current HCI-aware approaches for SBAs adaptation monitor users' interactions with the application: the actions taken by the users ("user event streams") are the inputs for an analysis to infer the users' intentions, then correspondingly adapt the SBA as appropriate. We suggest that user model information is another valuable source of requirements for SBAs' implicit adaptation, and could trigger adaptation or personalisation of the SBA upon changes in the user model. In this case of figure, part of the monitoring focus would be on a user's user model rather than on services only. We are currently investigating mechanisms for 1) monitoring and detecting changes in user models 2) mapping them to relevant user requirements heuristics and 3) linking them to relevant services or service operations within an SBA for assessment of whether the user's needs and requirements are still being supported after the change, triggering the adaptation if that is not the case. Another area being explored is the application of user model discovery rules for runtime service discovery, rather than only at design time as is the case with our suggested approach.

**Relation to WP Challenges**: HCI and context aspects in the development of service based applications

**Relation to Research Framework**: Service engineering and Design

## *2.3 Codified Knowledge about User Task Modelling Applied to Service Discovery [3]*

**Context and Background**: Service-Oriented Computing (SOC) has been tipped as a major transformation to software development but it has yet to fulfil its potential. Some of the obstacles it will have to overcome in order to reach widespread adoption point at human and organizational issues rather than technological ones. As well as being accessed and used by other services or applications, services and Service-based Applications (SBAs) can require interaction with human users taking part in the business process enabled by the service, or imparting human intelligence to the relevant services (e.g. the Amazon Mechanical Turk web service). Until now Human-Computer Interaction (HCI) knowledge was treated in isolation from service engineering techniques for developing SBAs.

**Problem Statement**: Humans are present in SOC as end users and consumers, but also as service providers and designers. However, human specificities, diversity and tasks characteristics – properties that could be powerful drivers for SBAs configuration and personalization – are currently not taken into account in SBA design and delivery.

**Relevance of Problem and Progress from State of the Art**: Current service-oriented approaches rely primarily on business process models and notations such as BPEL to indicate the process-oriented context in which a service needs to be invoked; however, process models normally lack other important information about the actor who is performing the process and his actions. This fact has been recognised by initiatives such as BPEL4People, which attempts to incorporate human considerations into the specification of Business Processes. It does so by defining human tasks and describing them as activities, but stops at rendering human activities as simple processes without addressing their context.

**Solution Idea**: HCI task modelling techniques can contribute to the output of these changes by focusing on the tasks and the human users rather than on the system in place and the processes to be. They can also support the definition of appropriate level of granularity, and functional service cohesion for SBAs by helping to clearly scope and define tasks for their later implementation as service operations. Tasks models enable designers to represent and manipulate a formal abstraction of the activities that ought to be performed in order to reach user goals. In SBAs user tasks should be supported by services as demonstrated in the following simple user task example taken from the E-Government case study that pertains to citizens accessing government services online [see CD-IA-2.2.2]. An end user requests to use a governmental journey planning service. The underlying task model describes the context in which candidate solution services will be needed to fulfil the user goal, i.e. to receive personalised suggestions of available routes to a particular destination. The task model decomposes the journey planning user goal into sub-tasks and identifies the sub-tasks that solution services might deliver, for example sending journey planning request, receiving route suggestions, and following the directions. For this to happen these services need to be discovered. This paper describes how user task models can further contribute to the integration of human actors in the discovery and selection of SBAs by providing richer, more contextual descriptions and models than those currently available.

**Benefits and Evaluation**: During the use of SBAs new services need to be discovered if these services become available or currently invoked services need to be replaced by other services with improved qualities such as performance and reliability. Processes and techniques for service discovery have been researched extensively in previous projects. However, none of these processes and techniques explicitly use knowledge about user tasks to refine the discovery and selection of services appropriate to the user task.

**Discussion and Future Work**: We are currently building a prototype task knowledge base. In the first stage we are eliciting domain-specific knowledge that describes service-centric solutions for known tasks in the navigation domain based on the S-Cube E-Government case study scenarios. We will then extract the domain-specific task knowledge to generate domain-independent task knowledge that can be reused, similar to the KADS approach to knowledge modelling. Such domain-independent task knowledge can be used to describe more specific task knowledge in a new domain that decreases the cost for expanding the coverage of task knowledge. Two important requirements on each task model are that: (i) each task is sufficiently general to be applied across domains and across designs within a domain, and; (ii) the descriptive part of each task model is rich enough to match to service requests using the SeCSE service discovery algorithm. The validation of the presented task-based service discovery platform through future empirical studies is still in its infancy and a research open question. In this regard we plan to collaborate with all S-Cube partners to collaboratively build the above-mentioned task knowledge base.

**Relation to WP Challenges**: The paper addresses the research challenge of HCI and context aspects in the development of service based applications.

**Relation to Research Framework**: The approach focuses on Service engineering and Design; Adaptation and Monitoring.

## *2.4 Using Codified Context Knowledge to Facilitate End-user Requirements Elicitation [4]*

**Context and Background*:*** End-users communicate their needs and wishes in form of natural language. Such statements are often used to start activities such as requirements elicitation and negotiation which result in the specification of agreed key stakeholder requirements. Requirements analysts usually facilitate these cost and time consuming tasks. Traditional requirements engineering does not focus on identifying individual user needs and does not consider enriching the requirements elicitation process using other available knowledge.

**Problem Statement:** Novel software engineering paradigms such as service-oriented computing require approaches which allow the cost-effective identification of individual end-user needs. Our research investigates on how end-users can be empowered to document their individual needs themselves, which allow the provision of tailored service-based application. The goal of our research is to explore how codified context knowledge can support end-users in specifying individual needs and self-customizing service-oriented solutions. We aim to build tools and techniques that enable end-users in gathering requirements and consequently customizing a service-based application.

**Relevance of the Problem and Progress from State of the Art:** Software applications are increasingly being part of our everyday lives. Novel software engineering paradigms such as service-oriented computing promote reusing of available functionality and allow the cost-effective composition of tailored software systems. With such developments, it is inevitable to adapt traditional Requirements Engineering (RE) approaches and to strengthen end-user involvement in early software system design. We foresee that in the near future end-users will be directly involved in customizing and tailoring applications to immediately get a software system fulfilling their needs. Such a vision has to consider several constraints and has significant implications for requirements engineering research and practice. Currently there are no such approaches that make use of codified contextual knowledge to enhance the requirements elicitation process. Our approach is therefore a novelty in the field.

**Solution Idea and/or Solution and/or Research Method:** In this paper, we present a tool-supported approach combining end-user driven requirements elicitation and end-user driven customization of service-based applications. We propose to use (contextual) knowledge codified in software product line variability models to inform end-user driven requirements elicitation. This approach shows the potential to enable end-users to specify their needs using natural language text while sophisticated product line modelling and configuration generation tools are used to provide further input for requirements gathering. Particularly, end-users are asked questions about missing details regarding their needs. The advantage of this approach is the possibility to automatically evaluate given answers for further processing and customization of service-based applications. Thereby it will be possible to provide a service based system fulfilling individual end-users' needs within a short amount of time.

**Benefits and Evaluation:** Application of our tools enables end-users to elicit requirements and customize service-oriented applications themselves. We are currently working on initial evaluation of the approach by carrying out studies with end-users. If they are relevant, these studies will be presented in future publications.

**Discussion and Future Work:** Rigorous modelling methods, languages, and tools are needed to describe and manage the context of service-oriented applications and to implement effective means for configuring and tailoring them. More importantly, the involvement of end-users to make use of these models and tools is a key to any significant breakthrough in this area.
We consider product line variability models to be suitable for modelling and presenting contextual information to the end-users. The primary focus and contribution of this paper lies on increasing the creativity and stimulating new requirements during requirements elicitation. However, applying this approach has several other benefits. In ideal cases, the end-users can construct tailored applications themselves (by utilizing domain-specific product generators and reusable artefacts documented in the

product line model). In the normal run, the requirements elicited using our approach is made of textual description of users' needs and a prototypic configuration of available services based on the users' interaction with the product line model.

In the future, we aim to continue research in this area by carrying out user-studies to measure and validate the effectiveness of the requirements elicitation approach. Based on the feedback from users, we will work towards applying our approach in real-service repositories, empowering users to customize service-oriented applications themselves. This will provide us with further feedback for further improvements of the approach and the tools.

**Relation to WP Challenges**: The contribution of this paper is related to the challenge "HCI and context aspects in the development of service based applications."

**Relation to Research Framework:** This work is related to the Conceptual Research Framework element "Engineering and Design" and to the Life Cycle phase "Requirements Engineering & Design".

## *2.5 Mining and Recommending Web-based Tasks [5]*

**Context and Background:** Most of the activities people traditionally performed in their everyday lives can be modelled as workflows consisting of *tasks* somehow composed together. In our vision, people will be increasingly interested in exploiting the Web for accomplishing those activities. Thus, Web usage should change dramatically because people will access the Web for *executing* their tasks instead of simply *retrieving* Web pages. A typical approach for analyzing how people usually search the Web deals with mining Web Search Engines (WSEs) query logs.

**Problem Statement:** Following the shift in Web usage we claimed, we aim at identifying task-based sessions within WSEs query logs that is search sessions related to human-based tasks and processes that users try to accomplish using the Web. Thus, we will be able to collect a knowledge base of tasks (and processes), above which we plan to setup new recommendation strategies. Such strategies go beyond traditional query suggestion, nowadays available in most popular WSEs. Indeed, recommendation should be task-based, taking into account the task as a whole instead of simple queries.

**Relevance of the Problem and Progress from State of the Art:** According to the most authoritative Web community people, WSEs should soon focus on helping people to get a bigger task done, instead of supporting one search at a time. Such novel way of searching the Web "by tasks to be executed", instead of "by documents to be retrieved" has to be enabled by new mechanisms, especially in terms of Web search and recommender systems.

**Solution Idea and/or Solution and/or Research Method:** We organized our work according to the following 3 orthogonal steps. First, we planned to identify small search goals from a WSE query log by using a novel clustering technique for grouping topic-related queries. Each identified cluster could represent a specific user intent aiming to achieve an atomic task, which potentially can be a part of a more complex workflow of tasks. Moreover, since clusters lack of semantic information, we have to fill up that gap by adding meaningful labels to clusters of queries. Founded clusters of queries together with their semantic labels will constitute a valuable knowledge base of the tasks people aim to perform. Therefore, we plan to learn a model dealing with how users enact complex tasks on the Web, i.e., how atomic tasks are composed together. Finally, as the ultimate and most important goal, we aim to investigate how workflows of tasks or parts of them can be recommended, going one step further than current Web recommender systems of modern WSEs.

**Benefits and Evaluation:** We started evaluating our technique for detecting task-based sessions from WSEs query logs. Evaluation is conducted in terms of user studies and the obtained results are measured using traditional Information Retrieval metrics (e.g., *precision*, *recall*, *F-measure*, etc.).

**Discussion and Future Work:** We are currently approaching the second half of our research plan, starting to investigate how to exploit the knowledge base of tasks we extracted. This large knowledge base constitutes a good starting point for building a model of users' behaviours. Then, we will be able to devise a novel recommender system that goes beyond the simple query suggestion of modern WSEs. Our system has to exploit the knowledge base of Web-mediated processes and the learned model of users' behaviours, to generate complex insights and task-based suggestions to incoming users while they interact with a WSE.

**Relation to WP Challenges:** The paper addresses the research challenge of "HCI and context aspects in the development of service based applications".

**Relation to Research Framework:** BPM, Service Composition and Coordination, Requirements Engineering and Design, Operations & Management.

## *2.6 A model transformation for increasing value in service networks through intangible value exchanges [6]*

**Context and Background:** Modern service systems are becoming more complex over time since the cost and speed of storing and exchanging information is becoming lower and the number of participants is becoming higher. These systems are not only large, but they are set in an environment that is always changing both in requirements and in the number of participants. Therefore an intelligent way to analyze and keep or improve their value is needed.

**Problem Statement:** These service systems may be modelled as networks of entities that export services (providers) and entities that use services (users). The main assumptions in these networks is that the environment is not controllable by participants (risk), there is lack of knowledge for matching users to the most suitable service providers (no transparency), and lack of knowledge for allowing a user to act as a provider (no information flow). The problem is therefore to find a qualitative and quantitative way to decide if a network transformation that tries to reduce risk, that tries to increase transparency among participants, and that allows knowledge transfer, may be more profitable than the original situation. In particular the attention is focused on the insertion of a new class of entities in the network with the role of "matchmakers" between providers and users. Its purpose is to reduce risk and allow knowledge transfer using an information sharing mechanism such as a reputation management system.

**Relevance of the Problem and Progress from State of the Art:** Current literature in the area of value optimization in service networks is addressing the same problem in different ways, such as analyzing the structural properties of the network, or estimating value based on the results of actual transactions that have been observed in the network. What this work wants to show is to use the latest results in literature in the field of value evaluation and combine them with a method that is more typical of the software engineering area such as the definition and the reuse of some sort of patterns that may be introduced in existing service networks to optimize their value. This contribution expects to give the bases for a possible automated pattern transformation that may be integrated in the life-cycle of a Business Process Management Systems, with the final goal of having a service network that is able to react more efficiently to changes in its context/environment.

**Solution Idea:** To address the problem described above a possible network pattern transformation has been provided. The idea is to extend the original network this way: each participant focuses on its core competencies and on the appropriate alliances to increase its profitability and flexibility to changes. The participants of the transformed network will still act as (more specialized) service providers and

customers, but with a third type of participants that focuses on the transfer of knowledge, on managing feedbacks, and on making the emergence of such "agility" possible. The decision whether to perform the service network transformation or not is based on an evaluation of the expected value before and after the transformation. This metric has been based on Auto Regressive-Moving Average (ARMA) models, and the measurement over a certain period of time of total costs, revenues, and satisfaction of each participant.

**Benefits and Evaluation:** The main benefit is that the overall process may be applied in very different contexts, and may be also partly automated by Business Process Management software. The evaluation has been performed taking as an example the service network of a car sharing company, using as evaluation metrics public data available on the web. The result is a set of criteria and conditions over which the modified car sharing company may be better than the original one (an example is the possibility for a private car owner to become a service provider and earn some money when his car is not needed).

**Discussion and Future Work:** The main strengths of this work are the fact that some characteristics that are commonly found in service networks have been classified as patterns. Moreover, we have seen that such patterns may be transformed into new patterns with the aim of improving the overall value of the network. This allows the creation of more information among the network and it has obvious benefits in terms of competence transfer, trust, and overall satisfaction, which may be a dominant value outcome. Some of the shortcomings are the fact that there are still issues on making the process fully automated since many choices and many parameters have to be tuned depending on the particular problem. However, in future such methodology may be integrated into the rationalization part of the SN4BPM architecture to take into account the reconfigurations proposed in the analysis phase and in the model generation phase of the BPM lifecycle. A possible follow-up is to find additional patterns and examples for taking advantage of intangible service networks characteristics. Other important aspects that worth investigating are new models for taking the decision whether to reconfigure the service network or not. Possible models offered by existing literature include Game Theory models as well as emergent social network analysis techniques.

**Relation to WP Challenges:** This contribution addresses part of the challenge "Measuring, controlling, evaluating and improving the life cycle and the related processes" and part of "Understanding when an adaptation requirement should be selected". The first challenge is addressed by the proposed method for the estimation of the overall value of the service network (which comes from the value of the underlying processes); the second is addressed by the fact that, after a monitoring and evaluation phase, the network and the underlying processes may be changed and improved using the proposed transformation pattern.

**Relation to Research Framework:** This approach tries to apply some engineering principles to model service network systems (JRA-1.1). The approach may then be used as a base for possible extensions to the adaptation capabilities of the SN4BPM architecture presented in JRA-2.1.

## *2.7 QUADS: Quality-Aware Design of dependable Service-based processes [7]*

**Context and Background:** Service-based processes are typically executed by composing and invoking a number of available Web services. Such services are often not under the control of process designers since they are offered by external providers. This introduces critical dependencies between service-based processes themselves and the services they are exploiting. These last ones, in fact, could fail without notice or be unavailable for undetermined time intervals. Failures may be of various nature and they can concern either the inability to provide a given service or a loss in the service quality. Therefore, in service-oriented systems in which applications are required to have a high level

of autonomy, processes should be appositely designed to satisfy dependability requirements even in faulty situations.

**Problem Statement:** The main problem addressed in the paper is to find ways to evaluate and guarantee process dependability. Different user groups are seen as major influencing factor on process dependability. The paper analysis the role of these user groups when evaluating and guaranteeing process dependability.

**Relevance of the Problem and Progress from State of the Art:** The literature proposes various corrective and preventive strategies to improve dependability. The effectiveness of these strategies depends on the application context and users' requirements. Integrating monitoring and repair mechanisms in the SBA has proven to increase process dependability (or to reduce the risk of process failures) since a problem could be corrected at runtime. However, each such repair strategy is characterized by different properties (e. g., complexity, execution time, architectural constraints) and may impact some features of the process positively while the impact on other features may be negative. Therefore, a single repair strategy is not suitable for all situations and, as a consequence, the best available strategy should be chosen according to the given situation. This choice should be considered at design time.

**Solution Idea and/or Solution and/or Research Method:** In the paper we propose a new design for dependability approach that supports process designers in the usage of the available preventive and corrective improvement actions that enhance dependability. The strategies for improving process dependability are evaluated against the global evaluation of the quality of the resulting process. Different user's requirements and context are taken into consideration during the assessment, to evaluate the impact of each improvement action of the global quality and dependability of the process.

**Benefits and Evaluation:** An evaluation of the proposed method has been performed on a case study, analyzing the results of the approach with the support of a design tool environment.

**Relation to WP Challenges:** The paper contributes to the following challenges: Run-time Quality Assurance Techniques, Multi-level and self-adaptation since it proposes a method to design processes with adaptive actions taking into account the global quality of the resulting process. It relates also to Context and HCI -aware SBA monitoring and adaptation since the assessment of quality of the resulting process depends also both on the evaluation of the repair actions by the involved users and on the evaluation of the importance of the quality dimensions by the process stakeholders.

**Relation to Research Framework:** The solution of the paper is related to the elements of the S-Cube Research Framework. The paper is related to Engineering & Design, Monitoring and Adaptation, and Quality definition and assurance, BPM. In the life cycle view it concerns in particular construction and quality assurance; concerning, the logical run time architecture, it provides input to the adaptation engine; in the logical design environment it is related to BPM and Q&M modeling.

## *2.8 A context-driven Adaptation Process for Service-based Applications [8]*

**Context and Background**: When building open systems the evolution of requirements and context is the norm rather than the exception. Therefore, it is important to make sure that the system is able to evolve as well without necessarily starting a completely new development process, and possibly on the fly. In such an application, adaptation mechanisms should be enacted to react to changes in the user requirements or in the context. In particular, the focus of the research is on the role of the context in the adaptation activities; namely, we would like to investigate the relationships among the changes in the context and the adaptation strategies to enact accordingly.

**Problem Statement:** Adaptable Service Based Applications (SBA) have to react to changes in the user's requirements or context. In order to have adaptable applications, factors such as adaptation and context should be considered since the early phases in the development life cycle. In particular, we are interested in outlining the relationships among changes in the context factors and the adaptation strategies that can be triggered to react to them. We investigate how the knowledge about the context can be modeled and gathered during the lifecycle of a SBA, and how it can be exploited to drive adaptation.

**Relevance of the Problem and Progress from State of the Art:** In some cases the evolution of the user requirements and context should be managed on the fly during the execution of an application. The literature offers techniques addressing specific aspects of the problem, but, to our knowledge, a comprehensive approach to design and develop adaptable Service-Based Applications (SBAs) is still missing. We would like to achieve the provisioning of guidelines in order to support the designer from the requirements elicitation to the construction of proper adaptation mechanisms. We argue that there is a need for a properly defined life cycle, where each phase takes explicitly into account adaptation- and context- specific aspects.

**Solution Idea and/or Solution and/or Research Method:** We propose a context model that is an XML representation of the context dimensions individuated for a service based application: the time in which the user is accessing the application, the location from where the request is coming, the typology of the user accessing the application, the business goals of the application, and the devices the user is using during the request. Moreover, we define a three phases approach for enabling context-driven adaptation. The approach starts from the identification of the context dimension relevant for the considered application and from the evaluation of the impacts that each context factor has on the application, goes through the identification of the associations between the adaptation strategies and the triggers till the construction of monitoring and adaptation mechanisms.

**Benefits and Evaluation:** The paper focuses on the role of the context in the adaptation activities for a SBA. The approach has been described on the basis of the life-cycle emphasizing the importance of the context elements in the different facets of adaptation. We propose a model for the context considering all the factors influencing the system behaviour. On the basis of the context model the proposed approach provides guidelines for the identification of the relevant context dimensions to monitor and for the definition of relationships among the adaptation triggers and the adaptation strategies. The effectiveness of discussed principles and guidelines has been evaluated by considering a case study based on one of the pilot cases defined in the WP-IA-2.2, the e-government scenario.

**Discussion and Future Work:** The adaptation process shown in the paper should be refined. Moreover, a more systematic validation is needed. Future works will focus on the development of the mechanisms and tools supporting the methodology.

**Relation to WP Challenges:** The paper addresses some of the research challenges defined for the WP JRA-1.1; the focus was on the refinement of the lifecycle for the adaptable service based applications concentrating on the definition of a context model and on the associations between the context factors and the adaptation strategies. ("Definition of a coherent life cycle for adaptable and evolvable SBA", "HCI and context aspects in the development of service based application" and "Understand when an adaptation requirement should be selected").

**Relation to Research Framework:** Referring to the Research Framework, the approach proposed in the paper covers the elements "Engineering and Design" and "Monitoring and Adaptation". The approach, moreover, focuses on all the phases of the lifecycle, refining them with context-dependent elements.

## *2.9 Improving the Adaptation of Service-Based Applications by Exploiting Assumption-Based Verification Techniques [9]*

**Context and Background**: Service Based Applications (SBAs) are composed of services provided by service providers that are often different from the company that is operating the SBA. In this way the core component of the SBA is not under the control of the SBA owner, as the SBA owner cannot control the provisioning, execution, management and evolution of externally provided services. This means that the SBA designer must rely on the ability of the service providers to meet the expected functionality and quality of those services (encoded, for instance, as service-level agreements). Once the SBA is put into operation, those expectations may—intentionally or unintentionally—be violated; for instance, a service might fail. The operator of the SBA must not only recognize these violations but also decide whether those violations mean that the overall SBA requirements will no longer be met. In such a case an adaptation of the SBA can become necessary.

**Problem Statement**: Our approach presented in [9] is able to detect run-time problems and violations of SBA's requirements and to identify specific root causes for those problems in order to determine appropriate adaptation actions.

**Relevance of Problem and Progress from State of the Art**: Currently, monitoring is used to trigger the adaptation of a service-based application. However, existing monitoring techniques—as detailed below — exhibit several limitations which impact on taking adaptation decisions. Failing to make those decisions may lead to unnecessary or harmful adaptations.

- *Monitoring individual services*: It is possible to monitor specific events and elements of the SBA, such as monitoring the constituent services. Such approaches recognize whether a service delivers the expected functionality or quality. However, it is unclear whether this violation of the contract eventually leads to a violation of the SBA's requirements. Without this information we cannot decide whether the SBA should be adapted or not. Assume, for instance, that a service takes 1s longer than expected. It may be the case that the service is part of a parallel control flow in the service composition and that such a delay does not have any impact on the performance of the parallel control flow and thus the overall quality of the SBA.
- *Monitoring service compositions / SBAs*: The requirements to the whole service composition may be monitored. In this way it is possible to check whether the composition behaves as required. However, in this case, the identification of the source of the requirements violation is not trivial. Assume, for instance that a service composition takes 30s longer than expected to terminate. "Debugging" as an additional step would then be needed to determine, which service(s) caused that delay. It is important to know the cause of the problem to compensate for it by adapting the system; e.g., one could replace the service that caused the delay.
- *Combined efforts*: Even a combination of the above two techniques has limitations. Indeed, in case of complex SBAs, a variety of events and violations may occur. How to debug and identify a specific cause of the requirements violation in order to trigger proper adaptation actions remains an open problem in such a case. Additionally, even with the combined approach we can only identify a problem of the service composition when this is identified by monitoring. This especially means that it is not possible to "predict" whether a violation of a service contract (detected by monitoring individual services) may eventually lead to a violation of the requirements of the service composition.

**Solution Idea**: To achieve this, our approach augments monitoring techniques (to detect service failures) with formal verification techniques (to determine requirements violations). The central idea of our approach is to observe specific properties — assumptions — that (1) are explicitly related to the requirements and (2) characterize the constituent services of the SBA. Thereby, our approach allows (a) verifying whether a problem can lead to a violation of requirements, and (b) tracing the violation to its root cause, which facilitates adaptation.

**Benefits and Evaluation**: The approach proposed comes with two prospective benefits:

1. The approach supports pro-active adaptation, e. g., it allows issuing an adaptation trigger before the SBA instance terminates.
2. The approach avoids unnecessary adaptations since an adaptation is only triggered if a violation will be violated.
3. Once an adaptation trigger is issued, the root-cause of the problem can be identified, leading to more effective adaptation strategies.

**Discussion and Future Work**: In the future we are going to implement our approach using the Astro/Dynamo monitoring framework and standard verification techniques. This implementation is used to validate the feasibility of our approach. Other research questions, which will be addressed in the future include:

1. The extension of the approach to contextual knowledge, e.g., to use the approach for triggering adaptation once the context changes.
2. The formulation of the assumptions in a way that a violation of the assumptions leads to a violation of the requirements and, thus, makes the re-verification step unnecessary.
3. Development of a process, which supports the definition of the assumptions, requirements and the SBA.

**Relation to WP Challenges**: This paper concentrates on "HCI and context aspects in the development of service based applications", "Run-time Quality Assurance Techniques" and "Quality Prediction Techniques to Support Proactive Adaptation".

**Relation to Research Framework**: QDNA, Operation and Management, Run-time QA Engine

## *2.10 Architecture Views illustrating the Service Automation Aspect of SOA [10]*

**Context and Background:** As services are the core components of a SBA, a decision must be made whether each of the services should be automated (e. g. realised by a software system) or should be provided by a human. Especially if services execute complex tasks, an automation may require a long software development process and, therefore, may hinder the agility of the entire SBA once the requirements and context situations of the SBA change.

**Problem Statement:** Given the context and background from above, the decision on whether services in a SBA should be supported by software or provided by humans should be rationalised. The paper deals with this questions and show, which factors influence the automation decision of services.

**Relevance of the Problem and Progress from State of the Art:** Although desirable, completely automating services are not always technically feasible or are often restricted by domain-specific factors. Therefore, there is always a certain proportion of the SBA, which must be executed manually (e. g. by a human). Consequently, a good balance between human-provided and software services should be achieved. Current approaches, however, do not discuss when such a balance is "good". The present paper is an initial step towards rationalising the decision on automating services and describes the factors influencing this decision.

**Solution Idea and/or Solution and/or Research Method:** We took a viewpoint approach for framing a basic set of concerns relating to service automation and providing a set of models, methods and notations to illustrate the way in which the concerns are addressed in architecture design.

**Benefits and Evaluation:** The approach presented in the paper has successfully shown their capability of framing service automation concerns and illustrated the relevant solution space in three different business domains and one scientific experiment in an educational setting. The positive feedback from

the users confirms that the corresponding views do address their concerns and even make their unconscious concerns explicit.

**Discussion and Future Work:** More validation on the applicability of the 3D service automation viewpoints need to be done.

**Relation to WP Challenges:** This paper concentrates on "HCI and context aspects in the development of service based applications".

**Relation to Research Framework:** Framework (Adaptation and Monitoring; Engineering and Design, Quality Definition, Negotiation and Assurance), Life Cycle (Requirements engineering and design; Deployment and provisioning; Operation & management; Identify adaptation need; Identify adaptation strategy), Infrastructure (Monitoring engine; Adaptation engine), Logical design environment (A&M modeller)

# 3 Conclusions

The deliverable comprises seven papers, which are related to the topic of exploiting of codified contextual knowledge for SBAs. As we have seen the papers address different aspects of context ranging from HCI factors to classical context factors. Especially [10] introduced service engineering design decision as new context factor, which was not considered by the project so far.

Given the coverage of the life cycle we clearly see a movement from approaches, which only cover individual phases to approaches, which cover overarching aspects of the life cycle. A good example of such integrated approach is provided in paper [8].

In the forthcoming deliverables we will continue pursuing the integration of HCI and contextual aspects within the SBA life cycle.

Moreover, the measurability of the processes and products of the life cycle will be analyzed in more details. The SBA life cycle will be connected more clearly with the way the runtime framework for adaptation defined in JRA-1.2 will work. Moreover, the adaptation and evolution strategies and mechanisms defined within JRA-2 will be properly integrated within the life cycle. The initial attempt presented in this deliverable (see paper [6]) of applying software engineering techniques to the specific issues raised within JRA-2 will be also continued.

# References

[1] Kounkou, A.; Zachos, K.; Maiden, N.: *Exploiting user error knowledge for service discovery*. – not yet submitted.
[2] Kounkou, A.; Zachos, K.; Maiden, N.: *Exploiting user model information for service discovery*. – not yet submitted
[3] Zachos, K.; Kounkou, A.; Maiden, N.: *Codified Knowledge about User Task Modelling Applied to Service Discovery*. – not yet submitted.
[4] Dhungana, D.; Seyff, N.; Graf, F.: *Using Codified Context Knowledge to Facilitate End-user Requirements Elicitation*. – not yet submitted.
[5] Lucchese, C.; Orlando, S.; Perego, R.; Silvestri, F.; Tolomei, G.: *Detecting Task-based Query Sessions using Wiktionary*. – not yet submitted.
[6] Dubois, D. J.; Nikolaou, C.; Voskakis, M.: *A model transformation for increasing value in service networks through intangible value exchanges*. In : International Conference on Service Science, ICSS2010, May 13-14, Hangzhou, China, 2010 – accepted for publication.
[7] Cappiello, C.; Pernici, B.: *QUADS: Quality-Aware Design of dependable Service-based processes*. To be submitted to Transactions on Software Engineering.

[8] Bucchiarone, A.; Kazhamiakin, R.; Cappiello, C.; di Nitto, E.; Mazza, V.: *A Context-driven Adaptation Process for Service-based Applications*. In: on Principles of Engineering Service-Oriented Systems (PESOS 2010). – accepted for publication
[9] Gehlert, A.; Bucchiarona, A.; Kazhamiakin, R.; Metzger, A.; Pistore, M.; Pohl, K.: *Exploiting Assumption-Based Verification for the Adaptation of Service-Based Applications*. In: Proceedings of the 25th Annual ACM Symposium on Applied Computing, Track on Service Oriented Architectures and Programming, March 21 - 26, 2010, Sierre, Switzerland. 2010.
[10] Gu, Q. ; Cuadrado, F. ; Dueñas J. C., Lago, P.: *Architecture Views illustrating the Service Automation Aspect of SOA*. In: Service Based Systems: Surveys by the S-Cube Project, Springer-Verlag, 2010, Ch. – accepted for publication
[11] Maiden, N. (Ed.): *Codified Human-Computer Interaction (HCI) Knowledge and Context Factors*. S-Cube Deliverable PO-JRA-1.1.3, 2009.
[12] di Nitto, E. (Ed.): *State of the art report on software engineering design knowledge and Survey of HCI and contextual Knowledge*. S-Cube Deliverable PO-JRA-1.1.1, 2008.
[13] Gehlert, A.; Pistore, M.; Plebani, P.; Versienti, L. (Eds.): *First Version of Integration Framework*. S-Cube Deliverable CD-IA-3.1.3, 2009

# Appendix A Input to the Integrated Research Framework

## *A.1 User Error for SBA Engineering*

| **Research Result** | |
|---|---|
| *Name* | Exploiting user error knowledge to inform SBA engineering |
| *Synopsis* | HCI knowledge about user error can enhance SBA's recovery and error handling mechanisms |
| *Authors* | Angela Kounkou, Kos Zachos, Neil Maiden |
| ***Type*** | Method |
| *Description* | Fault-tolerance for services and SBAs does not exploit knowledge on the human sources of faults occurring in SBAs; it is however well-documented in HCI that most system faults find their roots in errors committed by the human stakeholders, and that knowledge about user error is useful in the design of more robust, fault-tolerant systems. User error taxonomies and interaction models can be drawn upon to frame the common user error types liable to occur at various stages of a user interaction with SBAs. The resulting insights can be used to derive fault prevention or handling strategies effected during:<br>• service discovery at design time, to inform the service discovery process and specifically seek to select services handling the common or likely errors a user is susceptible to make.<br>• service discovery at runtime, to enact adaptation as a reaction to SBA faults possibly introduced by user errors. |
| ***Challenges*** | HCI and context aspects in the development of service based applications |
| ***IRF elements*** | Service engineering and Design<br>Adaptation and Monitoring |
| ***Related questions*** | Identifying relevant HCI knowledge for SBA engineering |
| *References* | PO-JRA-1.1.3 Codified Human-Computer Interaction (HCI) Knowledge and Context Factors<br>CD JRA 1.1.5. Analysis on how to exploit codified HCI and codified context knowledge for SBA engineering (upcoming) |

| | |
|---|---|
| *Glossary* | HCI, Service based application, User error |
| *Keywords* | HCI, Service based application, User error |

| **Research Result** | |
|---|---|
| *Name* | Approach to using user error knowledge for service discovery |
| *Synopsis* | Codified user error knowledge to provide additional criteria and filters for the discovery of services implementing specific user error-avoidance or user error-handling strategies. |
| *Authors* | Angela Kounkou, Kos Zachos, Neil Maiden |
| ***Type*** | Method |
| *Description* | User error taxonomies and interaction models can be drawn upon to frame the common user error types liable to occur at various stages of a user interaction with SBAs. The resulting insights can be used to derive fault prevention or handling strategies effected during:<br>• service discovery at design time, to inform the service discovery process and specifically seek to select services handling the common or likely errors a user is susceptible to make.<br>• service discovery at runtime, to enact adaptation as a reaction to SBA faults possibly introduced by user errors.<br>User error knowledge is codified as heuristics and selection rules for design time service discovery, and as constraint queries during runtime service discovery to specify additional constraints that a candidate service's specification must match on top of matching the structural and behaviour of an existing service to be replaced. |
| ***Research questions*** | Exploiting user error knowledge to inform SBA engineering |
| ***Related research results*** | |
| *References* | PO JRA 1.1.5 |
| *Glossary* | HCI, Service based application, User error |
| *Keywords* | HCI, Service based application, User error |

## *A.2 Exploiting User Model Information for Service Discovery*

| ***Research Question*** | |
|---|---|
| *Name* | Exploiting user model knowledge in SBA engineering |
| *Synopsis* | SBA engineering does not currently take into account end users' properties such as abilities, needs and preferences. User models, used in HCI to encapsulate this type of information, are investigated for use in SBA engineering. |
| *Authors* | Angela Kounkou, Kos Zachos, Neil Maiden, , |
| ***Type*** | Method |
| *Description* | [confer to general questions for HCI knowledge codification] |
| ***Challenges*** | ▪ HCI and context aspects in the development of service based applications<br>▪ Measuring, controlling, evaluating and improving the life cycle and the related processes |
| ***IRF elements*** | **Life cycle:**<br>▪ Early Requirement Engineering,<br>▪ Requirement Engineering and Design,<br>▪ Construction and Quality Assurance, |

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|---|---|
| | ▪ Deployment and Provisioning,<br>▪ Identify Adaptation Requirements,<br>▪ Identify Adaptation Needs<br>**Framework:**<br>▪ Service engineering and Design<br>▪ Adaptation and Monitoring |
| ***Related questions*** | Identifying relevant HCI knowledge for SBA engineering |
| *References* | PO-JRA-1.1.3 Codified Human-Computer Interaction (HCI) Knowledge and Context Factors |
| *Glossary* | HCI, Service based application, User model |
| *Keywords* | HCI, Service based application, User model |

| **Research Result** | |
|---|---|
| *Name* | Approach to using user modelling for service discovery |
| *Synopsis* | Codified user model facets and user-based rules that provide additional criteria and filters for the discovery of candidate services whose specifications match a user model's requirements. |
| *Authors* | Angela Kounkou, Kos Zachos, Neil Maiden |
| ***Type*** | Method |
| *Description* | Proposed method to use UM information in service discovery. Developed a user model as a faceted representation of aspects of the user; then a set of these facets was codified into XML-based templates and added to the UCaRE module, to provide information about the user. Plain-text heuristics expressing the alterations or qualities an SBA would ideally make or have (respectively) to best match a user's requirements were developed, then codified to be added as user model rules to the repository of SeCSE service queries. They were formalised to: specify the relevant user model facet and providing the path to its relevant node; link to the relevant service description facet by providing its path node for the verification of the rule; specify the type of verification to be performed (e.g. existence of a criterion, ranges the criterion had to be within); and suggest keywords for the query expansion for each of these rules. |
| ***Research questions*** | Exploiting user model knowledge in SBA engineering |
| ***Related research results*** | |
| *References* | PO JRA 1.1.5 |
| *Glossary* | HCI, Service based application, User model |
| *Keywords* | HCI, Service based application, User model |

## *A.3 Codified Knowledge about User Task Modelling Applied to Service Discovery*

| **Research Question** | |
|---|---|
| *Name* | Codified Knowledge about User Task Modelling Applied to Service Discovery |
| *Synopsis* | During the use of SBAs new services need to be discovered if these services become available or currently invoked services need to be replaced by other services with improved qualities such as performance and reliability. Processes and techniques for service discovery have been researched extensively in previous projects. However, none of these processes and techniques explicitly use |

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| | knowledge about user tasks to refine the discovery and selection of services appropriate to the user task. |
| *Authors* | Konstantinos Zachos, Angela Kounkou, Neil Maiden |
| ***Type*** | Method |
| *Description* | Current service-oriented approaches rely primarily on business process models and notations such as BPEL to indicate the process-oriented context in which a service needs to be invoked; however process models normally lack other important information about the actor who is performing the process and his actions. HCI task modelling techniques can contribute to the output of these changes by focusing on the tasks and the human users rather than on the system in place and the processes to be. They can also support the definition of appropriate level of granularity, and functional service cohesion for SBAs by helping to clearly scope and define tasks for their later implementation as service operations. |
| ***Challenges*** | - HCI and context aspects in the development of service based applications |
| ***IRF elements*** | Service engineering and Design<br>Adaptation and Monitoring |
| ***Related questions*** | Identifying relevant HCI knowledge for SBA engineering |
| *References* | PO-JRA-1.1.3 Codified Human-Computer Interaction (HCI) Knowledge and Context Factors |
| *Glossary* | HCI, Service based application, Task model |
| *Keywords* | HCI, Service based application, Task model |

| **Research Result** | |
|---|---|
| *Name* | Task-based Service Discovery using User Task Knowledge |
| *Synopsis* | SBA engineering does not currently take into account end users' properties such as abilities, needs and preferences. User models, used in HCI to encapsulate this type of information, are investigated for use in SBA engineering. |
| *Authors* | Konstantinos Zachos, Angela Kounkou, Neil Maiden |
| ***Type*** | Technique |
| *Description* | We propose the application of user task models as part of a new requirements-based service discovery approach to integrate human actors in the discovery and selection of SBAs. The approach describes how user task models will enhance the service discovery process based on a task knowledge base. In order to populate such a task knowledge base we elicit domain-specific knowledge that describes service-centric solutions for known tasks in the navigation domain based on the S-Cube E-Government case study scenarios. Then, we extract the domain-specific task knowledge to generate domain-independent task knowledge that can be reused, similar to the KADS approach to knowledge modelling. Such domain-independent task knowledge can be used to describe more specific task knowledge in a new domain that decreases the cost for expanding the coverage of task knowledge. |
| ***Challenges*** | ▪ HCI and context aspects in the development of service based applications<br>▪ Measuring, controlling, evaluating and improving the life cycle and the related processes |
| ***IRF elements*** | **Life cycle:**<br>▪ Early Requirement Engineering,<br>▪ Requirement Engineering and Design, |

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|---|---|
| | ▪ Construction and Quality Assurance,<br>▪ Deployment and Provisioning,<br>▪ Identify Adaptation Requirements,<br>▪ Identify Adaptation Needs<br>**Framework:**<br>▪ Service engineering and Design<br>▪ Adaptation and Monitoring |
| ***Related questions*** | Identifying relevant HCI knowledge for SBA engineering |
| *References* | PO-JRA-1.1.3 Codified Human-Computer Interaction (HCI) Knowledge and Context Factors |
| *Glossary* | HCI, Service based application, User model |
| *Keywords* | HCI, Service based application, User model |

## *A.4 Using Codified Context Knowledge to Facilitate End-user Requirements Elicitation*

| **Research Question** | |
|---|---|
| *Name* | Codified Context Knowledge for enhancing Requirements Elicitation |
| *Synopsis* | The goal of our research is to *explore how codified context knowledge can support end-users in specifying individual needs and self-customizing service-oriented solutions*. We aim to build tools and techniques that enable end-users in gathering requirements and consequently customizing a service-based application. |
| *Authors* | Deepak Dhungana, Norbert Seyff, Florian Graf |
| ***Type*** | Technique |
| *Description* | Short description of the question. |
| ***Challenges*** | HCI and context aspects in the development of service based applications. |
| ***IRF elements*** | Framework (Engineering and Design), Life Cycle (Requirements Engineering & Design) |
| ***Related questions*** | |
| *References* | |
| *Glossary* | |
| *Keywords* | End-user requirements elicitation; codified context knowledge; software product lines; automated customization of applications |

| **Research Result** | |
|---|---|
| *Name* | Product Line Modelling approaches for codifying context knowledge. |
| *Synopsis* | By using established product line modelling approaches for codifying context knowledge and using such models to enhance the requirements elicitation approaches, we have developed a tool to stimulate the end-users creativity during requirements elicitation. |
| *Authors* | Deepak Dhungana, Norbert Seyff, Florian Graf |
| ***Type*** | Technique |
| *Description* | We propose a solution which facilitates end-users requirements elicitation by providing contextual information codified in models of reuse-based approaches such as software product line engineering. We present a “smart” tool for end-users allowing them to specify their needs and to customize a service-oriented software system based on given contextual information. |
| ***Research questions*** | Codified Context Knowledge for enhancing Requirements Elicitation |

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| ***Related research results*** | |
| *References* | |
| *Glossary* | |
| *Keywords* | End-user requirements elicitation; codified context knowledge; software product lines; automated customization of applications |

## *A.5 Detecting Task-based Query Sessions using Wiktionary*

| **Research Question** | |
|---|---|
| *Name* | Activity model extraction to recommend human-based tasks. |
| *Synopsis* | Is it possible to devise coherent groups of human-performed activities oriented towards a common goal? E.g. a person willing to buy a car will start looking for different subjects such as: different types of engines, different types of car, different price levels, etc. |
| *Authors* | Fabrizio Silvestri, Gabriele Tolomei |
| ***Type*** | Method |
| *Description* | Following the shift in Web usage is it possible to identify task-based sessions within usage logs? In other words, we look for sessions related to human-based tasks and processes users try to accomplish using the Web. Thus, we will be able to collect a knowledge base of tasks (and processes), above which we plan to setup new recommendation strategies. Such strategies go beyond traditional query suggestion, nowadays available in most popular WSEs. Indeed, recommendation should be task-based, taking into account the task as a whole instead of simple queries. |
| ***Challenges*** | ▪ Extract and recommend human-based tasks as reusable components performed on the Web<br>▪ HCI and context aspects in the development of service based applications |
| ***IRF elements*** | BPM, Service Composition and Coordination, Requirements Engineering & Design, Operation & Management. |
| ***Related questions*** | Devise a Web-based task model. |
| *References* | Gabriele Tolomei: Search the web x.0: mining and recommending web-mediated processes. RecSys 2009: 417-420. |
| *Glossary* | User Experience, Task Modeling. |
| *Keywords* | task recommender systems, log analysis, process mining. |

| **Research Result** | |
|---|---|
| *Name* | Task based human-performed session extraction |
| *Synopsis* | We defined a novel similarity metric for human-based web activity and we tested it on queries submitted to a Web search engine and recorded in query logs.<br>We proposed the use of two popular clustering algorithms (i.e. DBScan, and X-Means) using the previously defined metric to extract coherent sessions from the usage data we have. |
| *Authors* | Claudio Lucchese, Salvatore Orlando, Raffaele Perego, Fabrizio Silvestri, Gabriele Tolomei. |
| ***Type*** | Method |
| *Description* | We defined a novel similarity metric for human-based web activity and we tested it on queries submitted to a Web search engine and recorded in query logs.<br>We proposed the use of two popular clustering algorithms (i.e. |

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| | DBScan, and X-Means) using the previously defined metric to extract coherent sessions from the usage data we have. |
| ***Research questions*** | Activity model extraction to recommend human-based tasks. |
| ***Related research results*** | Collect a large knowledge base of human-performed Web tasks. |
| *References* | |
| *Glossary* | User Experience, Task Modeling. |
| *Keywords* | task recommender systems, log analysis, process mining. |

## *A.6 A model transformation for increasing value in service networks through intangible value exchanges*

| **Research Result** | |
|---|---|
| *Name* | A model transformation for increasing value in service networks. |
| *Synopsis* | Study and identification of common patterns in service networks, and evaluation of possible transformations for increasing their value. |
| *Authors* | Daniel Dubois, Christos Nikolaou, Manolis Voskakis |
| ***Type*** | Method. |
| *Description* | This contribution proposes a method for increasing the agility of a service network in such a way that the network and the underlying business processes are able to spontaneously react to changes in the requirements or in the environment. This is done by making extensive use of knowledge transfer and intangible interactions among network participants. The study is supported by a technique for estimating the value and therefore to support the final decision whether to reconfigure the network or not. The approach we proposed has then been exemplified using a traditional car sharing scenario as a case study. |
| ***Research questions*** | How to improve Business Process Management in Service Networks.<br>How context information could be exploited during the lifecycle. |
| ***Related research results*** | Design for Adaptation of Service-Based Applications: Main Issues and Requirements.<br>Calculating Service Fitness in Service Networks. |
| *References* | D.J. Dubois, C. Nikolaou, M. Voskakis, A model transformation for increasing value in service networks through intangible value exchanges. International Conference on Service Science, 2010 (submitted for publication, currently under peer review). |
| *Glossary* | BPM, Context. |
| *Keywords* | Value networks, business process management, service networks, value analysis. |

## *A.7 QUADS: Quality-Aware Design of dependable Service-based processes*

| **Research Result** | |
|---|---|
| *Name* | Quality-Aware Design of dependable Service-based processes |
| *Synopsis* | Process modelling takes into account both the global quality of the resulting process, and the adaptation capability of the underlying infrastructure, and the stakeholders' evaluation of the process quality. |
| *Authors* | Cinzia Cappiello, Barbara Pernici |

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| ***Type*** | Method |
| *Description* | A quantitative method to select design actions to improve the service-based process dependability |
| ***Research questions*** | Definition of a coherent life cycle for adaptable and evolvable SBA, HCI and context aspects in the development of service based applications |
| ***Related research results*** | |
| *References* | C. Cappiello, B. Pernici, QUADS: Quality-Aware Design of dependable Service-based processes, under submission |
| *Glossary* | Adaptable Service-Based Application, Adaptation Strategy, business process modelling, constructive quality assurance, design for adaptation, Quality of Service-Aware Service Composition, requirement, user modelling |
| *Keywords* | Service-based process, dependability, adaptivity |

## *A.8 A context-driven Adaptation Process for Service-based Applications*

| **Research Result** | |
|---|---|
| *Name* | Define a suitable context model and a context-driven adaptation process for adaptable service-based applications |
| *Synopsis* | We define a context model taking into account the main dimensions characterizing the status of an application. We investigate how the knowledge about the context can be modelled and gathered during the lifecycle of a SBA, and how it can be exploited to drive adaptation. |
| *Authors* | A. Bucchiarone, C.Cappiello, E. Di Nitto, R. Kazhamiakin, V. Mazza |
| ***Type*** | methodology |
| *Description* | We defined a context model taking into account the main dimensions characterizing the status of an application. The dimensions we considered were six: Time, Service, User, Ambient, Business and Computational aspects. Each dimension refers to a particular context factor useful for the context definition. We instantiated the context model on the e-government case study, defining for each considered dimension, the set of admissible values. Moreover, we have defined the relationships among changes in the context factors and the adaptation strategies that should be enacted. In particular we have proposed an approach for the context-driven adaptation; such process is structured in three phases including the context modelling, the modelling of the adaptation triggers and the requirements and, finally, the construction of contextual monitors and adaptation mechanism. In particular, during the first phase (the context modelling), the model we proposed for the context formalization is instantiated by identifying the list of the context dimensions that can trigger an adaptation or evolution of the functionalities provided by the considered application. In fact, depending on the application, context dimensions could have more or less impact on the behaviour. Once the list of the relevant context dimensions has been defined, they have to be put in relationships with the element of the SBA. After the first phase, it is necessary to properly capture and define the adaptation aspects. In particular, it is important to define when the contextual changes are critical for the application behaviour (adaptation trigger), and what |

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| | should be done or achieved when these changes take place (adaptation needs). Moreover, the associations between the contextual changes, the adaptation needs, and the related adaptation triggers have to be defined. Finally, the results of the analyses performed in the previous phases support the SBA designer in the realization of monitors and adaptation strategies that should be included in the SBA design. |
| ***Research questions*** | How context information could be exploited during the lifecycle, Design for Adaptation |
| ***Related research results*** | Design for Adaptation of Service-Based Applications: Main issues and Requirements. |
| *References* | A. Bucchiarone, C. Cappiello, E. Di Nitto, R. Kazhamiakin, V. Mazza, "A Context-driven Adaptation Process for Service-based Applications", submitted to PESOS 2010 |
| *Glossary* | Context-Awareness, Context, Design for Adaptation |
| *Keywords* | design for adaptation, context model |

## *A.9 Exploiting Assumption-Based Verification for the Adaptation of Service-Based Applications*

Already part of the IRF.

## *A.10 Architecture Views illustrating the Service Automation Aspect of SOA*

| **Research Question** | |
|---|---|
| *Name* | The identification of automation viewpoints of SBA adaptation. |
| *Synopsis* | The need of service-oriented viewpoints to address specific concerns related to the service adaptation process, in particular, concerns related to human participation. These viewpoints should provide guidance on the service adaptation process. |
| *Authors* | Qing Gu, Patricia Lago |
| ***Type*** | Modelling |
| *Description* | During the service adaptation process, often a decision has to be made between automating an activity and letting a human actor to take over the control. The decisions on automating adaptation activities are often influenced by some domain specific factors, such as the technical skill of the human actor, the characteristics of services and infrastructures, the feasibility of defining adaptation rules, etc. Thereby, making good decisions is one of the concerns of SOA architects. From the field of software architecture, the concept of viewpoints is often used to frame concerns. The challenge is to identify a set of concerns related to service adaptation process and to develop a set of viewpoints to illustrate (in an effective and systematic way) how the concerns are addressed. |
| ***Challenges*** | Mixed initiative SBA adaptation |
| *IRF elements* | Framework (Adaptation and Monitoring; Engineering and Design, Quality Definition, Negotiation and Assurance), Life Cycle (Requirements engineering and design; Deployment and provisioning; Operation & management; Identify adaptation need; Identify adaptation strategy), Infrastructure (Monitoring engine; Adaptation engine), Logical design environment (A&M modeller) |

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| ***Related questions*** | What factors influence human participation in service adaptation activities? |
| *References* | [1] Q. Gu and P. Lago, "On Service-Oriented Architectural Concerns and Viewpoints," in 8th Working IEEE/IFIP Conference on Software Architecture (WICSA) Cambridge, UK, 2009, 4 pages.<br>[2] Q. Gu and P. Lago, "Exploring service-oriented system engineering challenges: a systematic literature review". Service Oriented Computing and Applications, 2009. 3(3): p. 171-188<br>[3]http://wwwp.dnsalias.org/wiki/WICSA_2009_BAVF:Architecture_Viewpoints_and_Frameworks |
| *Glossary* | Architectural knowledge; service aspect; adaptation, HCI |
| *Keywords* | Architecture concern, architecture viewpoint, service aspect, HCI, service adaptation |

| **Research Result** | |
|---|---|
| *Name* | 3-D Architecture Viewpoints on Service Automation |
| *Synopsis* | We address the need for explicit modelling support for the automation aspect at the architectural level, and we define three viewpoints illustrating the automation of services. These three viewpoints, respectively,: expresses decisions about automation; helps identifying the level (degree) of automation required, and represents the specific data required to support automation in services. |
| *Authors* | Qing Gu, Felix Cuadrado, Patricia Lago, Juan C. Duenas |
| ***Type*** | Architectural knowledge, modelling |
| *Description* | The 3D (decisions, degree, and data) viewpoints have been applied to three industrial case studies and one academic experiment. Results show that the viewpoints successfully aid both technical and non-technical stakeholders in understanding how their service automation-related concerns have been addressed. Furthermore, the application of the 3D viewpoints to different domains exhibits promising general applicability to SBAs. |
| ***Research questions*** | The identification of automation viewpoints of SBA adaptation. |
| ***Related research results*** | |
| *References* | |
| *Glossary* | Architectural knowledge; service aspect; adaptation, HCI |
| *Keywords* | Architecture concern, architecture viewpoint, service aspect, HCI, service adaptation |