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SOA Development and Service Identification

A Case Study on Method Use, Context and Success Factors

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Abstract

Although SOA development and service identification are widely discussed among academics and practitioners alike, little is known about how they are performed in practice. Thus, this paper investigates how SOA development and service identification work in real-life projects. An explorative single case study analysis is chosen as research methodology. It analyzes the ADAGE project, in which researchers implemented a service-oriented architecture in an Australian company. Furthermore, a situation-specific research process is developed. Elements of grounded theory and interpretative techniques are used to analyze interviews and documentations and to generalize the findings. Subsequently, 16 observations that describe SOA development and service identification in the ADAGE case are identified. Through generalization, these observations are transformed into hypotheses. In order to guide this generalization, both principles of interpretative field studies as well as abstraction mechanisms of conceptual modeling are utilized. The analysis of data and the generalization are accompanied by permanent comparison to discussions in related literature. A set of model fragments illustrating relationships of certain concepts and abstract categories are a major result of this case study. Aditionally, a number of opportunities for further research are outlined.

Keywords: Service-oriented Architectures, Service Identification, Business Process Management, Web Services, Case Study Research

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Content

1 Introduction

Service-orientation is currently a dominating paradigm for enterprise and IT architectures, and a topical subject in research and practice alike. Service orientation and service-oriented architectures (SOA) promise a greater flexibility of IT and a faster adoption to changing business needs; furthermore it is expected that reusability of services reduces redundancies and subsequently saves costs for maintenance and operation of applications and software systems.

Despite the high expectations, empirical knowledge on SOA development as well as on service identification, which is a critical early phase in every SOA endeavour, is rare. This corresponds to the level of empirical knowledge in most areas of systems and software development (Jarke, 2009; Charters et al., 2009).

Although a number of approaches exist to support the development of SOA in general and service identification in particular (Birkmeier et al., 2009; Börner and Goeken, 2009; Thomas et al., 2010), little is known about the advantages and situational appropriateness of the different approaches. Similarly, little is known about how SOA projects work in practice, for example, whether they are guided by methods, whether they are business or IT driven etc. We assume that empirical knowledge on the way of working in real life projects is important to pursue both, exploratory, descriptive, or explanatory research goals on the one hand and design-oriented research on the other.

Theory and understanding of SOA development and service identification are currently not well developed. Therefore, an interpretative and qualitative research design was used, taking into account that our research goal was to explore and understand a single case in detail and to structure observations, to derive hypotheses, and to develop a small set of model fragments which can best be interpreted as middle range theories.

The paper is organized as follows: Following this introduction, in section 2 we present the underlying research approach by discussing the appropriateness of the case methodology for the study at hand and outlining the research process. After a general case description in section 3, observations, hypotheses and model fragments are discussed in detail to allow the reader to follow our argumentations and generalizations (section 4). Section 5 discusses the findings and limitations of our study, and outlines future research needs. Section 6 comprises a general conclusion with respect to the research questions.

2 Methodology

In this section, we discuss the appropriateness of the selected research method and our philosophical stance. We also present our research process and describe the activities in detail. The aim is to clarify the methodology to reveal our underlying assumptions and to be compliant with proposed guidelines for the conduct of case study research (Klein and Myers, 1999; Atkins and Sampson, 2002).

2.1 The Appropriateness of Case Study Research

Even though case studies are widely accepted research methods in information systems, there is no common definition (Myers, 2009). For instance, case study research cannot be easily distinguished from field study research. Darke et al. (1998) point out that "the case researcher has less prior knowledge of constructs and variables" (p. 275), whereas Eisenhardt (1989) argues that the specification of a priori constructs is valuable for building theory from case study research. Klein and Myers (1999) instead imply that field studies include in-depth case studies. Hence, we choose a broad definition which is frequently used: "A case study is an empirical inquiry that investigates a … phenomenon within its real-life context." (Yin, 2003) (p. 41)

Despite the popularity of SOA, there is only little understanding of how to convey all advantages frequently mentioned in related literature. Moreover, little is known about methodological approaches in SOA development and how it takes place in practice. This corresponds to a low uptake of empirical research in systems and software development in general (Jarke, 2009).

Against this backdrop, we believe that qualitative case study research can make a useful contribution. Case studies are particularly relevant for research in its "early, formative stages" (Benbasat et al., 1987; Myers, 2009) which applies to the field of SOA (see also Luthria and Rabhi (2009) and Stebbins (2001)). As case studies can be descriptive and explorative in nature, they are supposed to give insights into how SOA development is performed. Furthermore, Benbasat et al. (1987) state that case study research is particularly appropriate for the study of information systems development, implementation, and use within organizations. Since we look at the development and implementation of an SOA, case study research is appropriate to investigate proceedings and reasons for the application of methods (see also Orlikowski (1993)).

The goal of our research is to understand and to explore how SOA development in its early stages and service identification in particular are performed in real-life projects. Due to this explorative objective, we consider case study research to be an appropriate method because a contemporary phenomenon is to be studied in its natural context (Yin, 2003), and we want to "provide descriptions of phenomena" (Darke et al., 1998). Descriptions and explanations of why a phenomenon occurs are provided by giving insight into the "generative mechanisms at work" (Walsham, 1995) (p. 79) observed within the case data.

With respect to our research goal, we derive hypotheses from the observations that have been made. Thus, we take the first steps in developing theory. The third research goal pointed out

by Darke et al. (1998) – apart from providing descriptions and developing theory – is the testing of hypotheses and theory which is not envisaged in this research.

Many authors criticize single case studies for several reasons. For instance, Lee (1989) outlines four problems of single case studies, namely making controlled observations, make controlled deductions, allowing for replicability, and allowing for generalizability. However, according to Darke et al. (1998), a single case study may provide the basis for developing explanations of why a phenomenon occurs. Accordingly, Walsham (1995) indicates that sin-gle cases allow researchers to investigate phenomena in depth to provide rich descriptions and understanding. A single case study is appropriate when it represents i) a critical case (it meets all the necessary conditions for testing a theory), ii) an extreme or unique case, iii) a representative or typical case, or iv) a revelatory case (Yin, 2003).

Our case study, referred to as the ADAGE project, is certainly an extreme case since project members did not explicitly apply certain work methods and since documentation or requirements were not provided in written form. Most of the information was communicated verbally, and many process steps were chosen intuitively with methods being implicit in the best case. Furthermore, the project's principal was not aware of business processes, and the concept of services was virtually unknown at the beginning of the project. Even though we regard ADAGE as an extreme case, it is not unique. The absence of method use is frequently encountered in system development projects and represents one of the main reasons for failure (Standish Group International, 1994). Additionally, it is often the case that project participants not only develop a new system but that they are also confronted with a new technical and conceptual environment. Therefore, we also consider ADAGE an interesting case to improve the understanding of this phenomenon.

We chose an interpretative stance for the current research. By interpreting individual viewpoints of relevant stakeholders/actors and moving back and forth between the collected data and theoretical hypotheses, we tried to develop a picture of the whole. In doing so, we considered the details "in light of a larger sense of the whole." (Boland et al., 2010) (p. 4) this should improve the understanding of the subject matter and help to develop a consistent set of hypotheses (Walsham, 2006; Klein and Myers, 1999). We also acknowledge that the observations made in the field cannot be completely value-neutral. Instead, we assume the relativity of our own position. We therefore attach importance to the transparency and traceability of the process and to the justification of our observations and derivation of hypotheses.

2.2 Research Process of Our Case Stuy

Following Eisenhardt (1989), we designed a research process for the study at hand which is depicted in Figure 1. The process commenced with the explication of "a priori constructs" (see section 2). These a priori constructs also help to guide the case analysis. However, they must not be confused with observations or hypotheses which are the results of the analysis performed later on. Furthermore, the **first activity** included creating an initial research question and more specific questions for investigation (see section 2). This is an important first Stepp to guide the case analysis and focus efforts.

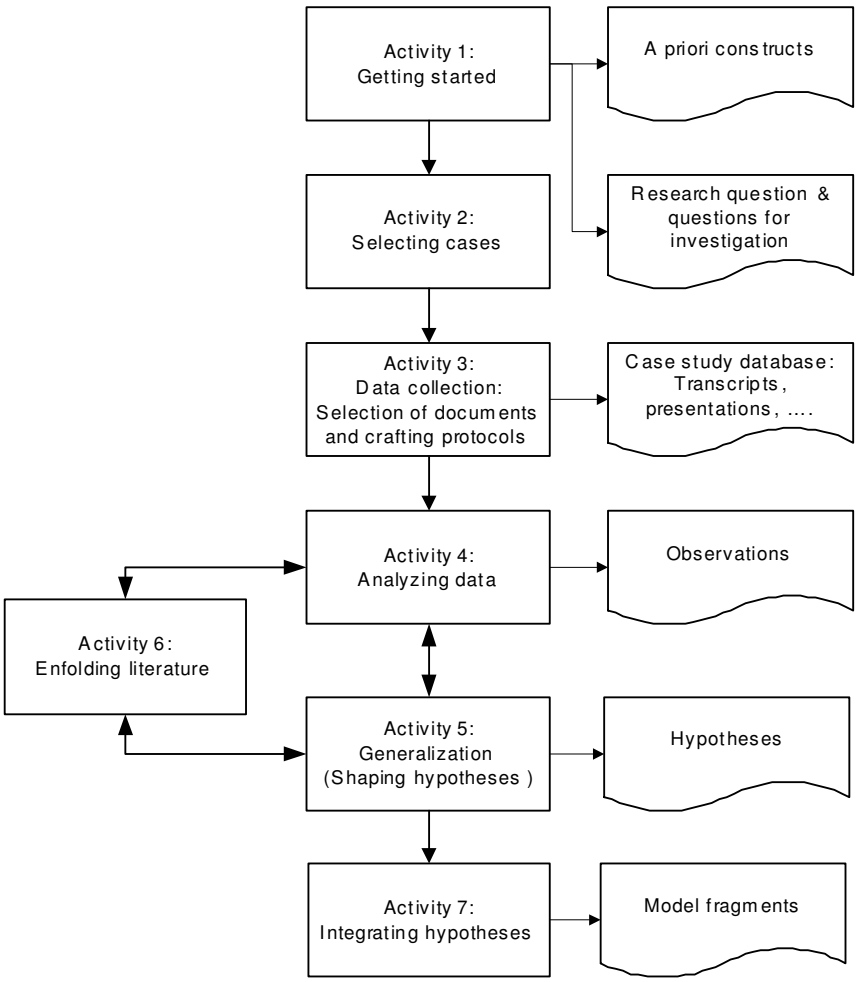

Figure 1: Activities and Deliverables of our Research Process

In a **second activity**, an appropriate case had to be selected. Since the objective of this case study was to enhance understanding and develop theory rather than testing it, the chosen case did not have to be representative. A theoretical sampling though is "particularly suitable for illuminating and extending relationships and logic among constructs" (Eisenhardt and Graebner, 2007) (p.27). Hence, we intentionally chose an extreme case as described earlier in this section.

Multiple data collection methods such as interviews and analysis of documentation were used in the **third activity** (see section 4.2). In order to have a solid and profound basis to build upon, collected data had to be gathered from multiple sources of evidence. Using different sources serves to underpin the completeness and correctness of data. Inconsistencies can be made obvious through the use of various sources. This triangulation of data is important for the reliability of the case study's outcomes (Yin, 2003). Flexible and opportunistic data collection methods allow for reacting to emergent themes by adjusting data collection when necessary (Eisenhardt, 1989). A case study database was created to make results and conclusions comprehensible for the reader. First, primary data such as project progress reports, presentations as well as published and unpublished papers were stored and listed. Second, reports of the investigation itself were provided. Interview schedules, a list of project members, anno-

tated bibliographies, audio records of the interviews, and interview transcripts are examples for this second class of documents in the database.

The **fourth activity** – analyzing data – began with the description of the project which was subject of our case study (see section 3) and continued with the grounding of our observations, as described in section 4.3. This was followed by the shaping of hypotheses through generalization, which is the subject of section 4.4. In the presentation of our research, we distinguish between observations and hypotheses (analyzing data and generalization, respectively) in order to enhance transparency, traceability, and reliability of the procedure, even though they are closely interwoven.

Activity four was dedicated to properly grounding concepts and patterns by triangulation. Construct validity was supported by using multiple sources of evidence (Eisenhardt, 1989). The identification of concepts and patterns was conducted by employing techniques from grounded theory, for example, open and axial coding (Strauss and Corbin, 1990), and interpretative techniques (see Walsham (1995) and Boland et al. (2010) for hermeneutical exegesis in IS). Even though we did not use the coding techniques to their fullest extent, the general approach and respective tools supported the assignment of statements from the interviews and documents to concepts. The goal was to detect relevant particulars within the idiographic details and to identify relevant concepts as well as "the "why" of what is happening"(Eisenhardt, 1989) (p. 542). Examining the texts and interviews in their contexts – for example, by answering questions like 'who wrote the text, for what purpose, and what is the state of the project at the moment of writing' – allowed for deeper interpretations of the mea-ning of statements and comments (Myers, 2009). In this respect, interpretative techniques and coding helped to describe the generative mechanisms at work and to discover the underlying reasons for why a relationship or pattern exists.

This activity resulted in observations which are judgments or inferences from what we observed in the field and for what we found deeper grounding in the data and in related literature (adapted from Merriam-Webster). These judgments/inferences are a first abstraction from this data, the "first-order concepts" as Van Maanen (1979) labels them. Second-order concepts (analogous to the concepts forming our observations) are "notions used by the fieldworker to explain the patterning of the first-order data" (van Maanen, 1979) (p. 451)

While concepts and observations are closely linked to the idiographic details, we generated hypotheses consisting of abstract categories in **activity five** (generalization). Extending Van Maanen's terminology (1979), we might label these hypotheses third-order concepts, which thus represent abstractions of abstractions of first-order data. We performed this by relating concepts described in the observations to categories applying interpretative techniques and principles of interpretative field studies (Klein and Myers, 1999) as well as abstraction mechanisms transferred from conceptual modeling. The categories and relationships between them should apply to multiple situations and hereby reach a certain level of generality.

Lee and Baskerville (2003) cast doubt on the generalizability of empirical descriptions in a case study beyond this given case. Nevertheless, they acknowledge that other researchers allow for generalization from empirical statements to theoretical statements (e.g., Walsham (1995)). Similarly, Klein and Myers (1999) recommend generalizations if they are "carefully

related to the case study details … so readers can follow how the researcher arrived at his or her theoretical insights" (p. 75).

In order to prevent excessive overestimation of the generalizability, the resulting hypotheses formed by categories and relationships should be viewed as tendencies (Walsham, 1995). The introduction of abstraction mechanisms of conceptual modeling (section 4.4) extends existing research techniques. Our intention was to make "controlled deductions" (Lee, 1989) and thus improve reliability and make the development of hypotheses traceable and transparent to the reader, thus relating hypotheses and observations carefully.

The **sixth activity** in the research process illustrated in Figure 1 consisted of a comparison with related – conflicting or similar – work, so called "enfolding literature." It aims at comparing opinions and positions found in related literature with the observations we made and improving the hypotheses. This results in hypotheses "with stronger internal validity, wider generalizability, and higher conceptual level." (Eisenhardt, 1989) (p. 544). Analyzing data (4) and generalization (5) are closely interwoven and both supported by the analysis of literature. According to Gadamer (1976), "the harmony of all the details with the whole is the criterion of correct understanding" (p.117), and in a number of iterations "a complex whole of shared meaning emerges" (Klein and Myers, 1999) (p. 71). This is represented by the iterative layout of activities four to six. The focus is on constantly comparing hypotheses and data, iterating towards a set of hypotheses which closely fits the data (Eisenhardt, 1989).

Finally, **activity seven** integrated several hypotheses to build model fragments (section 4.5). Through another generalization, these fragments have an even higher level of abstraction and are thus more remote from the first-order data. Figure 2 illustrates the increase of abstraction with each activity performed moving from left to right. Considering semantic levels, model fragments encompass both the level of instances and the level of types. They incorporate categories used in our hypotheses but also include concepts – including those we were not able to observe in our case study.

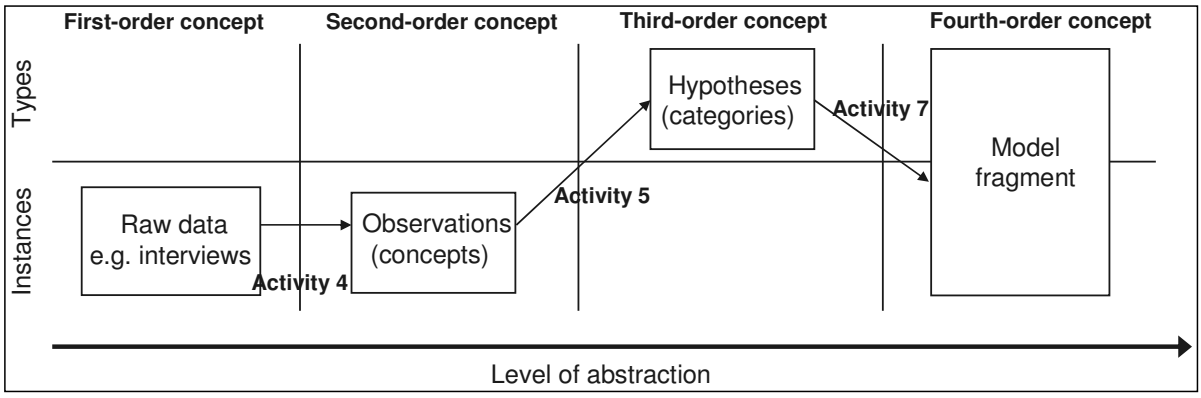

Figure 2: Abstraction and Semantic Level

We consider the resulting model fragments to be middle range theories as they are of limited conceptual range and to be intermediate to the hypotheses derived from the observations and the total conceptual structures of "grand theories". At this point our notion of theory is adopted from Gregor's classification (Gregor, 2006). While the set of interconnected categories -

forming the hypotheses - are "statements provide a lens for viewing or explaining the world", the middle range model fragments are "statements of relationships among constructs" (p. 613) in terms of generative mechanisms.

3 Case Description

3.1 Stakeholders

"Ad-hoc DAta Grids Environments" (ADAGE) is a collaborative research initiative between a university (UNSW) and an industry partner (SIRCA). It can be regarded as an umbrella for three sources of funding, so it aims to address differing motivations of its various stakeholders.

a) The first and most important part is the project "Efficient Management of Information Resources Over Ad-Hoc Data Grids," which is funded by the Australian Department of Education, Science and Training (DEST) and its successor the Department of Innovation, Industry, Science and Research, respectively. Funds were granted for a three year period from January 2007 until March 2010.

b) The second part of ADAGE was SIRCA's interest to use its huge data repository to better suit their customers' requirements. Due to the successful prototyping of services, SIRCA's support for ADAGE has been extended until June 2010.

c) Finally, the UNSW contributed to the project, for instance by providing a PhD student position to support research in the field of service-oriented architectures.

3.2 Scope and Goals

In the context of the ADAGE project, researchers at the UNSW implemented a service-oriented architecture for SIRCA. "The project aims to investigate how to efficiently gather, store, query, and manage ad-hoc data grids from both a manager and an end-user perspective, benefiting various applications including in e-science and e-research." (Department of Innovation, 2010) Its objective is to provide researchers a platform for easier retrieval and analysis of heterogeneous data from different sources (grid environment) spontaneously in an unforeseeable fashion (ad-hoc). Neither business processes nor SOAs were the selling point of the project. The former were hardly considered at all, whereas the latter was chosen as the preferred architectural paradigm of this project. Services (and their identification) were used as a means to meet SIRCA's requirements rather than being the subject of analysis themselves.

SIRCA provides a huge data repository containing historical news and financial market data, such as quotes, trades, and market depth data. It normalizes data and makes it accessible. Their aim is to supply this data to researchers worldwide, but so far their academic customers are mostly Australian and New Zealand universities. SIRCA also makes the same data available to industry customers through Thomson Reuters. Thus, their business model is quite simple and is covered by one business process only.

SIRCA was not familiar with the idea of business processes management, so that no model was delivered that could have been analyzed in the course of service identification. However, SIRCA's management had some requirements in mind that had to be fulfilled by services. Unfortunately, the former were not documented which makes traceability difficult. Requirements were communicated to the project team in scheduled weekly meetings and workshops.

Service candidates were identified on the basis of these meetings and subsequently prototyped. In an iterative approach, the functionality of these candidates was adjusted to finally meet SIRCA's requirements. In some cases, they were completely dismissed and new ones had to be created. A close collaboration between SIRCA's research and development department and UNSW's project team was critical to ensuring the successful identification of services.

SIRCA's management did not aim at the implementation of an SOA in particular. The idea of services was basically advocated by UNSW's project team. SIRCA had been using web services in specific areas, such as enabling remote access to its data. However, know-how as far as SOAs are concerned was limited to the service technology level. At the outset of the project, funding for three years was provided. Towards the end of the project, funds for further six months were approved to implement the prototype and make it accessible to SIRCA's customers.

In ADAGE, services were created based on the availability of data. This led to a technical understanding of services which is, for instance, reflected by the synonymous use of the terms "service" and "web service" by project team members. Hence, the scope of service identification in this project was limited to software services.

First and foremost, the search for services was driven by the idea to retrieve and integrate data from different sources. In a second step, project members developed ideas about the types of services that could support researchers in analyzing data. This included, for example, building time series of financial data, merging data from different sources, and visualizing events. The identified and implemented services were offered to third parties, thus supporting their business processes, only after the completion of these steps. Clearly, this was a requirements-driven bottom-up approach. Goals included the provision on a graphical user interface (GUI) to customers, enabling the latter to directly invoke services in an ad-hoc fashion to analyze news and financial market data. This implies a distinct degree of customer interaction which influences the identification of services significantly.

3.3 Proceedings

The official project start was in January 2007, after funds were secured in September 2006. As described previously, there were manifold motivations for all involved parties to cooperate with one another. On the one hand, there was SIRCA's huge Thomson Reuters archive and its need for innovation. On the other hand, more complex demands from a wide range of user groups (e.g., Thomson Reuters, academics, etc.) had to be satisfied. In order to achieve this, the expertise offered by UNSW researchers, working in different groups across faculties, was to be utilized. The three following research groups contributed to the project:

a) The Finance IT Research Group of the School of Information Systems, Technology and Management provided know-how concerning financial information systems. The group had already conducted a number of capital markets projects between 2001 and 2004.

b) The Service-Oriented Computing (SOC) Group of the School of Computer Science and Engineering had plenty of experience in databases, information processing, and web technologies. It had been involved in major international SOC initiatives linked to business partners, such as IBM, HP, and SAP.

c) The Bibliometric and Infometric Research Group (BIRG) of the School of Information Systems, Technology and Management contributed through their experience in developing metrics related to document management and information services.

Before the project's official start, the following collection of initiatives (see Table 1) with respective responsibilities was presented in December 2006. A major objective of these initiatives was to capture domain knowledge in the different fields of cooperation in order to use existing data in a meaningful way.

Initiatives	**Responsibilities**
Requirements analysis of news systems	Finance IT Group
Technical overview of Reuters data	Finance IT Group
Conceptual modelling of financial data	Finance IT Group
Story reconstruction and news retrieval	BIRG Group
Metadata analysis	BIRG/Finance IT Group
Multidimensional navigation of news data	SOC Group
Summarization	SOC Group

Table 1: Initiatives as of December 2006

After the project start in January 2007, some of the initiatives (pilot projects) shown in Table 1 were mapped to project milestones that are illustrated in Figure 3. Each milestone had a manager, project teams, and objectives, respectively.

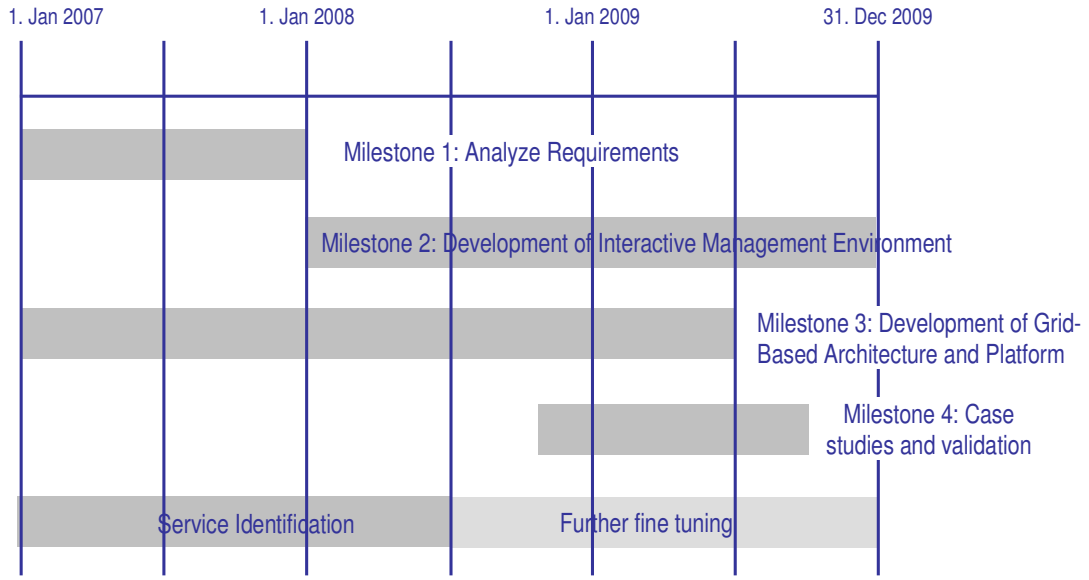

Figure 3: Milestones of the ADAGE Project

For the purpose of this paper, the focus will be on milestones one and three. The first goal of milestone one was the definition of data grid requirements in the context of ad-hoc data currently managed by SIRCA. Therefore, a review and assessment of existing ad-hoc data grid processing approaches was planned. Existing data formats had to be investigated and sample data repositories were created. Existing grid architectural models, tools, and platforms had to be analysed in milestone three. An architecture for processing queries across a large number of ad-hoc sources had to be defined and a respective prototype had to be developed. Regular monthly meetings with SIRCA were complemented by technical meetings based on the needs occurring in the project. Milestone four consisted of the news summarization case and the financial market data analysis case to prove applicability of the developed services.

Modeling and understanding of news and market data was a central activity in the first half of 2007. The identification and definition of possible services for the architecture to be developed was a major task and part of the Finance IT Research Group's responsibilities. By July 2007, project members had gained an insight into SIRCA's datasets and identified key shared user requirements. Since SIRCA could not provide documentation such as entity relationship models (ERM), it was basically left to the project team to use their full access to SIRCA's data to explore its structure.[1]

In October 2007, an event-based data model had been developed (Rabhi et al., 2009a). In the context of the SOA for processing e-market data, a couple of query and analysis services had been implemented. Services for news and market data as well as for data mining and statistical analysis had yet to be developed. Business processes and their corresponding workflows and end-user composition belonged to the work in process. By the end of 2007, communities of users that might benefit from the project were identified for use in cases one and two (finance and business intelligence, respectively).

[1] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010

Several financial data analysis processes had been studied exemplarily by September 2008 in order to capture specialist (domain) knowledge. Thus, requirements for tools and components could be defined and fulfilled. Besides implementing these requirements, the focus was on reuse of components and facilitation of a user's ability to design processes. In order to achieve both objectives, different levels of granularity and complexity were addressed. Easy to use tools allow end users to invoke elementary services and perform simple operations on data-sets. More complex processes can be composed by users themselves. This is done through a drag and drop GUI (see Figure 4).

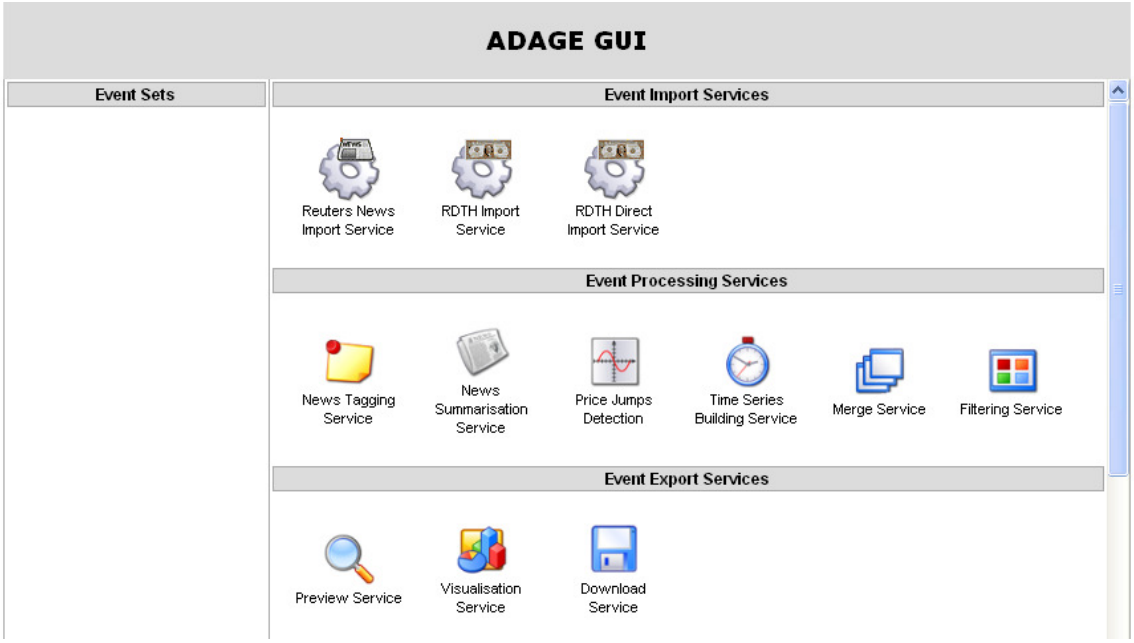

Figure 4: Graphical User Interface of ADAGE

The GUI empowers users to manually compose services to support a process at hand. Instead of letting users do this job, an automated composition of services is also possible. Workflow management systems facilitate enacting business processes as compositions of existing elementary services. Although such a tool (Triana) was trialed by Prof. Omer Rana's group at Cardiff University (Rabhi et al., 2009b), it was not used any further in the ADAGE project. Instead, it was deemed much more effective if users were allowed to orchestrate services themselves.

By the end of 2008, the project had yielded several outcomes. A core element and basis for all other results was the data model developed by Rabhi et al. (2009a). Moreover, a service-oriented architecture and a composition framework were designed. A new technique for time-series analysis which operates on financial market data had been developed (Guabtni et al., 2010; Rabhi et al., 2010). An additional outcome was the enhancement of existing clustering and ontology-driven summarization techniques for the analysis of time-sequenced unstructured data such as news (Pham et al., 2009).

It was not until January 2009 that process design approaches, such as Business Process Modeling, were taken into consideration. Although specialist knowledge had been captured earlier, a systematic process modeling exercise occurred for the first time. The service identification

then concentrated on reusability and the facilitation of a user's ability to design services. Due to the way users analyzed data, business modeling (and thus service composition) could not be static but had to be rather dynamic. Furthermore, it is assumed that the service development process and service identification cannot be centralized. These activities should be organically driven, i.e., there cannot be one central instance (like the ADAGE project) which can, for example, provide services for data extraction from all conceivable data sources. Thus, the ADAGE SOA can only provide a framework which hopes to trigger other developers to publish their own services that enable an extraction of data from their respective sources (for meta design, see Fischer et al. (2009)). The data model is used as a solution to match business requirements with technical web services.

The ADAGE SOA was designed according to user-driven requirements, allowing execution of processes to be piloted by users at any stage of their execution. Services are therefore categorized into:

a) Event Import Services: These services provide market and news events. They are used for querying, filtering, and mapping of data. Extraction of data from databases (e.g., from Reuters Datascope Tick History) is done by Event Import Services.

b) Event Processing Services: Services in this category are used to process financial market and news events. For instance, the sampling period and financial measures that the user wants incorporated in an analysis can be selected.

c) Event Export Services: These services allow for the extraction of information from financial market and news events analyses. Visualization is one option that enables the user to explore patterns within the data. Another possibility (Download Service) is to save (export) the information in various file formats.

Milestone four in the project utilized a case study to ensure the usefulness and applicability of this categorization. A comprehensive overview of all services implemented in the course of the ADAGE project can be found in Appendix C. Although specialist knowledge was captured and example processes were analyzed, a technical viewpoint was taken in the first place. A major challenge was whether services could be easily composed by users on an ad-hoc basis. The DEST project officially ended on 31st March 2010.

4 Case Analysis

4.1 Getting Started

As illustrated in Figure 1, outlining the theoretical background in the sense of "a priori constructs" was the first step of our research process. Since the research question is the foundation for the analysis of every case study (Eisenhardt, 1989), our research process continued with the formulation of a research question. As outlined in section 2, the identification of services is recognized as one of the most important steps while implementing an SOA. Shortly after the beginning of the case study, it became obvious that a single focus on service identification might not deliver satisfactory results in the ADAGE case. Thus, we extended the scope of our analysis to the early stages of the SOA lifecycle, namely the design and development of services and the service-oriented architecture in ADAGE (see Figure 5). Additionally, the framework presented by Börner and Goeken (2009) provides a number of criteria that will be used in the following.

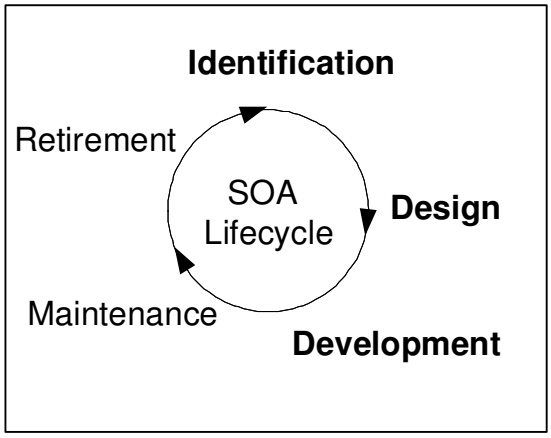

Figure 5: SOA Lifecycle

Some authors have already developed methods to support identification, design, and development of services. However, little is known about service identification and the early stages of the SOA lifecycle in real-life projects. Thus, in order to guide us through the analysis, we formulated the following initial research question:

How does SOA development and service identification work in real-life projects?

The rather generic nature of our research question necessitated the formulation of further, more concrete questions, the *questions of investigation*. These helped to focus our analysis and support, for example, the hermeneutic analysis of the interview transcripts. The questions of investigation were reflected by the interview guidelines. To provide an example, we attached the interview guidelines for the UNSW researchers in Appendix D.

It is widely accepted that method use improves the outcome of system development efforts (Avison and Fitzgerald, 2008; Sommerville, 2006; Lehman and Ramil, 2002). We therefore rate method use as an important aspect of SOA development and service identification in real-life projects. Hence, our first question of investigation was: *Are methods used at all and if yes,*

which ones? This leads directly to another interesting aspect: *Which consequences does method use (or its absence) have for an SOA?*

Our investigation into the ADAGE project aimed at capturing the setting, i.e., all preconditions and circumstances, as completely as possible. Such external factors, so called "context factors," are commonly considered to play an important role in software development projects. Thus, we tried to find out: *Which circumstances influence the proceedings of the service identification process?*

To examine the social context in more detail, we explored the roles of the different people within the project, their skills and knowledge as well as the evolution of skills and knowledge. One focus of our investigation was therefore: *What is the stakeholder's understanding of services? Did this understanding change/develop in the course of the project? Was there a change of the skill level of the project participants?*

A fourth area of investigation dealt with technical aspects which might be related to the aforementioned methodological, contextual, and skill-/knowledge-related aspects. It comprised design decisions made during the project and design principles the project team applied. *How was the SOA implemented technically? Which software development techniques had been used?*

Furthermore, we considered the outcome of the project as important for investigation. We did not apply a catalogue of predefined success measures but wanted to capture how stakeholders assessed and evaluated the outcome of ADAGE. *Was the project a success? What criteria/measures were (implicitly) used to evaluate the outcome?*

4.2 Case Selection and data Collection

The initial situation is based on the historical data of the whole seven months. Table 1 displays the results of the initial simulation.

4.2.1 Documentation

Major sources of documentation about project proceedings are 19 presentations that were held between December 2006 and November 2009. With only one exception, these presentations were compiled by a professor of the UNSW who acted as principal investigator and were presented in meetings with SIRCA. All of them provide a good overview of the general proceeding, achieved objectives, and next steps required at the time of the presentation. The only presentation made for a different purpose used the project as a case for a user-driven SOA for financial market analysis and took a slightly different point of view.

Furthermore, official progress reports give a structured overview of how a project is proceeding. Three progress reports were delivered after the first, second, and third year of the project, respectively. They addressed the Australian Department of Education Science and Training (DEST) and its successor, the Department of Innovation, Industry, Science and Research, which were responsible for funding the ADAGE project. Due to their much more formal character (compared to the previously described presentations), these reports offer less in-

sights into actual work practices, such as the identification of services. As far as funding is concerned, a Statement of Income and Expenditure is also part of the yearly progress reports.

A considerable number of published and unpublished papers were authored by project team members in the course of the project. These papers encompass many intermediate results of the project and highlight different aspects of ADAGE. The variety of publications in which the papers have appeared shows the scientific and practical value of the project's outcomes.

Additionally, various websites about the project or involved parties were used to retrieve background information. Of course, the graphical user interface (GUI), one of the important results of the ADAGE project, was itself accessible on the internet. Appendix B contains a list of the most important websites used for the case study.

Some newspaper articles about the project could be found as well and were added to the case study database for a matter of completeness. Information given in these articles was found to contribute only little to the questions of the case study.

4.2.2 Interviews with project participants

In order to retrieve additional information, particularly about the identification of services in the ADAGE project, four interviews were conducted. Three of the interviewees were project team members at the UNSW. In the following, they will be referred to according to their roles as principal investigator, second investigator and postdoctoral fellow. All of them were involved in identifying and designing services in the project. The interviews were conducted on 4th and 5th March, 2010 at the UNSW (see Appendix A for detailed schedule). Another interviewee was a representative of SIRCA who was interviewed on 9th March at SIRCA's premises on the 9th floor of 80 Clarence Street in Sydney's Central Business District. He will be referred to as industry coordinator in the following.

Before the interviews, a short introduction about the interviewer himself, his field of research, the purpose of the interview, and usage of the gathered data was given to the interviewees. All interviewees consented to the recording of the interviews. Thus, the case study database includes digital audio files of all interviews as well as complete transcripts for further analysis. The interviews were open-ended. However, guidelines with questions were used in each case. For the three project team members at the UNSW, the same question guidelines applied (Appendix D), whereas a different guideline was used in the interview with SIRCA's representative. The interview transcripts served as an important basis for the analysis of the service identification process.

The data collection procedure allowed for the accumulation of evidence from diverse sources. In the presentation of the results, we are going to combine details from different sources in order to triangulate them, to investigate the subject matter from different perspectives, and, in doing so, to provide a deeper grounding of our observations.

4.3 Analyzing Data

The aforementioned sources of evidence were analyzed thoroughly and led to a number of observations that will be outlined in this section. Through this analysis, we arrived at several concepts that we consider to be important for the success of the ADAGE project. Grounded in document studies and interviews, 16 observations – in terms of judgments from what was perceived in the data – describe these concepts and their relationships. According to the contextualization principle presented by Klein & Myers (1999), we try to present the subject matter in its "context so that the intended audience can see how the current situation under investigation emerged" (p. 73). All observations directly refer to the ADAGE case study. The first column of Table 2 gives an overview of all identified concepts.

As mentioned before, an examination of "enfolding literature" supports the derivation of hypotheses. Therefore, the presentation and justification of our observations in this section will be accompanied by references to related literature. Some observations are new in the sense that they have not been discussed in related literature yet. Others confirm and reinforce assumptions that have already been made in this field of research, whereas a third type is contrary to common belief.

Observation 1: The generous funding significantly influenced the way of service identification.

If you have to deliver defined outcomes within a tight time frame and under pressure from a paying customer, the focus will usually be on the result, i.e., a service delivering exactly what was asked for rather than on the elaborate identification and design that adheres to some proper methodological approach. Thus, one might generally expect that commercial projects sometimes tend to seek "quick and dirty"-solutions just to make things work as fast as possible. On the other hand, in academic projects like ADAGE with a generous funding secured for three years, one might rather expect an extensive use of methods that satisfy academic standards. Interestingly, for many reasons, it was different in the ADAGE case. Although it was an academic project with limited economic pressure on participants, service identification was far from being a rigorous process. The following excerpt argues that the latter was rather intuitive because the project was academic in nature and was intended to deliver innovation.

"Very intuitively, yes. And also if we were a commercial project, then we (would) have a contract. You have to make exactly what the client wants, otherwise they can sue you. But because this was a research project, the main requirement wasn't to deliver a precise thing, it was to deliver innovation. And the innovation was to take this domain and do services. So, the services we built [were] more like example services rather than we-had-to-dos. That's probably the difference between what we have done and maybe if services were developed in a more sort of commercial environment where you have this contract, your obligations."[2]

Nevertheless, this statement shows that the academic environment in which ADAGE took place clearly influenced the way team members identified services – however, in a different

[2] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

way than originally assumed. Even in this kind of non-commercial project, the budget affects the identification and design of services concerning the effort that is put into the development.

"Somehow the cost it takes to develop a particular service should be factored into the methodology."[3]

The budget encompasses such resources as time and manpower which are directly linked to the costs of a project. Not only ADAGE project members consider the budget to be an important contextual factor for the choice of methods. Other authors such as Becker, Knackstedt, Pfeiffer, and Janiesch (2007) state that "appropriate methods for problem solving must be chosen, adapted, or designed depending on the specific characteristics of a situation, such as qualification, number of employees, or available time." (p. 1) Hence, they confirm this relationship.

Observation 2: SIRCA's small company size significantly influenced the way of service identification.

SIRCA itself can be categorized as a small or medium-sized enterprise (SME). In the words of one staff member:

"We are a very simple outfit, we are a data repository. We collect lots of data, we do fairly substandard processing to it to normalize it, and make it easily accessible."[4]

Asked whether analyzing financial data was their main process, he responded: "This is our reason to be."[5] Hence, there is only one business process that can be identified for SIRCA. Since there is no need for process landscapes or industry reference models that are commonly used by larger companies, there are fewer inputs to be incorporated in the service identification process. This confirms the generally held belief that company size is a considerable contextual factor in many kinds of software projects (see also Sedera (2008)).

Observation 3: People's skills significantly influenced the way of service identification.

People's skills had a direct influence on applied methods in the ADAGE case as the following explanation shows:

"Another thing which is important in our context is people's skills. Sometimes we had to do certain services because we had the people who had the skills to. (…) We didn't do the asset identification because we didn't have anyone who knew about that but if we had then, we would have done it. So you are constrained by the cost it takes to develop, but also you were constrained by people's skills and in our case that's a big big problem because with service-oriented architectures and technologies there are not many people who understand them well enough to develop them and that is a big constraint."[6]

[3] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[4] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[5] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[6] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

Employees' skills are commonly accepted to play a major role in software development projects (Faraj and Sproull, 2000) and the choice of respective methods (Becker et al., 2007). On the one hand, available skills result in the application while a lack of such skills results in the omission of certain techniques, as described in the above statement. On the other hand, this leads to communication structures that can be bound to and depend upon single persons. This will be elaborated in more detail under Observation 6.

The significance of budget, company size, and employees' skills is visible in the ADAGE project and is echoed in related literature. Besides these contextual factors, Börner (2010) mentions the geographic scope of operations and the existence of a designated IT department within an organization (Anderson et al., 2005) as significant contextual factors that determine situations in the sense of situational method engineering. The latter could neither be confirmed nor denied by the case study at hand.

Observation 4: The implemented SOA satisfied users although no formal method for the identification of services was used.

Throughout the presentations held by researchers of the UNSW during the project, the successful progress of the project can be traced. Tasks that are work-in-progress in one presentation can usually be found under achieved goals in one of the following presentations. If they do not reoccur explicitly, it can be assumed in most cases that they were successfully implemented. Additionally, the interviews conducted come to the same conclusion and thus support the assumption expressed in Observation 4. According to the interview guidelines (see also Appendix D), all interviewees were asked if the implementation of the SOA and respective services in the ADAGE project was successful. In a number of the following statements, interviewees often use the term "case study" for what is commonly referred to as a "use case." It must not be confused with the research methodology we applied.

"Based on the (…) three case studies, I think it's quite successful because for the three we achieved what we wanted."[7]

This first statement clearly stresses the researchers' point of view. The project team analyzed user requirements to describe use cases. Subsequently, they identified services to meet these requirements. By implementing these services, the project was a success from their perspective. Asked if SIRCA was satisfied with what they got, the answers from the project team were as follows:

"The only feedback we got from them is actually, they were very happy with the ad-hoc way of doing this processing. Because for them, it's like quite new to have these services and you just use them"[8]

So far, the statements have shown how researchers of the UNSW perceived the success of ADAGE. Of course, their answers are partially based on feedback they received from

[7] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[8] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010

SIRCA's representatives, staff, or clients. However, it is important to consider a primary source, in this case the manager of SIRCA's research and development unit.

"It's been demonstrated to us on a number of occasions that various styles of development and the evolution has been satisfactory for us, and the services that we have seen demonstrated what can be done and enable us to think about how we might incorporate things into our standard offerings which we give to people in a non-service-based environment at this point."[9]

The progress shown in several documentations accounts for the project's success. In the excerpts above, interviewees often state that customers were "happy" with what they got, so we can assume that customers were satisfied. Apart from the business intelligence use case of ADAGE where "the system has not been used by anybody"[10], the interviews support the assumption that the project can be considered successful.

As far as method use is concerned, the presentations and progress reports that were analyzed provide only little information about the actual service identification process. These documents describe primarily results rather than procedures. However, many insights were gained from the interviews that were conducted. The first obvious result is that actually "there was no methodology"[11] used for the identification of services, i.e., at least no explicit method was used. The approach used by the project team was indeed rather unstructured. Basically, team members analyzed data structures, observed users' behavior where possible ("I think the method should have been a kind of observing, how finance people use tools."[12]), and talked to SIRCA's staff. Of course, there must have been some way of identifying services, so we can assume that some kind of method was implicitly used at one or the other point of the project. Statements like the following show this implicit application of methods:

"So, it's actually case study based. This is not the best method but it's one of the methods."[13]

Other interviewees said the identification "was based on experience we [the project team] applied,"[14] and admitted that they had "done it a bit in an archaic way. It was a step-by-step approach where we could identify services."[15]

Why was ADAGE successful although no service identification methods were used? On the one hand, the limited complexity of SIRCA's business processes made the identification of services quite simple.

"Our processes are fairly, you know, atomistic. (…) then people access the data with some fairly straight-forward enterprise in that regard."[16]

[9] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[10] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010
[11] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010
[12] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[13] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[14] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010
[15] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

On the other hand, interaction and communication between SIRCA and UNSW's project team were intense. The latter aspect will be considered in more detail under Observation 6. Overall, not only researchers at the UNSW but also SIRCA seemed to be convinced of the project's success. Actually, SIRCA extended the funding of the project for further three months to implement the ADAGE services in their IT infrastructure and offer them to their customers.

Related literature generally recommends the application of methods. Vessey and Glass (1998), for example, argue that the use of formal software methods leads to significant gains in software productivity under some circumstances. At least for our case, we can conclude that a method for service identification was not necessary for the success of the ADAGE project which contradicts the assumption made in literature.

Observation 5: Little SOA experience led to a technical understanding of services.

The project primarily dealt with the ad-hoc usage of data from multiple sources to provide users with easier access to data and support them in the analysis of this data. At the outset of the project, it was not exactly clear how user requirements were supposed to be implemented. The implementation of services in the context of an SOA thus presented one possibility for a target infrastructure.

"SIRCA wasn't aware of the concept of services, so we brought the concept of services. (…) In a way we succeeded because now SIRCA thinks in terms of services and looks at their offers in terms of services."[17]

On SIRCA's side, no one had thought about services before. Although a deeper knowledge of the actual implementation of an IT system should not be the principal's concern in the first place, a common understanding of how services can contribute to fulfill user requirements certainly helped to make the project a success. The idea of services was used to capture user requirements in a structured way.

"So we haven't been given descriptions of services but we suggested to SIRCA that the use of services could be to gather the most common functions that people do."[18]

Even on the UNSW's side, not many people were familiar with the SOA concept. This in turn focused large parts of the communication on the project leader. In later stages of the project, more team members became familiar with services and the latter became a central point of ADAGE. In a presentation dated 24th September, 2008, "Learning/understanding/modeling" associated with services was explicitly part of the project agenda. The structure of the graphical user interface[19] clearly shows the service-oriented mindset behind the implemented software. Nonetheless, both statements show that thinking in terms of services is not intuitive and has to be learned by all involved stakeholders. This assumption is largely confirmed by litera-

[16] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[17] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[18] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[19] http://129.94.172.120/adagegui7/ , last accessed on 07 June 2010

ture. Many companies are still function-oriented (Vergidis et al., 2008), and many employees only consider individual tasks with a limited scope in their daily work. In order to implement successful service-oriented architectures, they will have to get used to the concept of services.

Observation 6: Personal communication was vital to meet user requirements.

According to presentation slides dated February 2007, team members of the UNSW and representatives of SIRCA arranged monthly meetings. Additionally, they agreed on technical meetings whenever a need would arise. These frequent meetings with SIRCA were necessary to retrieve information that was not documented anywhere, to understand the systems they used, to access their technical infrastructure, and for psychological reasons, as the following statement shows.

"This project could never have been done the way it's been done if I wasn't going there on a weekly basis. So I had to go there, I was talking to them. Simply because there [are] many reasons. One is domain knowledge (…) there [are] a lot of things that are not written anywhere. (…) So there is a lot of knowledge that we can only acquire by these frequent interactions. Secondly, SIRCA actually asked us to do other things for them that helped us (…) for example, they had developed a system, they needed documentation and we did documentation for them. By doing the documentation we got to understand the systems better. And thirdly, when we build our services we had to tap into SIRCA's technical infrastructure and that could only be done by being there. So it required frequent interactions for the domain knowledge, for access to the technical infrastructure and also for sort of general, I think for psychological reasons. You know, they see you, they help you better. I think that's a lesson I've learned, yes."[20]

In contrast to the presentation slides that refer to regular, planned monthly meetings, the statement provides evidence that weekly meetings took place to ensure a high level of personal communication. The mostly verbal nature of communication was also confirmed by SIRCA's representative who said:

"The bulk of our communication was in the form of meetings where we would discuss what we would like to support."[21]

On top of this, unscheduled meetings were held whenever there was a need for more information or clarification. From the very beginning, there had been frequent feedback loops between SIRCA and the ADAGE team.[22] This means meetings were not merely part of the project organization or even an annoying weekly obligation. Both sides appreciated the intense exchange and the direct way of communicating. Another aspect of that communication seems striking. Within both parties, there was basically one contact person who was responsible for project-related communication. According to SIRCA's representative, he "primarily (…) dealt

[20] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[21] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[22] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

with Fethi directly,"[23] and communication was "mainly discussion through me, rather than formal documentation."[24]

Asked if SIRCA provided any kind of documentation like data models, entity relationship models, or information about the data structure, the answer was:

"Largely we gave the group pretty much unfettered access to the data and stood back and let them do the analysis."[25]

This statement confirms the project leader's previous proposition that UNSW researchers wrote some documentation for SIRCA's software system that was unavailable at the beginning of the project. Since no one at SIRCA had been thinking in terms of business processes, two researchers of the UNSW explicitly confirmed that there was no documentation available. Even in the concrete matter of service identification, instead of formal methods, direct communication was the first choice: "We have had discussions and we agreed upon the service would do a thing."[26]

Most of the existing literature argues that in order to design services, methodologies and representations of service models, such as unified modeling language (UML) sequence diagrams, are valuable (Glushko, 2008). Contrary to common belief, our case leads to the assumption that these documentation techniques are not always crucial for the success. Documentation is important to provide a common understanding among project members. It might become less significant when – as in the ADAGE case – communication is focused on only one person. Eventually, it might even be more effective to do without documentation in the situation at hand.

Besides other documents, a presentation to SIRCA in September 2009 finally stated that requirements for tools and components were successfully implemented. This evidences that the direct communication actually led to a fulfillment of user requirements.

Observation 7: A technical understanding of services led to very fine-grained services.

The ADAGE project ended up with very fine-grained or so-called elementary services. Starting with SIRCA's huge data repository, the project team analyzed the given data structures and looked for feasible services from this technical perspective.

"The idea is that you have elementary services and then you can compose these services to make bigger services. Unfortunately, our whole work has been on elementary [services]."[27]

After identifying services this way, the ADAGE team investigated how users could be supported with these elementary services. Depending on the users' requirements, services can be composed to support (parts of) a business process. Team members agree that the project team

[23] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[24] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[25] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[26] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[27] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

approached the identification from a technical point of view[28] and they talk of a layer of elementary services[29], too.

Many authors state that – in contrast to top down modeling – (pure) bottom up techniques typically lead to fine-grained services or functional modules (Erradi et al., 2007; Kohlborn et al., 2009b). Hence, given the technical perspective taken in the ADAGE case, fine-grained services conform to what could have been expected based on existing literature.

Observation 8: A technical understanding of services led to a bottom up direction of analysis.

Since there were no business processes to base a service identification upon, data structures and the existing system served as the starting point. An analysis of these data structures, software, and interfaces is necessarily very technical in nature. The first project presentation in February 2007 stated that existing data formats had to be investigated. A later presentation dated 3rd July 2007 showed that project members had analyzed SIRCA's datasets and enabling technologies. The following statement also supports the assumption that identifying services was actually done in a bottom up direction. Business processes that are a precondition for any top down analysis were rather an outcome of composing technical services in a meaningful way.

"We had to build some services and put them together in some kind of business process to show that it is possible to do that kind of things."[30]

An asset analysis – a typical technique in bottom up approaches – was used in ADAGE. Asked for this kind of analysis, one team member answered:

"Yes, we look at what we have. (…) It should be like a tree and basically you need to place it somewhere. If you cannot place it within an existing bunch of services (…) it's something new."[31]

Again, this shows a very technical understanding of services. Even the categories, such as "import services" or "visualization services," to which services belong, were designed in a bottom up fashion as the following statement indicates.

"Every time we have a new case study, we try to re-engineer the categories that we have. (…) When we add a service we need to put it somewhere in a category, in a bunch of services."[32]

A more process-oriented approach would have determined categories from a business process perspective. One example for a fine-grained service is "Import RDTH data" since it merely represents a database query. However, its high reusability (see also Observation 10) shows that bottom up approaches and fine-grained services do not have to be a disadvantage. Ac-

[28] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010
[29] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[30] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[31] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[32] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010

cording to Inaganti and Behara (2007), a technical perspective – focusing on the data level – leads to the application of bottom up techniques. However, to avoid problems stemming from pure bottom up approaches, many authors advocate hybrid approaches that cover top down techniques, such as business process analysis, as well as bottom up methods, such as asset analysis (Klose et al., 2007; Kohlmann and Alt, 2007). Due to the limited complexity of our case, the utilized bottom up approach seems to be sufficient.

Observation 9: The implemented fine-grained services provided flexibility for users and developers at the same time.

On the one hand, the service-oriented architecture implemented in ADAGE provides an enormous flexibility for users because they can simply use the web browser based GUI to compose services according to the analysis at hand.

"The graphical user interface enables you to invoke and compose services in different ways."[33]

On the other hand, it provides flexibility for developers as well. The architecture can be easily extended and complemented by other services.

"That gives us the flexibility to develop more services and plug them in, or allow others to plug into the environment in the future."[34]

As stated above, ADAGE is also meant to provide a framework for other developers to contribute by creating their own services. For instance, one developer team (such as UNSW's project team) cannot provide a data extraction service for every existing database. Thus, if a user needs a data import from a specific database he can create a service himself and add it to the ADAGE framework. "The idea is to make it open, and basically people can develop services themselves."[35] That way, users of the ADAGE GUI (and the services provided by it) can actively participate in the development and build their own services.

"The flexibility to plug in a service, which could be developed quite quickly to do another step in the analysis process [is] important for various researchers."[36]

Providing a high degree of flexibility for users, developers and those users who become developers themselves by adding further services, the ADAGE case confirms existing literature. Flexibility is frequently said to be one of the most important features of SOAs (Alonso et al., 2003; Papazoglou and Georgakopoulos, 2003). It enables the agility that finally leads to a competitive advantage of organizations (Erl, 2007). According to Levy (2009), many companies plan to use SOA to drive increased flexibility in application development.

[33] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[34] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[35] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[36] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010

Observation 10: Fine-grained services supported reusability.

Reusability of services is a frequently mentioned feature of service-oriented architectures. In essence, the objective is to avoid redundancies of provided software functionality. In ADAGE, an event-based data model for news and financial data was developed (Rabhi et al., 2009a) in October 2007. With this data model, both types of data can be processed at a high level of abstraction reusing the same services.

"Some of the things started as different services, and then you realize there is a common functionality that can be extracted out and offered separately. And this way you get the better SOA."[37]

One conclusion we can draw from the statement above is that the reusability of services was not pursued in a structured way in the ADAGE project. Instead, it was an iterative process. After services had been initially created, someone had to identify common functionalities. This implies that the reusability aspect has to be on the agenda of the person overlooking an SOA implementation. This rather iterative approach is also confirmed by the following statement:

"Because it always links to what the user wants and, in some cases, if it is not something reusables we make it part of a bigger service. If it is something reusable a lot, then it becomes a service, but that is still linked to what the user wants."[38]

On the customer's side, the reusability aspect was seen from a slightly different perspective. Avoiding redundancies or saving development costs were not SIRCA's primary concern. However, due to the graphical user interface, they had a quite precise idea of what the services were doing. Thus, even on SIRCA's side, the advantages of an SOA in terms of reusability were visible. The fine-grained services provided by the ADAGE GUI guarantee a high reusability and provide for the implementation of user requirements at the same time. According to all interviewees, services in ADAGE are frequently reused. A number of authors have praised the reusability of services as a core aspect of service-oriented architectures (Papazoglou, 2003; Erl, 2005; Josuttis, 2008). Krafzig, Banke and Slama (2004) argue that the use of a service should not be restricted to the project for which it was originally developed. Advantages such as the reduction of maintenance and development costs, reduction of testing effort for new functionalities, and a shorter time to market are often mentioned. Unfortunately, there is only little empirical evidence so far. On the contrary, a case study at Credit Suisse, one of Europe's largest banks, attests only poor reusability of services (Hagen, 2003). Our case study confirms the non-empirically grounded claim of SOA literature that such an architecture indeed supports reusability of services.

Observation 11: Orchestration of services significantly contributed to flexibility.

There are two ways of composing services in order to support business processes. One of them is orchestration, i.e., a central instance (either a user or a workflow system) invokes services to support business processes. The second approach is the so called choreography, in

[37] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[38] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

which one service invokes one or several others. According to business rules implemented in these services, the composition of services happens without a central instance controlling it.

"The graphical user interface is allowing ad-hoc processes. So you don't define the process like this, but basically you do it in ad-hoc ways. (…) People don't know exactly what they want to find. So they take data, they apply some tools or services and then, depending on the results, they will decide 'Oh, it looks interesting. Let's try this tool now.'"[39]

In the ADAGE case, the composition of services is supposed to be possible on an ad-hoc basis. Therefore, orchestration is the only feasible option. There is no business logic that could be known and implemented in advance to reflect the necessity or sequence in which services are invoked. Thus, orchestration provides for the demanded flexibility of financial data analysis. The end user represents the central instance that invokes services on demand and this provides a high degree of flexibility. This is also evidenced by several presentations, for example, on 21st October, 2008 and 17th February, 2009. In contrast, Janssen and Kuk (2007) argue that decentralized coordination, i.e., choreography, is associated with high flexibility because this coordination mechanism can do without a central instance.

Observation 12: Fulfilled user requirements led to user satisfaction.

The incorporation of user requirements in ADAGE was done in a rather ambiguous way. On the one hand, there were significant efforts to acquire domain knowledge from experts in order determine these requirements. This is well documented in the presentations in which, for example, "capturing specialist knowledge" is a frequently revolving theme (beginning in early presentations in February 2007 and still ongoing in September 2008). From the interviews, statements like the following confirm this effort.

"We have the analysis of the needs and the communities of users. What tools do they require?"[40]

On the other hand, the analysis was strongly data-driven, i.e., many services were developed on the basis of existing data structures. Only afterwards the users' requirements were considered.

"So the way we came, we said 'Okay, let's not look at what your user wants, but what your user could want.'"[41]

However, the GUI that is presented to users aims explicitly at usability. Users are enabled to compose services easily according to their needs. Hence, user orientation in ADAGE consists of two aspects that have to be considered separately. Firstly, the identification of services was data-driven rather than user-driven. Only after building services, those were matched to user requirements gained from experts. The importance of acquiring domain knowledge from either customers themselves or employees who know the needs of customers (so called "bound-

[39] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[40] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[41] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

ary spanners" (Bowen and Schneider, 1985)) is acknowledged, for example, by Shostack (1987). Secondly, in contrast to the first aspect, the presentation of services to and composition by users is focused on usability and indeed very user-oriented. Several other cases that can be found in literature also focus on usability, which is sometimes used as a benchmark for the success of services (Zimmermann et al., 2004).

Observation 13: Identification and development of services were incremental and iterative processes that supported fulfillment of user requirements.

In the process of identifying services, researchers of the UNSW chose a step-by-step approach to address user requirements with an adequate number and scope of services. First, certain functionalities were implemented as a service. Second, this service was published in the ADAGE GUI. Third, users tested the service and its functionalities and gave feedback. Fourth, this feedback was used to improve existing services or design new ones. After this, the cycle was started again. This incremental approach is clearly outlined in a presentation dated 10th August, 2009 and supported by the following statement:

"So, the method is basically incremental, that case study after case study you are getting more and more services. And at some stage, having the users contributing as well. The idea is to make it open, and basically people can develop services themselves."[42]

In the near future, users will be able to develop services themselves. The latter can complement existing services after being released by the project team. The iterative character in which services were designed is shown in the following statement.

"We generated the output and then we sent it to Dennis, and Dennis was checking it manually, check if it works fine. (…) And then for weeks and weeks he was sending back defects."[43]

Once existing services were sufficiently improved, new ones were added one after the other in an incremental approach. Thus, starting from a small basis with only few services, the offer of services was broadened step by step.

Looking at methods for service identification in literature, the sequence of activities to identify services constitutes an important element of such methods. Frequently, a linear sequence of activities is proposed, leaving only little room for iterative steps or feedback loops (Börner and Goeken, 2009). The observations in the ADAGE case contradict these approaches. The method that emerged in the course of the project (emergent method – see Observation 4) was feedback-driven and based on "builds" in terms of increments. The feedback-driven fashion also entailed a high degree of user participation. These elements (feedback-driven processes, builds/increments, user participation, and iterations) are typical core elements of iterative and incremental development approaches (Larman and Basili, 2003; Gilb and Finzi, 1988). Based on a field study, Haines and Rothenberger (2010) argue that "building the service infrastructure requires a rigorous – and perhaps more waterfall-style – approach focusing on long-term planning to achieve well-designed and reusable services. On the other hand, composite appli-

[42] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010
[43] Personal Communication, Interview with the postdoctoral fellow (UNSW), 05.03.2010

cation development may in many circumstances benefit from using a more agile, yet rigorous, software development approach." (p. 137)

The realization of an iterative and incremental development approach – even if it was emergent – allowed for flexibility in reacting to user requirements as well as for the integration of new ideas and unforeseen demands concerning functionality. We regard this as an important factor to achieve the user satisfaction we encountered in the case study.

Observation 14: The flexibility provided by services led to user satisfaction.

Generally, flexibility is one of the most commonly cited properties of service-oriented architectures. Oftentimes, it is associated with the flexible composition of services by a company in order to support business processes that need to be adapted at an ever increasing speed. Flexibility for users can be considered just as important.

"The flexibility to plug in a service, which could be developed quite quickly to do another step in the analysis process, would be important."[44]

The following statement shows that this flexibility leads to increased customer satisfaction.

"So [users] like that flexibility that the system offers in composing services in different ways."[45]

By satisfying customers, the flexibility of the ADAGE services contributes to the overall success of ADAGE. Again, in many presentations throughout the whole project, flexibility through end-user composition and customization are revolving topics on a number of slides. Related literature acknowledges that flexibility represents a major value potential of SOAs (for an overview see (Becker et al., 2009)).

Observation 15: User satisfaction was a success measure.

Satisfied customers were clearly a goal of SIRCA and thus of the ADAGE project. Although customer satisfaction was not explicitly defined as a success measure, we consider it to be elementary for the success of ADAGE.

"Yes, they see the service at the graphical user interface level, so they like the graphical user interface level. (…) So, they like that flexibility that the system offers in composing services in different ways. And this is why they sort of continue supporting us."[46]

If customers "like" the GUI, they are satisfied with it, and the continuing support from SIRCA's side clearly indicates the project's success. In many presentations (e.g., one dated 24th September, 2008), the objective Implement the requirements is outlined. This implies

[44] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010
[45] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[46] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010

that reaching this goal was considered necessary for users' satisfaction and, hence, a successful SOA implementation. This aspect strongly supports Observation 15.

According to the DeLone and McLean IS success model (DeLone and McLean, 2003), "customer satisfaction" is a result of system quality, information quality, and service quality alike. It is thus one important success measure to evaluate the success of information systems. Hence, our observations from the ADAGE case conform to DeLone and McLean's view.

Observation 16: Reusability was a success measure.

The objective Reusing existing components was part of the overall strategy, as can be gathered, for example, from a presentation dated 21st October, 2008. It reoccurs in many presentations throughout the whole project. Whereas success was seen from a business perspective so far, this is a rather technical aspect that can be used to evaluate success. From this point of view, an SOA can be seen as a success if it provides for reusability and thus reduces redundancies. A significant amount of money can be saved by reducing costs for development and maintenance of functionalities which are represented by services (Bieberstein et al., 2005; Legner and Heutschi, 2007). Hence, not only literature considers reusability as a success measure but also the ADAGE project team. Furthermore, SIRCA sees the benefit of reusable services as well. Although services are used for only one business process at the moment, SIRCA can at least imagine deploying the former in other processes, as the following statement shows.

"Could we puzzle them in different ways to do different things? - Absolutely!" [47]

Table 2 gives an overview of our observations in the first column. In the following section, we will use these observations to derive hypotheses. Abstraction mechanisms are utilized for a generalization that transforms observed concepts to abstract categories. This will result in a model of hypotheses and their relationships (Figure 6).

4.4 Generalization: Shaping Hypotheses

The generalizations to derive hypotheses are based upon the observations described above. According to Walsham (1995), generalization aims at giving explanations of phenomena "which may be valuable in the future in other organizations and contexts" (p. 79). He outlines four types of generalizations: the development of concepts, the generation of theory, the drawing of specific implications, and the contribution of rich insight. Our main goal is to generalize our observations and, in doing so, create a set of hypotheses.

As mentioned earlier, we repeatedly apply principles and techniques of interpretative case study research as well as abstraction mechanisms of conceptual modeling in order to guide this activity. While the principles are well known in case study research, to the best of our knowledge, the latter have not been used in the realm of qualitative research. We believe that

[47] Personal Communication, Interview with the industry coordinator (SIRCA), 09.03.2010

these mechanisms provide a stable set of well described (and in some way formalized) ways to abstract from instances (resp. parts) to types (resp. sets). This will promote transparency and traceability of the generalization procedure in this activity.

In the following, we will briefly introduce two prominent abstraction mechanisms which are later applied to several observations (Goeken, 2006; Olivé, 2007; Mattos, 1989):

- Classification relates instances with a type, or to be more precise, it consists of determining the types which an object is an instance of (Olivé, 2007) (pp. 12 and 383). Instances have common properties and are assembled into a new entity for which uniform conditions hold.

- Aggregation (Composition) defines part-whole structures of instances.

The concepts we identified in our observations can be interpreted as instances, and thus we can use abstraction mechanisms to generalize from these observations. The resulting types or sets form the components of our hypotheses, and we have labeled them categories. Hence, by applying abstraction mechanisms, we create abstract categories (e.g., we can classify the concept "fine-grained services" as an instance of the category "granularity"). Of course, the categories induced will have more concepts than those which we have observed in our case study. For instance, the category "granularity" also has the instance "coarse-grained services." Using these alternative instances of categories, we go beyond the details observed and further generalize the findings.

In applying these abstraction mechanisms, we clearly move beyond the observations. We acknowledge that we leave the firm empirical foundation when deducing types and adding instances not observed in the case study. However, by making the generalization as transparent as possible, we argue that the generation of reasonably grounded hypotheses can be justified. Furthermore, while formulating our hypotheses, we bear in mind the criteria of good hypotheses like falsifiability, consistency, testability, or disconfirmability (Lee, 1989).

In the following, we present our hypotheses, support them and describe how the generalization and the merging of the observations was performed, applying the aforementioned abstraction mechanisms. The mapping of our observations to the hypotheses is illustrated in Table 2. As in activity four, related literature is given and compared to our findings.

Observation	**Hypothesis**	**Related Literature**	**Compared to literature**
1. The generous funding significantly influenced the way of service identification.	1. Context factors significantly influence the way of SOA development and service iden-	Becker et al. (2007), Sedera (2008), Faraj and Sproull (2000), Börner (2010), Anderson et al.	+

2. SIRCA's small company size significantly influenced the way of service identification.	tification.	(2005), Bucher et al. (2007)	+
3. People's skills significantly influenced the way of service identification.			+
4. The implemented SOA satisfied users, although no formal method for the identification of services was used.	2. Not using a formal method for service identification does not necessarily lead to a failure of SOA projects.	Vessey and Glass (1998), Balzert (2001), Sommerville (2001), Kohlmann and Alt (2007), Klose, et al. (2007), Winkler (2007), Arsanjani et al. (2008), Kohlborn et al. (2009a)	-
5. Little SOA experience led to a technical understanding of services.	3. SOA project experience leads to a different understanding of services and thus affects success measures.	Vergidis et al. (2008), Börner et al. (2009), Anderson et al. (2005), Baskerville et al. (2005), Becker et al. (2009)	+
6. Personal communication was vital to meet user requirements.	4. Personal communication can substitute utilization of formal methods.	Glushko (2008), Faraj and Sproull (2000), Ancona and Caldwell (1992)	-
7. A technical understanding of services led to very fine-grained services.	5. The understanding of services affects both the granularity of services and the direction of the service identification approach.	Erradi et al. (2007), Kohlborn et al. (2009b), Inaganti and Behara (2007), Klose et al. (2007), Kohlmann and Alt (2007), Kohlborn et al. (2009a)	+
8. A technical understanding of services led to a bottom up direction of analysis.			+
9. The implemented fine-grained services provided flexibility for users and developers at the same time.	6. The right granularity of services can affect multiple success measures and depends strongly on the project at hand.	Alonso et al. (2003), Papazoglou and Georgakopoulos (2003), Erl (2007), Levy (2009), Rabhi et al. (2009a), Papazoglou (2003), Erl (2005), Josuttis (2008), Krafzig et al. (2004), Hagen (2003), Elfatatry (2007)	+
10. Fine-grained services supported reusability.			o

11. Orchestration of services significantly contributed to flexibility.		Janssen and Kuk (2007)	-
12. Fulfilled user requirements led to user satisfaction.		Bowen and Schneider (1985), Shostack (1987), Zimmermann et al. (2004)	+
13. Identification and development of services were incremental and iterative processes that supported fulfillment of user requirements.		Börner and Goeken (2009a), Larman and Basili (2003), Gilb and Finzi (1988), Haines and Rothenberger (2010)	o
14. The flexibility provided by services led to user satisfaction.		Becker et al. (2009)	+
15. User satisfaction was a success measure.	7. The success of SOA projects is expressed through technical and business-oriented success measures.	DeLone and McLean (2003), Bieberstein et al. (2005), Legner and Heutschi (2007), Luthria et al. (2007), Papazoglou (2003)	+
16. Reusability was a success measure.			+
Legend: Our findings "+" largely confirm literature, "o" confirm some but refute other literature or "-" refute literature, respectively.			

Table 2: Observations, Hypotheses and Enfolding Literature

Figure 6 shows how the relation between concrete concepts (observations) is mapped to an abstract view that generalizes from the ADAGE case to other settings of SOA implementations. The upper part shows types and respective hypotheses.

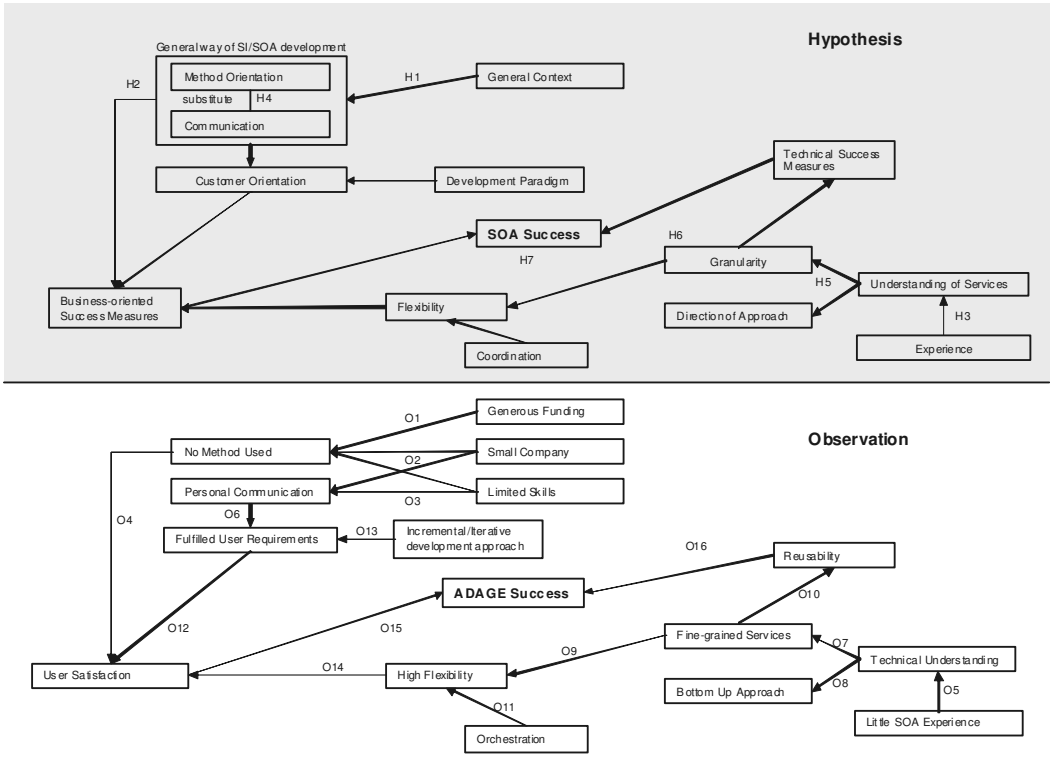

Figure 6: Interrelationships of Observations and Hypotheses

Hypothesis 1: The general context significantly influences the method of SOA development and service identification.

Certainly, there are many factors that affect the approaches to service identification in general and the choice of certain methods in particular. Some of them cannot be influenced by the project team and have to be taken for granted (Bucher et al., 2007). In the following, such conditions and circumstances shall be referred to as *context factors*.

We observed generous funding, small company size, and limited skills in ADAGE as conditions and circumstances in this respect (observations 1 to 3). Applying the abstraction mechanism classification, we can generalize these instances by determining their types and, furthermore, define part-whole structures of instances and types (aggregation): Figure 7 exemplarily shows the generalization from observations 1, 2, and 3 to Hypothesis 1. For instance, the category "company size" is the result of classification from the observed concept "small company." Thus, there is a has-instance-(instance-of-) relationship between these two. Furthermore, an aggregation of both concepts and categories leads to "ADAGE context" and "general context," respectively. They are connected to the original concepts and categories through is-part-of-relationships. Budget, company size, and people's skills are the resulting categories that are related to the concepts described in observations 1 to 3. These categories are generic "context factors."

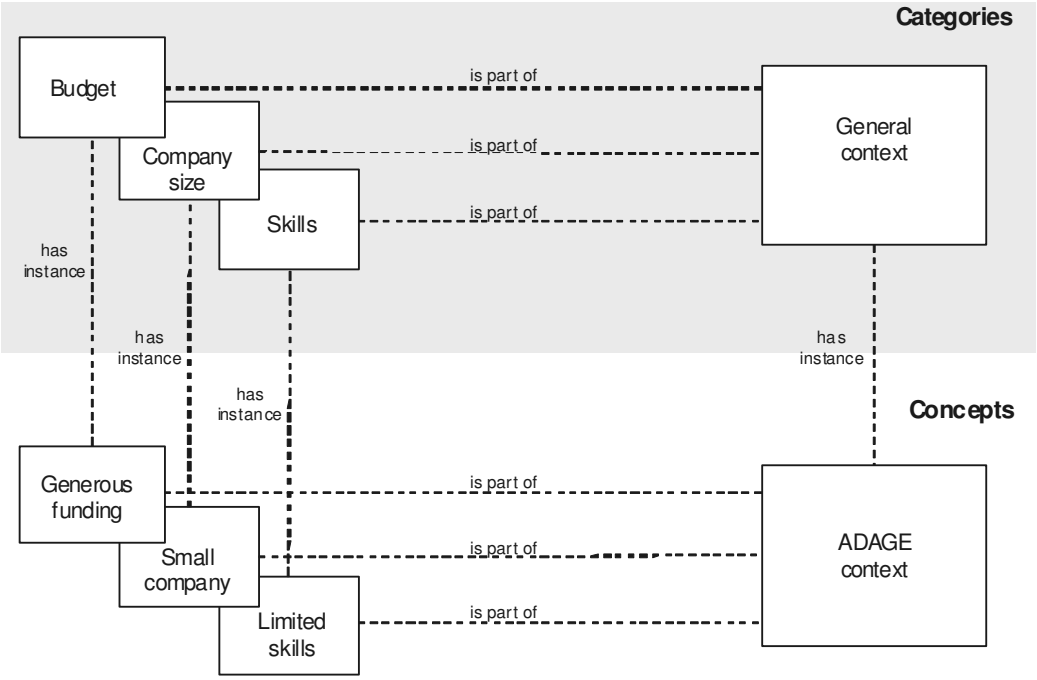

Figure 7: Generalization and Aggregation at the Example of Hypothesis 1

As shown in the observations, the combination of a small company and employees with limited skilled (trumping the opportunities of a generous budget and an academic environment) led to an absence of formal methods in service identification. This is certainly an extreme case. However, context factors significantly influence the way of service identification. Thus, we hypothesize that large companies with highly skilled employees will use different methods for SOA development and the identification of services.

Hypothesis 2: Not using a formal method for service identification does not necessarily lead to a failure of SOA projects.

A method orientation, i.e., using or not using one or more methods, depends on context factors. Certain situations (as combinations of context factors) can make a method obsolete. The right choice of methods (or the decision to use no method at all) influences the success of software projects in general and SOA projects in particular (Balzert, 2001; Sommerville, 2001). This influence is expressed indirectly through customer satisfaction, which is one possible success measure for SOA projects.

However, the following statement gives reason to assume that – for simple settings like in the SIRCA case – a method is not absolutely necessary.

"It was very simple. You use a method when it's very complex. (…) In business processes something like that would make sense."[48]

[48] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010

Although no particular method was used, the ADAGE project can be considered successful after all, as Observation 4 showed in detail. Thus, Hypothesis 2 is supported by the evidence given in the interviews.

Most literature on service identification argues that an application of methods is essential (Kohlmann and Alt, 2007; Klose et al., 2007; Winkler, 2007; Kohlborn et al., 2009a; Arsanjani et al., 2008). However, none of the authors discusses if the adoption of a method depends on the complexity of a project or its context factors, respectively.

At least in one case, the absence of a method did not lead to a failure of the project. In other situations, however, there might be a need for methods to support service identification. We assume that certain situations, i.e., the combination of context factors, make the application of methods either obsolete or necessary. This respective situation further influences the concrete configuration of a method that should be used in the situation at hand.

Hypothesis 3: SOA project experience leads to a different understanding of services and thus affects success measures.

In ADAGE, we observed that little SOA experience accompanied with the dominance of IT specialists resulted in a technical understanding of services (Observation 5). Classifying the concepts observed, we assume that the level of experience influences the understanding of services. We therefore hypothesize that companies with a track record of service implementation tend to involve business departments early in the process of service identification. Therefore, the understanding of services is much more process-oriented. Through multiple cause-and-effect relationships shown in Figure 6, success measures such as reusability are affected.

The task of planning a service-oriented architecture should be tackled by both business departments and an organization's IT division (Börner et al., 2009). Implementing an SOA is primarily a technical challenge. We assume that – like in the ADAGE case – many SOA projects underestimate the importance of properly planning an implementation. Hence, consideration of business processes is often poor, and employees of the IT division take the lead in these projects. Especially in companies that have little or no experience with the nature of services, the dominance of IT specialists might lead to a technical understanding of services. More experience in this field might lead to different outcomes. A project team might decide to use a process-oriented approach, a user-oriented approach, or even choose a technical approach if suitable. The most significant difference is that an experienced project team with a broader understanding of SOA is free to choose an adequate approach from a range of options. Unfortunately, this makes a prediction almost impossible. The only cause-and-effect-relationship that can be established here is that more experience allows for different opportunities whereas little experience most certainly leads to a technical understanding.

Anderson et al. (2005) argue that the "extent to which the enterprise architect, service developer, and operations project staff in the internal IT department of the firm are skilled" (p.68), i.e., their experience and subsequently their understanding of services, is a critical factor for web service implementation. Looking at our observations 5, 7, and 10, we can further hypothesize that SOA experience indirectly influences reusability of services. This is confirmed by Baskerville, Cavallari, Hjort-Madsen, Pries-Heje, Sorrentino, and Virili (2005), who show

that "very few web services could be reused exactly as originally implemented" (p. 7) and thus, experience is essential for SOA implementations. Becker et al. (2009) state that "especially in the early phases of SOA maturity [i.e., with little experience] there is no experience about [what] a reusable service would look like" (pp. 7-8). This is another hint that SOA project experience tends to change the understanding of services and enhances reusability.

Hypothesis 4: Personal communication can substitute utilization of formal methods.

A combination of the small company size and the lack of skilled staff made direct communication crucial for the success of ADAGE. Thus, this direct communication was vital for the service identification as Observation 6 highlights. It finally delivered services that cover user requirements and satisfy customers. Figure 8 illustrates that different forms of communication and method orientation influence concrete concepts of how services are identified and SOAs are developed. Generally, we hypothesize that in certain situations communication can substitute the utilization of methods.

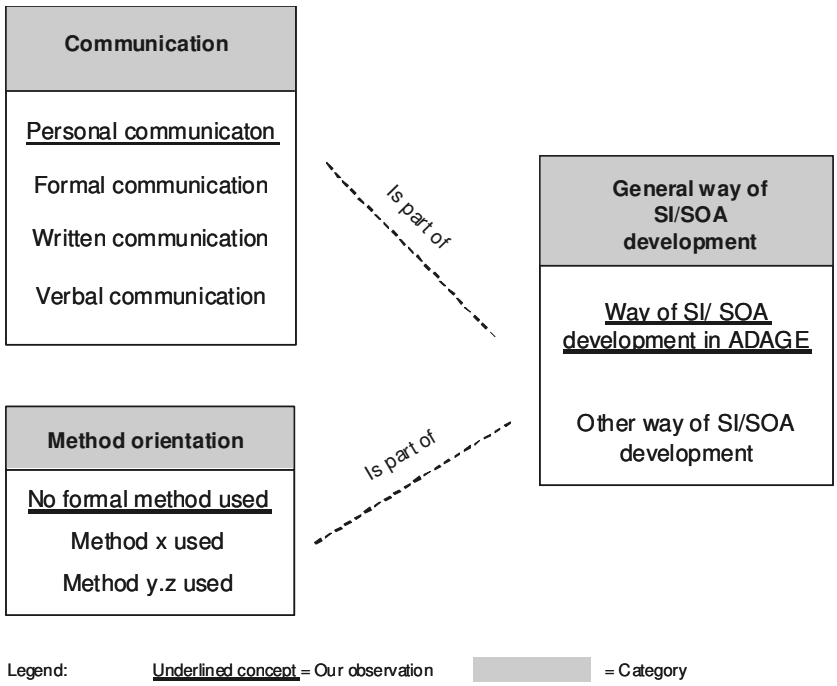

Figure 8: Communication and Method Orientation as Part of a Way of SI/SOA Development

These situations are characterized by the combination of context factors. In a case in which people's skills are very limited, the company size is rather small, and the budget is tight, communication is likely to be intense and to focus on one person with respective knowledge. The same can be true even if the budget (and consequently the time frame) is more generous, as in the ADAGE case (see observations 1 to 3). Certainly, in larger projects with a substantial number of staff involved on both sides, a structured approach using appropriate methods for identifying services and implementing an SOA can hardly be replaced by communication alone. Administrative measures for the coordination of development teams are discussed, for example, in Faraj and Sproull (2000) and Ancona and Caldwell (1992). This is evidence that

larger teams (in larger projects) necessitate a higher degree of formal organization, and personal communication is unlikely to meet demands.

Hypothesis 5: The understanding of services affects both the granularity of services and the direction of the service identification approach.

In the ADAGE project, a technical understanding of services led to very fine-grained services and a bottom up approach stressing technical aspects of the underlying (data) infrastructure (see observations 7 and 8). Firstly, we can hypothesize that a different understanding of services led to different granularities. Moving on a scale from technical to business-oriented understanding, the identified services might become coarser-grained along this line. From a business perspective, services should support processes or at least sub processes. Hence, they encompass more functionalities than an elementary service that, for example, reads an address from a database. The latter will more likely be the outcome if service identification is conducted from a technical point of view.

Secondly, the direction of the approach is influenced by this understanding. Again, moving along the above scale will result in the application of bottom up approaches on one side and top down approaches on the other side. It is unlikely to end up with a pure instance of any of the approaches. Even in the ADAGE case, a very technical understanding did not result in a pure bottom up approach. However, the share of techniques that are typically assigned to top down approaches (such as strategic analyses) will increase with a business-oriented understanding of services. Accordingly, in their comparison of service analysis approaches, Kohlborn et al. (2009a) differentiate two types of SOA concepts, i.e., understandings of SOA. One of them is rather technical and, thus, delivers so-called software services while the other (business-oriented) one results in business services.

Hypothesis 6: The right granularity of services affects multiple success measures and depends strongly on the project at hand.

In service-oriented architectures, granularity of services is a widely discussed issue among researchers and practitioners alike. Our observations 9 and 10 indicate that fine-grained services positively contributed to both reusability and (indirectly) customer satisfaction in the ADAGE case. Thus, we hypothesize that granularity indeed plays a major role for the success of SOAs in general since it potentially affects more than one success measure. Granularity, flexibility, and success measures are therefore categories which constitute Hypothesis 6.

Many authors have argued that – for a successful SOA implementation – a business point of view is indispensable. Accordingly, only coarse-grained services that support a business functionality or a business process provide a value for an organization and make an SOA a success. From a technical point of view, reusability, for example, suffers from too coarse-grained services. The finer-grained a service is the higher its reusability.

Whereas the ADAGE case showed clear advantages of fine-grained services, coarse-grained services might be the better choice in other settings. Some customers might not be interested

in the flexible composition of services every time they use them. If they simply want to outsource part of a business process, they might prefer a coarse-grained service that encompasses all necessary functionalities and delivers a comprehensive result. Accordingly, Elfatatry (2007) argues that "the appropriate level of granularity for a service and its methods is relatively coarse. A service generally supports a single distinct business concept or process." (p. 38) In the ADGAE case, fine-grained services enhanced both reusability and user satisfaction, i.e., technical and business-oriented success measures, respectively. In other cases, the granularity of services might be a trade off because effects on these two kinds of measures could be converse.

We argue that, due to different preconditions, the right granularity of a service has to be elaborated depending on the situation at hand. There is no silver bullet for right-sizing a service without considering the context of service implementation. Thus, a situation-specific approach to the choice of methods is important to provide for an adequate granularity.

Hypothesis 7: The success of SOA projects is expressed through technical and business-oriented success measures.

In our observations 15 and 16, we found user satisfaction and reusability to be success measures for the ADAGE project. Both contribute to the overall success of the project but are quite different in nature. Reusability is a rather technical aspect, whereas user satisfaction is a clearly business-oriented measure. Thus, we assume that the overall success of an SOA consists of both business-oriented and technical success measures.

From the business side, customer satisfaction (as the category corresponding to user satisfaction with ADAGE services) is a crucial issue to generate new business and maximize turnover and profit. According to DeLone and McLean (2003), the "use" of a system and the "intention to use" are just as important since they indicate user acceptance. Whereas customer satisfaction was observed to be a success measure in our case study, the other two factors were not observable. Since DeLone and McLean argue that these three factors are closely interrelated, we aggregate them under business-oriented success measures.

Due to the immature state of the service implementation, SIRCA's customers had not been able to use services directly.

"So at the moment if somebody needs something, I use the service to do what they want, simply because they are not mature, but part of the follow-up project is to release the toolset to the right public."[49]

Nonetheless, the project team did care about the use of services and implicitly considered this use to be a success measure. In this context, a researcher of the UNSW mentioned that in the business intelligence use case of ADAGE "the system has not been used by anybody."[50]

[49] Personal Communication, Interview with the principal investigator (UNSW), 04.03.2010
[50] Personal Communication, Interview with the second investigator (UNSW), 04.03.2010

IT departments tend to use technical measures for success. Observation 16 identified reusability as being such a success measure. IT departments pursue the objective to cut costs and improve the overall reliability and manageability of the IT infrastructure, for example, by avoiding redundancies. Typically, standardization is another frequently mentioned technical success measure (Luthria et al., 2007; Papazoglou, 2003).

Factors contributing to these success measures usually stem from different perspectives regarding an SOA. However, there are concepts that might influence both types of measures. Observations 9 and 10 show that granularity (indirectly) affects both business-oriented and technical measures. A reduced time-to-market (or development time) is another example for a concept having an impact on both kinds of measures but could not be observed in our case.

4.5 Integrating Hypotheses

Through generalization of our observations, we created hypotheses as illustrated in Figure 6. Due to the fact that the concepts observed as well as the categories in the different hypotheses overlap, we can combine the hypotheses in a model or in a small set of model fragments. Our observations and hypotheses are closely linked to the primary data we retrieved from documentation and interviews. In the following, we will describe phenomena that move beyond this data. By performing another generalization and looking at causal links between concepts, we arrive at middle-range-theories that were not necessarily obvious beforehand.

The resulting models (model fragments) can best be interpreted as a “middle range theory” because they are sufficiently abstract to be applied to different contexts but do not offer a set of general laws. Middle range theories allow contextual explanations and “lie between the minor but necessary working hypotheses that evolve in abundance during day-to-day research and the all-inclusive systematic efforts to develop a unified theory that will explain all the observed uniformities of social behaviour, social organization and social change.“ (Merton, 1967) (p. 39) The model fragments we present in this chapter have limited scope and are applicable to limited conceptual ranges as they only grasp phenomena from the systems development / SOA domain. Furthermore they refer to selected aspects in the realm of SOA development because we focused our analysis on the questions of investigation presented in 4.1.

Partitioning our model, we can identify chains of interconnected hypotheses (sections 4.5.1 to 4.5.3). These “partial models” allow for further detailing and variations and, hence, the formulation and discussion of alternative theories. Even though this discussion moves beyond our case data, it is still linked to the hypotheses and indirectly grounded in them. Since these theories are based on chains of several hypotheses, they provide new insights. In the following subsections, three models which present an external, internal, and a success perspective are elaborated.

Furthermore, by analyzing the interplay of different observations and hypotheses, we identify a phenomenon worth discussing in more detail. We develop a construct called “emergent method” by applying a different “type of generalization” suggested by Walsham (1995).

4.5.1 Contingency Model (CM)

Context factors such as budget, company size, and people's skills are consolidated in Hypothesis 1. All of them ("general context") influence the application of methods, communication, and the general approach to implementing SOA projects. We assume that alternative instances of the mentioned categories will result in different ways of SI/SOA development, as depicted in Figure 9. Furthermore, the list of categories constituting our contingency model is limited to those we were able to observe in our case study. For instance, in a more business-driven SOA implementation project, the choice of a BPM software tool could influence the way of SI/SOA development. Since there was no BPM tool used in our case, we were not able to observe such an impact. Accordingly, the way of SI/SOA implementation will most likely include more concepts than method orientation and communication which we were not able to observe.

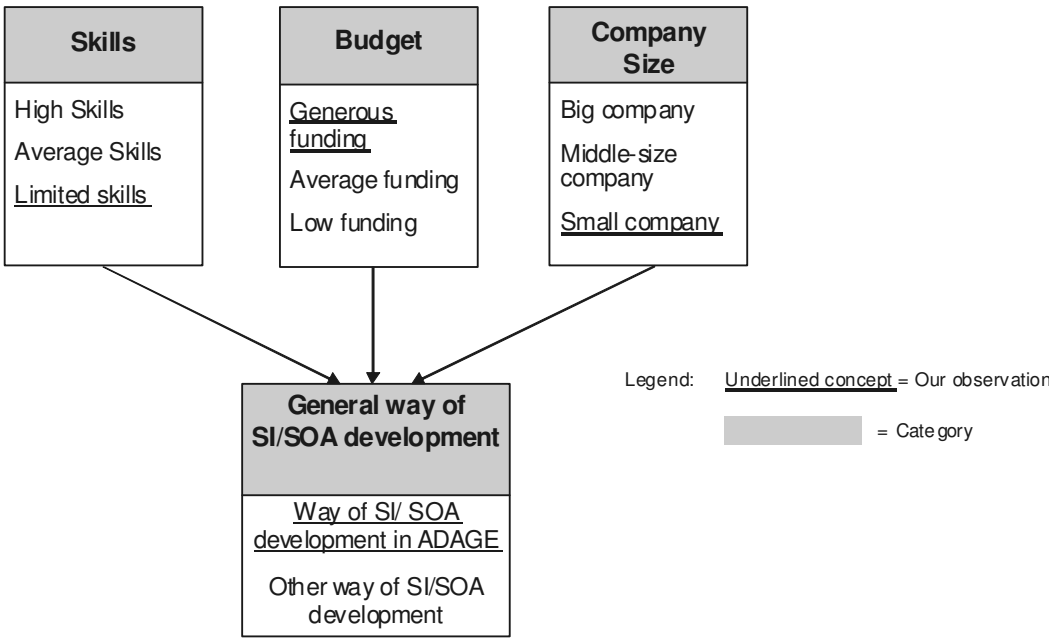

Figure 9: Influence of the General Context on the Way of SI/SOA Implementation (Contingency Model – CM)

4.5.2 Model of Soft Factor Transition (MSFT)

The model fragment which ties together hypotheses 3, 5, and 6 is depicted in Figure 10. Our observations (underlined concepts) and the resulting cause-and-effect chain show that a team with only little SOA experience produced a highly flexible service-oriented architecture and highly reusable services. In our hypotheses, experience leads to a distinct understanding of services (H3). This results in different granularities and directions of approaches (H5) and subsequently in a certain degree of flexibility and reusability (H6). Hence, the experience of project teams influences flexibility and reusability as well as the direction of the identification approach through a chain of cause-and-effect relationships as depicted in Figure 10. Teams with little SOA experience and limited knowledge regarding business functions and processes are forced to rely on the experience they have, which is basically technical. We assume that

developing an SOA based on the knowledge stemming from experience made with traditional, more technical driven software engineering paradigms, for example, object-oriented programming or modules, results in fine-grained services. The understanding of services and granularity are the generative mechanisms in this model fragment.

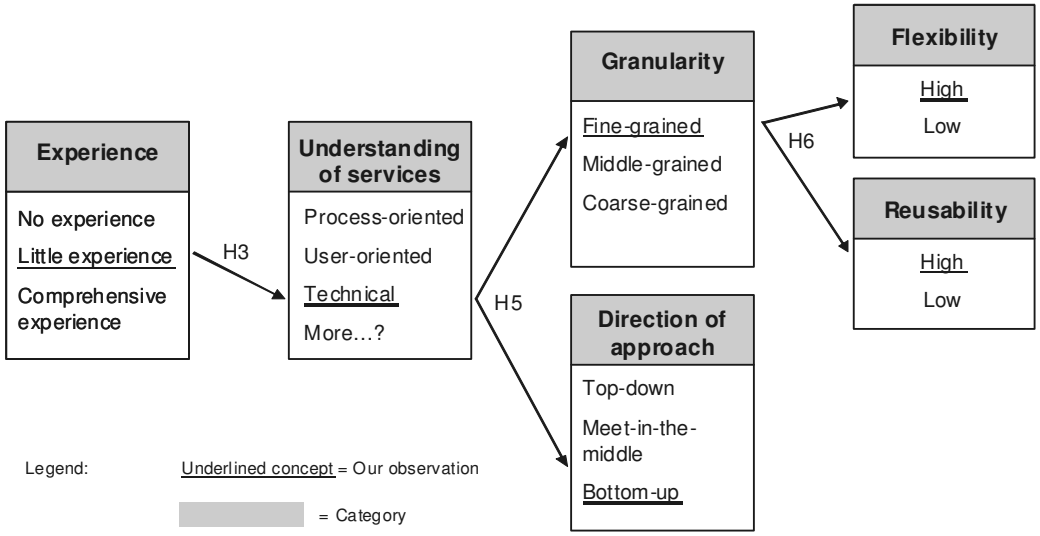

Figure 9: Causal Link of Experience and Flexibility/Reusability (Model of Soft Factor Transition – MSFT)

We could assume that a very experienced team might have a process-oriented understanding which leads to rather coarse-grained services that provide less flexibility. Since flexibility is regarded to be a big advantage of SOAs, this causal link is counter-intuitive. We would expect an experienced team to be able to reap the benefits of SOAs, including an enhanced flexibility. Figure 11 illustrates our observed pattern (dotted line) and the assumed possible pattern described above (dashed line).

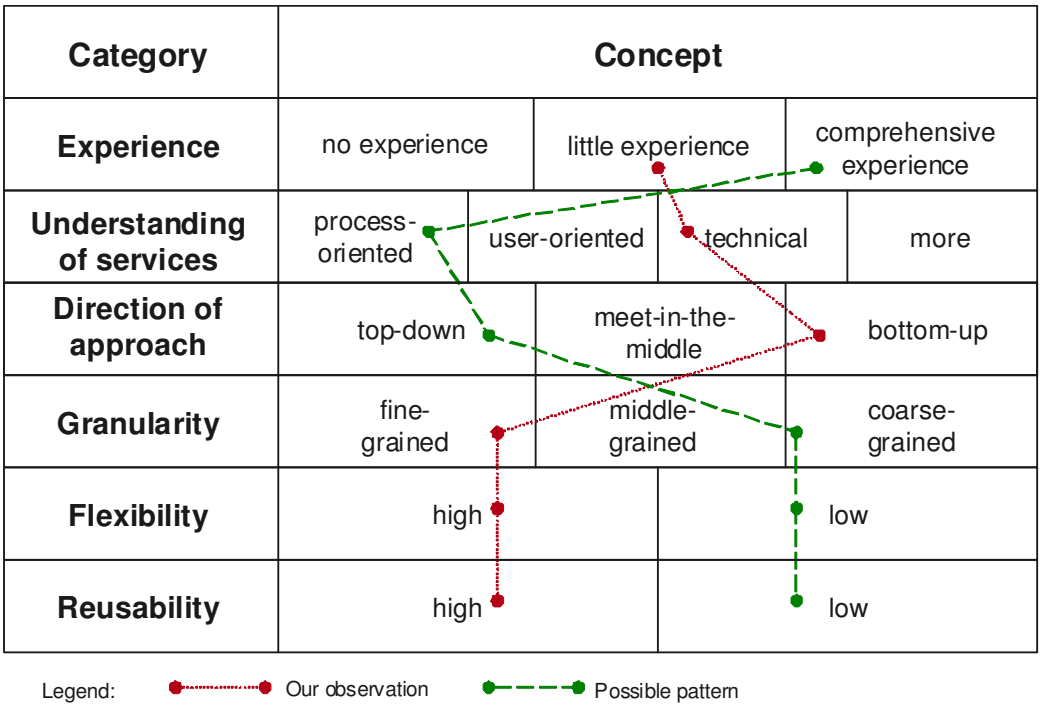

Figure 10: Project Patterns

However, we have to keep in mind that more experience does not necessarily lead to one specific understanding of services but enables an adequate choice of approach and understanding, as argued in Hypothesis 3. A comprehensive experience, for instance, is not closely knit to a process-oriented understanding and could as well produce middle-grained services. A large number of patterns are thus conceivable. We argue that – depending on multiple context factors in projects – the resulting patterns represent certain types of projects. An identification of such project types could lead to a targeted application of methods supporting SOA development and the identification of services. Project types can define situations in the sense of situational method engineering and would subsequently contribute to more sophisticated service identification through the use of situational methods (Bucher et al., 2007).

Observations 7 and 8 showed that the technical understanding of services in the ADAGE project led to fine-grained services and an almost pure bottom up approach for identifying services. In this regard, the lack of experience once again led to a rather object-oriented thinking which reveals another generative mechanism at work in our case study. In Hypothesis 5, these observations are generalized. Undoubtedly, there is an effect of this understanding on granularity and the direction of service identification approaches. Actually, the question of granularity continues to be an unresolved issue among scientists and practitioners alike and constitutes an active research area (e.g., Artus (2006)). The right size of a service is always "a trade-off between its potential for reuse and better management of quality issues." (Luthria and Rabhi, 2010) (p. 8)

4.5.3 Success Model (SM)

Many observations as well as hypotheses are bound to the notion of success. Naturally, the primary objective of every project is to be completed successfully. This is also true for SOA

implementation projects. But how can you evaluate the success of such a project? Our observations and hypotheses utilized several success measures that are influenced by a number of different concepts in our model illustrated in Figure 6. In our observations, we found success factors such as reusability and user satisfaction. These success factors reflect the success of an SOA. However, they take different view points and usually represent interests of different stakeholders. On the one hand, reusability is a rather technical aspect. Subsequently, in most cases, it is pursued by the IT department that implements a service-oriented architecture. The number of business processes that invoke a service and the frequency of invocation can serve as a unit of measurement. If the IT department can prove that a service is reused frequently in many processes, it is easy to argue that maintenance and development of this single service is much cheaper than having the same functionality provided by multiple applications scattered across the organization. On the other hand, user satisfaction is clearly a business goal. Users have little interest in cost savings or technical demands on the company's side. Instead, they appreciate flexibility and a timely satisfaction of their demands in a good quality. Hence, business processes must be flexible and agile to result in a certain degree of user satisfaction. As argued before, a successful SOA can cater to these demands.

A number of success measures can be employed (see, e.g., the framework by Börner and Goeken (2009)). Business departments can thus consider flexibility and time-to-market as important factors. From the technical side, autonomous services or a high degree of standardization might be important. In both cases, the measurement of success factors is far from trivial, and appropriate measures will have to be defined to operationalize the measurement of SOA success. To which extent technical and business-oriented success factors are aligned or not is an interesting question that is left to further research. Based on a literature review and expert interviews, Lee, Shim, and Kim (2010) identify 20 critical success factors in SOA implementation. However, their interrelationships and contribution to success are not clear.

4.5.4 Emergent Method as a New Construct

Observation 4 shows clearly that no formal method was applied in the ADAGE case. User requirements were analyzed, as can be seen in Observation 11. According to Observation 13, an iterative and incremental approach was established during the course of the project.

Hence, our observation that no method was used, which was originally based on interview statements (see Hypothesis 2), may be questioned with good reason. Of course, no explicit method was used. However, certain rules developed during the course of the project and these were applied repeatedly, as Observation 13 evidences. Following Mintzberg's ideas of "emergent strategies" (Mintzberg, 1994), we argue that within the ADAGE project a method emerged. We consider a method as an "emergent method" if a pattern develops in the absence of intentions or despite them (Mintzberg, 1987). In ADAGE, the pattern emerged in the absence of a pre-defined and formal method.

Most likely, this observation can be made in other IT development projects as well. Under which circumstances emergent methods appear is another intriguing research question. An analysis of their stability and adaptability is of interest as well. Maybe those methods have a higher degree of acceptance among team members and are more reliable due to their emergence within the context of the project.

5 Discussion and Further Research

In the previsous section we developed three model fragments and created one new concept called emergent method. The model fragments cannot be treated as being independent. On the one hand, there are evident relationships that can be traced in Figure 6. Obviously, the notion of success which is operationalized by certain measures integrates the contingency model (CM) and the model of soft factor transition (MSFT). On the other hand, there are most likely more links that have not been observed in our case. As discussed earlier, the concept of skills in the CM is most likely related to what is called experience in the MSFT. Moreover, the way of SI/SOA development (CM) is probably influenced by the direction of the identification approach, which is currently not part of the contingency model but of the MSFT. Hence, we assume that there are more causal links on several levels of our proposed model, so that the latter will have to be adjusted after more elaborate work on this topic is performed.

5.1 Discussion of Findings and Further Research

In our contingency model, we explained the influence of a number of context factors on the way of SI/SOA development. An extension of the list of factors, which form part of the general context, will be left to future research and can be achieved for instance through further case studies or expert interviews. Moreover, based on only one case study, it is impossible to determine the extent to which a single factor contributes to certain outcomes. After conducting more case studies, a factor analysis could help to understand more reliably how the combination of identified factors affects the use of methods. Since there is already a large body of literature that provides a comprehensive list of context factors for domains different from SOA, future research should concentrate on identifying those that have a significant impact on SOA implementation projects and, in doing so, understanding the generative mechanisms more deeply.

The model of soft factor transition links experience with SOA design and implementation aspects (flexibility and reusability) and provides a description of a generative mechanism which is likely to be at work. One question for future research that arises from this model is if a technical (resp. business-oriented) understanding of services necessarily leads to fine-grained (resp. coarse-grained) services and a bottom up (resp. top down) approach. Most likely, more experience would enable the project team to flexibly adapt granularity, create services on different levels of granularity, or apply a top down (resp. a hybrid) approach. Further case studies would help to shed light on these cause-and-effect relationships.

Furthermore, there might be other context factors that have strong effects on granularity and the direction of the approach. For instance, a high degree of top management commitment might support top down approaches because strategic aspects on an organizational (or even inter-organizational) level have to be incorporated. These aspects might be neglected if only middle management or the IT department were involved in the project.

Another intriguing question is whether one of these mindsets yields more success, and if this is the case, by which measure? According to most literature, business orientation is crucial for

successful SOA implementations because only this focus ensures that services can support business processes. However, the ADAGE case showed that an almost pure bottom up approach and very fine-grained services stemming from a technical understanding still can result in a successful SOA implementation. Of course, the ADAGE architecture is far from being business process-oriented. Nonetheless, it can be considered a success. Since case studies can be used for generating hypotheses (like in this paper) and testing hypotheses (De Vries, 2005), a multiple case study could be useful to investigate correlations of service understanding and success in SOA projects.

In general, concepts and categories in our model fragments are designed based on the evidence retrieved from the ADAGE project. However, relationships and interdependencies which we were not able to observe may exist. For instance, we identified skills of employees to be an important context factor influencing service identification methods. Furthermore, SOA experience had an impact on concepts such as understanding of services and, subsequently, flexibility and reusability. Most likely, concepts such as skills and experience are somehow related, even though there is no explicit hint to be found within the collected data. Literature argues that experience is one possible source to improve skills (see, e.g., Adelson and Soloway (1985), Dokko, Wilk and Rothbard (2009), Guile (2002)). Thus, further empirical evidence might support interdependencies found in literature and make an adjustment of our model necessary.

Our success model shows that multiple concepts more or less directly influence success of an SOA. This success can be viewed from different perspectives, i.e., technical or business-oriented. A model illustrating how these success factors contribute to the overall success of an SOA implementation could be a result of further empirical research. Using multiple case studies is one possibility to find supporting or contradicting evidence for the generated hypotheses. This would enable a cross-case pattern search and underpin the validity of the hypotheses (Eisenhardt, 1989). Further interviews, surveys, and document examination could be a basis for qualitative or (in large numbers) even quantitative cross-sectional analyses that are common and wide-spread methodologies in ISR (Wilde and Hess, 2007).

Currently, the success measures in our model are not well operationalized. Future research should improve the conceptualization of success measures as well as their measurement. It is necessary to describe how to measure these factors and which units to use. Finally, an evaluation of the importance of a single concept (e.g., the direction of approach) and to what degree it influences the success of an SOA would be desirable. Such quantification could be achieved by a factor analysis of context factors.

5.2 Methodological Considerations – Discussion of the Research Process

Although single case studies are an appropriate and accepted method for our purpose (see section 3), there are limitations to this approach. According to Darke et al. (1998), “where explanatory research is undertaken, a single case may provide the basis for developing explanations of why a phenomenon occurs, and these may then be further investigated by applying them to additional cases in other settings.” (p. 281) Moreover, a search for cross-case patterns using divergent techniques as proposed by Eisenhardt (1989) is only possible with multiple case studies. Although statistical, sampling-based generalizability cannot be provided by sin-

gle case studies, Lee & Baskerville (2003) provide a framework that distinguishes four types of generalizability and allows for the use of single case studies. However, more cases would be desirable to support the hypotheses generated in this paper on the basis of a single case study.

Since our case study is explorative in nature, it is well suited to show starting points for further research in this field. Our observations are grounded in facts retrieved from various sources, such as documentation and interviews. The hypotheses, however, have been generated in an interpretative manner and, thus, demand additional empirical evidence and testing. It has to be noted that in a single case study there is a certain probability that important concepts and categories were missed. Therefore, further research should not only focus on testing the hypotheses provided but should maintain openness to new phenomena arising.

Regarding the research process, we modified the established framework of Eisenhardt (1989) and extended methodological work in the realm of qualitative research (Klein and Myers, 1999; Myers, 2009) by applying abstraction mechanisms of conceptual modeling as guidelines for generalization. The intention was to enhance transparency and traceability of the generalization and to better justify the derivation of hypotheses. In this respect, it could be argued that these mechanisms might reduce creativity and limit abduction in the interpretative analysis. On the other hand, there are more abstraction mechanisms (e.g., aggregation, contextualization, kind-of …) which could be applied in a similar way. A more detailed elaboration, for example, the development of an appropriate framework for the use of abstraction mechanisms in qualitative research, requires further intensive methodological work.

6 Conclusion

Based on a case study of an SOA implementation project in an Australian company, we have made 16 observations and subsequently developed seven hypotheses, three model fragments, and one additional concept. In our research process, which is based on Eisenhardt (1989) and adapted as explained in section 3.2, we used techniques such as abstraction and generalization to interpret first-order data retrieved in the case study. We tried to provide evidence for the generation of hypotheses and the exploration of areas where existing knowledge is limited.

All our findings help to answer our initial research question because each unveils facets of how SOA development and service identification work in real-life projects. Moreover, our questions of research (section 5.1) have been answered satisfyingly:

- Whereas literature recommends the use of methods, there was no method used in our case. This must not necessarily lead to a failure of a project. Under certain circumstances, i.e., in some contexts, the absence of formal methods can be compensated for by intense communication.

- Several observations, hypotheses, and model fragments deal extensively with the context factors that influence the proceedings of the service identification process. We were able to observe some of these factors and to investigate their influence on SOA implementation projects.

- The understanding of services and related skills significantly influence the way of SOA development. Several hypotheses and model fragments show that concepts such as granularity, the direction of the identification approach, and finally the success of an SOA implementation are more or less directly influenced by the understanding of services (which is usually subject to change with increasing experience).

- Due to the absence of a method for service identification, we were not able to observe a stringent application of software development techniques. Due to the limited scope of the project, software development was mostly intuitive and bound to few developers.

- Our findings identified user satisfaction and reusability as success measures. More generally speaking, they suggest that it might be meaningful to differentiate between business-oriented and technical success measures, an issue which should be studied in future research.

The ambiguous results concerning the effects of method use, service understanding, granularity, etc. show that a method for service identification has to be tailored to a project at hand. The general context – including numerous context factors – has to be considered in order to appropriately support service identification. Especially the interplay of these factors has to be elaborated in order to develop situation-specific methods for service identification.

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Appendix

Appendix A: Interview Schedule

Date	Time	Room	Interviewee Role
04.03.2010	14.15-14.45	CSE Building, UNSW, Sydney	Second investigator
04.03.2010	15.15-15.45	CSE Building, UNSW, Sydney	Principal investigator
05.03.2010	11.00-12.00	CSE Building, UNSW, Sydney	Postdoctoral fellow
09.03.2010	16.00-16.30	80 Clarence St., 9th floor, Sydney	Industry coordinator

Appendix B: List of Websites

Website	URL
ADAGE GUI	http://129.94.172.120/adagegui7/
ADAGE Project Website	http://cgi.cse.unsw.edu.au/~soc/adage/index.php?n=Main.HomePage
Competitive Grants Round 10 Outcomes	https://grants.innovation.gov.au/ISL/Pages/Doc.aspx?name=CGR10.htm
SIRCA Homepage	http://www.sirca.org.au/
LibreSource – ADAGE project	http://soc-server.cse.unsw.edu.au/projects/adage

Appendix C: List of Services

Categories	Services	Description
Import	Reuters News Import Service	Each service imports news as event sets from a particular source. RNIS imports from the Reuters archive.

	RDTH Import Service (Market data from file)	Imports events from the Reuters Datascope Tick History (RDTH) system1 into the shared event repository. These events are mostly trades and quotes from every financial exchange worldwide. In addition, RDTH gives prices for every asset identified by the Reuters Identification Code (RIC), such as currency exchange rates, indices, and interest rates. This service allows events to be selected according to a wide range of criteria, such as period, RICs, exchange etc. This was a test service to avoid connecting to external systems
	RDTH Direct Import Service (Market data from external systems)	Each service imports market data as event sets from a particular source. RDTH Import Service imports from the Reuters Data Tick History (RDTH) service
Processing	Time series building	Processes trades and quotes to produce trade price time-series sampled at equal time intervals. This service is highly customizable as it allows the sampling period to be modified and a number of measures (such as the return, spread, and vwap) to be included in the time series. In addition, events from different event sources can be combined within a single time series. For example, the service can determine prices of multiple stocks and the index in which they belong. Another example is to combine a stock, its futures, and the interest rates in one time series. Each time series value is modeled as a Measure in our data model. Builds a time series of user-defined financial measures from market data event sets
	Merge	Used to merge different time series, for example, equity with index data
	Tagging	Used to tag events with “appropriate tags.” For example, news can be tagged with keywords inside the news story. Must be done prior to summarization.
	Price Jump	Used to detect abnormal returns by comparing two price time series with each other

	News Summarization	Used to group together news stories with the same tags.
Export	Download	Exports a time series from the shared event repository into a text format (e.g., CSV) suitable for processing using a statistical package like SPSS or Matlab. Used to download event sets on the local computer
	Visualization	Used to visualize event sets. Different graphs are shown depending on the type of events
	Preview	Gives some information on an event set

Appendix D: Interview Guidelines for UNSW Researchers

1. Can you tell me about your participation in the ADAGE project? (tasks, time frame, direct communication partners at SIRCA)

2. What kind of documentation on business processes did SIRCA provide?

3. Which other documents were provided?

4. How did SIRCA communicate user requirements?

5. Which primary business processes did you identify from the information you got from SIRCA?

6. How did you get from SIRCA's processes and requirements to services? What was the starting point? When was the identification completed?

7. How did you decide on cuts in services? Where does one service start/end?

8. Do you think some of your services have different granularities?

9. Are there different service layers?

10. Did you think about visualization techniques (like service landscapes)?

11. How did you model relations between services and inputs/outputs?

12. Did your services give the support that SIRCA expected? How do you know?

13. Was the service identification straight forward or more of an iterative approach?

14. Did you frequently use feedback loops to match your services with SIRCA's requirements?

15. Did you have to redesign or replace services?

16. How did you make sure that the implemented services met SIRCA's needs?

17. Were there any other stakeholders apart from SIRCA?

18. Do you think the SOA/services you implemented are a success? By which measure would you judge this?

19. Were there any requirements you were not able to implement as a service? Why?

20. What were the main difficulties in identifying services?

21. Looking at SOA principles, would you say your services are

    a. reusable

    b. loosely coupled

    c. autonomous

    d. interface-oriented

    e. flexibly composable

22. Did you use any method or guidelines to pursue the service identification? If not, would you feel more confident about the quality of implemented services if you had used a method (guidelines) when identifying them?

23. Is there room for an improvement in identifying and designing services so that user needs are better met?

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