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Approaches of Service Identification: Selective Comparison of Existing Service Identification Methods

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A B S T R A C T

The increasing digitalization in all spheres of life has resulted in complex business processes and interactions for companies worldwide. For this reason, they see themselves forced to implement efficient information systems which enable a simple and flexible coordination of all business processes within a company. The concept of service-oriented architecture has evolved to tackle this challenge by designing an enterprise architecture that is capable of a rapid response to changing business needs within a company or its environment. One of the very first steps in this context is the identification of services, which is argued to be key for a successful design and implementation. Numerous researchers have come up with models for a structured service identification process. The purpose of this study is to identify the most coherent approach with regard to its degree of detailedness and practicability from a business perspective. A structured literature review of 116 approaches was conducted of which 20 were selected for a detailed analysis using a specific set of comparison criteria. Given the analysis scope of the study, SOPLE-DE – design in the context of service-oriented product line engineering – by Medeiros et al. (2010) was found to be most conclusive for the identification of services.

Keywords: service science, service-oriented architecture, service identification

Ⅰ. Introduction

Since business processes and interactions become increasingly complex with rising demands and expectations, an efficient information system which coordinates all business processes within a company is highly important. **Service-oriented architecture** is a relatively new paradigm to tackle this challenge. It aims to design an enterprise architecture, which can quickly react to changing business needs within the company or its environment. Until today, there is no best practice for the introduction of an efficient service-oriented architecture. Most researchers agree that one essential task is the identification of services, which is one of the first tasks and the basis for the successful design and implementation of a service-oriented architecture. There are numerous approaches which attempt to establish an efficient service identification method. Noticing great differences between them, this paper pursues to compare some of the existing approaches with regard to their detailedness and practicability. The comparison is conducted using a specific set of criteria.

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In the course of this study, the respective literature was first reviewed. Based on the literature review, section 2 examines the basic concepts and definitions relevant for service identification. In section 3, the methodology of approach selection and comparison is presented providing a table of the selected approaches with the respective comparison criteria as a result. The classification tables are split into tables comprising criteria which were taken from other comparative studies (SIM Comparison – Existing Criteria), and tables which attempt to analyze the approaches taking into consideration the concept of situational method engineering (SIM Comparison – Elements of SME). The Service Identification Method (SIM) by Medeiros et al. (2010), which was found to be the most explicit one considering the set of classification criteria, is explained in more detail in section 4 and lastly, conclusions are drawn in section 7.

Ⅱ. Basic Concepts and Definitions

Service identification is widely understood as a building block of a service-oriented architecture. Therefore, it is crucial to understand the concept of service-oriented architecture and the meaning of service in this context before tackling on service identification approaches. In the following, the terms service, service-oriented architecture, and service identification shall be explained in a generic way pointing out the different definition frames.

A. Services

Erl (2008: 39) describes services in the context of service-oriented architecture as "physically independent software programs with distinct design characteristics that support the attainment of the strategic goals associated with service-oriented computing." Specifying these distinct design characteristics, Heutschi's (2007: 22) definition of services include their ability to "provide other applications with stable, reusable software functionality at an application-oriented, business-related level of granularity using widely applied standards" (quoted in: Boerner 2012: 1). This definition implies that services in a service-oriented architecture should fulfil certain requirements. Researchers generally agree on the following service requirements: interoperability[1], reusability, loose coupling and composability (e.g., Erl 2008: 50; Gu & Lago 2010: 37; Huergo et al. 2014: 2, Svanidzaite 2012: 202, Börner 2012: 2-4).

B. Service Oriented Architecture

The concept of service-oriented architecture was introduced in order to cater to changing business needs (Sivakumar 2010). From the general service requirements mentioned above, a service-oriented architecture can be defined as "a framework for integrating business processes and supporting IT infrastructure as secure, standardized components – services – that can be reused and combined to address changing business priorities" (quoted in Börner 2012: 1). Opinions from researchers are diverged, whether service-oriented architecture should be viewed as a technology, a middleware or an architectural paradigm. However, a tendency towards the latter understanding can be observed from literature (e.g. Rieks: 6).

C. Service Identification

In general service identification addresses the question regarding actions of the business processes of a company that should be realized by a service (Winkler 2007: 257). It is one of the first steps in the service-oriented development process and recognized as the basis for a successful implementation (Birkmeier 2008: 256). The extent of the service identification phase varies across different approaches. Fischbach

1) Definition: ability of different systems to collaborate seamlessly (http://www.duden.de/rechtschreibung/Interoperabilitaet, accessed on 20.12.2015)

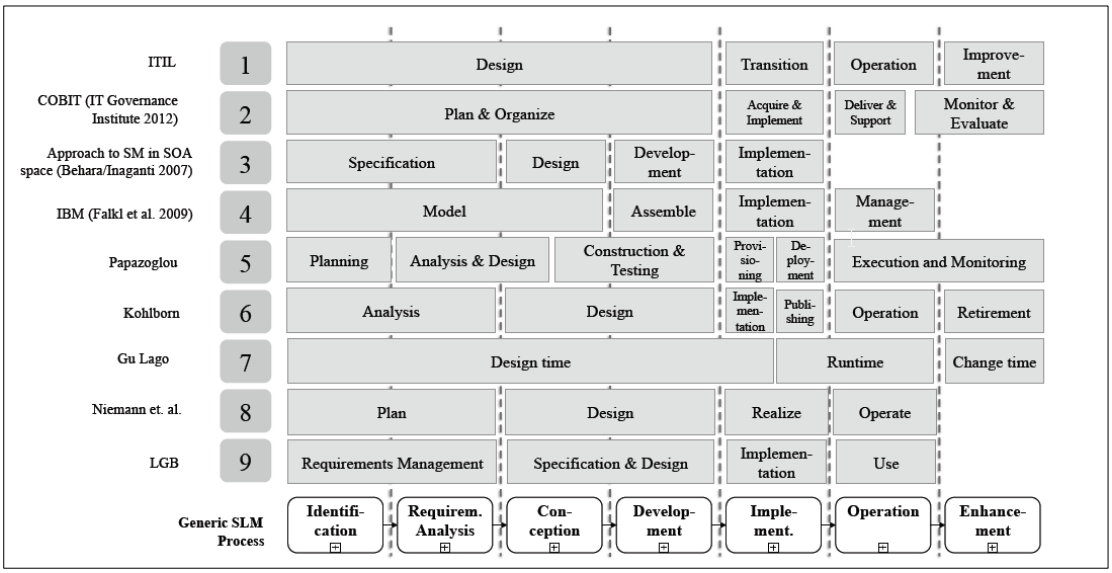

Figure 1. SLM process structure approaches (Fischbach 2014: 84)

(2014) illustrates how the tasks of different phases in a service lifecycle management process can diverge (see Figure 1).

He derives seven steps of a generic SLM process, which are identification, requirement analysis, conception, development, implementation, operation, and enhancement. Focussing on the identification phase in figure 1, it is clear that the scope of this task varies, ranging from analysis to service design. This different understanding of service identification constitutes one challenge of comparing different service identification methods. The scope of the service identification step may be measured by comparing the outputs of different service identification methods.

Ⅲ. Comparison of Service Identification Methods

After providing the basis for understanding service identification processes, this section entails the focus of this research paper – the comparison of selected service identification methods. First, the methodology will be explained, which includes the procedure of selecting specific service identification methods and classification criteria for the comparison. Section 3.2 presents the comparison results tabularly.

A. Methodology

For the collection of existing service identification approaches, the main focus was on the literature review of existing comparative studies. Table 1 presents the studies, which are adopted and considered in this research paper.

A list of service identification methods presented in the literature from Table 1 can be found in the appendix (Annex 1[2]). The process of breaking down this list was executed in two steps. First, research papers by the same author are reduced to adopt only the author's latest research paper, underlying the assumption that the latest research by one and the same person is an update to her previous work. Research papers which are not publicly available were also disregarded. In the second step, the number of service

2) Service Identification Methods, which were not selected for the comparison, are not included in the references.

Table 1. Existing Service Identification Method Surveys

Author	Year of Publication	Title	Number of approaches
Gu & Lago	2010	Service Identification Methods: A Systematic Literature Review	38
Huergo et al.	2014	A systematic survey of service identification metbods	105
Svanidzaité	2012	A Comparison of SOA Methodologies Analysis & Design Phases	5
Börner & Goeken	2012	Identification of Business Services - Literature Review and Lessons Learned	5

Table 2. SIM Exclusion Criteria

No.	Methods	Exclusion Criteria
1	Mathematically Optimizing Method	This method tends to neglect business perspective and management of business processes
2	Service Hierarchies	This method does not include different hierarchical service levels
3	Service Types	This method does not differentiate service types as a compulsory criterion

identification methods is further reduced by applying three exclusion criteria (s. Table 2);

Mathematically optimizing methods. Methods based on mathematical calculations are excluded from the comparison because they tend to neglect the business perspective. As described in section 2, service-oriented architecture is a paradigm which moves the management of business processes in the centre of attention. Therefore, this study focusses on the comparison of service identification methods addressing business needs for the construction of service-oriented architectures.

Absence of Service Hierarchies. Recalling the service requirements named in section 2.1, composability implies the existence of different hierarchical levels. It is therefore assumed that identifying services with different granularity and differentiating them in a hierarchical way will contribute to the advantages of a service-oriented architecture.

Absence of Service Types. The differentiation of service types was selected as a compulsory criterion because methods, which attempt to identify different service types, are presumed to be more profound and detailed. Erradi et al. (2007: 610) argue that service classification is an important step “to guide the non-functional aspects of service design”.

A list of the selected service identification methods can be found in Annex 2. After reducing the methods by using the above-mentioned criteria, a set of comparison criteria is defined;

Direction of Approach / Underlying Service Definition. Depending on the underlying service definition, which can be either technical- or business-oriented, the direction of approach can be divided into three approaches; *bottom-up, top-down* or *meet-in-the-middle*. A researcher who defines services on **a technical basis** will tend to **identify them bottom-up**, meaning that the focus is on exposing the existing application environment and modularize it from a technical perspective. Business perspective is included only in the second step, and identified modules will be matched with business needs resulting in a service. If a researcher suggests **a business oriented service definition**, he will rather proceed in **a top-down approach**. Using the top-down approach, the application domain is exposed and the services are derived from business concept models before they undergo a technical specification. Many researchers have found that choosing one of the described approaches may not yield the desired results. Neglecting either the business or the technical perspective could, for example, result in a redundant realization of functionalities as a component of different services or the realization of dependent services from a business perspective. Therefore, numerous methods with hybrid approaches, namely the meet-in-the-middle approach, were developed

to combine both, business and technical needs in an early stage of the service lifecycle (Birkmeier et al. 2008: 259).

Superordinated Model. The comparison of the methods using this criterion can be divided into three categories; first, the method might only concentrate on the service identification process without mentioning any superordinated model (*None*). Second, the method focuses on the service identification process highlighting that it is one of several steps within a greater process (*General*). And last, the study may not concentrate on the service identification method only but suggests a method, of which service identification is one task (*Specific*).

Degree of Formalization. This research differentiates two types of degree of formalization. These are *general guidelines* and *structure*. While general guidelines give hints of what has to be considered when identifying services, a structured method provides a step by step process guideline.

Service Hierarchy Structure. This criterion attempts to analyze the amount of hierarchical levels used by a method. Service hierarchies are typically visualized in service layers (see Figure 2). The differentiation of composite and atomic services is regarded as a two-layers-hierarchy.

Service Types. As will be shown in the comparison tables (Table 2a-c), there are different service type classifications. Analyzing different dimensions of service type classification is a complex task and goes beyond the scope of this paper.

Type of Output. This criterion aims to highlight what is the output of each service identification method. This research differentiates three types of output; the *informal service specification* comprises identified services with a list of terms such as service description, input and output. A *service model* illustrates the service landscape in terms of diagrams, and last, the *formal service specification* describes the identified services using standard language, for example WSDL (Gu & Lago 2010).

Tool Support. The criterion tool support is categorized into two questions; does the suggested method mention or provide any tool support? If the method suggests a tool, is it a new tool, an amended tool or a generic tool? In the comparison tables, the tools used in the method are named.

Validation. Methods can be validated in different ways. In the course of this research the following validation possibilities were found: *case study, project*, and *real-life application*. There are also researchers who do not validate their method.

Quality Statement. Ideally, the identification method can guarantee the correctness of the results (Birkmeier et al. 2008: 261), for example by conducting qualitative and quantitative evaluation.

Elements of Situational Method Engineering. In addition to this set of comparison criteria, which are taken from other comparative studies (see Table 1), this paper attempts to break the method down into the method of engineering components, which are illustrated in Figure 3. This break down serves

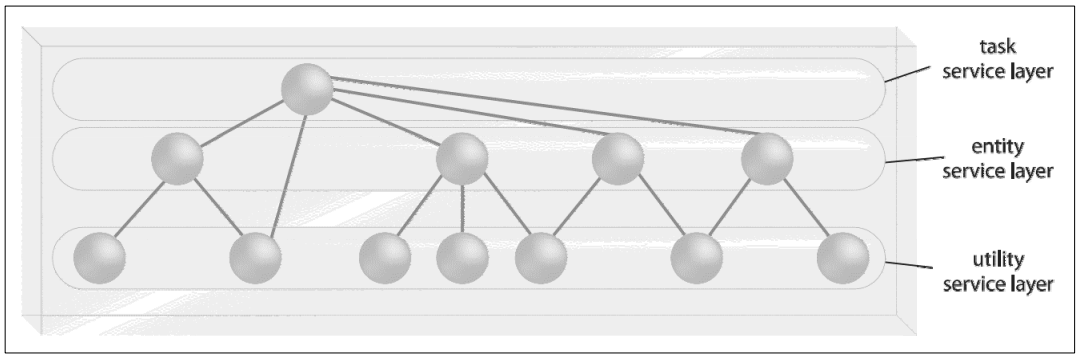

Figure 2. An example of service layers (Erl 2008: 43)

as a supplement to the set of comparison criteria in order to analyze the explicitness of the methods. Börner (2012) extends the conventional method engineering concept by adding two more elements, namely *flexibility* and *configurability*. These elements support the idea of situational method engineering, which argues that "methods have to be adaptable to different kinds of situations" (Börner 2012: 51). Flexibility examines whether the sequence of activities can be rearranged, while configurability reviews the possibility of choosing method elements, which depend on certain situations (Börner 2012: 256).

B. Results of the Service Identification Method Comparison

After reducing a total of 116 research papers dealing with service identification, 20 service identification methods were selected for the comparison. Tables 2 to 4 present the results of the comparison using the set of criteria described in the previous section,

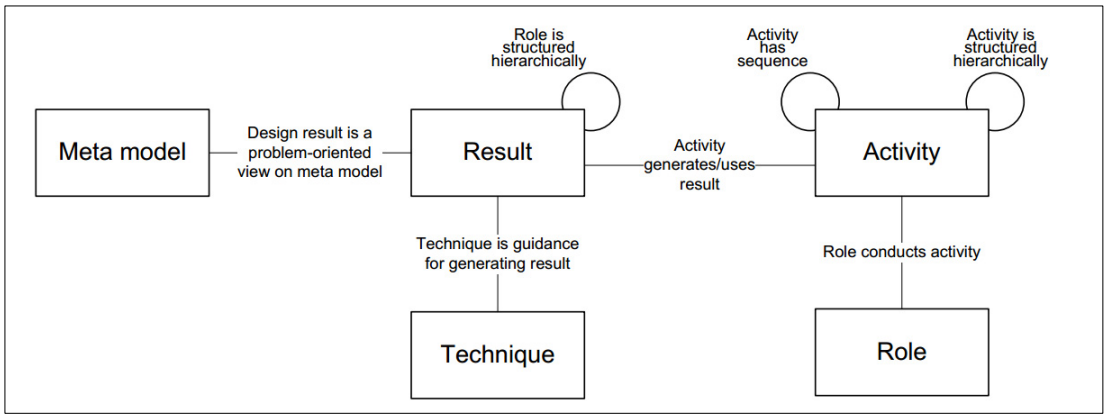

Figure 3. Method Engineering Elements (Börner 2012: 251)

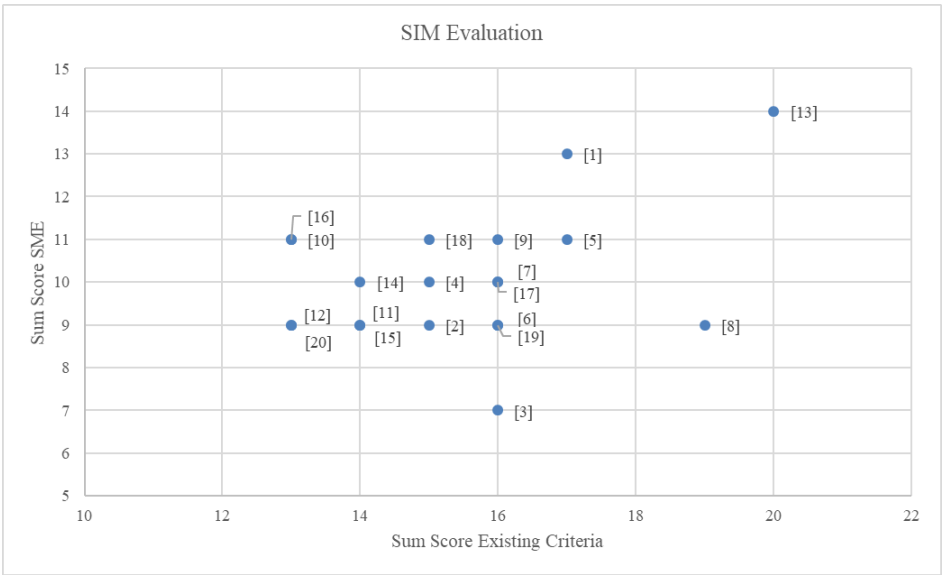

Figure 4. SIM Evaluation using sum scores for existing criteria & SME criteria

Table 3. SIM Comparison – Existing Criteria (1)

	SIM \ Criteria	Direction of Approach	Superordinated Model	Degree of Formalization	Service Hierarchy	Service Types	Type of Output	Tool Support	Validation	Quality Statement
[1]	Adamopoulos et al. (2002)	top-down	specific <SE Framework>	structure	2 layers	pre- & post-conditions of service operations	service model	none	real-life application	none
[2]	Alahmari et al. (2010)	bottom-up	general <SOEA project lifecycle>	structure	2 layers	process service, business service, transactional-data service, master-data service, utility service, infrastructure service	informal service specification	IBM Rational Software Architect > UML class diagram IBM WebSphere Busines Modeler > business process XML schema Rational Rose > Eclipse Modeling Framework IBM Model Transformation Framework	real-life application	none
[3]	Baghdadi (2006)	bottom-up	specific <RE Process>	structure	2 layers	2-dimensional: 1. composition types: coarse-grained web services, applications, business processes, new e-business solutions 2. operation types: create, retrieve, update, delete	formal service specification	CASE	none	none
[4]	Beverungen et al (2008)	meet-in-the-middle	general <SOA concept>	structure	2 layers	task service, entity service	formal service specification	none	project	none
[5]	Birkmeier et al. (2013)	meet-in-the-middle	none	structure	multiple layers	domain specific services, basic services, cross sectional services	service model	none	case study	Empirical evaluation: controlled study - quantitative result analysis - perceived usefulness questionnaire
[6]	Dinh & Nguyen Ngoc (2010)	top-down	specific <SO-IOIS>	structure	2 layers	multi-dimensional: 1. informational: data-as-a-service (entity) 2. operational: action-as-a-service (task), process-as-a service 3. legal	informal service specification	none	case study	none
[7]	Erl (2005 & 2008)	meet-in-the-middle	specific <SOA methodology>	general guidelines	3 layers	entity service, task service, utility service	service model	none	case study	none

Table 4. SIM Comparison - Existing Criteria (2)

SIM \ Criteria	Direction of Approach	Superordinated Model	Degree of Formalization	Service Hierarchy	Service Types	Type of Output	Tool Support	Validation	Quality Statement
[8] Erradi et al (2007)	meet-in-the-middle	specific <SD process>	general guidelines	6 layers	multi-dimensional: 1. scope: cross-business service, channel service, channel specific service 2. degree of reuse: core entersprise service, common service, specific application service 3. hierarchical: process service, application service, shared data service, infrastructure service	service model	none	case study	none
[9] Fareghzadeh (2008)	meet-in-the-middle	general <SOA development process>	structure	3 layers	application service, business service (task & entity service), process service (compose other services)	service model	none	case study	none
[10] Huayou et al. (2009)	top-down	specific <SOAD method>	general guidelines	2 layers	interface service, computing service, extended service, control service	informal service specification	none	case study	none
[11] Klose et al. (2007)	meet-in-the-middle	none	structure	2 layers	basic services: entity (create,modify, view, delete) & task services	informal service specification	none	project	none
[12] Kohlmann & Alt (2007)	meet-in-the-middle	none	structure	2 layers	process service, rule service, entity service, [infrastructure service]	informal service specification	none	case study	none
[13] Medeiros et al. (2010)	top-down	specific <SOPLE-DE (design in the context of service-oriented product line engineering)>	structure	3 layers	2-dimensional: 1. layers: composition layer: composite service service layer: self-contained service, business-aligned service component layer: mandatory service, optional service, alternative service components (variability of a service) 2. task service, entity service, utility service	formal service specification	none	project	Empirical evaluation: - quantitative analysis - feedback questionnaire

SIM \ Criteria	Direction of Approach	Superordinated Model	Degree of Formalization	Service Hierarchy	Service Types	Type of Output	Tool Support	Validation	Quality Statement
[14] Nakamura et al (2011)	bottom-up	none	structure	multiple layers	common/uncommon, data-/control-dependent, fine-/coarse-granular	service model	none	case study	none

Table 5. SIM Comparison Existing Criteria (3)

SIM \ Criteria	Direction of Approach	Superordinated Model	Degree of Formalization	Service Hierarchy	Service Types	Type of Output	Tool Support	Validation	Quality Statement
[15] Perin-Souza et al. (2011) / Avezedo et al. (2009)	top-down	none	structure	multiple layers	operations types: create, retrieve, update, delete	informal service specification	none	case study	none
[16] SAP (2005)	meet-in-the-middle	specific <DDES>	general guidelines	2 layers	component service, process service, entity/engine service, utility service	Informal service specification	none	none	none
[17] Shirazi et al. (2009)	meet-in-the-middle	general <SOA delivery lifecycle>	structure	3 layers	Application services, business services (task & entity centric), process services	service model	none	case study	none
[18] Weigand et al. (2009)	meet-in-the-middle	none	structure	3 layers	core services, complementary services, enhancing services (publication, access & management services), support services (informational service, utility service), coordination services (identification, negotiation, actualisation, post-actualisation service), business service, decision service	service model	none	case study	none
[19] Yousef et al. (2009)	top-down	none	structure	multiple layers	operations types: create, retrieve, update, delete, atomic function	service model	RACER > automatic computing of classification and satisfiability	case study	none
[20] Yun et al. (2009)	top-down	general <SOAD method>	structure	2 layers	quality attribute, effect attribute, result attribute	informal service specification	none	case study	none

Table 6. SIM Comparison - Elements of SME (1)

	Criteria / SIM	Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[1]	Adamopoulos et al. (2002)	1. service requirements analysis 2. service analysis 3. service design	service developers, service designers	1. use case 2. (ancillary) service conceptual models, service sequence diagram, service operation contract 3. service interaction diagram, service design class diagram	1. assemble, document, structure requirements on the service from involved stakeholders 2. service decomposition, define (pre- and post-condition of service) operations 3. define interacting service COs, create service interaction diagram, specify software classes with strict and informative notation	sequence of steps > some might be done parallel	yes, because iterative and incremental service development process (continuous optimization)
[2]	Alahmari et al. (2010)	1. analysis and re-engineering 2. service elements identification 3. evaluate candidate services against the SOEA meta-model	-	1.1 analysis model 1.2 activity porfolio, knowledge portfolio 1.3 process portfolio (legacy system behavior), knowledge portfolio, business processes model, activity diagram, Eclipse Modeling Framework 2. candidate services 3. services	1.1 workshop, questionnaire, interview, available documents 1.2 review business and design documents, UML modelling 1.3 transform UML to BPMN diagrams 2.1 bottom-up analysis of atomic processes and data relative business entities from UML, BPMN and analysis model 2.2 apply clustering metrics using business logic and CRUD functions 3. combine classification and clustering metric	-	-
[3]	Baghdadi (2006)	1. identify web services 2. specify web services 3. apply CRUD patterns	-	1. basic web services 2. specified web services	1. transform relation schema and its constraints to web services 2. apply CRUD patterns	-	-
[4]	Beverungen et al. (2008)	1. preparation 2. service analysis 3. service specification	-	1. regulatory framework, process models 2. analysis scheme, evaluated service candidates 3. service catalog, basic services, process services	1. create regulatory framework (reference design by Meise 2001), limit object of analysis, create/amend detail process models 2. identify actors using outputs of step 1, analysis from business perspective using guiding questions, analysis from IT perspective using a criteria catalog 3. categorization of service candidates, specification of categorized services based on the chosen technical form of realization for the SOA (suggestion: basic services in WSDL, process services in BPMN)	repetition of initial steps if necessary (e.g. if identified service is too coarse-granular)	-

Table 7. SIM Comparison - Elements of SME (2)

Criteria / SIM		Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[5]	Birkmeier et al. (2013)	1. identify and bundle functionalities 2. complete implicit functionalities 3. group functionalities into services 3.1 align with service architecture 3.2 remove realized functionalities 3.3 identify service candidates 3.4 identify new services 4. align with service catalog 5. align with business architecture 6. classify new functionalities and services	business analyst solution architect	1. initial list of functionalities 3. new services, service profiles 3.1 reduced list of functionalities 3.2 reduced business process models 3.3 hierarchy of service candidates 3.4 detailed service profile 6. detailled solution concept	1. bundle process activities which belong together logically using existing business process models which are relevant in the specific project context, rearrange functionalities to ensure constant granularity 2. add implicit functionalities that are required to provide IT support 3.1 mark all functionalities which can be realized through existing services, generate a reduced list of functionalities that still have to be realized in new services 3.2 remove all realized functionalities from the business process models 3.3 identify service candidates using several heuristics (partially from Avezedo et al.) 3.4 evaluate each service candidate on the basis of several guidelines adopted from SAP Enterprise Services Design Guide and German Federal Enterprise Architecture Framework 5. validate functionalities and evaluated related business functions and sub-functions based on the business architecture	-	Yes, overall process can be customized to incorporate specific modeling techniques and maturity levels
[6]	Dinh & Nguyen Ngoc (2010)	1. service analysis 2. general service design 3. service implementation	-	1. overlap protocols (set of rules and procedures governing interchange of shared information between economic entities) 2. overlap situations, organization of services 3. UML class diagram, petri-net diagram	1. network configuration to determine relationships between economic entities and information-intensive service requirements 2. identify overlap situations and agree on roles and responsibilities conforming to the overlap protocoll 3. define and model shared information, services and governance	-	-
[7]	Erl (2005 & 2008)	1.1 analyze business models and requirements 1.2 service modeling	1.1 business analyst 1.2 business analyst & technology architect	1.1 business processes & requirements 1.2 service candidates	1.2 business process decomposition, business process steps filtering, top-down analysis of enterprise business models, identification of process-specific logic using SOA layers, application of service-orientation principles, scenario documentation, mini-analysis of operation candidates using guiding questions, review current service inventory, examine logical relationships, activity scenario mapping	-	-

	SIM \ Criteria	Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[8]	Erradi et al (2007)	1. business service identification 2. application identification 3. existing functionality identification 4. reusable infrastructure services identification 5. service classification	-	1. product, channel, business process, business activity, use case, to-be business process 2. conceptual map of business services 3. list of all the fine-grained activities 4. reusable infrastructure services 5. services	1. domain decomposition, business process modelling 2. process-to-application mapping 3. application stakeholder interviews, tool combination 4. activity decomposition	-	-

Table 8. SIM Comparison - Elements of SME (3)

	SIM \ Criteria	Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[9]	Fareghzadeh (2008)	1. initial analysis 2. in-depth analysis 3. make a service taxonomy 3.1 identify entity services 3.2 identify application services 3.3 identify task services 3.4 identify process services	system analyst, project stakeholders	1. vision document, business process model, exisiting assets, glossary of terms 2. stakeholders, business actors & entity, business use case, business use case model, operation service cadidate, business rules 3. services	1. document business process which corresponds to service specific modelling conventions 2. business process decomposition, stakeholder separation (external & internal business partners), determine interrelate dependencies, extract operation service candidate and business rules, business use case modelling, system definition refinement 3.1 check existing services, separate operation service candidates related to one or more dependent entities, scale and categorize operation candidates, derive service interface using principles of service-orientation 3.2 implement utility service model, review existing inventory of application services, separate process steps, categorize remaining operation candidates 3.3 review work logic extract from business use case model and relations, define business goals and steps 3.4 separate business and application logics	-	-

SIM \ Criteria	Situational Method Engineering					
	activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[10] Huayou et al. (2009)	1. service classification 2. use case script elaboration 3. extending points reduction 4. interface & computing services identification, control policy identification 5. extended services identification and description 6. control service construction	analyst	1. service model 2. use case sentences 4. atomic services 5. extended services 6. control services	1. service model design 2. conform use case script to description criterion 3. combination of too fine-grained steps 4. design of atomic services description according to corresponding sentence's context 5. extending point and control policy as input 6. service = use case, service process = main path	-	-
[11] Klose et al. (2007)	1. preparation 1.1 scope determination 1.2 process model preparation 1.3 stakeholder identification 2. business & IT feasiblity analysis 3. definition of service types, operations & compositions	-	1. framework, process model, analysis scheme 2. service candidates, usage scenarios 3. specified basic services & service compositions	1. framework documentation, review existing process models 2. questionnaire, SOA design principles 3. bottom-up alignment of business and IT, proposition for basic distinction of elemental and composed services	-	-
[12] Kohlmann & Alt (2007)	1. model selection, identification of area of service identification 2. service analysis 3. service verification 3.1 check existing services 3.2 service candidate assessment 4. service detailing	-	1. enterprise model, process model, network model 2. service candidate 4. service list	2. deduct services top-down based on service criteria, design principles and roles, name service candidate & describe function 3. examine, if service candidate fulfils criteria and design principles and if it fits the business needs of the process and the role 4. allocate candidate to one of the three service layers, affiliate service to service list, specify relations to other services	-	-

Table 9. SIM Comparison - Elements of SME (4)

SIM \ Criteria		Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[13]	Medeiros et al. (2010)	1. architectural elements identification 2. variability analysis 3. architecture specification 4. architectural elements specification 5. design decisions documentation	1. domain architect, SOA architect, business analyst 1.1 SOA architect 1.2 business analyst 2. domain architect 3. domain architect, SOA architect 4. service designer, domain designer 5. domain architect, SOA architect	1. interaction pattern, service model, feature model, attribute scenario, service & compoinent candidates 2. services & components 3. architectural views 4. architecture document 5. set of solutions for each specific problem	1. business process decomposition, service modelling from use cases, features modelling, ping/echo & hearbeat tactic, communication flow with SOAP/REST 3. UML notation 4. UML diagram design and complement of description, interfaces, pre-conditions, invariants, post-conditions, quality attributes in the architecture document	design decisions documentation	product development cycle: specialization of architectural elements to a particular context
[14]	Nakamura et al. (2011)	1. hierarchical DFD from a given program 2. data flow categorization 3. data dependency analysis 4. apply service extraction rules	system maintainer	1. hierarchical DFD 2. external data, system data, module data 3. dependency data flow 4. self-contained services	1. conventional reverse-engineering techniques (explanation out of scope) 4. six rules of service extraction	-	-
[15]	Perin-Souza et al. (2011) / Avezedo et al. (2009)	1. activities selection 2. identification and classification of candidate services 3. consolidation of candidate services	analyst	1. automatable activities 2. candidate services	1. consideration of automatable activities 2. application of heuristics on selected activities 3. application of consolidation heuristics on candidate services	-	-
[16]	SAP (2005)	1. scenario & business process analysis 2. service requirement analysis	solution designer	1. enterprise service requirements, set of indicators that suggests how services might be beneficial 2. list of issues that could be addressed by services	1. set of indicators 2. design draft	sequence of indicators > no fixed sequence	indicators > other service indicators can be added

Criteria / SIM		Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[17]	Shirazi et al. (2009)	1. identify business process 2. make business use-case model 3. identify entity centric services 4. recognize application services 5. identify task centric services 6. recognize process centric services	-	1. business requirements, business vision, business process 2. business actors, entity-business use case, business use case model, operation service candidate, business rules 3. entity centric services 4. application services 5. task centric services 6. process centric services	1. - 2. use case modelling 3. utilize outcome of 1st and 2nd step to identify operation candidates' dependencies, scale operation candidates & categorize as logical groups (entity centric services) 4. separate process requirements dependent on technology and application programs, check operation candidates with existing services' functionalities, categorize remaining operation candidates into logical groups (application service) 5. review and amend logic of workflow and every possible relation 6. separate business logic and application logic, recognize and separate all business rules, condition rules, exception logic and sequence logic, assign operation candidates of all controlling, conditions and exception operations, categorize related operation candidates as logical groups	-	-

Table 10. SIM Comparison - Elements of SME (5)

Criteria / SIM		Situational Method Engineering					
		activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[18]	Weigand et al. (2009)	1. value model creation or adaption 2. business service identification 3. software service identification	web service designer	1. value model 2. business service model 3. service realization model	1. e3value modeling 2. table notation of business rules and policies 3. top-down informational service identfication starting from business services identified in phase 2 OR mim-approach starting from available applications, apply generic solutions to derive informational services from e3value model, design decision services that incorporate business rules, design infrastructural support including sourcing and required SLA level	-	Yes, step 3: TD or MIM

SIM \ Criteria	Situational Method Engineering					
	activities	roles	results (inputs & outputs)	techniques	flexibility	configurability
[19] Yousef et al. (2009)	service candidate identification	-	candidate services, software service oriented model	1. match each pool in a BPMN process model to a business line in BPAOnt 2. match each task in the BPMN model to an atomic function in BPAOnt 3. identify matched functions that can be automated according to the BPAOnt ontology 4. tag each of the identified functions with the business line it belongs to 5. eliminate redundant functions 6. relate the resulting functions to all EBEs in the BPAOnt according to the CRUD functions 7. create the CRUD matrix 8. apply the EEAT clustering technique to group functions into services so as to enhance the correctness of mapping business services to associated software services 9. refine services according to QoSOnt; 10. validate the generated service oriented model	-	Domain Independency
[20] Yun et al. (2009)	1. DFD elaboration 2. process design 3. service attribute identification 4. composite service design	-	1. DFD 3. atomic services 4. composite services	1. new DFD for coarse-grained atomic processes, DFD deletion for too fine-grained atomic processes, conform DFD to corresponding criterion 2. name processes (XX, writeXX, readXX) 3. view atomic processes as service and define input and output 4. add feedback line & link into DFD diagram	-	-

and Tables 5 to 9 complete the comparison results using the Situational Method Engineering elements as described in section 3.1.

In order to summarize the results presented in Tables 2 to 9, a SIM (Service Identification Method) evaluation using MS Excel was tabulated by generating sum scores for the existing criteria on the one hand, and the SME (Situational Method Engineering) criteria on the other hand. Figure 4 illustrates the results of the SIM evaluation.

Figure 4 shows that SIM approach [13] received the highest score in both categories. Therefore, the next section will describe and explain this approach in more detail.

Ⅳ. Service Identification Method by Medeiros et al. (2010)

Medeiros et al. (2010) developed a method called SOPLE-DE, designed in the context of service-oriented product line engineering. This method aims to combine software product line[3] and service-oriented architecture because they share common goals like flexible and cost-effective software systems and reusability of existing software (Medeiros et al. 2010: 70). In the following, the approach is described using the comparison criteria explained in section 3.

SOPLE-DE uses the identification of services from business processes as a starting point (Medeiros et al. 2010: 72). Therefore, it follows a top-down approach. Legacy systems are disregarded in this approach, but they are mentioned in the conclusions as an aspect for future work (Medeiros et al. 2010: 78). The superordinate model can be classified as specific since SOPLE-DE is a method fully developed by Medeiros et al. (2010) and goes beyond service identification. However, recalling the different definitions of service identification (section 2.3), one might also conclude that a superordinate model is non-existent if SOPLE-DE is regarded as a pure service identification approach leaving out the operational part of the service lifecycle. Looking at the degree of formalization, the approach suggests a clear structure. As argued by Medeiros et al. (2010: 71), "the key difference of the work [⋯] is the systematization of the design, which provides a set of sequential activities and sub-activities with clearly defined inputs and outputs". SOPLE-DE is based on a service hierarchy which is commonly used in SOA (Service Oriented Architecture). It is divided into three different layers: service composition, services, and components (Medeiros et al. 2010: 71). Medeiros et al. (2010: 71, 75) suggest a two-dimensional classification of service types. First, they differentiate services according to the service oriented architectural layers. While the composition layer consists of composite/ orchestrate services, services in the service layer are separated into self-contained and business- aligned services, and the component layer comprises of mandatory, optional and alternative service components depending on their variability. These services in turn are classified according to their type of logical extension of reusable potentials, and their relation to other existing domains into entity, task and utility services (Erl 2008: 43). Entity services manage information, whereas task services processes tasks (Birkmeier et al. 2008: 260). Utility services, in contrast, are not business-centric, but provide utility functionality (Erl 2008: 46). The output of SOPLE-DE is clearly defined in section 2 of Medeiros et al.'s (2010: 71) study. It is classified as a formal service specification because an architecture document is generated with the help of UML (Unified Modeling Language) models to represent the behavior of the architectural elements. The research does not mention any specific tools to support the activities. SOPLE-DE underwent an extensive validation process using quantitative and qualitative methods. An experimental study was conducted, which was evaluated using four metrics – a) service coupling, b)service instability, c) lack of service cohesion, and d) applicability problems – for the purpose of quantitative validation (Medeiros et al. 2010: 76). The qualitative analysis

3) Definition of Software Product Line: "Set of similar service-oriented systems that supports the business processes of a specific domain and can be developed from a common platform or set of core assets." (cited in Medeiros et al 2010: 70).

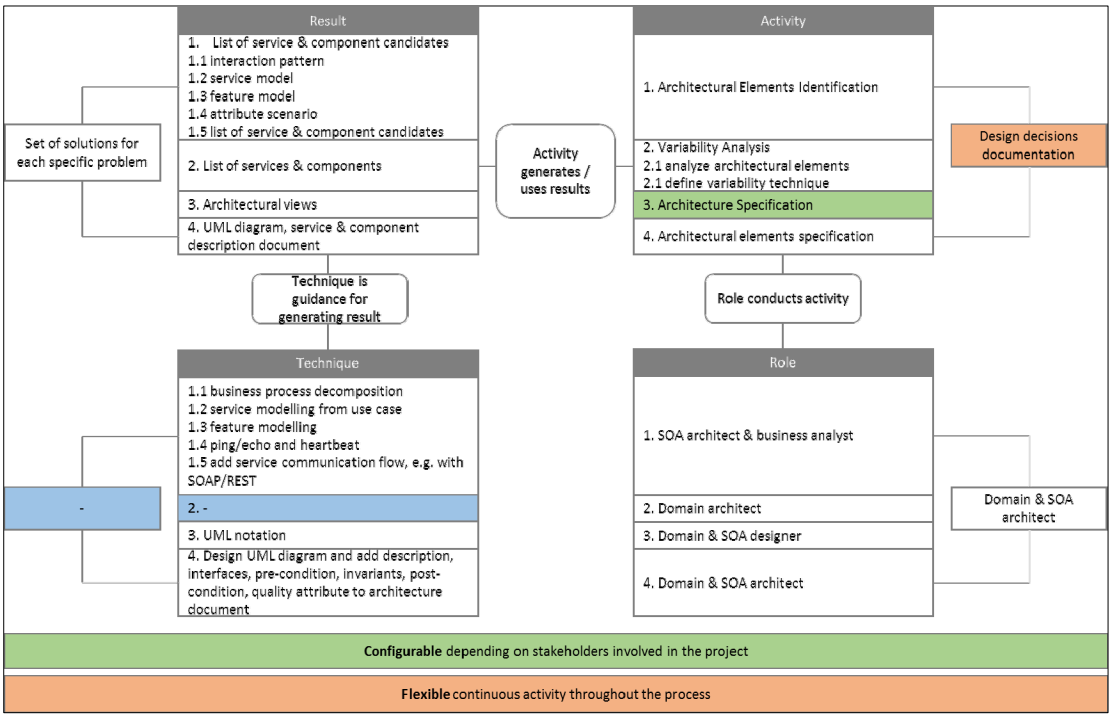

Figure 5. Elements of SME in SOPLE-DE (Own illustration)

was based on a feedback questionnaire using four aspects – a) training analysis, b) usefulness, c) quality of the documentation and instruments, as well as d)quality of the architecture document produced by the participants (Medeiros et al. 2010: 78). The research is concluded with a quality statement derived from the experimental study stating that the analysis is not conclusive, but achieved positive results if users have experience in software projects (Medeiros et al. 2010: 78).

Figure 5 serves to illustrate the explicitness of SOPLE-DE with respect to the Situational Method Engineering concept. The illustration follows the ME (Method Engineering) concept shown in figure 3 complemented by an emphasis on the configurable and flexible parts of the method. Missing Method Engineering element is highlighted in blue.

In conclusion, except for a specific tool support, the approach delivers input for all selected comparison criteria.

Ⅴ. Conclusion

The aim of the present study was to compare existing service identification approaches with respect to its relevance in the design of a cohesive service-oriented architecture. When explaining the basic concepts related to service identification, it becomes evident that finding an explicit definition and scope of the service identification process is a difficult task. This challenge was especially observed when attempting to extract the activities from the approaches. As explained in the previous section, the degree of formalization can be interpreted differently depending on the extent of the service identification. Future research may therefore set one specific frame for service identification and analyze the existing approaches according to it, so that a more appropriate comparison can be conducted.

Another challenge was to reduce the numerous existing approaches to a reasonable number for a

detailed comparison. For this purpose, criteria selected need to be fulfilled in order for a service identification approach to be considered in the comparison procedure. By putting the focus on the degree of explicitness and practicability of an approach, nine comparison criteria were chosen from existing comparison studies. The comparison was complemented by analyzing the situational method engineering elements, which helped to examine the structure and the extensive details of an approach. The Service Identification Method by Medeiros et al. (2010) is adopted as an example to explain the comparison criteria in further detail.

In summary, this research contributes to a relatively detailed description of various service identification approaches with an adequate set of comparison criteria. In order for the comparison to be more precise, it is suggested that the service identification process be defined with a specific scope, which shall serve as a guideline to describe different approaches.

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Appendix

Annex 1. List of Service Identification Methods

Research Paper	Compared in
Abdelaziz EF, Mustapha A, Mohammed S (2011) A service oriented approach for information systems development. In: Proceedings of the 2011 international conference on multimedia computing and systems (ICMCS 2011). IEEE, USA, pp 1−6	Huergo et al. 2014
Abdelkader M, Malki M, Benslimane SM (2013) A heuristic approach to locate candidate web service in legacy software. IntJ Comput Appl Technol 47(2−3):152−161	Huergo et al. 2014
Abu-Matar M, Gomaa H (2011) Variability modeling for service oriented product line architectures. In: Proceedings of the15th international software product line conference (SPLC 2011).IEEE Computer Society, Piscataway, pp 110−119	Huergo et al. 2014
Adamopoulos DX, Pavlou G, Papandreou CA (2002) Advanced service creation using distributed object technology. IEEE CommunMag 40(3):146−154	Huergo et al. 2014
Stephan Aier. How Clustering Enterprise Architectures helps to Design Service Oriented Architectures. In 2006 IEEE International Conference on Services Computing (SCC 2006), 18-22 September 2006, Chicago, Illinois, USA, Seiten 269−272. IEEE Computer Society, 2006.	Birkmeier et al. 2008
Alahmari S, de Roure D, Zaluska E (2010) A model-driven architecture approach to the efficient identification of services onservice-oriented enterprise architecture. In: Proceedings of the14th IEEE international enterprise distributed object computingconference workshops (EDOCW'10). IEEE Computer Society,Washington, pp 165−172	Huergo et al. 2014
Antonia Albani, Jan L.G. Dietz und Johannes Maria Zaha. Identifying Business Components on the basis of an Enterprise Ontology. In D. Konstantas, J.-P. Bourrieres, M. Leonard und N. Boudjlida, Hrsg., Interoperability of Enterprise Software and Applications, pp. 335−347, Geneva, Switzerland, 2005. Springer Verlag. Antonia Albani und Jan L.G. Dietz. The Benefit of Enterprise Ontology in Identifying Business Components. In IFIP World Computing Conference, Santiago de Chile, Chile, August 2006.	Birkmeier et al. 2008
Alizadeh K, Seyyedi MA, Mohsenzadeh M (2011) Mapping service concept and enterprise ontology in service identification. In: Proceedings of the 7th international conference on networked computing (INC 2011), pp 22−27	Huergo et al. 2014
Andersson B, Johannesson P, Zdravkovic J (2009) Aligning goals and services through goal and business modeling. Inf Syst e-BusManag 7(2):143−169	Huergo et al. 2014
Ali Arsanjani. Service-oriented modeling and architecture - How to identify, specify, and realize services for your SOA. IBM developerWorks Web services zone, Nov. 2004.	Birkmeier et al. 2008
Arsanjani, A., Ghosh, S., Allam, A., Abdollah, T., Ganapathy, S. and Holley, K. (2008). SOMA: A method for developing service-oriented solutions, IBM Systems Journal, 47, 3, 377-396	Börner 2012 Huergo et al. 2014
Asadi M, Mohabbati B, Kaviani N, Ga˘sevi´c D, Bo˘skovi´c M,Hatala M (2009) Model-driven development of families ofservice-oriented architectures. In: Proceedings of the first international workshop on feature-oriented software development (FOSD'09). ACM, New York, pp 95−102	Huergo et al. 2014
Asadi M, Mohabbati B, Ga˘sevi´c D, Bagheri E (2011) Developing families of method-oriented architecture. In: Ralyté J, MirbeII, Deneckère R (eds) Proceedings of the 4th IFIP WG 8.1 working conference on method engineering (ME 2011). IFIP advances in information and communication technology, vol 351,pp 168−183. International federation for information processing (IFIP)/Springer, Berlin	Huergo et al. 2014
Aversano L, Cerulo L, Palumbo C (2008) Mining candidate web services from legacy code. In: Proceedings of the 10th international symposium on web site evolution (WSE 2008). IEEE, Piscataway,pp 37−40	Huergo et al. 2014

Research Paper	Compared in
Azevedo LG, Santoro F, Baião F, Souza J, Revoredo K, Pereira V,Herlain I (2009): A method for service identification from business process models in a SOA approach. In: Halpin T, Krogstie J, NurcanS, Proper E, Schimidt R, Soffer P, Ukor R (eds) Proceedings of the 10th international workshop on business process modeling, development and support (BPMDS 2009) and 14th international conference on exploring modeling methods in systems analysisand design (EMMSAD 2009). Lecture notes in business information processing, vol 29, pp 99−112. Springer, Berlin	Huergo et al. 2014 Gu & Lago 2010
Baghdadi Y (2006) Reverse engineering relational databases to identify and specify basic web services with respect to service oriented computing. Inf Syst Front 8(5):395−410	Huergo et al. 2014
Bao L, Yin C, He W, Ge J, Chen P (2010) Extracting reusable services from legacy object-oriented systems. In: Proceedings ofthe 2010 IEEE international conference on software maintenance(ICSM 2010). IEEE, USA, pp 1−5	Huergo et al. 2014
Daniel Beverungen, Ralf Knackstedt und Oliver M¨uller. Entwicklung Serviceorientierter Architekturen zur Integration von Produktion und Dienstleistung - Eine Konzeptions-methode und ihre Anwendung am Beispiel des Recyclings elektronischer Ger¨ate. Wirtschaftsinformatik, 50(3):220−234, 2008.	Birkmeier et al. 2008
Bianchini D, Cappiello C, De Antonellis V, Pernici B (2009)P2S: a methodology to enable inter-organizational process design through web services. In: van Eck P, Gordijn J, Wieringa R (eds) Proceedings of the 21st international conference on advanced information systems engineering (CAiSE 2009). Lecture notesin computer science, vol 5565, pp 334−348. Springer, Berlin	Huergo et al. 2014 Gu & Lago 2010
Bianchini D, Cappiello C, De Antonellis V, Pernici B (2013)Service identification in interorganizational process design. IEEETrans Serv Comput 7(2):265−278	Huergo et al. 2014
Birkmeier DQ, Gehlert A, Overhage S, Schlauderer S (2013): Alignment of business and IT architectures in the German FederalGovernment: a systematic method to identify services from businessp rocesses. In: Proceedings of the 46th Hawaii international conference on systems sciences (HICSS 2013). IEEE Computer Society, Piscataway, pp 3848−3857	Huergo et al. 2014
Böhmann, T. and Krcmar, H. (2005) Modularisierung: Grundlagen und Anwendung bei IT-Dienstleistungen, in Thomas Herrmann, Uwe Kleinbeck and Helmut Krcmar (Eds.) *Konzepte für das Service Engineering. Modularisierung, Prozessgestaltung und Produktivitätsmanagement*, Heidelberg	Börner 2012
Boerner, René (2012): Situationsspezifische Methoden zur Serviceidentifikation in serviceorientierten Architekturen. Grundlagen, empirische Befunde und Konstruktion einer Meta-Methode. Frankfurt am Main, 5/4/2012.	Börner 2012
Brzostowski K, Reku´c W, Sobecki J, Szczurowski L (2010:) Service discovery in the SOA system. In: Nguyen NT, Le MT,´Swia¸tek J (eds) Proceedings of the second international conference on intelligent information and database systems (ACIIDS'10)−part II. Lecture notes in computer science, vol 5991,pp 29−38. Springer, Berlin	Huergo et al. 2014
caetano A, Silva AR, Tribolet J (2010) Identification of services through functional decomposition of business processes. In: Abramowicz W, Tolksdorf R (eds) Proceedings of the 13thinternational conference on business information systems (BIS2010). Lecture notes in business information processing, vol 47,pp 144−157. Springer, Berlin	Huergo et al. 2014
Canfora G, Fasolino AR, Frattolillo G, Tramontana P (2008): A wrapping approach for migrating legacy system interactive functionalities to service oriented architectures. J Syst Softw81(4):463−480	Huergo et al. 2014
Chaari S, Biennier F, Favrel J, Benamar C (2007) Towards aservice-oriented enterprise based on business components identification.In: Gonçalves RJ, Müller JP, Mertins K, Zelm M (eds)Enterprise interoperability II. Part V. Springer, United Kingdom,pp 495−506	Huergo et al. 2014
Chang SH (2007) A systematic analysis and design approachto develop adaptable services in service oriented computing. In: Proceedings of the 2007 IEEE congress on services (SERVICES2007). IEEE Computer Society, Piscataway, pp 375−378	Huergo et al. 2014

Research Paper	Compared in
Chen F, Li S, Yang H,Wang CH, ChuWCC(2005) Feature analysisfor service-oriented reengineering. In: Proceedings of the 12thAsia-Pacific software engineering conference (APSEC'05). IEEEComputer Society, Piscataway	Huergo et al. 2014
Chen F, Zhang Z, Li J, Kang J, Yang H (2009) Service identification via ontology mapping. In: Proceedings of the 33rd annua lIEEE international computer software and applications conference (COMPSAC'09), vol 1. IEEE Computer Society, Washington, pp 486–491	Huergo et al. 2014 Gu & Lago 2010
Cho M, Je C, Rim KH, Hong SG, Keceli Y, Park JY (2008) Service identification and modeling for service oriented architecture applications. In: Proceedings of the 7th WSEAS international conference on software engineering, parallel and distributed systems(SEAPADS'08), pp 193–199. World Scientific and Engineering Academy and Society (WSEAS), Stevens Point	Huergo et al. 2014 Gu & Lago 2010
Chung S,WonD,Baeg SH, Park S (2009) Service-oriented reversereengineering: 5W1H model-driven re-documentation and candidateservices identification. In: Proceedings of the 2009 IEEEinternational conference on service-oriented computing and applications(SOCA 2009), pp 1–6. IEEE Computer Society, Piscataway	Huergo et al. 2014
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Dinh TL, Nguyen-Ngoc AV (2010) A conceptual framework for designing service-oriented inter-organizational information systems. In: Proceedings of the 2010 symposium on information and communication technology (SoICT'10). ACM, New York, pp 147–154	Huergo et al. 2014
Dwivedi V, Kulkarni N (2008) A model driven service identificationapproach for process centric systems. In: Proceedings ofthe 2008 IEEE congress on services–part II (SERVICES-2 2008).IEEE Computer Society, Washington, pp 65–72	Huergo et al. 2014 Gu & Lago 2010
T. Erl, Service-Oriented Architecture: Concepts, Technology and Design. Prentice Hall PTR, 2005. T. Erl, SOA Principles of Service Design. Prentice Hall PTR, 2008.	Svanidzaite 2012 Birkmeier et al. 2008
Erradi A, Anand S, Kulkarni N (2006) SOAF: an architecturalframework for service definition and realization. In: Proceedingsof the 2006 IEEE international conference on services computing(SCC'06). IEEE Computer Society, Piscataway, pp 151–158	Huergo et al. 2014 Birkmeier et al. 2008 Svanidzaite 2012
Erradi A, Kulkarni N, Maheshwari P (2007) Service design process for reusable services: financial services case study. In: Krämer BJ, Lin KJ, Narashimhan P (eds) Proceedings of the 5th international conference on service-oriented computing (ICSOC 2007). Lecture notes in computer science, vol 4749, pp 606–617. Springer, Berlin	Huergo et al. 2014
Fareghzadeh N (2008) Service identification approach to SOAdevelopment. In: Proceedings of the world academy of science,engineering and technology, vol 45	Huergo et al. 2014 Gu & Lago 2010
Flaxer D, Nigam A (2004) Realizing business components, businessoperations and business services. In: Proceedings of the 2004IEEE international conference on e-commerce technology fordynamic e-business (CEC-EAST'04). IEEE Computer Society,Washington, pp 328–332	Huergo et al. 2014
Fuhr A, Horn T, Riediger V, Winter A (2013) Model-driven softwaremigration into service-oriented architectures. Comput SciRes Dev 28(1):65–84	Huergo et al. 2014
Gacitua-Decar V, Pahl C. Automatic business process patternmatching for enterprise services design. In: Proceedings of the2009 world conference on services–part II (SERVICES-2 2009),pp 111–118. IEEE Computer Society, Washington	Huergo et al. 2014
Gordijn J, Yu E, van der Raadt B (2006) e-Service design usingi* and e3 value modeling. IEEE Softw 23(3):26–33	Huergo et al. 2014
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Research Paper	Compared in
Han F, Moller E, Berre AJ (2009) Organizational interoperabilitysupported through goal alignment with BMM and service collaborationwith SoaML. In: Proceedings of the international conferenceon interoperability for enterprise software and applicationsChina (I-ESA'09). IEEE Computer Society,Washington, pp 268−274	Huergo et al. 2014
Huayou S, Yulin N, Lian Y, Zhong C (2009) A service-orientedanalysis andmodeling using use case approach. In: Proceedings ofthe 2009 international conference on computational intelligenceand software engineering (CiSE 2009). IEEE, Piscataway	Huergo et al. 2014
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