NEXOF-RA

NESSI Open Framework – Reference Architecture

IST- FP7-216446

Deliverable D2.1b

Service Centric System Architecture Contributions to Model and Architecture

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Change History

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0.2	07/06/10	Draft	Debora Desideri	Section 1.2 and 4.2 has been updated
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EXECUTIVE SUMMARY

The NEXOF-RA work package “Service-Centric Systems Engineering” focuses on the following areas of service based software (SW) systems: specification, discovery, design and composition of services.
The goal of the work package “Service-Centric Systems Engineering” is to contribute on these areas to the NEXOF reference architecture specification.

The scope of this document is to summarize the activities and the results of the work package “Service-Centric System Engineering”. In particular, it describes the contributions to the reference architecture and the overall process that has been followed to contribute to the model and to the specifications. It also describes the most important results that have been achieved.

Such results have been produced by elaborating the inputs of the external contributors according to the principles, the guidelines and the templates of the project.

This document contains:

- a summary of the process that have been followed to obtain the contributions (see section Contribution from the open process)
- a summary of the achieved results (see section Contribution to the Reference Architecture and Contribution to the PoCs);

The aim of NEXOF is to deliver a reference architecture for the NESSI Open Service Framework. In the NEXOF-RA work packages “Reference Architecture: Model” and “Reference Architecture: Specification” nine concerns[1] turned out to be a guideline for the whole project. The focus of the work package “Service-Centric System Engineering” has been on the following four concerns: Services, Messaging, Discovery and Composition.

Investigations teams (ITs) on the following five different topics (relate to the above 4 concerns) were managed: Service description (see 3.1.2.1), Design time service composition (see 3.1.2.2), Service discovery (see 3.1.2.3), Interoperability of message-based service invocation (3.1.2.4), Service runtime composition (see 3.1.2.5) and contributions from external contributors (including NESSI strategic projects members) were gathered[2]. The most interesting and mature contributions have been selected (also according to the requirements gathered by the “Requirements and Assessment Criteria” work package), elaborated and made compliant to the NEXOF-RA rules and templates.

They have been used to contribute to the NEXOF-RA reference architecture, in particular to the model and to the specifications.

The contributions to the Reference Model has been done in terms of:

[1] RA Model V2.0, http://www.nexof-ra.eu

[2] The whole text that has been produced by the external contributors and the final reports of each investigation action can be found in the documents listed in the section “Appendix B: Investigation Teams Contributions”.

- Contribution to the glossary
- Contribution to the conceptual model by introducing functionality of core service area Service, Message, Discovery, Composition

In particular an important result comes from the Service Description IT. The target of such IT was to provide an answer to the question: “what is a service?”. In order to answer this question, a deep analysis about the service characterization was needed to avoid ambiguity, vagueness and, more in general, to provide a solution that try to fill the gap bared by existing standards. The result obtained contributes to the NEXOF-RA conceptual model and provides a reference for all the decisions concerning architectural choices of NEXOF Compliant Platforms.

The most important contribution to the Reference specification has been done in terms of Architectural patterns: they have been developed by experts and architects of NEXOF-RA project and by external contributors by the open process.

The work package “Service-Centric System Engineering” has produced:

- 5 patterns for Enterprise SOA (ESOA)
- 5 patterns for Internet of Service (IoS)
- 6 patterns for both ESOA and IoS

Moreover:

- 6 additional patterns for ESOA domain has been discussed and initially described in the context of the ITs.

Consider that:

- 17 patterns (of a total of 22) have been produced integrating the results of four ITs (Design time service composition (see 3.1.2.2), Service discovery, Interoperability of message-based service invocation, Service runtime composition

The achieved results have been described in details in section Contribution to the Reference Architecture.

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1 INTRODUCTION

This work package focuses on providing the "core" layers of the Reference Architecture[3] of the NESSI Open Framework, in particular to the

- Reference Model (RM)
- Reference Specification (RS)

The term "core" layer refers to four concerns captured by the NEXOF Reference Model: **composition**, **discovery**, **message** and **service**. They are comprised as service centric system engineering.

1.1 Scope of the deliverable

The scope of the deliverable is to summarize the activities and the results of the work package "Service-Centric System Engineering" in particular the contributions to the reference model and to the reference specification.

It describes the overall process that has been followed to contribute to:

- the model, in particular to the conceptual model fragments and the glossary
- the specifications, in terms of architectural patterns

The results have been produced starting from the inputs of the external contributors and elaborating them by applying the principles and the pattern template provided by the "Reference Architecture: Specifications" and described in the deliverable D7.2b[4].

1.2 Description of the work

This work package has investigated the core layers of a service-oriented architecture (SOA layers). Thereby it has provided the basis for the development of the RM and RS.

The work package's initial approach to develop its contribution to the reference architecture specification was by taking into account the functional and non-functional requirements from business processes in concrete business scenarios (these requirements resulted by "Requirements and Assessment Criteria" work group activities).

Then, the work package "Service-Centric System Engineering" has analysed the state of the art of existing SOA reference models and architectures and relevant existing standards.

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[3] D13.5 section 3.4 Usage of the NEXOF Reference Architecture, http://www.nexof-ra.eu

[4] http://www.nexof-ra.eu/sites/default/files/D7%202b%20Definition%20of%20an%20architectural%20framework%20and%20principles.pdf

Inconsistencies and missing parts have been identified starting from the survey of existing reference architecture models and reference architecture specifications.

This analysis and the initial set of requirements were useful to identify the list of topics for the first and second investigation calls to trigger work from the external contributors. The procedure follows the open process, which is called Open Construction Cycles [2].

During each investigation phase this work package has coordinated several investigation teams to gather external contributions and to elaborate them for integrating them into the Reference Architecture. This integration phase has been performed by reviewing and enhancing our contributions according to the principles and foundations of the NEXOF-RA.

The actual work carried out in work package “Service-Centric System Engineering” resulted in contributions to the reference model and architecture (work package “Reference Architecture: Model” and work package “Reference Architecture: Specifications”) and to direct contributions to their deliveries”, in particular:

- Specific reference models (results included in “Reference Architecture Model V1.0” (D6.1)):
  Analysis of OSGi, SCA, SeCSE, WSA, OASIS
- State-of-the art report (results included in “State of the art report” (D7.1)):
  Survey of standards/technologies related to SOA, incl. acceptance and competing standards
- Contribution to the NEXOF-RA Model by the definition of some terms of the glossary and functionality of core service area (Service, Message, Discovery and Composition) (reported in D6.2)
- Contribution to the NEXOF-RA Specification by architectural patterns of the core service area (Service, Message, Discovery and Composition) (reported in D7.5a and D7.5b)
- Contribution to the PoCs to validate the quality attributes of some architectural patterns (reported in D8.1c)

2 INITIAL POSITION

The work package "Service-Centric System Engineering", as well as all other work packages of the complete NEXOF-RA project, started its work in the awareness, that there are already SOA architecture specifications in place. They realize different prioritised and different domain-specific requirements. Work package "Service-Centric System Engineering" contributed to the deliverable “State of the art report” (D7.1) of the work package "Reference Architecture: Specification" (see [23], section 2).

Further starting from typical application scenarios the consortium had collected in work package "Requirements and assessment criteria”, requirements were derived. In work package "Service-Centric System Engineering" these requirements were analysed and they helped to specify and detail the scope of work package “Service-Centric System Engineering“. The result of the requirement analysis (result is included in deliverable “RA Model V2.0” (D6.2) [27], sections 7 – 9) as well as the analysis of present models (listed in section 4.2.3, result is included in “Reference Architecture Model V1.0” (D6.1), section 3.1, 3.2 and appendices) was run in work package ”Reference Architecture: Model” and work package “Reference Architecture: Specification“. The analysis were driven by the competencies available in the team of work package “Service-Centric System Engineering“.

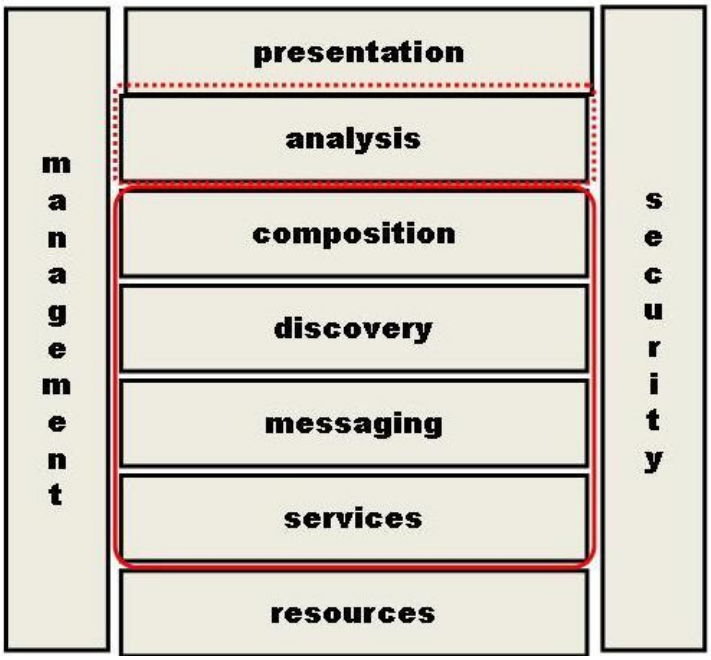


Figure 1 Position of work package “Service-Centric System Engineering“ concerns in NEXOF-RA

After a first analysis of present models and the user requirements the following separation of concerns (done in work package “Reference Architecture: Model” and work package “Reference Architecture: Specification“) turned out to be a

guideline for the whole project (see Figure 2, see “NEXOF RA Model” (D6.2), section 4.3, [27]). These concerns correspond to the top-level requirements introduced in the concepts and the main concerns of a NEXOF Compliant Platform (see “NEXOF RA Model” (D6.2), section 4 [27]):

- **Services** – It addresses the underlying building blocks of SOA
- **Messaging** – It enables services to communicate and interact
- **Discovery** – It provides the bases for reuse
- **Composition** – It links services into business processes
- Analysis – It enables continuous process improvement
- Presentation – It incorporates people into the SOA equation
- Management – It addresses service levels and governance
- Security – It makes SOA reliable
- Resources – It makes SOA effective

Though the activities of work package “Service-Centric System Engineering” and its contributions to the model and specifications the focus of work package “Service-Centric System Engineering” is on the concerns Services, Messaging, Discovery, Composition and in a smaller amount on Analysis. During the reporting period the topic Analysis was out of scope.

Beyond the concerns, the analysis of requirements and models showed that architectural components for creating, describing, and composing services meeting business requirements shall cover the following two topics:

- The entire service lifecycle
- Consistency and coherence of the reference architecture

3 CONTRIBUTION FROM THE OPEN PROCESS

3.1 Activities related to the open process

As part of the open process invitations (the first and the second call) to contribute to the Open Reference Architecture for service frameworks by NEXOF-RA have been published. The work package "Service-Centric System Engineering" played a major role in preparing and executing call 1 and 2 for the open contribution process (see [13]), since finally most of the topics are related to the concerns of the work package "Service-Centric System Engineering".

The actions that has been performed by the work package "Service-Centric System Engineering" for producing the contributions to the Reference Architecture according to the open process are the following:

- The topics of interests have been pointed out, according to the system requirements and to the main concerns of a NEXOF Compliant Platform and after the analysis of the state of art. The identified topics are: service description, design time service composition, service discovery and interoperability of message-based service invocation for call 1 and run time service composition for call 2
- The invitation to contribute cards was prepared and published on the NEXOF-RA web site[5]
- During the kickoff of the open investigation process:
  - an overview presentation and the work package was prepared and gave;
  - the investigation teams (ITs) was created according the position papers submitted by the participants and their interests and expertise;
  - a responsible for each IT was selected;
  - the work in the teams was started.
- Meetings and conf call of the teams to work on the specific topics have been organized
- The contributions of each IT has been collected and analysed
- The contributors (domain experts and members of NESSI strategic projects) have been guided to formalize the contributions:
  - in architectural patterns according to the principles and guidelines of the NEXOF-RA framework.
  - to enhance the conceptual model or the glossary
- The final results have been produced: the architectural patterns produced by this work group have been developed according to the refinement process described in D7.2[6] section 4.

[5] http://www.nexof-ra.eu/?q=register_in_topics

[6] http://www.nexof-ra.eu/sites/default/files/D7%202b%20Definition%20of%20an%20architectural%20framework%20and%20principles.pdf

3.1.1 The proposed Topics

From an analysis of existing research and in particular from ongoing NESSI strategic projects, which was done by the other horizontal work packages, too, the work package “Service-Centric System Engineering” chose topics for the first call and provided topics for later calls.

For analysing all RFP (request for proposal) topics have been collected in a table. The work package “Service-Centric System Engineering” evaluated and rated it with respect to the concerns of the work package “Service-Centric System Engineering” and discussed the overlap with work package “Non functional aspects”.

The complete analysis matrix (the open process topics matrix) is too big to be published here, but it can be found in the NEXOF-RA Wiki (see [29]). One important criterion was the availability of results from the NESSI strategic projects. Since the projects that can deliver results to the work package “Service-Centric System Engineering” area started later than NEXOF-RA, for the first call no results could be expected. Hence the topics were chosen in order to cover the baseline of the work package “Service-Centric System Engineering”.

Work package “Service-Centric System Engineering” partners authored and managed the following four topics in the first call.

Topic	Concern	Responsible
Service Description	Service	Engineering
Design time service composition	Composition	Atos
Service Discovery	Discovery	Atos
Interoperability of message-based service invocation	Messaging	Siemens

Here after the topic for the second call.

Topic	Concern	Responsible
Run time service composition	Composition	Atos

The following table shows the list of topics that have been proposed in relationship with the System requirements they are derived from.

Table 1: IT List

Topics	System Requirements[7]
Service Description	SR 1.1. How can a service be specified to be implemented? SR 2.2. How can a service be described to be invoked? SR 3.1.1. How can a service be described in order to be found (provider entity description, etc.)?
Design Time Service Composition	SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)? SR 5.2. How can a process be implemented?
Service Discovery	SR 3. How can a service be discovered?
Interoperability of Message-Based Service Interaction	SR 2. How can a service be invoked?
Runtime Service Composition	SR 5.3. How can a process be enacted?

3.1.2 The Investigation teams

For each topic has been set up an investigation team that has produced contributions to the reference architecture.

The following table summarize some information on each investigation team.

Table 2: IT Process Report

Investigation Team	start	end	Registered participant	Position paper	Effective participant	Meeting	Phone Call
Service Description	Oct-08	Jen-09	39	17	14	1	2
Design Time Service Composition	Oct-08	Mar-09	44	13	7	1	3
Service Discovery	Oct-08	Mar-09	38	9	8	1	3
Interoperability of Message-Based Service Interaction	Oct-08	Mar-09	7	7	3	1	5

[7] D10.1 Requirements Report

Runtime Service Composition	Mar-09	Sep-09	12	11	7	1	1

The following 5 subsections report a detailed description of the investigation teams that worked on the topics in the first and second call and their results.

3.1.2.1 Service Description

Rationale

The concept of service plays a key role in SOA infrastructure characterization providing the basic element for a rational treatment of the related subjects. It is the "glue" concept amongst all the concerns related to SOA infrastructures and they can be managed in a consistent way if they use a clear, consistent and unambiguous basis. Thus, it is fundamental to provide a clear and shared characterization of the service-concept.

On the other hand, the analysis of the most used standards provided by W3C [5], OASIS [6], OMG [7] point out a lack of deep analysis about service characterization, providing in most cases unclear, vague, ambiguous or even contradictory definitions of service. In literature the term "service" is used with a multitude of meaning, e.g. in some case it is used to indicate an *action* performed by somebody, in other cases a *capability* to perform some action, or even to indicate the *result* of an action that is a change affecting an object or a person. Moreover, despite the goal of future Internet of Services is to allow peoples and computers to smoothly interact with services in the real life, both traditional Web services approaches, as well as the more recent Semantic Web Services (SWS) proposals, seem to focus mainly on the aspects related to data and control flow, considering services as black boxes whose main characteristic is to interoperate in a well-specified way [8].

A deep analysis addressing the issues related to service concept cannot be found in literature, thus it was the goal of the service description investigation team to address these issues, motivated by the strategic importance of this concern for NEXOF and NSPs.

Objectives

The team results aim to contribute to the NEXOF-RA conceptual model and to provide a reference for all the decisions concerning architectural choices. Therefore, all the architectural choices of NEXOF-RA compliant architectures would take into account the characterization of service provided by the service description investigation team.

Criteria to issue the call

Because of its strategic importance, the call concerning the service description topic required to be issued as early as possible since it affects the whole architecture, even impacting on NESSI Strategic Projects which was called to contribute during the definition phase. Thus, the call was issued during the first phase of the NEXOF-RA open construction process.

Setup of the team
The Investigation Team was constituted as one team wherein all interested participants collaborate.

The team was constituted by 14 persons representing 9 different affiliations:

- Francesco Torelli, Engineering I.I., SLA@SOI
- Nicola Guarino - Roberta Ferrario, ISTC-CNR
- Sophie Ramel - Eric Grandry, CRP Henri Tudor, Adict
- Agustin Yague Panadero, Universidad Politécnica de Madrid, OVAL/PM, FLEXI
- Antonio Puliafito - Francesco Longo - Salvo Distefano, University of Messina
- Arne J. Berre, SINTEF, SHAPE
- Luis Rodero - Juan Caceres, Telefonica I+D, RESERVOIR
- Francesca Arcelli, University of Milano Bicocca, Adict
- Xavier Franch, Universidad Politécnica de Catalunya

The position papers submitted by the participants are available on NEXOF-RA web site[8].

Concrete objective
During the kick off meeting, a brainstorming session with the participants focused on the target of the service description topic and the position papers submitted to point out the concrete objectives and final results that the team would address. The participants identified the following two tasks:

1. Identification of the properties of services that are mandatory for the definition of the service concept. The goal of this task is the definition of a conceptual pattern that captures all the behavioural aspects concerning services from a very general perspective.
2. Identification of the informational aspects of service definition that can be managed by Information Technology. Then, the team aims to recognize the features of a software system to properly help the automation of the services.

Results
The target of the service description investigation team was to provide an answer to the question: “what is a service?”. To answer this question a deep analysis about the service characterization was needed to avoid ambiguity, vagueness and, more in general, to provide a solution that try to fill the gap bared by existing standards and ongoing research works.

[8] http://www.nexof-ra.eu/sites/default/files/SDIT%20Position%20papers.zip

The result obtained contributes to the NEXOF-RA conceptual model and it provides a reference for all the decisions concerning architectural choices of NEXOF Compliant Platforms.
The notions existing in literature [8], and shortly addressed in the rationale, are somehow connected, and they contributes to better specify the notion of service but the experts participating to the Service Description Investigation Team agreed on the fact that none of them can be properly identified with what people are commonly referring to when asking for a service.
Moreover, it was stated that the service definition is required to address the second task of the investigation team that is to address the problem of describing and representing services to identify the features of a software system to properly help the automation of the services.

At a first stage the team identified the concepts that are relevant for the definition of service, then the definition of service were selected according to the consensus of the team's participants.

NEXOF-RA adopts the following definition of service:

Definition of Service:
An action performed by one entity (provider) that matches a request of another (requesting entity), according to the interpretation of the latter

Such definition captures the following things:

- a requesting entity (R) that makes a request (Q) to a provider entity (P) to perform a certain action (A);
- a provider entity (P) that performs the requested action (A).

Thus, it is stated that the service depends on a provider entity, a requesting entity and an action that depends on an explicit request. Shortly it is possible to express this concept by using these notations:

- (textual): C2 =def [P,A(Q),R]
- (graphical):

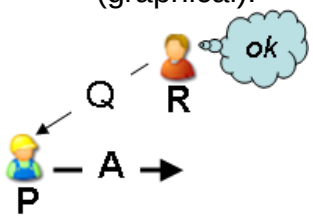


Figure 2 Graphical Notation

- (UML):

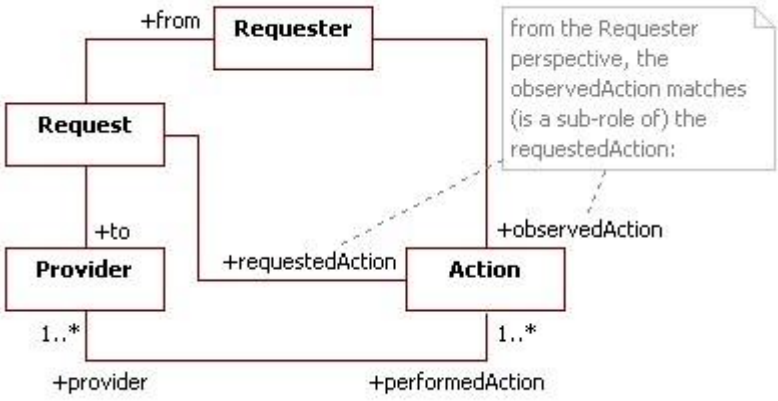


Figure 3 UML Notation

The definition of service is captured by a very general perspective and it is independent from Information Technology. However, it is useful to fit such definition to the Information Technology in order to provide a definition of Software Service. It is required to add some constraint to the current definition in order to address which the entities are interacting to request/perform an action.

Therefore, a Software Service is a Service which requester and provider are software agents. It is important to specify that:

- the interaction between requester entity and provider entity is mediated by software agents, which are requester agent and provider agent. The direct interaction never happens between humans
- it is not excluded that humans can interact among them. Indeed, to fulfil their duty software agents can make use of human interaction

The results here described are reported with more details in the Service Description Investigation Team final report (see Appendix B: Investigation Teams Contributions) available on NEXOF-RA portal and they were also reported in deliverable D6.2 as part of the NEXOF-RA conceptual model.

Roles assigned

The work was organized as a “virtual round table” and each member of the team was invited to share their experience with the other participants. No explicit role was assigned to the participants who share a common role of contributor to provide inputs to the investigation team and to address the objective defined by the tasks.

Moreover, Arne J. Berre who is a member of OMG proposed the discussion held by the team to OMG, promoting a comparison between service description investigation team and OMG.

Process followed
The tools activated to enable the collaboration among the participants are the following:

- a mailing list (service-description_it@nexof-ra.eu), to enable the comparison among participants by email exchange
- a Google spreadsheet [9], to fix and share definition of concepts and related information useful for the active discussion
- a repository to share documents, available on the NEXOF-RA portal [10]

The work was mainly performed by mail exchange, but conference calls were also arranged to consolidate partial results and to speed up the work when the mail exchange was not sufficient. Two conference calls were scheduled when a straight comparison among participants was required by the status of the work.

The plan for assessment and finalization of the results was defined as follows:

- December 1st, 2008 end of the first phase and assessment of the results of the first task. Start of the second phase addressing the subjects of the second task.
- January 31st, 2009 end of the second phase and assessment of the results of the second task. Finalization of a document to report the results obtained.

Moreover, the progress of the work was assessed by periodical check and the partial results of the investigation work were steadily evaluated.

At the first deadline on December 31st the objective of the first task was partially achieved and the rearrangement of the plan was needed. Then, the deadline to assess the first task results was delayed to January 31st, 2009.

At the final deadline on January 31st the team provided an answer to the first task issues. The answer provides the definition of the service concept and also the definition of other concepts that are useful to define the service.
The definition of the service concept affects the NEXOF-RA conceptual model, and of course the NEXOF-RA glossary.

The time was insufficient to address the objective of the second task.

Impact on standardization
As the deep analysis performed by the investigation team cannot be found in literature, the team aims to impact the initiatives of the standard organizations with the achieved results. As already stated in this document, the comparison with OMG was accomplished and the inputs provided by the service description investigation team to the OMG UPMS/SoaML standard has been appreciated. Actually, this discussion is still ongoing inside OMG group.

3.1.2.2 *Design Time Service Composition*

Rationale

SOA encourages the building of ICT systems by combining software components which expose services, since those services behave as composable building blocks. This procedure is quite common not only in the SOA domain but in other component-based approaches. SOA speeds up the software development process since it relies on already available and tested services which can be combined to create rapidly and efficiency more complex software components which offer extra functionality, thanks to the standards applied, which abstract the implementation of services from the functionalities they offer.

SOA standards enable the quick creation of composite services which may be specified with XML-based languages, what does not require a heavy engineering process (coding, compiling, deploying, testing, debugging) and speeds up the composition process.

This composable SOA approaches have proven quite useful to realize business processes, since each activity to be performed in the process can be mapped to a concrete operation offered by some service. Thereby, SOA composite services have received much attention, not only in the SOA domain but also in the BPM domain.

Even if SOA composite services have been the focus of both academic and industrial initiatives, there are still important challenges in the field, as described in this Investigation Team (IT) call, since the composition process is mostly manual, prone-to-error, time-consuming, not suitable for long lasting processes with human participation, not suitable to account for exceptional situations, with poor support for self-healing, self-configuring, self-adaptation, etc.

Due to the importance of composite service in SOA world and within the NEXOF core service area, we selected this topic within the first list of potential candidates. Considering the magnitude of this topic, we decided to split it into two topic call, one for design time service discovery (this one) and another one for runtime service discovery (issued for call 2).

Objectives

The service composition topic was identified as a core concern within this work package since the very beginning, deserving an important place in the service core architecture. SOA developments are mostly based on the aggregation of existing services to realise more complex and featured applications.

Thereby, it was understood that the service composition system would have an important place in the NEXOF reference architecture model and specification.

Considering the relevance of this topic and the vast knowledge acquired during the last and current research initiatives, it is not affordable by the limited number of ICT experts involved in NEXOF core service area to cope with an intensive survey and critical analysis of existing results and missing gaps. Therefore, we targeted at complementing our group of experts recruiting other experts and researchers who are being working on the topic in the last years. These researchers provided their (different) vision and solutions for the problem of composing services, so we have been able to gather more information and analyse those patterns applied in the tools developed for creating compositions.

Criteria
Due to the importance of this concern we included it in the first list of potential topics to issue in the first IT call. Besides, some NEXOF-RA partners have participated and/or are participating in some national and EC FP6/7 projects where the service composition concern was intensively studied, such as GODO, Composetour, SeCSE, SUPER, INFRAWEBS, SOA4ALL, etc. Therefore, we were aware of the promising available results and improvements on this topic domain and the current research baseline.

Placement in architecture
Service composition concern is part of the service core area, that is, an essential SOI feature, located between the underlying SOI and the SOA applications. Service composition system is located in the same layer as service creation, messaging, discovery, mediation, interoperability, etc.

Investigation Team Reports
The results of the design time service composition IT have been collected in an IT report [see Appendix B: Investigation Teams Contributions]. This IT report contains all the received contributions and an analysis and integrated overview of those contributions highlighting similarities, differences, relationships, subtopics not or insufficient covered and a short summaries of suggested standards. The number of received contributions was up to ten. There were up to 5 active contributors.

Topics
Design time service composition IT identified several subtopics relevant in the domain scope of the team. However, most of the different subtopics were so interwoven that there was not a real chance to split the IT into small teams. It was better decided, as aforementioned, to split the whole IT across calls, one topic at design time and another at runtime, which are closely related but represent a logical separation.

Setup of the team
The IT was constituted as a unique team with all interested participants within. Active participants were:

- Franz Brosch, from FZI
- Natallia Kokash, representing REO project
- Annapaola Marconi, representing ASTRO project
- Francisco Javier Nieto, from ESI, representing SeCSE project
- Richard Sanders, from SINTEF, representing SIMS project
- Bruno Volckaert, from IBBT

Those participants have background expertise in the scope of service composition using orchestration and choreography approaches, validation and verification, semantic, AI planning and other techniques for automatic composition, UML2 modelling of service collaborations, and so on.

Concrete objective

As described in this IT topic call, the objectives of this IT are

- To describe the most suitable techniques and solutions available both from the industrial and research initiatives to satisfy the functional and non functional requirements of the service composition domain at design time.
- To address both the orchestration and choreography approaches, although the former has received much more attention than the latter so we expect more results in that case.
- To propose best techniques to reduce the development cost (time and resources) and improve the accuracy (error-free) and reliability of composite services at design time, to include the participation of human actors within long lasting process implemented as composite services, the validation, simulation and verification of composite services, and others concerns relevant during the design of composite services.

Summary of activities

Except the initial kick off meeting there were not more physical meetings. We hold three conference calls, one before starting the first iteration and two more after each iterative phase.

IT participants submitted their contributions during the first iteration. They were integrated by the IT coordinator who tried to provide a coherent and consistent view of those contributions relating each other when possible, highlighting similarities, dissimilarities, complementarities, etc. IT participants were asked on concrete topic points for clarifications, which were incorporated to this holistic view.

During the second iteration, IT participants were asked to provide additional contributions, to refine those already submitted according to the comments issued by email or during the previous conference call. At the end of this second iteration, a refined version of the IT report was issued and commented by the IT participants. This IT report was finalized and submitted to NEXOF-RA consortium by the end of the IT.

Results

This IT has received and analysed 10 main contributions. They can be categorized as follows:

- some contributions on the semiautomatic composition of services using assisted techniques like semantic reasoning, AI planning, aggregation of composite primitives, selection and expansion of business process templates
- some contributions for the validation/verification and simulation of compositions
- a contribution on the prediction of NFR such as composition performance
- a contribution for the modelling and the validation of choreographies,
- other contributions on concrete technical problems encountered in choreographies
- a contribution for the materialization of business process as composite services, involving actors with different expertise and background, etc

As expected, most of the focus was captured by semiautomatic composition and validation of orchestrations, which represent the main generic patterns in the field, implemented in different ways. Some concepts have been highlighted, such as business process templates, autonomic computing algorithms, goals, semantics, etc.
The collaborative approach between services in choreographies has received less attention (an important gap). Some aspects have been partially covered, such as the collaborative involvement of domain experts and SOA designers in the modelling of business process and their materialization as composite services. Other aspects suggested in the IT topic call have not received attention, such as the participation of human roles in long lasting service compositions.
Thanks to these contributions, several design patterns and a set of concepts related to the topic have been identified and published in the mentioned IT report [Appendix B: Investigation Teams Contributions].

Roles assigned
The work was organized as a "virtual round table" and each member of the team was invited to share their experience with the other participants during the meetings and teleconferences. No explicit role was assigned to the participants who share a common role of contributor to provide inputs to the investigation team and to address the objective defined by the tasks.
Only J. Gorroñogoitia had the role of chair during the meetings and integrator of results.

Process followed
The working methodology followed by the IT was as follows. The IT working period was roughly divided into two even iterative phases. Each phase was organised similarly: a first time slot to prepare and submit contributions, a second time slot to understand and integrate contributions, a third time slot to received further comments upon the integrated view and refine it.
The first iterative phase aimed at providing a first working document describing those design patterns relevant in the topic domain. The second iterative phase aimed at fulfilling the gaps identified during the first phase and refining the received contributions.
Communication and collaborative tools were: a) the NEXOF-RA portal repository, b) email discussions, c) regularly scheduled conference calls.
The IT coordinator decided to accept all received contributions since a) all of them were within the topic scope, b) we were not only interested in documental contributions, but in recruiting the experts behind those contributions, in order to participate in the discussions.
Unfortunately, we failed in involving the IT participants to discuss among them, since most of the interactions were between each individual participants and the IT coordinator, through the email usage. Even during the scheduled conference calls, most of the interactions occurred only between the IT coordinator and each individual IT participant. Besides most of the interactions occurred as reactions to the IT coordinator requests, lacking a real discussion of ideas between participants.

Innovative points
More than emphasizing innovative points this IT has posed the baseline of the state of the art for service composition at design time, since the received contributions are a good representation of the past and current research initiatives in the domain of semiautomatic composition mostly following a choreographed approach. Indeed, most of the contributions share similar accepted principles and patterns, such as requirement-driven service composition, the usage of repositories of available composite primitives or business activities, the intensive use of reasoning on the interface and behaviour description of services, etc, which can be also encountered in other research initiatives not contributing to the IT. So, the main result of the IT is the identification of widely accepted service composition patterns and the current trends on the research domain.

Impact on standardization
The purpose of the IT was not to influence or impact on any ongoing standardization process, even if some standards or those still under standardization are used or commented within the contributions: WSDL, WSMO, OWL-S, SAWSDL, WS-BPEL, WS-CDL, WS-CL, BPMN, SCA, JBI etc.

3.1.2.3 Service Discovery

Rationale
As SOA presents services as functionalities published and reused by many applications, so the selected services will be able to cover some expected requirements (functional and non functional) when they are invoked. In this SOA approach there are three main roles: a consumer, a provider and a broker. The consumer invokes a particular service exposed by the provider. But this invocation it is not possible if there is not a mechanism to enable both the consumer and provider to know each other and collaborate in a loosely manner. This mechanism consists on a combination of service advertisement and provisioning, conducted by the broker role. The broker enables service providers to advertise their services by posting services descriptions into a public registry. The broker enables service consumers to procure useful services through a lookup mechanism.
This complete picture is crucial for the successful implementation of a SOA system since, otherwise, tight-coupled connections between service consumers and providers need to be established in advance, limiting a lot the SOA loose coupling principle.
Hence, providing powerful advertising and provisioning mechanisms is an essential feature expected in a SOI.
There are some SOA related standards that cover this area, such as UDDI and ebXML, but with some limitations especially in case of machine processable service advertising and provisioning. Past and current research in this area has intensively explored techniques to overcome this and other limitations, obtained promising results.
Service advertising and provisioning can be considered a cross-cutting concern since it is required and used by other SOA concerns like composition,

messaging, service front-ends, etc. Those links reinforce the importance of this concern.
Those reasons have motivated us to issue a call on Service Discovery to collect and describe the techniques a service oriented infrastructure (SOI) should offer to consumers and providers for the advertisement and provisioning of services.

Objectives
The service discovery topic, which covers service advertisement and provisioning, was identified as a core concern within the work package "Service-Centric System Engineering" since the very beginning, deserving an important place in the service core architecture.
Besides the reasons aforementioned to justify this concern in the overall SOA landscape, we realized that a coherent and consistent core service area architecture description would not be possible due to the strong dependencies of other core service area concerns on the service discovery concern.

Thereby, it was understood that the service discovery system would be an essential building block both for the NEXOF reference model and architecture.

Considering the relevance of this topic and the vast knowledge acquired during the last and current research initiatives, it is not affordable by the reduced number of ICT experts involved on NEXOF core service area, to cope with an intensive survey and critical analysis of existing results and missing gaps. Therefore, we considered to complement our group of experts recruiting other experts and researchers who are being working on the topic in the last years.

Criteria used
Due to the importance of this concern and the number of dependencies of other SOA concerns on it, we included it in the first list of potential topics to issue in the first IT call. Besides, some NEXOF-RA partners have participated and/or are participating in some EC FP6/7 projects where the service discovery concern was intensively studied, such as SeCSE, INFRAWEBS, SOA4ALL, etc. Therefore, we were aware of the promising available results and improvements on this topic domain and the current research baseline.

Placement in architecture
Service discovery concern is part of the service core area, that is, an essential SOI feature, located between the underlying SOI and the SOA applications. Service discovery system is located in the same layer than service creation, messaging, composition, etc.

Investigation Team Reports
The results of the service discovery IT have been collected in an IT report [Appendix B: Investigation Teams Contributions]. This IT report contains all the received contributions and an analysis and integrated overview of those contributions highlighting similarities, differences, relationships, subtopics not or insufficient covered and a short summaries of suggested standards. The

number of received contributions was up to eight. There were up to 4-5 active contributors.

Topics
Service discovery IT identified several subtopics relevant in the domain scope of the team. However, the different subtopics were so interwoven that there was not a real chance to split the IT. Besides the reduce number of IT participants discouraged us of splitting the team.

Setup of the team
The IT was constituted as a unique team with contributors from several projects. Active participants were:

- Aliaksandr Birukov, from Trento University
- Mike Boniface and Nikolaos Matskanis from IT-Innovation, representing the GRIA project
- Costas Kotsokalis, representing the SLA@SOI project
- Andras Micsik, from SZTAKI, representing INFRAWEBS project
- Valentín Sánchez, from Robotiker Technalia, representing the e-NVISION project
- Dimitris Skoutas, from IMIS

Those participants have background expertise in the service advertising and provisioning domain, in the specification of services (functional and non-functional capabilities) with textual and semantic metadata, in the storage of WS descriptions within federated repositories, in the procurement of WS in B2B scenarios, in the SLA-based service discovery, in the IR and semantic matchmaking and ranking algorithms, and so on.

Concrete objective
The IT identified some subtopics relevant for the successful implementation of a complete service discovery system. We identified two main features: a) advertising of WS, b) provisioning of WS. WS advertising focused on service catalogues, since the specification of WS is provided elsewhere. Concrete categorization of services within catalogues, support for browsing and subscription, lookup, etc was included. WS provisioning focuses on the lookup techniques available to discover adequate WS which may match the consumer expectations.
Regarding all those subtopics, we were interested in describing the most suitable techniques and solutions available to satisfy the functional and non functional requirements associated to services.

Summary of activities
Except this kick off meeting there were not more physical meetings. We hold three conference calls, one before starting the first iteration and two more after each iterative phase.
IT participants submitted their contributions during the first iteration. They were integrated by the IT coordinator who tried to provide a coherent and consistent view of those contributions relating each other when possible, highlighting similarities, dissimilarities, complementarities, etc. IT participants were asked on

concrete topic points for clarifications, which were incorporated to this holistic view.
During the second iteration, IT participants were asked to provide additional contributions, to refine those already submitted according to the comments issued by email or during the previous conference call. At the end of this second iteration, a refined version of the IT report was issued and commented by the IT participants. This IT report was finalized and submitted to NEXOF-RA consortium by the end of the IT.

Result
The main result obtained after analysing all the contributions is a set of related concepts for service discovery, as well as a set of architectural patterns related to the tools which give solutions for performing service discovery.
An important part of the received contributions have focused on the available algorithms for service matchmaking, ranking and selection, both based on IR or semantic reasoning techniques. Those techniques are complemented by template-based techniques (described in other contributions) to specify consumer's requirements which are translated into the canonical format imposed by the particular discovery engine. Some contributions extend this approach to embrace not only functional and not functional requirement but SLA constraints, so that the discovery process is extended to incorporate the negotiation phase. Another contribution proposes a multimodal service discovery approach which combines consecutive different techniques (in precision and time-cost) upon an iteratively constrained target of available services, in order to improve the trade-off between precision and response time. Other contributions complement the canonical service discovery approach (based on requirements versus capabilities matchmaking and ranking) with a service usage experiences historic. Last but not least, one contribution focused on federating P2P service registries to improved scalability and domain specialized services. Additional details can be found in the IT report.
The patterns identified are in line with the contributions received, but it is clear that the main generic pattern identified is Service Discovery matchmaking and ranking. The concepts have been extracted from the analysis of the contributions as well (templates, matchmaking, ranking, selection, etc.).
As can be realized, most of the contributions have focused on the provisioning of WS using service discovery features; WS advertisement has received less attention. Maybe there was confusion with the scope of this IT topic and the Service Description IT, since they are closely related and they should be in the same line. That implies than important aspects of service advertisement have not been covered well by the IT, while provisioning is much better covered.

Roles assigned
The work was organized as a "virtual round table" and each member of the team was invited to share their experience with the other participants during the meetings and teleconferences. No explicit role was assigned to the participants who share a common role of contributor to provide inputs to the investigation team and to address the objective defined by the tasks.

Only J. Gorroñogoitia had the role of chair during the meetings and integrator of results.

Process

The working methodology followed by the IT was as follows. The IT working period was roughly divided into two even iterative phases. Each phase was organised similarly: a first time slot to prepare and submit contributions, a second time slot to understand and integrated contributions, a third time slot to receive further comments upon the integrated view and refine it.

The first iterative phase aimed at providing a first working document describing those design patterns relevant in the topic domain. The second iterative phase aimed at fulfilling the gaps identified during the first phase and refining the received contributions.

Communication and collaborative tools were: a) the NEXOF-RA portal repository, b) email discussions, c) regularly scheduled conference calls.

The IT coordinator decided to accept all received contributions since a) all them were within the topic scope, b) we were not only interested in documental contributions, but in recruiting the experts behind those contributions, in order to participate in the discussions.

Unfortunately, we failed in involving the IT participants to discuss among them, since most of the interactions were between each individual participants and the IT coordinator, through the email usage. Even during the scheduled conference calls, most of the interactions occurred only between the IT coordinator and each individual IT participant. Besides, most of the interactions occurred as reactions to the IT coordinator requests. The exception to this rule occurred during the KOM hold in Brussels to constitute the IT, where there was a live discussion and active participation. Face to face meetings are proven to be more fruitful.

Innovative points

More than emphasizing innovative points this IT has posed the baseline of the state of the art for service discovery, since the received contributions are a good representation of the past and current research initiatives in the domain of service advertising and provisioning. Indeed, most of the contributions share similar accepted principles and patterns, such as matchmaking and ranking, template-based querying, multiphase discovery, etc, which can be also encountered in other research initiatives not contributing to the IT. So, the main result of the IT is to pose the wide accepted service discovery patterns and the current trends on the research domain.

Impact on standardization

The purpose of the IT was not to influence or impact on any ongoing standardization process, even if some standards or those still under standardization are used or commented within the contributions: UDDI, ebXML, WSMO, OWL-S, SAWSDL, WS-Policy, etc.

3.1.2.4 *Interoperability of Message-Based Service Invocation*

The interoperability working group, which had been established in the first call for contributions, finished its task with delay in respect to the planned reporting period. Thus the results are published now in this present update of the deliverable.

Rationale

Interoperability is a core feature of service interaction: services basically operate by exchanging messages with each other. And thereby, they need to understand each others' messages completely and unambiguously. Services, however, are developed independently according to different standards and techniques and, furthermore, standards are often used in different ways. This clearly jeopardizes the interoperability between services.

Objectives

The objectives of the "INTEROP Investigation Team" are

- to provide a survey of standards related to interoperability in the context of message-based service interaction,
- to collect guidelines, best practices and patterns for the solution of the messaging-related interoperability problems, and
- to place the findings into the context of the ensuing conceptual NEXOF Reference Architecture.

Criteria

Message-based interoperability is concerned with (data) format interoperability, protocol interoperability and, most importantly, with the semantics of the exchanged messages. Interoperability is also highly relevant with respect to higher level (application and domain independent) protocols that describe how sequences of messages are interrelated, in particular, if transactions or sessions are involved.

In the presence of standards, interoperability is often impeded by ambiguities and incomplete specifications. Here, additional constraints or new versions are used to unify and formalize the intent of a standard.

Regarding higher level protocols, standards are not commonly adopted or are still missing and best practices vary a lot. In particular, sessions are implemented using very different standards.

In the absence of standards or in the presence of conflicting standards, interoperability becomes a mediation challenge.

This topic is therefore one of the key features for services. The situation concerning standards leads to the expectation to cope with many gaps.

Due to the importance of this concern, we included the topic in the first list of potential topics to be issued in the first call.

Placement in architecture

"Interoperability of Message-Based Service Interaction" is strongly focussed on the concern "Messaging" and is thus located in the same layer as service creation, messaging and composition. But of course, it is cross-cutting to the

other concerns as well. This makes interoperability a strong requirement for the NEXOF Reference Architecture and consequently, it has, for example, be identified as a system requirement (see [27], section 13.1.1 resource infrastructure requirements).
The NEXOF Reference Architecture is intended to underpin an open, ubiquitous service ecosystem. Interoperability between independently developed and deployed systems is therefore an essential feature. To achieve interoperability for bringing together such independent developed and deployed systems of such rather heterogeneous systems and services, guidelines and best practises supposedly prove to be rather helpful. It therefore was proposed to develop such NEXOF-RA specific guidelines and best practices which were particularly adjusted to the architectural patterns of NEXOF-RA.

Investigation Team Reports
The investigation team report was finalized on July 2009, 30th. It includes the following topics:

- Interoperability Concepts & Dimensions
- Examples (good practices & pitfalls) and standards application from existing projects
- Integration of the thereby collected Guidelines/Best Practices into the NEXOF Conceptual Architecture

Thus, the report of the "INTEROP Investigation Team" [see Appendix B: Investigation Teams Contributions] presents (a) a survey of standards related to interoperability in the context of message-based service interaction, (b) collected guidelines, best practices and patterns for the solution of the messaging-related interoperability problems, and (c) a placement of its findings into the context of the ensuing conceptual NEXOF Reference Architecture. The final part of the report eventually shows how to integrate the results into the NEXOF Conceptual Architecture and what in future has to be done to achieve better interoperability.

Topics
The topics defined by the "INTEROP Investigation Team" are – in accordance with the structure of the envisaged investigation team report: (a) The embedding of message based interoperability into the overall SOA interoperability concepts, (b) good practices, guidelines and applicable standards, selected according to practice in existing projects, and (c) a mapping of the results and findings into the NEXOF Conceptual Architecture.

Setup of the team
The "INTEROP Investigation Team" was formed within the first Open Construction Cycle of NEXOF's Open Architecture Specification Process in the Core Service Framework Area and is concerned with the topic Interoperability of Message-Based Service Interaction in relation to the NEXOF work package 2. Nine position papers were submitted, all from different affiliations.

The Investigation Team was constituted as one team wherein all interested participants collaborate. Active Participants was:

- Peter Graubmann, Siemens
- Stanislav Pokraev, Telin
- Eric Piel, TU Delft, representing the project Poseidon (see [22])
- Francisco Javier Diez, Tekniker, representing the projects KOBAS and eEe (see [21],[20])

Concrete objective and result
The Investigation Team identified the following concrete objectives:

1. identification of interoperability models to use as a conceptual base
2. derivation of a taxonomy of problems in the context of message-based interoperability
3. identification of concrete examples with appropriate solutions
4. extracting best practises and relevant standards

The “INTEROP Investigation Team” decided to start with a clarification and explanation of the theoretical background of message-based interoperability. That meant to define interoperability and to separate the different types of interoperability, which are syntactic, semantic and pragmatic interoperability. Furthermore, two models, the LCIM[9] and the SOSI[10] are presented and a taxonomy for message-based interoperability problems is introduced. Based on this taxonomy, interoperability problems and their solutions are described. To this section, three different projects - the eEe[11], the KoBas[12] and the Poseidon[13] project contributed concrete examples. This section is followed by a list of interoperability standards which clearly distinguishes syntactic and semantic standards. The presented standards are published by different organisations, like the W3C, the WS-I and the IEEE, and they are partly overlapping. This is one reason, why simply using one standard doesn’t make a service interoperable in the heterogeneous NEXOF context, where another service, that is expected to interoperate, uses a different standard. The like problems and also the patterns and best practices that help to avoid them are collected in this report as well.

Initially, the focus of the “INTEROP Investigation Team” seems to have been slightly too broad, so the advancement was not as efficient as it could have been. Yet, the start of the top level pattern activity brought the missing guidance and the integration of Guidelines/Best Practices into the NEXOF Conceptual

[9] IT Report Interoperability of Message-based Service Interaction (section 2.3.1), http:// http://www.nexof-ra.eu
[10] IT Report Interoperability of Message-based Service Interaction (section 2.3.2), http:// http://www.nexof-ra.eu
[11] IT Report Interoperability of Message-based Service Interaction (section 5.1), http:// http://www.nexof-ra.eu
[12] IT Report Interoperability of Message-based Service Interaction (section 5.2), http:// http://www.nexof-ra.eu
[13] IT Report Interoperability of Message-based Service Interaction (section 5.3), http:// http://www.nexof-ra.eu

Architecture became much clearer and easier. Now, from the patterns, guidelines and best practises, identified by the Investigation Team, the relevant patterns should be extracted in a future activity and integrate into the NEXOF pattern system. In particular, the mediator pattern, that describes the encapsulation of the communication between objects within a mediator object, should gain particular attention: a NEXOF specific mediator pattern should be developed, which, of course, would have to be part of an interoperability guideline targeting on NEXOF-RA characteristics and specific features.

Future work should also focus on standards. Many interoperability problems show that standards certainly enhance interoperability. But standards don't produce interoperability automatically and, even worse, they can be a source of interoperability problems, caused by:

- Ambiguity in the standard
- Error in an implementation
- Mismatch in profiling -- different choices of options in standard
- Non-standardised features, added by a vendor
- A vendor-established market with a "non-compliant" implementation
- Unexpected combination of different standards
- Competing standards

On the one hand, NEXOF should recommend standards that should be used to achieve interoperability, and on the other hand, work package 9 could influence standardization activities which are within the focus of NEXOF and the contributing projects, so that interoperability can be well supported by NEXOF.

Moreover, in order to support the usability of NEXOF-RA, it could be useful to evaluate, whether it is valuable to define an interoperability process for NEXOF-RA.

Regarding the results of the interoperability team, the main future task should be a deeper evaluation of the interoperability models, patterns and guidelines under the consideration of application domain and interoperability requirements. A special focus should be on implementation issues.

The result should be a feasible interoperability model, guidelines and patterns integrated in NEXOF-RA. Of course, simply demanding interoperability is not enough. There are different areas where interoperability has to be actively established:

- in the architectural concepts
- in the existing architecture of running services and systems
- in interoperability assessment and analysis tools
- in operational interoperable environments

Thus, the final part of the report shows how to integrate its results into the context of the NEXOF Conceptual Architecture and what has to be done in future to improve interoperability.

Roles assigned
The team members were invited to share their experiences. There were no particular roles assigned to the participants during the set-up of the team. Each participant was intended to act as contributor to the Investigation Team and everyone was, in principal, invited to address all the objectives defined by the investigation tasks.

During the reporting period Peter Graubmann played the driving role in co-ordinating the collection of examples and best practices, in providing input for the conceptual base and as writer of the document.

Process followed
The nine contributors of position papers took part at the kick-off meeting. During this meeting, the team formed itself as a group with three contributors from outside NEXOF-RA (see them listed in the section “Setup of the Team”). The actual working period started at the beginning of 2009. A first draft of concrete objectives was discussed and agreed. The next step was the collection of requirements relevant for interoperability, based on the experience of the participants. This was done in parallel to the definition of the document structure, according to which the work on the concrete tasks (see section “Concrete objective and result”) was organised. The last step was to analyse the results and to finalize the IT report. This was mainly done by Siemens, supported by reviews of the other team members. The result of the analysis is part of the IT report [see Appendix B: Investigation Teams Contributions].
Communication and collaboration take place via conference calls and email exchange. There were no face-to-face meetings.

Innovative points
Although the “INTEROP Investigation Team” hasn’t succeeded in exploring unique innovative interoperability issues, the results establishes a profound groundwork for deeper evaluation of the interoperability models, patterns and guidelines under consideration of application domain and interoperability requirements. In future, a special focus should be on implementation issues. It is expected that further activities, in continuation of the work done, will lead to innovative results like a feasible interoperability model, guidelines and patterns that become integrated in and extend a reference architecture like the future full-featured NEXOF-RA.
In this context, tools – based on application-specific scenarios – could be very useful that allow assessing the degree of mutual interoperability of arbitrary components.

Impact on standardization
One of the objectives of the IT was to identify best practises and relevant standards. In the investigation team report, a section is dedicated to the presentation of the most common interoperability standards (focused on web services) whereby syntactic and semantic interoperability standards have been clearly separated. The syntactic interoperability standards are ordered

according the aspects “Interoperability Issues”, “Messaging Specifications”, and “Metadata Specifications”.

The provided list of standards is definitely not complete, but completeness was not feasible in the given IT setting., It should be also mentioned here that to include a gap-analysis into the report wouldn’t have made sense, because problem examples which could have been investigated were not yet available.
The section of the investigation team report about interoperability standards serves as input for the NEXOF-RA work package ”Standardisation Bodies Liaison”.

3.1.2.5 Runtume Service Composition

Rationale

As stated for the Design Time Service Composition Investigation Team, SOA encourages the building of ICT systems by combining several services which represent different software components, as composable building blocks. This way, it is possible to create more complex software components which offer extra functionality with a low coupling level, thanks to the SOA standards.
SOA standards for composition are focused on specifying the composition using XML-based languages. These compositions, at the end, are used for realizing business processes, mapping activities to a concrete operation offered by some service.
The Design Time Service Composition IT has already studied several approaches and solutions for challenges related to the composition concern, but they are focused only in design time, when developers may define the behaviour of the composite service and in which the objective is to improve the engineering process.
In the case of Runtime Service Composition, the challenges are focused on the way to manage the composite service once it is under execution or about to be executed. Some of these challenges have been already mentioned and are related to exceptional situations, where self-healing, self-configuring, self-adaptation, etc, are needed. But this applies as well in situations when it is interesting to provide alternatives to the user (such as different QoS levels, linked to signed SLAs) and the composition must adapt itself because of business reasons.
Therefore, it is necessary to gather information, not only about the benefits and needs related to runtime, but also to the existing solutions and any other functionality required related to the topic and the approaches for providing the tools which will solve the identified problems.
Due to the importance of composite service in SOA world and within the NEXOF core service area, we selected this topic within the second list of potential candidates, complementing the topics launched in the first call.

Objectives

The service composition topic was identified as a core concern within this workpackage since the very beginning, deserving an important place in the service core architecture. As the importance of the topic was recognized, the

challenges to be analyzed were large and there are many points of view and different solutions for some of the issues, it was clear that the best solution was to involve more ICT experts in NEXOF core service area to cope with an intensive survey and critical analysis of existing results and missing gaps.
Therefore, we targeted at many experts and researchers who are being working on the topic in the last years. These researchers provided their (different) vision and solutions for the problem of composing services, so we have been able to gather more information and analyse those patterns applied in the tools developed for creating compositions, trying to find the common points and the variants which may provide alternatives in the Reference Architecture.

Criteria to issue the call

It is the same as for Design Time Service Composition. Due to the importance of the Service Composition concern, we included it as one of potential topics to issue in the IT calls. As explained, Design Time composition was launched in the first call, and Runtime was launched in the second call. Besides, some NEXOF-RA partners have participated and/or are participating in some national and EC FP6/7 projects where the service composition concern was intensively studied, such as GODO [4], Composetour [5], SeCSE [6], SUPER [7], INFRAWEBS [8], SOA4ALL [9], etc. Therefore, we were aware of the promising available results and improvements on this topic domain and the current research baseline.

Placement in architecture

Service composition concern is part of the service core area, that is, an essential SOI feature, located between the underlying SOI and the SOA applications. Service composition system is located in the same layer as service creation, messaging, discovery, mediation, interoperability, etc.

Investigation team reports

The results of the Runtime Service Composition IT have been collected in an IT report [see Appendix B: Investigation Teams Contributions]. This IT report contains all the received contributions and an analysis and integrated overview of those contributions highlighting similarities, differences, relationships, subtopics not or insufficient covered and a short summaries of suggested standards. The number of received contributions was up to six. There were up to 3-4 active contributors.

Topics

As explained before, Design Time Service Composition IT identified several subtopics relevant in the domain scope of the team. However, most of the different subtopics were so interwoven that there was not a real chance to split the IT into small teams. It was better decided, as aforementioned, to split the whole IT across calls, one topic at design time and another at runtime, which are closely related but represent a logical separation.

In the case of Runtime, main topics are related to the dynamic creation and adaptation of services compositions during their execution and light monitoring

about the execution of the composition, which can serve as input for the adaptation.

Setup of the team

The IT was constituted as a unique team with all interested participants within. Active participants were:

- Ingo Zinnikus, from DFKI, representing COIN project
- Fulvio Frati, from UNIMI
- Georgios A. Gionis, from NTUA
- Leire Bastida and Marisa Escalante, from ESI, representing SeCSE project
- Rainer v. Ammon, from CITT
- Paolo Zampognaro, from Engineering, representing SLA@SOI project
- Flavio Oquendo, representing ArchWare project

Those participants have background expertise in the scope of service composition using orchestration and choreography approaches, monitoring, validation and verification, semantic, AI planning and other techniques for automatic composition, UML2 modelling of service collaborations, and so on

Summary of activities

Except the initial kick off meeting there were not more physical meetings. We hold two conference calls, one during the first iteration and one more after the physical meeting and the reception of the complete contributions, in the second iteration.
IT participants submitted their contributions during the first iteration, through a position paper. They were integrated by the IT coordinator who tried to provide a coherent and consistent view of those contributions relating each other when possible, highlighting similarities, dissimilarities, complementarities, etc. IT participants were asked on concrete topic points for clarifications, which were incorporated to this holistic view.
During the second iteration, IT participants were asked to provide additional contributions, to refine those already submitted according to the comments issued by email or during the previous conference call. At the end of this second iteration, a refined version of the IT report was issued and commented by the IT participants. This IT report was finalized and submitted to NEXOF-RA consortium by the end of the IT.

Role assigned

The work was organized as a “virtual round table” and each member of the team was invited to share their experience with the other participants during the meetings and teleconferences. No explicit role was assigned to the participants who share a common role of contributor to provide inputs to the investigation team and to address the objective defined by the tasks.
Only J. Gorroñogoitia and F.J. Nieto had the role of chair during the meetings and integrator of results.

Process followed

The working methodology followed by the IT was as follows. The IT working period was roughly divided into two even iterative phases. Each phase was organised similarly: a first time slot to prepare and submit contributions, a second time slot to understand and integrate contributions, a third time slot to received further comments upon the integrated view and refine it.
The first iterative phase aimed at providing a first working document describing those design patterns relevant in the topic domain. The second iterative phase aimed at fulfilling the gaps identified during the first phase and refining the received contributions.
Communication and collaborative tools were: a) the NEXOF-RA portal repository, b) email discussions, c) scheduled conference calls.
The IT coordinator decided to accept all received contributions since a) all of them were within the topic scope, b) we were not only interested in documental contributions, but in recruiting the experts behind those contributions, in order to participate in the discussions.
Unfortunately, we were not able to involve the IT participants to discuss among them, since most of the interactions were between each individual participants and the IT coordinator, through the email usage. Even during the scheduled conference calls, most of the interactions occurred only between the IT coordinator and each individual IT participant. Besides most of the interactions occurred as reactions to the IT coordinator requests, lacking a real discussion of ideas between participants.

Results

The main result obtained after analysing all the contributions is a set of related concepts for Runtime Service Composition, as well as a set of architectural patterns related to the tools which give solutions for performing service composition at runtime or functionalities related to that composition.
An important part of the received contributions have focused on the available algorithms for modifying, during the service composition execution, the workflow or the invocations to be performed. Some of them enable just the dynamic change of the endpoint to be invoked, while others assume that functionality and exploit it for adapting the whole workflow or part of it, using semantics as the base or rules related to each invocation activity.
These contributions are not related to the assisted composition, which looks for supporting humans in their developments, but to fully automated actions taken in conjunction with the execution engine, without human intervention or which limit human intervention to the provided designs for the composition.
Moreover, some patterns have been proposed in order to gather information about the services behaviour, by monitoring them with probes which will provide information to be used when adapting the workflow.
The patterns identified are in line with the contributions received. The concepts have been extracted from the analysis of the contributions as well (rules, dynamic binding, monitoring, etc.).

Innovation points

More than emphasizing innovative points this IT has posed the baseline of the state of the art for Runtime Service Composition, since the received

contributions are a good representation of the past and current research initiatives in the domain of activities related to the composition of services at runtime. Several topics have been covered, such as monitoring aspects related to the composition and the dynamic binding of services (using agents, rules, etc), which can be also encountered in other research initiatives not contributing to the IT. So, the main result of the IT is to pose some alternatives for Runtime Service Composition by means of several patterns and the current trends on the research domain.

3.2 Collaboration with NESSI STRATEGIC projects

The project NEXOF-RA depends on the active involvement of external partners, in particular on contributions from NESSI Strategic Projects.
The collaboration with the NESSI Strategic Projects took place via the Architecture Board that was held every 6 weeks.

The content of work package “Service-Centric System Engineering“ is more closely related to those of SOA4All and SLA@SOI than those to EzWEB, MASTER or RESERVOIR.

The link to SOA4All and SLA@SOI is such that an agreement on the basic architecture has to be reached. SOA4All and SLA@SOI both focus on a particular aspect of a SOA.
Since these projects started some time later than NEXOF-RA, the collaboration took place in one way, i.e. these projects assessed the results of NEXOF-RA.
Domain experts of these projects have participated to the Investigation Teams and have contributed to the realization and to the review of some architectural patterns. In particular SOA4All research has influenced Service Discovery and Design time Service Composition patterns (see section 4.2) while SLA@SOI has contributed with the usage of SLA-based templates to the Template-based Discovery pattern (see section 4.2.8).
External contributions has allowed the project to leverage the best-of-breed architectures and technologies also enhancing the quality and applicability of the overall architecture.

4 CONTRIBUTION TO THE REFERENCE ARCHITECTURE

The contributions of the work package “Service-Centric System Engineering” to the Reference Architecture is by SOA experts and architects of NEXOF-RA project and by the external contributors involved in the ITs. The most interesting and mature contributions coming from ITs have been selected (also according to the requirements pointed out by “Requirements and Assessment Criteria” work package), elaborated and made compliant to the NEXOF-RA rules and templates.

4.1 Contribution to the Reference Model

The contributions to the Reference Model has been done in terms of contribution to:

- Analysis of specific reference models (results included in “Reference Architecture Model V1.0” (D6.1)), in particular OSGi, SCA, SeCSE, WSA, OASIS
- Contribution to the glossary
- Contribution to the conceptual model by introducing functionality of core service area Service, Message, Discovery, Composition

The work package “Service-Centric System Engineering” contributes to the Reference Model insofar as they were introduced concepts included in the Conceptual Model defined in scope of NEXOF-RA project and terms included in the NEXOF-RA glossary.

The concepts and the terms introduced provides the baseline to define the Reference Specification mainly with respect to the concerns of responsibility of the work package “Service-Centric System Engineering” but some of them, like the definition of Service produced by the Service Description Investigation Team, affect the Reference Specification in the whole.

Contribution to the Conceptual Model

The work package “Service-Centric System Engineering” contributes to the Conceptual Model introducing concepts in the scope of each concern of responsibility of the work package “Service-Centric System Engineering” identified in the NEXOF-RA project. The following figure shows such concepts in a schematic illustration, yellow coloured to highlight them with respect to the overall model.

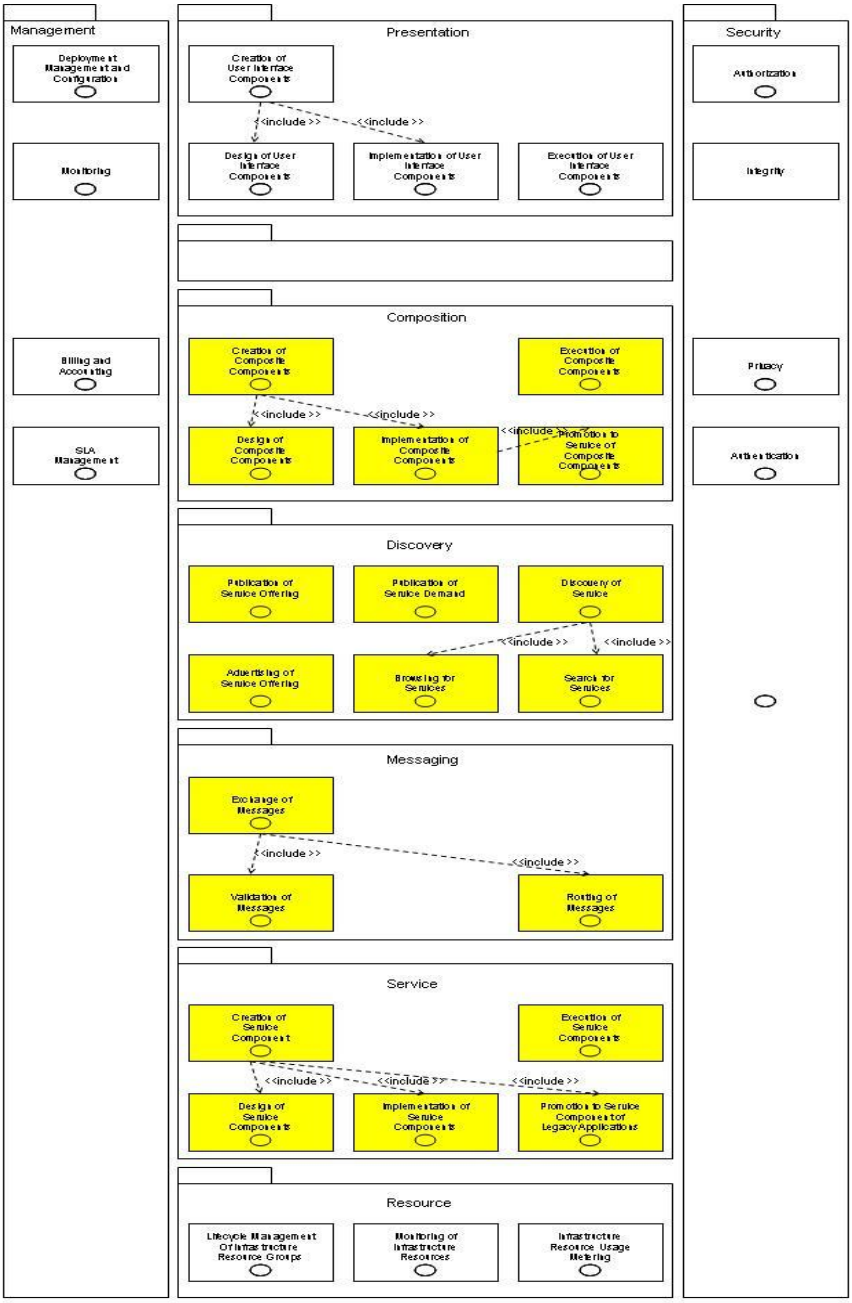


Figure 4: Contribution to the functionality of the conceptual model

The concepts showed in the figure are listed in the following table regrouped by concern.

Concern	Concept
Composition	Creation of Composite Components
	Design of Composite Components
	Implementation of Composite Components
	Promotion to Service of Composite Components

	Execution of Composite Components
Discovery	Publication of Service Offering
	Publication of Service Demand
	Advertising of Service Offering
	Discovery of Service
	Browsing for Services
	Search for Services
Messages	Exchange of Messages
	Validation of Messages
	Adaptation of Messages
	Routing of Messages
Service	Creation of Service Component
	Design of Service Component
	Implementation of Service Component
	Promotion to Service Component of Legacy application
	Execution of Service Components

Contribution to the glossary

In order to proceed to the effective analysis and characterization of the NEXOF Compliant Platform, it was needed to agree on a definition of Service widely accepted and shared in the SOA community. Such very challenging task was achieved by the Service Description Investigation Team that produce the definition of Service as following:

Definition of Service:
An action performed by one entity (provider) that matches a request of another (requesting entity), according to the interpretation of the latter

Such term definition contributes to the NEXOF-RA glossary.

It provides the baseline to build the Reference Specification produced in the scope of NEXOF-RA, and it affects the definition of many other concepts and terms introduced during the project execution. Thus, a number of new terms was introduced in the glossary that are either a consequence of such definition of service or that was affected in some way.

In the following table is provided a list of all the terms introduced in the glossary that are introduced in the scope of the work package “Service-Centric System Engineering”.

Term	Glossary (sub)section
Entity	NEXOF-RA Specific Term
Service	NEXOF-RA Specific Term
Software Service	NEXOF-RA Specific Term
Agent	NEXOF-RA Specific Term
Provider Agent	NEXOF-RA Specific Term
Requester Agent	NEXOF-RA Specific Term
Provider Entity	NEXOF-RA Specific Term
Requester Entity	NEXOF-RA Specific Term
Agent Description	NEXOF-RA Specific Term
Service Description	NEXOF-RA Specific Term
Service Component Specification	NEXOF-RA Specific Term
Software Component	NEXOF-RA Specific Term
Service Component	NEXOF-RA Specific Term
Simple Service Component	NEXOF-RA Specific Term
Process Component	NEXOF-RA Specific Term
Process Service Component	NEXOF-RA Specific Term
Connector Component	NEXOF-RA Specific Term
Connector Service Component	NEXOF-RA Specific Term
UI Component	NEXOF-RA Specific Term
Process Agent	NEXOF-RA Specific Term
Process Provider Agent	NEXOF-RA Specific Term
UI Agent	NEXOF-RA Specific Term
Connector Agent	NEXOF-RA Specific Term
Connector Provider Agent	NEXOF-RA Specific Term
Platform Software Component	NEXOF-RA Specific Term
Infrastructure Software Component	NEXOF-RA Specific Term
Business Software Component	NEXOF-RA Specific Term
Business Service	NEXOF-RA Specific Term
Business Software Agent	NEXOF-RA Specific Term

4.2 Contribution to the Reference Specification

The contributions to the Reference specification has been done in terms of contribution to

- State-of-the art report (results included in “State of the art report” (D7.1)): Survey of standards/technologies related to SOA, incl. acceptance and competing standards
- Conceptual architecture (results included in “Definition of an architectural framework and principles” (D7.2), “NEXOF RA Model” (D6.2)/ “Conceptual architectural view” (D7.3))
- The Reference Specification samples contained in D7.4
- Architectural Patterns: they have been developed by experts and architects of NEXOF-RA project and by external contributors by the open process

The most interesting and mature contributions coming from the ITs have been selected and adapted to the template of NEXOF-RA contained in D7.2[14].

Table 3: Patterns produced by each IT

Pattern	Investigation Team	Domain
Enterprise SOA		ESOA
Designer and Runtime Tools for E-SOA		ESOA
Distributed ESB in E-SOA		ESOA
Assisted Composition Designer		ESOA, IoS
IoS		IoS
Models Manager	Design Time Service Composition	ESOA
Semantic annotation composition	Design Time Service Composition	IoS
Data Mediation	Interoperability of Message-Based Service Interaction	ESOA
Federated Distributed Message Bus	Interoperability of Message-Based Service Interaction	IoS
Dynamic Binding of Services during Composition	Runtime Service Composition	ESOA, IoS
Service Discovery	Service Discovery	ESOA, IoS

[14] http://www.nexof-ra.eu/sites/default/files/D7%202b%20Definition%20of%20an%20architectural%20framework%20and%20principles.pdf

Multi-phase Discovery	Service Discovery	ESOA, IoS
Service Matchmaking and Ranking	Service Discovery	ESOA, IoS
Template-based Discovery	Service Discovery	ESOA, IoS
Trust Based model registry	Service Discovery	IoS
Semantic based Federated Registry	Service Discovery	IoS

The following patterns have been identified by the contributions of the ITs, but for reason of effort they have not been finalized and adapted to the NEXOF-RA Specification template.

Table 4: Patterns produced by each IT in-Conception

Pattern	Investigation Team	Domain
Process Level Composition	Design Time Service Composition	ESOA
Process Data Mining Composition	Design Time Service Composition	ESOA
Federated registry in ESOA	Service Discovery	ESOA
Rule-driven Service Composition	Runtime Service Composition	ESOA
Model-driven and Agent based Service Composition	Runtime Service Composition	ESOA
Runtime Semantic Monitoring	Runtime Service Composition	ESOA

Here after a chart representing the numbers of patterns by the contribution of each IT.

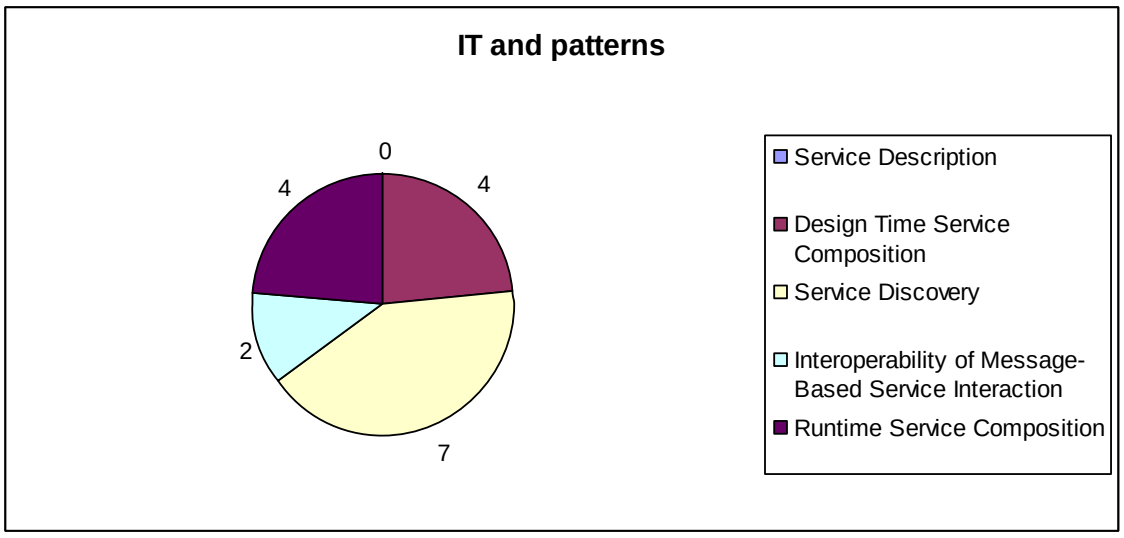


Figure 5: Patterns produced with the contribution of the ITs

A brief description of each pattern, the requirements they come from, the functionality of the model they address and its applicability can be found hereafter.

4.2.1 Enterprise SOA

Abstract

This pattern describes the architecture of an Enterprise SOA.

Starting from the identification of the base functionalities a SOA infrastructure, it provides a description of its architecture in terms of software components. Then it shows how these functionalities have been decomposed and allocated to each of them.

This pattern is described on a very abstract and high level and thus can not be seen as a design specification that directly allows for an implementation of the system. This pattern has been developed at this level of abstraction to enables the creation of several different patterns that specialize it and provide more specific architectural solution for such an infrastructure.

Requirements

SR 1. How can a service be created and executed?

SR 2. How can a service be invoked?

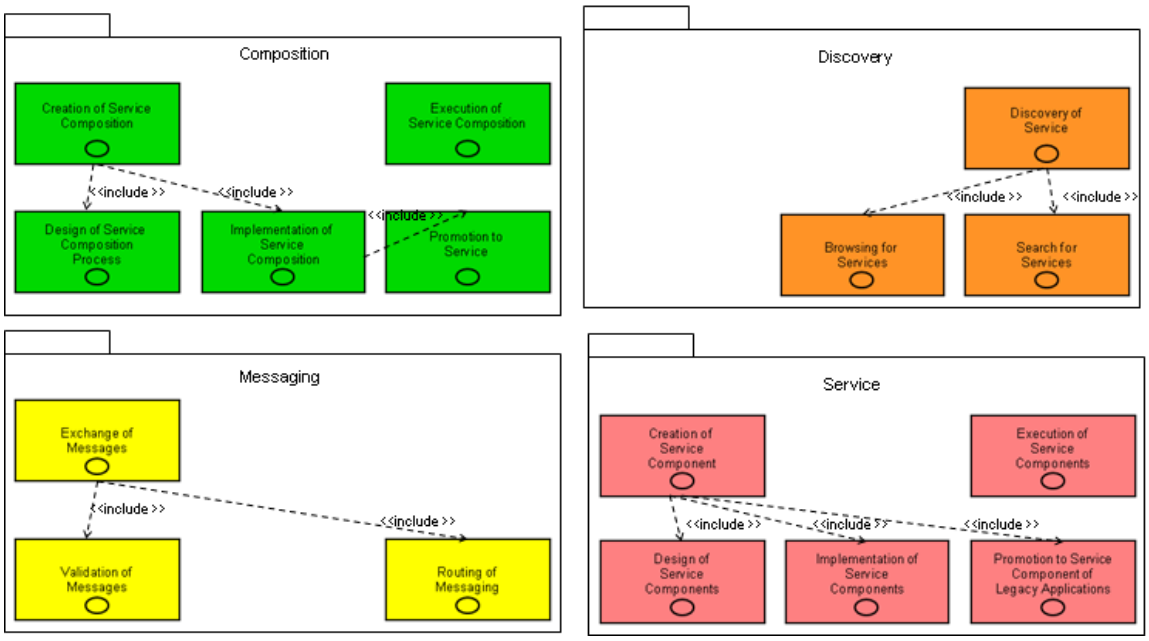
SR 3. How can a service be discovered?

SR 5. How can a process be realized by composing services?

The pattern also meets other requirements that are covered by the other NEXOF-RA research areas.

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern in the Service, Composition, Messaging and Discovery concerns.



Applicability

This pattern is applicable in the context of an enterprise that needs to factor the system in reusable functionality and make it easier to compose them to meet business requirements. It is also applicable in the general situation where an enterprise is organized in different divisions that autonomously manage their own services.

4.2.2 Designer and Runtime Tools for E-SOA

Abstract

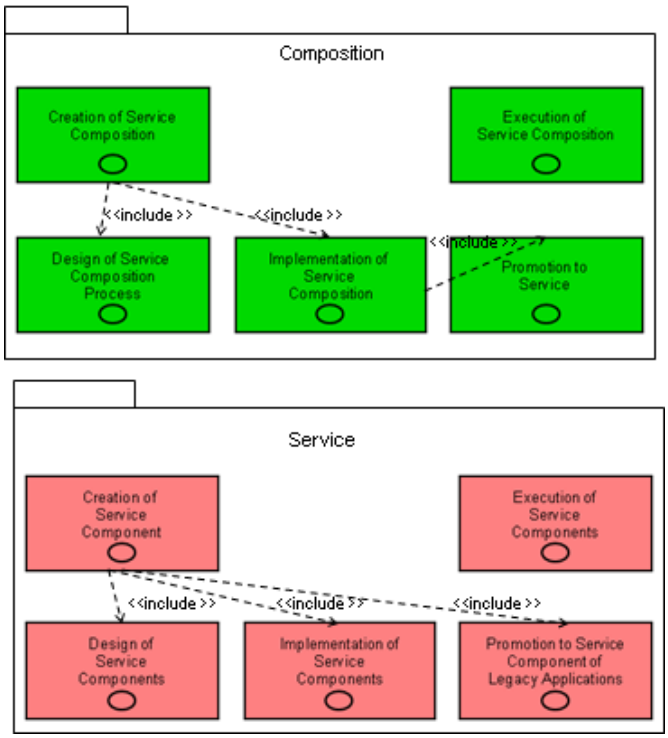
This pattern is a refinement of the Enterprise SOA pattern and focus on some of the architectural choices described into the top level pattern. In particular, it focuses on the functionalities provided by software components that are responsible for the design of software artefacts and their execution. The pattern starts from these subsets of software components and functionalities provided by the Enterprise SOA pattern and describes how they are decomposed according to the kind of software artefact to be designed or executed. The architectural choices made by this pattern describe a part of the SOA infrastructure at a very high level of abstraction and can be specialized to realize more specific architectural solutions.

Requirements

SR 1. How can a service be created and executed?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is applicable in Service Based Software systems that requires the capability to design and implement new Service Components or adapt legacy application to be used as service components. Moreover, it is applicable in the context where a runtime environment is required to execute existing service components.

4.2.3 Distributed ESB in E-SOA

Abstract

This pattern represents the bridge between two services which use different protocols and/or data types and need to interact. It is able to perform those transformations needed in order to enable interoperability.

Requirements

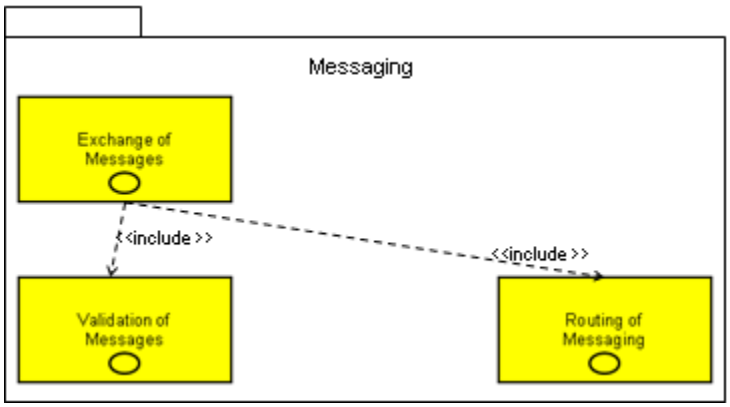
SR 2.1. How can services be identified and addressed?

SR 2.2. How can a service be described to be invoked?

SR 2.4. How can messages be sent/received to/from a service?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

There are several implementations of ESBs in the market. Some implementations are commercial, while others are open source. All of them are focused on performing transformations on different ways (between protocols and data types), and are useful every time it is necessary to integrate components using different ways of interaction mechanism.

4.2.4 Service Discovery

Abstract

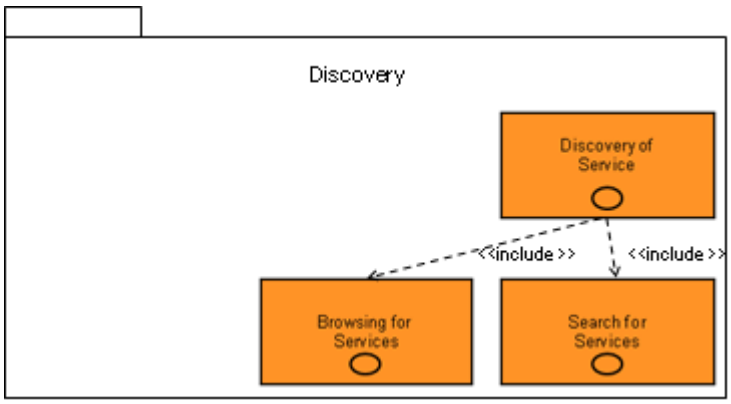
This pattern describes the main elements related to discovering services according to some requirements coming from users.

Requirements

SR 3. How can a service be discovered?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This is a quite abstract pattern which is useful for defining the main components to be included in an architecture in order to enable those functionalities related to the discovery of services according to some requirements. It allows its implementation with different approaches (such as search, browsing and subscription to services).

4.2.5 Multi-phase Discovery

Abstract

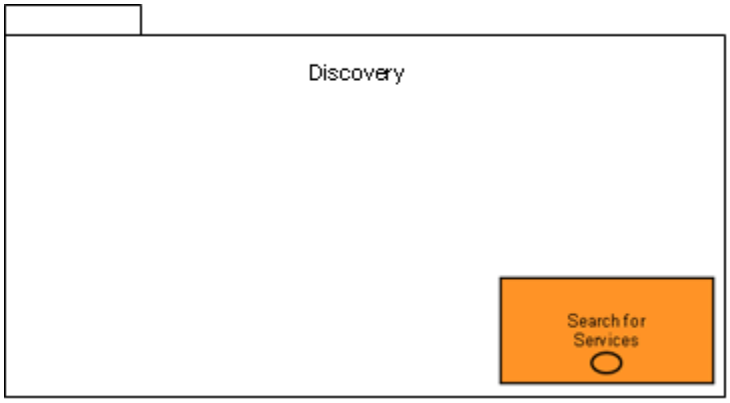
This pattern specifies a way to perform service discovery by applying different discovery algorithms in several phases, refining the list of candidate services in each phase.

Requirements

SR 3. How can a service be discovered?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is useful when the developer wants to introduce a mechanism for performing discovery in several phases, each phase applying a more restrictive algorithm, in order to gain performance and accuracy during the discovery process.

4.2.6 Data Mediation

Abstract

This pattern mediates between the incompatible and heterogeneous output and input messages exchanged between subsequent service invocations, whereby the output message of former service invocation can be consumed as input message by the later service.

Requirements

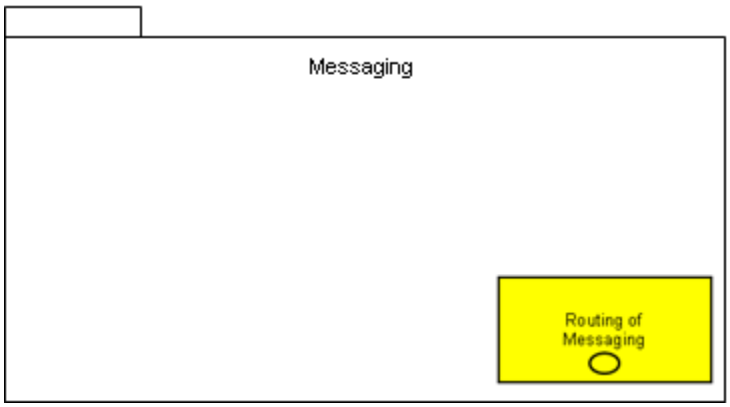
SR 2.1. How can services be identified and addressed?

SR 2.2. How can a service be described to be invoked?

SR 2.4. How can messages be sent/received to/from a service?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is a way to implement transformations between heterogeneous data sets. It is useful for instantiating ESBs with a good level of accuracy when performing the transformation, especially in open environments where different semantics need to coexist.

4.2.7 Service Matchmaking and Ranking

Abstract

This pattern defines those components involved in a simple discovery process which is divided in two tasks: matchmaking requirements and services and ranking candidate services

Requirements

SR 3.1.2. How can a service that satisfies client requirements be found (searching)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.

Applicability

The usage of this pattern provides a way to implement service discovery by means of complex searches of services. It enables the usage of different algorithms for performing the matchmaking and the ranking of services in the system.

4.2.8 Template-based Discovery

Abstract

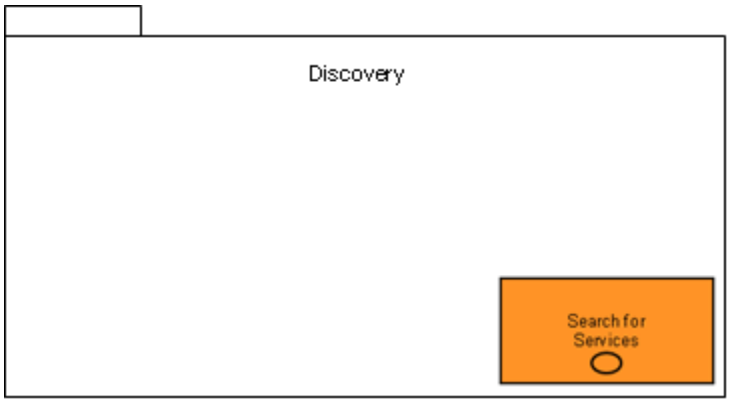
This pattern describes how to perform service discovery using as requirements a template which is filled-in by users who want to find services, as a way to support the requirements description.

Requirements

SR 3.1.2. How can a service that satisfies client requirements be found (searching)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern can be applied in those situations in which developers want to provide a mechanism for improving usability of the service discovery system, by providing a way to express easily the user requirements, which, later, are transformed into complex queries to be processed by the discovery engine.

4.2.9 Assisted Composition Designer

Abstract

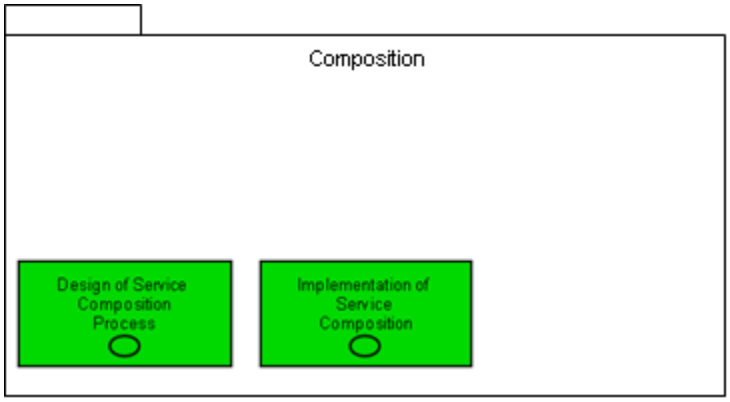
This pattern captures the main elements which should be part of a Process Designer Tool which is able to provide service compositions created in an automatic way, so it will be easier for developers to implement business processes.

Requirements

SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This is an abstract pattern which identifies the main components to be included when developers want to provide a way to assist users in the definition of services compositions. It only provides the main infrastructure, but it needs to be instantiated using one of the existing approaches for composing services in an (semi)automatic way.

4.2.10 Dynamic Binding of Service During composition

Abstract

This pattern enables dynamic execution of processes and invocation to services, by managing the services binding at the execution engine, which allocates invocations dynamically, reacting to the context. It is useful for adapting workflows during execution, as services are invoked according to runtime decisions.

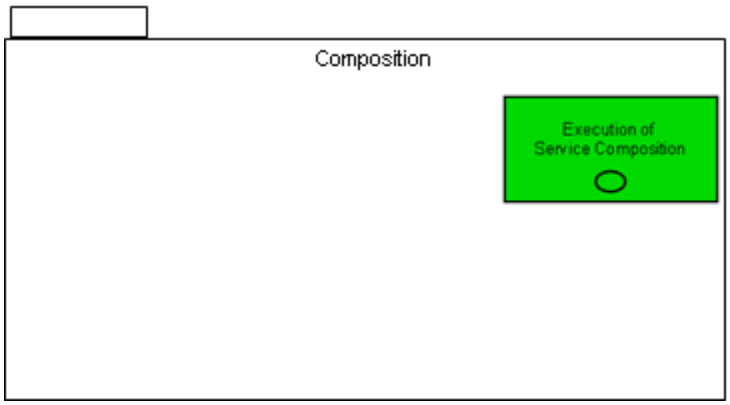
Requirements

SR5.1.1 How can a process be designed to select some of the services it composes at run-time in order to complete and satisfy QoS constraints (Dynamic composition, Dynamic Binding, Constraints Satisfaction)?

L6.2 On-the-fly service switching

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is useful for those systems which provide the possibility of adapting the service composition execution, by deciding the services to be invoked at runtime. It can be used in conjunction with other approaches for taking decisions.

4.2.11 Models Manager

Abstract

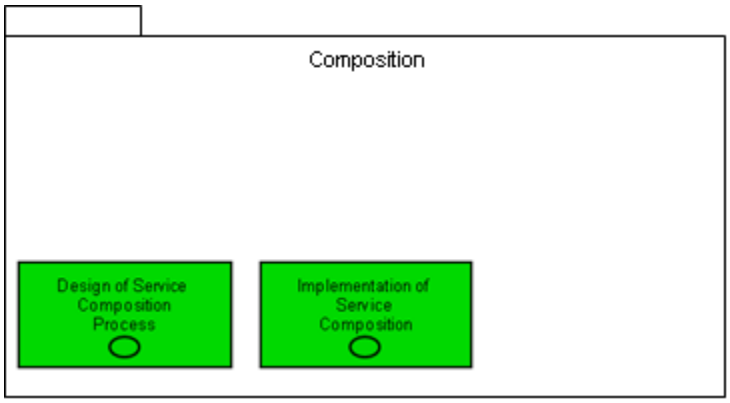
This pattern defines the elements involved in the management of models, which may represent languages for process execution, so a composition can be created and edited easily.

Requirements

SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern can be used in any situation in which a model needs to be managed dynamically. An editor for compositions is a good example, as developers will be modifying the model during their activity.

4.2.12 IoS

Abstract

The Internet of Services is a term used to describe several initiatives that will shape the future of how services are provided and operated on the Internet. Similarly to the Web, a platform developed on the Internet to enable the sharing of information at global scale, the Internet of Services aims to develop a platform on the Internet to enable anyone to deliver, consume and prosume services anywhere. With this respect, this pattern aims to provide an architectural design of such a platform. As a top level pattern, its main goal is to provide a very high level view of such a global platform.

Requirements

This pattern provides an architectural description of an internet based platform that mainly address the following functional requirements:

SR 1. How can a service be created and executed? (support the creation of new services by composing services made available at word wide scale)

SR 2. How can a service be invoked? (support the delivery of service from everywhere to everywhere)

SR 3. How can a service be discovered? (support the discovery of consumable services at world wide scope)

SR 5. How can a process be realized by composing services?

The design provided by the pattern is at very high level, for this reason it does not address any non-functional requirements. Of course it is expected that pattern that will refine this pattern will meet all those non-functional requirements that are peculiar to an internet-scaled platform such as:

1. Management of the platform can not be centralized.

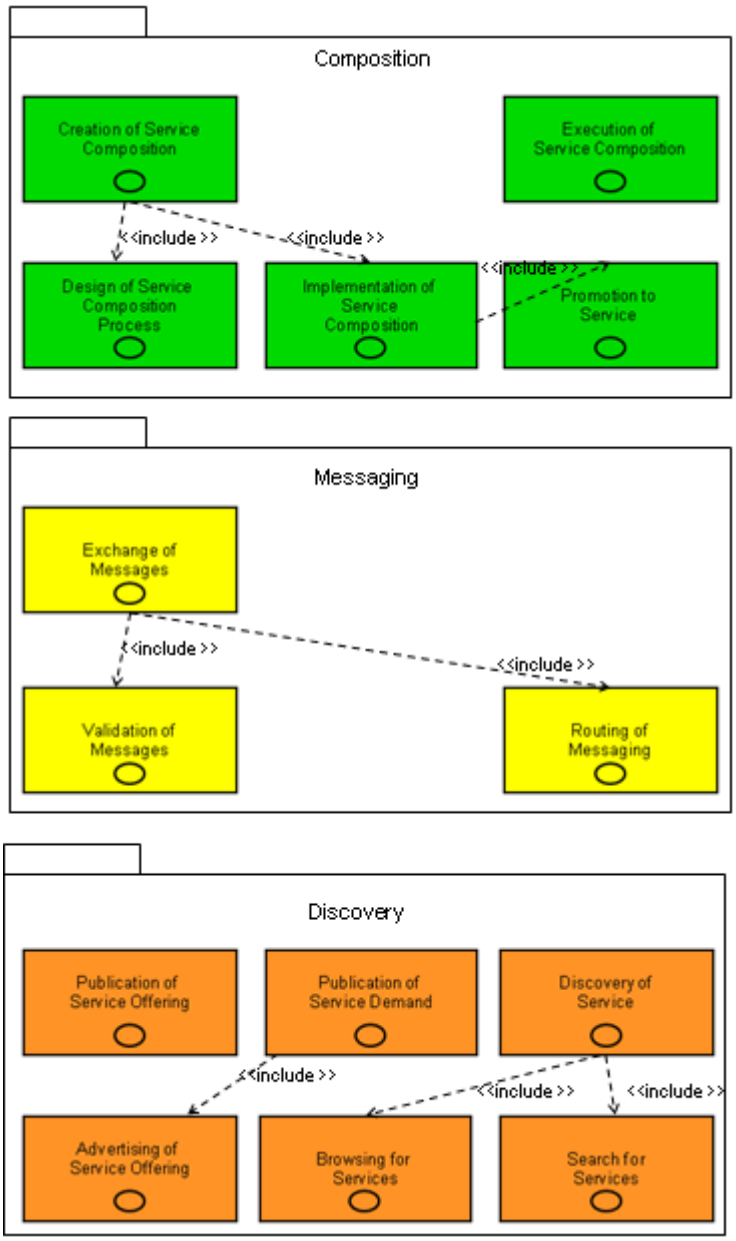
2. Service can be implemented by heterogeneous technology, but inter-operability must be enabled.

3. Service can be described by means of different techniques and with respect to different conceptualization models, but discovery must overcome this heterogeneity.

4. Service consuming must be supported under certain level of agreements between the provider and consumer, etc..

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern in the Service, Composition, Messaging and Discovery concerns.



Applicability

There are no specific restriction to the applicability of such a pattern, a part from the fundamental statement that it is designed for the Internet (the network of networks) as it is nowadays.

4.2.13 Trust Based model registry

Abstract

This pattern is a refinement of the Internet of Service pattern and focus on the architectural choices concerning the discovery of services described in the top level pattern. In particular, it focus on the definition of the components enabling the discovery of services on the basis of the quality of experience of the service's users. Moreover, it focus on the capability of the system to be scalable to fit in a large scale ecosystem and the capability of the system to enable the

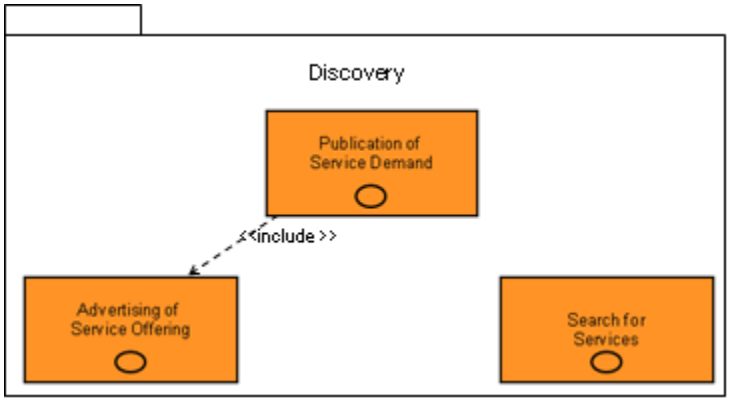
notification of services matching the requirements of the users. The architectural choices made by this pattern describes a part of the IoS infrastructure at a very high level of abstraction and can be specialized to realize more specific architectural solutions.

Requirements

SR 3. How can a service be discovered?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is applicable in Service based software system that requires mechanisms enabling the discovery of services. It mostly fit in large scale distributed software systems requiring a decentralized government and the capability to discover trusted providers.

4.2.14 Semantic based Federated Registry

Abstract

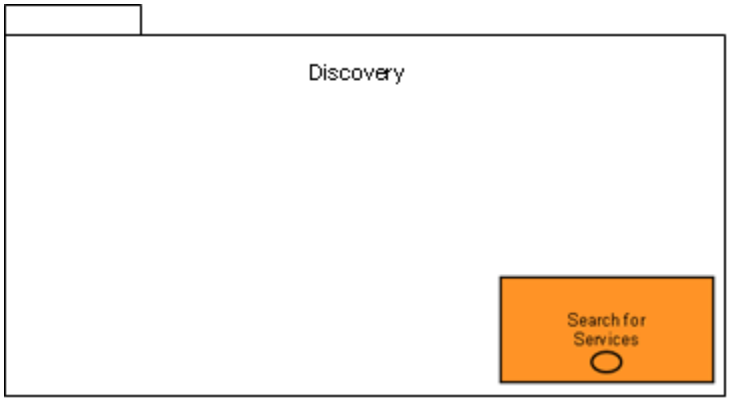
Based on semantic-annotation of business services, this pattern emphasizes how to design the architecture of the discovery sub system in order to be applicable and scale on the Internet, taking into account the fact that it should enable any user of Internet to discover (almost) any service published by any service provider of the Internet (global search). The solution also introduces components dedicated to solve the gaps between the various description techniques (languages) that different providers adopt.

Requirements

SR 3. How can a service be discovered?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern can be applied in any service based system which requires storing information about available services in the Internet of Services. As it provides the possibility of using federations, it is very useful in a distributed context in which information can be shared with other registries. It is the best option when users want to use semantics.

4.2.15 Federated Distributed Message Bus

Abstract

The solution provided by such a pattern emphasizes, for instance, the fact that, to properly scale on the Internet, we have to be based on a federated and distributed set of peer nodes, and there is no central point of control or failure. Moreover, it includes some semantic-based mediators that are capable to better deal with the syntactical and information heterogeneity of messages exchanged by software agents (those that participate to the realization of business services), that on the Internet scale are very likely expected.

Requirements

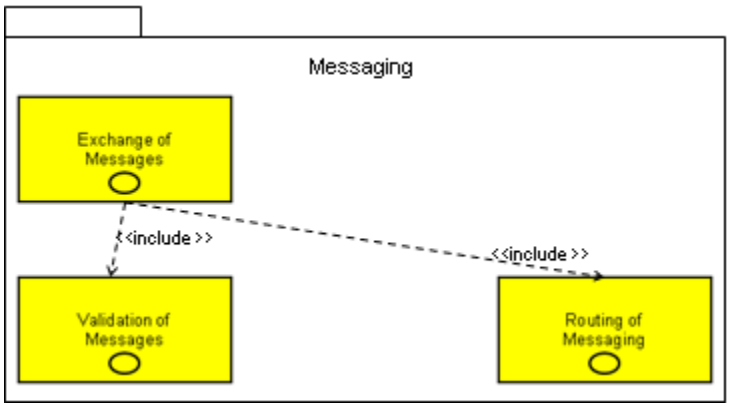
SR 2.1. How can services be identified and addressed?

SR 2.2. How can a service be described to be invoked?

SR 2.4. How can messages be sent/received to/from a service?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

Any system which requires improving interoperability and invoking heterogeneous services can obtain important benefits by applying this pattern. Moreover, in a domain such as Internet of Services, it is possible to get better results by using federations as the source to perform messages transformations in the best available way.

4.2.16 Semantic annotation composition

Abstract

This pattern describes how to perform dynamic service composition by exploiting semantic information such as OWL-S.

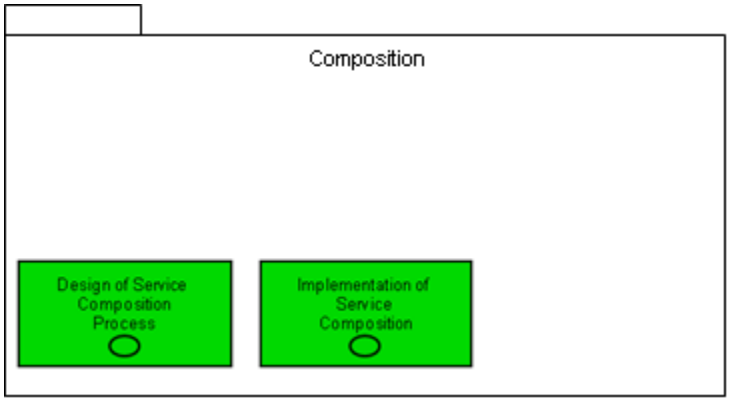
Requirements

SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)?

SR 5.1.1. How can a process be designed to select some of the services it composes at run-time in order to complete and satisfy QoS constraints (Dynamic composition, Dynamic Binding, Constraints Satisfaction)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is applicable in those systems used for designing services compositions, in which the process is automated by assisting users in the development of their services compositions. It is especially useful in those environments where semantics are applied, so its full potential can be exploited.

Hereafter a set of patterns that have been identified by the ITs; an high level description has been provided by the contributors, but for reason of effort they have not been finalized and adapted to the NEXOF-RA Specification template.

4.2.17 Process Level Composition

Abstract

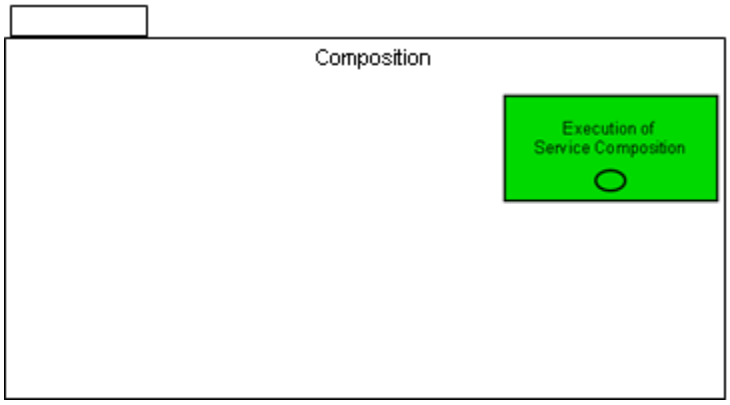
This pattern describes how to perform semi-automatic service composition by using some semantics and AI planning techniques.

Requirements

SR 5.3. How can a process be enacted?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

There are environments oriented to service composition development which can benefit from the solutions provided by this pattern. As it is more oriented to processes, it can be more useful in E-SOA domains, where a company has defined several processes and sub-processes, and want to combine them in more complex workflows.

4.2.18 Process Data Mining Composition

Abstract

It defines an approach for semi-automated services composition based on natural language ontologies exploitation and data mining techniques, for ensambling process chunks.

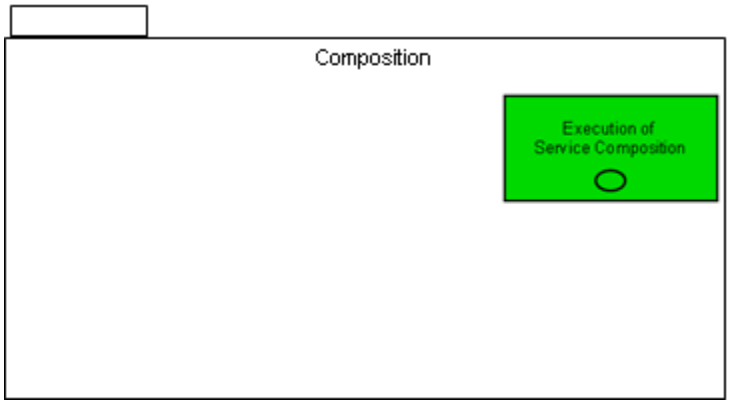
Requirements

SR 5.3. How can a process be enacted?

SR 5.6. How can services and tools for their execution and implementation be realized in order to participate to monitoring policy?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is applicable to any system willing to offer a way to automate service composition development. In this case, it is useful for complex systems with a lot of information about the compositions which can be performed and the activities involved. It is better for a domain specific context, where everything about a domain is well known and can be modelled.

4.2.19 Federated registry in ESOA

Abstract

SOA is essentially a collection of services. How to find these services become more and more important. On of the main SOA design principles is the so-called Service Discoverability. This design principle implies that services should be supplemented with communicative metadata by which they can be effectively discovered and interpreted. It also leads to the definition of a SOA module used to store services metadata and provide browsing and searching capabilities: the Service Registry/Repository.

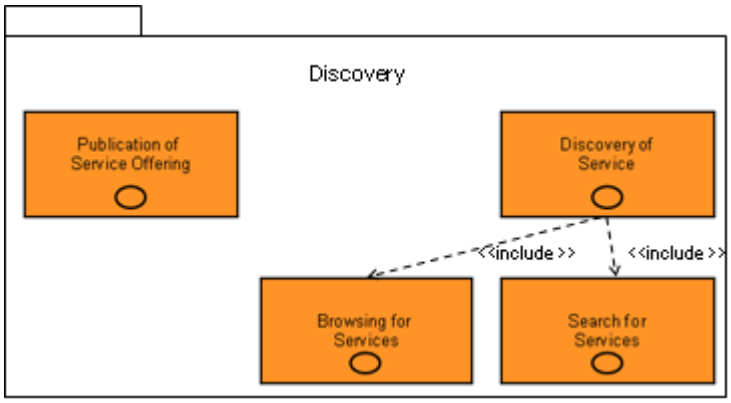
This pattern is intended to provide an architectural solution for the discovery of Service in an Enterprise SOA.

Requirements

SR 3. How can a service be discovered?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is applicable in the context of an enterprise SOA that requires mechanisms enabling the discovery of services.

4.2.20 Rule-driven Service Composition

Abstract

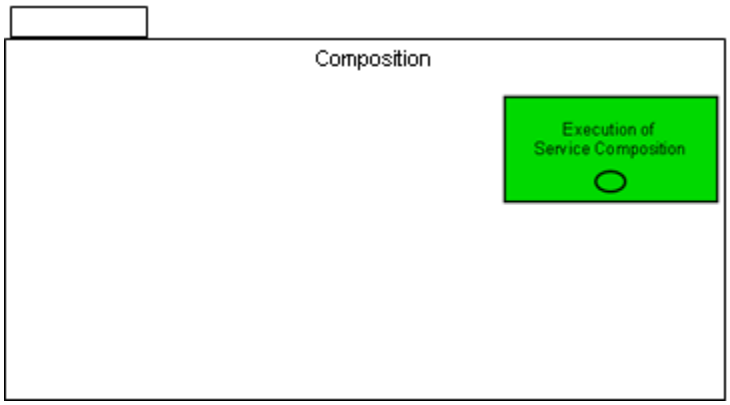
This pattern defines how to perform dynamic compositions, taking advantage of dynamic binding capabilities and using rules as the mean to select services to be called, during execution.

Requirements

SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is useful when the system wants to provide different options for the execution of service compositions. It provides adaptability to execution engines and the approach is interesting when users have clear the kind of rules related to the adaptative behaviour.

4.2.21 Model-driven and Agent-based Service Composition

Abstract

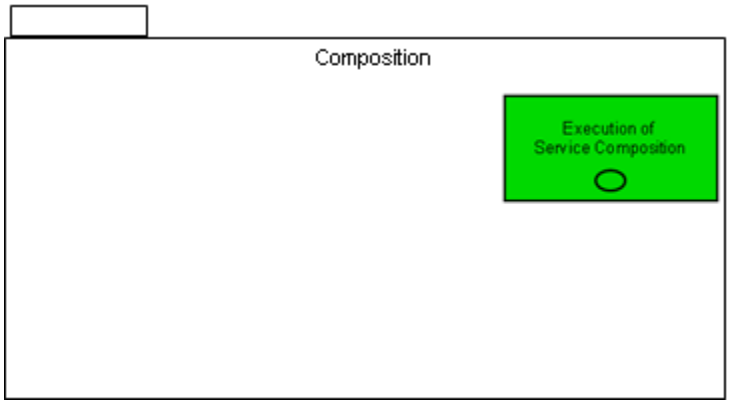
This pattern presents an approach for performing runtime composition according to post-conditions (declared in the composition model) and semantic web services.

Requirements

SR 5.1. How can processes be designed in terms of the services they are composed of (Orchestration, Choreography descriptions)?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

This pattern is useful in those systems which use semantics in service compositions and which may require a service composition to be modified or created at runtime, as a way to respond to the context or to any unexpected error. Due to its agent-based architecture, it can be used in distributed systems.

4.2.22 Runtime Semantic Monitoring

Abstract

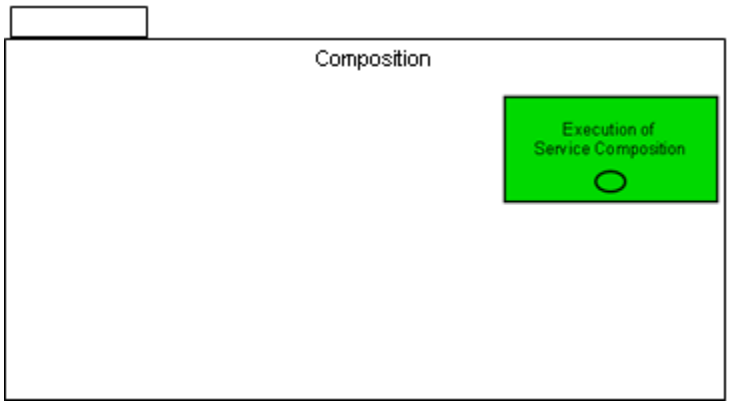
This is a pattern which adopts a Semantic Web technique to analyse logs and process definition files to find violation from the expected behaviour.

Requirements

SR 4.5. How can the system and its environment be monitored (which information, which mechanisms?

Link to the functionality of the conceptual model

Here after you can find the functionalities addressed by this pattern.



Applicability

Any system which depends on interaction with external services should include this kind of approach aiming at controlling what is going on during that interaction. It is important to guarantee that service compositions will execute correctly and to apply countermeasures in case there is any problem.

5 CONTRIBUTION TO THE POCS

Although not defined explicitly in DoW [1], it turned out that in order to achieve results in time and in order to set up the software baseline in time it was necessary to contribute to work package "Proof-of-Concept".
The work package "Service-Centric System Engineering" therefore collected software components for the baseline and initial practical example of concept examples.

Hereafter the PoC for which the work package "Service-Centric System Engineering" has contributed.

POC	***Patterns***	***Parts or components selected or developed by during the realization of PoCs***
Service Discovery PoC		
	Service Discovery	INFRAWEBS tools as reference for comparing
	Multi-phase Discovery	INFRAWEBS tools as reference for comparing
	Service Matchmaking and Ranking	INFRAWEBS tools as reference for comparing
Semi-automatic Service Composition at Design Time PoC		
	Assisted Composition Designer	SOA4ALL tools for implementing the PoC and ASTRO tools as reference for comparing
	Semantic annotation composition	SOA4ALL tools for implementing the PoC and ASTRO tools as reference for comparing
	Process Level Composition	SOA4ALL tools for implementing the PoC and ASTRO tools as reference for comparing

Here after each PoC has been described (see D8.1 Proof of Concept release[15] and D8.2 Proof-of-Concept – Report on Validation[16] for more details).

5.1 Service Discovery PoC

5.1.1 PoC Description

This PoC will demonstrate how it is possible to look for services by using a service discovery tool, according to a set of user requirements which represent user's desires and needs. Using those requirements as input, the tool will provide a list of candidates which fulfil the requirements, representing the best choices for the user.

The PoC will be focused in the "Crisis Management System of Systems" scenario, where several independent and heterogeneous systems have to interact in order to solve an emergency situation. This PoC is closely related to the "Semi-automatic Service Composition at Design Time" PoC, and it will represent a situation in which someone, who is modelling the process to be followed when an emergency occurs, needs to look for some services to be called during the execution of emergency processes. It will cover the runtime situation, when a service discovery action could be necessary for invoking a service due to failures or context needs.

The PoC aims at comparing the usage of two platforms which are similar, but which apply different approaches for assisting users during the creation of the service composition. SOA4ALL and INFRAWEBS platforms will be the ones used for performing service discovery according to the indications described in D10.1 for the mentioned scenario.

The objective of the PoC is twofold. In one hand, to proof that it is possible to obtain an implementation of the patterns defined in the Reference Architecture, and demonstrate the re-usability and applicability of the Service Discovery pattern. On the other hand, to compare both approaches and comment on the differences and the applicability of different approaches, but still fulfilling the generic patterns requirements.

Moreover it is a good opportunity to demonstrate the close cooperation between service discovery and service composition concerns and define the best way in which they may interact.

5.1.2 Scope of the PoC with respect the Reference Architecture

The PoC will cover those concerns related to service discovery. To be more concrete, it is focused on validating the statements done for the following patterns:

Pattern	*Description*

[15] D8.1 Proof of Concept, http://www.nexof-ra.eu/

[16] D8.2 Proof of Concept – Report on Validation, http://www.nexof-ra.eu/

Service Discovery	Describes the main elements related to discovering services according to some requirements coming from users
Multi-phase Discovery	This pattern specifies a way to perform service discovery by applying different discovery algorithms in several phases, refining the list of candidate services in each phase.
Service Matchmaking and Ranking	This pattern defines those components involved in a simple discovery process which is divided in two tasks: matchmaking requirements and services and ranking candidate services.

5.1.3 Summary of the results and conclusions

The PoC has evaluated not only some non-functional qualities related to the architecture of the patterns, but also the functional requirements which are related to the main use cases provided by the patterns.

In the case of the non-functional quality attributes, the result was that the theoretical approach had much more impact in the performance than the specified architecture and trade-offs. The usage of an external reasoner is one of the main causes of the performance, and it affects reliability as well. One of the conclusions is that mechanisms should be included to reduce the risk when using external elements, in order to enable the system recovery when something fails. Moreover, pattern developers were encouraged to include mechanisms for enabling the modifiability of the architecture and the system in general, as the impact in buildability is low, and to be careful with potential problems related to scalability.

About the functional requirements, thanks to some checkpoints defined, it was possible to demonstrate that the patterns fulfil those requirements related to service discovery in a proper way, by using two ontologies, a set of published service descriptions, etc...

5.2 Semi-automatic Service Composition at Design Time PoC

5.2.1 PoC Description

This PoC will demonstrate how it is possible to create service compositions in a semi-automatic way, by assisting users in the definition of the control and data flows, as well as in the selection of services to be used.

The PoC will be focused in the “Crisis Management System of Systems” scenario, where several independent and heterogeneous systems have to interact in order to solve an emergency situation. The PoC will represent a

situation in which someone has to model the process to be followed when an emergency occurs, being assisted by the system.

The PoC aims at comparing the usage of two platforms which are similar, but which apply different approaches for assisting users during the creation of the service composition. SOA4ALL and ASTRO platforms will be the ones used for developing a composition according to the indications described in D10.1 for the mentioned scenario.

The objective of the PoC is twofold. In one hand, to proof that it is possible to obtain an implementation of the patterns defined in the Reference Architecture, and demonstrate the re-usability and applicability of the Assisted Composition Designer pattern. On the other hand, to compare both approaches and comment on the differences and the applicability of different approaches, but still fulfilling the generic patterns requirements.

5.2.2 Scope of the PoC with respect the Reference Architecture

The PoC will cover those concerns related to service composition. To be more concrete, it is focused on validating the statements done for the following patterns:

Pattern	***Description***
Assisted Composition Designer	This pattern captures the main elements which should be part of a Process Designer Tool which is able to provide service compositions created in an automatic way, so it will be easier for developers to implement business processes.
Semantic annotation composition	This pattern describes how to perform dynamic service composition by exploiting semantic information such as OWL-S.
Process Level Composition	This pattern describes how to perform semi-automatic service composition by using some semantics and AI planning techniques

5.2.3 Summary of the results and conclusions

The PoC has evaluated not only some non-functional qualities related to the architecture of the patterns, but also the functional requirements which are related to the main use cases provided by the patterns.

In the case of the non-functional quality attributes, the result was that the theoretical approach had much more impact in the performance than the specified architecture and trade-offs. The usage of semantics, rules and reasoners is one of the main causes of higer or lower performances. Composition is a very complex task which requires a lot of computation and it is important to select the correct external components and try to optimize the implementation. Moreover, pattern developers were encouraged to include mechanisms for enabling the modifiability of the architecture and the system in general, as the impact in buildability is low, while the approach implementation could be modified, adapted or improved, for instance.

About the functional requirements, thanks to some checkpoints defined, it was possible to demonstrate that the patterns fulfil those requirements related to service composition in a proper way, by using an initial workflow, sub-processes, and ontology, etc...

APPENDIX A: CONTRIBUTION TO OTHER WPS

See the document D2.1 Appendix A: Contribution to other WPs

APPENDIX B: INVESTIGATION TEAMS CONTRIBUTIONS

This appendix is intended to report the results obtained by the Investigation Teams managed by this work package.

We have prepared five appended documents, one for each IT, to collects the contributions received and discussed within the IT and to summarise their results.

- D2.1 Appendix B - Service Description IT Report [31]
- D2.1 Appendix B - Service Discovery IT Report [32]
- D2.1 Appendix B - Interoperability Of Message-based Service Interaction IT Report [33]
- D2.1 Appendix B - Design time service Composition IT Report [34]
- D2.1 Appendix B - Runtime service Composition IT Report [35]

ABBREVIATIONS

ASTRO	research project in the field of web services and service-oriented applications , http://www.astroproject.org/
ATOS	ATOS Origin, international information technology service company, see DoW p.71
B2B	Business-to-Business
CRP Henri Tudor	Public Research Centre Henri Tudor, http://www.tudor.lu/
DoW	Deliverable of Work [1]
ebXML	Electronic Business XML http://www.ebxml.org/
EC FP6/7	European Commission Framework Program 6/7
ENG	Engineering Ingegneria Informatica S.p.A, see DoW p. 69
EzWEB	EzWeb project is based on the development of key technologies to be employed in building the front end layer of a new generation SOA architecture , ezweb.morfeo-project.org
FLEXI	Project Flexible Integration in Global Product Development, www.flexi-itea2.org/
GODO	Goal-oriented Service Discovery, project http://godo.atosorigin.es/
GRIA	a service-oriented infrastructure designed to support B2B collaborations through service provision across organisational boundaries in a secure, interoperable and flexible manner., http://www.gria.org/
IBBT	IBBT (Interdisciplinary Institute for Broadband Technology) is an independent research institute founded by the Flemish government to stimulate ICT innovation
IMIS	Institute for the Management of Information Systems, http://www.ipsyp.gr/
ISTC-CNR	Institute of Cognitive Science and Technology Italian National Research Council, http://www.loa-cnr.it/
IT	Investigation Team
JBI	Java Business Interoperability
KOM	European commission (Europäische Kommission)
MOMA	Modelli matematici ed applicazioni S.r.l, see DoW p. 77
NEXOF-RA	NESSI Open Framework – Reference Architecture
NFR	non-functional requirement
NSP	NESSI strategic project
OASIS	Organization for the Advancement of Structured Information Standards http://www.oasis-open.org/home/index.php
OMG	Object Management Group
OSGi	Open Service Gateway interface
OVAL/PM	MODELO DE PROCESO CENTRADO EN REQUISITOS DE OPERACIÓN Y PRUEBAS DE VALIDACION (OVAL/PM) TIN2006-14840 http://www2.upm.es/observatorio/vi/actividad.jsp?id_actividad=2985

OWL-S	Web Ontology Language for Web Services http://www.w3.org/Submission/2004/SUBM-OWL-S-20041122/
PoC	Prove of Concept
REO	Project, http://reo.project.cwi.nl/
RFP	request for proposal
RM	Reference Architecture model
RS	Reference Architecture specification
SAWSDL	Semantic Annotations for WSDL http://www.w3.org/2002/ws/sawsdl/
SCA	Service Component Architecture
SeCSE	project: SeCSE - Service Centric System Engineering, FP6-IST (IP) , http://secse.eng.it
SHAPE	Project Semantically-enabled Heterogeneous Service Architecture and Platforms Engineering, http://www.shape-project.eu/
SIMS	Project Semantic Interfaces for Mobile Services, http://www.ist-sims.org/
SINTEF	Norwegian: Stiftelsen for industriell og teknisk forskning is an independent research organisation in Scandinavia. http://www.sintef.no
SLA	Service Level Agreement
SLA@SOI	Service Level Agreement@Service Oriented Infrastructure
SOA	Service oriented Architecture
SOA4All	Service Oriented Architectures for All , a FP7 ICT 2007 Call 1 Integrated Project, http://sla-at-soi.eu/
SZTAKI	Computer and Automation Research Institute Hungarian Academy of Sciences, http://www.sztaki.hu
TIE	TIE Nederlands B.V., international B2B software company, see DoW, p. 83
UDDI	Universial Discription Discovery and Integration – a SOAP standard http://uddi.xml.org/
UML2	Unified modelling language 2 http://www.omg.org/docs/formal/07-11-04.pdf
UPM	Universidad Politécnica de Madrid, see DoW p. 85
W3C	World Wide Web Consortium, http://www.w3.org/
WP	Work package
WS	Web Service
WSA	web service architecture
WS-CDL	Web Services Choreography Description Language http://www.w3.org/TR/2004/WD-ws-cdl-10-20041217/
WS-CL	Web Services Conversation Language http://www.w3.org/TR/wscl10/
WSDL	Web Service Description Language http://www.w3.org/TR/wsdl.html
WSMO	Web service modelling ontology http://www.wsmo.org/
WS-Policy	Web Service-Policy http://www.w3.org/Submission/WS-Policy/

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