IT architecture for supporting business interoperability through the use of semantic annotation

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Presentation Layout

- FUSION
  - Short Info
  - Motivation and Research Challenges
  - Project Results

- EMPOWER
  - Short Info
  - Architectural overview
FUSION Short Info

- **Title**: Business process fusion based on Semantically-enabled Service-oriented Business Applications

- **Concept of SE-SOBA**
  - BA = Business Applications
  - SO = Service Oriented
  - SE = Semantically Enriched

- **Scope**: Promote efficient business collaboration and interconnection between enterprises (including SMEs) by developing a framework and innovative technologies for the semantic fusion of heterogeneous service-oriented business applications

- **Duration**: 2006 – 2008

- **14 partners**
  - BA Providers (SAP – ERP, SingularLogic – ERP, CAS – CRM)
  - IT Integrators (InfomatiX, BEELC)
  - Research Institutes (ICCS, SEERC, BUTE, TUK)
  - Pilot users (Germanos, Interjob, Pharos)
  - Dissemination issues (BCCI)
High Level motivations

- **Exploitation of previous knowledge and expertise** (Ontologies and Semantic Web technologies)
  - in the domain Enterprise Application Integration (EAI)

- Interested in **exploring the several aspects of Semantic Web Services** underlying technologies
  - life-cycle of SWS (discovery, annotation, publication, etc)
  - technologies (i.e. SA-WSDL, WSDL-S, WSMO, OWL-S)

- Interested in **examining the applicability** of Semantic Web technologies to **real-life, already deployed systems**
  - e.g. ERP, CRM, HRM
EAI Challenges

- The goal of EAI is to **integrate and streamline heterogeneous business processes across different applications** and business units.

- Current EAI trends and technologies (SOA, ESB, Web Services) are up to now **quite mature**.

- However, if we try **to increase the level of automation** we confront several problems and **challenges**, such as:
  - data and message level heterogeneities between interoperating services,
  - insufficient search and discovery of published Web Services in a common registry, and
  - inadequate process composition with regard to the desired functionality and the operational requirements.
Weaknesses of Syntactic Technologies

- Based on exclusively **syntax-oriented** technologies
- Not defining formally the **semantics** of
  - web services interfaces
  - the data structures of the messages web services exchanges
- Hard to manually interconnect heterogeneous applications
- Impeding the automation regarding application integration and data exchange
- Traditional web services technologies are weak to address:

  *the formalization and the documentation of the semantics related to the interfaces and the data structures of the deployed web services*
Examples of Message Heterogeneities

- **Domain Incompatibility**
  - semantically alike attributes have different descriptive names
    - Student (ID, Name) vs. Student (SSN, Name)

- **Entity Definition**
  - semantically alike entities have different descriptive names
    - EMPLOYEE (ID, Name) vs. WORKER (ID, Name)

- **Abstraction Level Incompatibility**
  - combination of domain and entity incompatibilities
  - semantically similar entities are represented at different levels of generalization / abstraction
Research Objectives

- **Semantically-enriched approach for dynamic data mediation** in Enterprise Application Integration scenarios
  - based on Ontologies, Semantic Web and Semantic Web Services Technologies

- Our approach focuses on the **semantic resolution of message level heterogeneities between collaborative enterprise services** exposed from the participating business systems
  - facilitating automatic, dynamic data mediation during execution time by providing formal transformations of the input and output messages (of the participating Web Services) to a common reference model, i.e. an enterprise data ontology
The needs of semantics in EAI

- A semantically-enriched approach in EAI will
  - hide systems, syntax, and structural heterogeneity
  - eliminate the need for knowing
    - the contents and structure of information resources
    - the structure and architecture of heterogeneous enterprise applications
  - provide a shared and common understanding of
    - data, services and processes
    - how to facilitate communication between people and IT systems
- We developed
  - An Enterprise Interoperability Ontology
    - that captures and represents formally all entities involved in the EAI scenarios i.e. data, services and processes
  - the Semantic Annotation and Profiling platform
    - which facilitates annotation of input and output message parts of native Web Service interfaces with business data entities
Starting with an in-depth state-of-the-art review and analysis

- **the industrial perspectives**
  - SAP Enterprise Services Architecture
  - IBM Service-Oriented Modeling Architecture
  - ORACLE Fusion Architecture

- **the research perspectives**
  - mathematical foundations
    - DL, FOL, Frame-logic
  - ontology editors
    - Ontolingua, Protégé, OntoEdit)
  - ontology reasoners
    - FaCT++, RacerPro, KAON2, Pellet

- **the Semantic Web Services technology**
  - SA-WSDL, WSDL-S, OWL-S, WSMO
We have come up with an “open” EAI Reference Model...

**Process Composition**

**Semantic Registry**

**Semantic Web Services**

**Enterprise Services**

**Enterprise Systems**

**Generation of abstract and executable process models**

**Publication of the semantic profiles on a semantically registry**

**Creation of the semantic profiles (SA-WSDL) of the exposed services**

**Precondition:** Exposed functionality utilizing WS technology

**Ontological Reference Model:**

*Enterprise Interoperability Ontology (ENIO)*
IT Architecture for supporting interoperability through the use of semantic annotations

...and a set of FUSION innovative research results

The FUSION Ontology
The Enterprise Interoperability Ontology (ENIO)

The FUSION Methodology

The FUSION Toolset
The SEAP Platform (1 of 3)

SEAP (Semantic Annotation and Profiling) allows
- selection and visualization of the native Web Services interfaces and the data-intensive enterprise interoperability ontology and
- facilitates the user to annotate (through a drag and drop utility) the input and output message parts of the selected Web Service interface with business data entities of the ENIO ontology.

Ontological Reference Model:
Enterprise Interoperability Ontology (ENIO)

Precondition:
Exposed functionality utilizing WS technology

Creation of the semantic profiles (SA-WSDL) of the exposed services
The SEAP Platform (2 of 3)

The SEAP platform is available at: http://sourceforge.net/projects/fusionprofiler
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The SEAP Platform (3 of 3)

<xsd:complexType name="Address">
  <xsd:sequence>
    <xsd:element name="hasAddressCityName" type="xsd:string"/>
    <xsd:element name="hasAddressRegion" type="xsd:string"/>
    <xsd:element name="hasAddressPostalZone" type="xsd:string"/>
    <xsd:element name="hasAddressStreetInfo" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>
Demo
EMPOWER Project

- And now the “FUSION inspired” EMPOWER: A semantic Service Oriented Private Adaptation Layer enabling the next generation, interoperable, and easy-to-integrate software products of European Software SMEs

An innovative framework and the enabling technologies that will allow the IT SMEs to create their next generation loosely coupled, interoperable and easy to integrate commercial-off-the-self software products

leveraging the quality of the application software and the integration services delivered to customers

Will be applied in 5 different systems of 5 SMEs
Main Architecture

The **System Interoperability Layer** addresses the underlying **technology requirements** of the proposed EMPOWER Framework, i.e. the ad-hoc definition and extraction (as Web Services) of specific pieces of system’s functionality, making use of the granularity defined through the Interoperable Enterprise Services Semantic Map.

**Main objectives of the Semantic Adaptation Layer** is to support the user, who is responsible for the **semantic annotation process**, to create, store, publish, edit and update the **semantic profiles** of selected **Web services**, i.e. the public Web services of legacy systems, selecting and utilizing semantic concepts from the EMPOWER Ontology.
IT Architecture for supporting interoperability through the use of semantic annotations

System Interoperability Layer at a Glance

- facilitates the service-oriented adaptation of proprietary software products,
- realizes the SOA and Web Services –enablement of the application software products
- supports the extraction of custom pieces of application software product functionality
  - addressing the level of the “Interoperable Enterprise Services”
- utilizes Web Services technologies on top of SQL-based database access, XML-RPC calls and/or file access utilities

With the term “Interoperable Enterprise Services”, we define services exposed from enterprise applications, realizing a specific piece of functionality with typical Web Service interfaces containing visible or not, interior, complex behavioural process model encapsulating a set of distributed business logic in a single point of interaction
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Semantic Interoperability Layer Architecture

Web Services Repository

WSDL description storage

refers to

Wrapper Definition and Customization

executable code for specific functionality extraction

service's functional requirements

Interoperable Enterprise Service Designer

System Interoperability Layer

Legacy System Wrappers

Legacy System IT Assets
(database, pieces of functionality, APIs)

functional schemas (RPC Signatures, CORBA Services)
data schemas (databases)

Legacy System IT Assets

concrete pieces of business logic

Interface Repository

Databases

Singular Logic
The System Interoperability Layer Components (1/2)

- Interoperable Enterprise Service Designer
  - allows the user-friendly, graphical and ontology-assisted design of pre-selected pieces of functionality of a given application software product
  - defines the desired service’s functionality, as well as the input and output messages,
    - utilizing entities and relations documented in the conceptual models (i.e. EMPOWER Ontology and Enterprise Service Semantic Map)
    - so as to follow the level of granularity identified by the Interoperable Enterprise Services
  - generates automatically the respective WSDL description (interface) of the designed service
The System Interoperability Layer Components (2/2)

- **Wrapper Definition and Customization**
  - enables the *low-level implementation* of the designed Web Service
  - **addresses the design requirements** specified in the Interoperable Enterprise Service Designer
  - supports the *development and testing* of the respective *service wrapper*
    - encapsulating specific *functional* (e.g. RPC signatures and COBOL services)
    - and *data* (e.g. databases) *schemes* of the given legacy system

- **Web Services Repository**
  - provides the *storage area* for the created, native *Web Services’ interfaces*, referring to the *software instances* of the deployed executable services’ wrappers
IT Architecture for supporting interoperability through the use of semantic annotations

Semantic Services Registry
- publishes the semantic profile

Interoperable Enterprise Service Wrapper
- Semantic Profile
- navigates, selects and uses ontological concepts for WSDL descriptions annotation
- selects and visualizes the WSDL descriptions of the native Web Services

Semantic Profile

Services Semantic Annotator
- selects and visualizes the WSDL descriptions of the native Web Services

Mediator Services Web Server
- refers to executable mediator services
- deploys the generated service package

Transformations Creator
- data transformations
- provides the data annotations for transformations generation

Transforms Repository
- stores and deploys transformations
- communicates

Transformations Repository
- utilizes predefined data transformations for service execution

Ontology Handling Utilities
- handles, edits and manages the EMPOWER Ontology

EMPOWER Ontology Repository
- utilizes data and functional semantics for defining the Interoperable Enterprise Services

System Interoperability Layer
- interoperable enterprise services semantic map

Web Services Repository
- WSDL description storage
- refers to

Wrapper Definition and Customization
- service's functional requirements
- executable code for specific functionality extraction

Interoperable Enterprise Service Designer
- uses the business services catalogue to retrieve the definitions of the Interoperable Enterprise Services

Legacy System Wrappers

Legacy System IT Assets
- (database, pieces of functionality, APIs)
- functional schemas (RPC Signatures, CORBA Services)
- data schemas (databases)

Concrete pieces of business logic

Interface Repository

Databases
In the context of the EMPOWER Approach, SAL supports:

- **the creation of the Semantic Profiles** of the exposed Interoperable Enterprise Services (semantic uplifting), involving:
  - the **semantic annotation of their operation functionality**
    - by selecting and importing functional semantics of the EMPOWER Ontology
  - the **semantic description of their input and output elements**
    - by utilizing data / information semantics of the EMPOWER Ontology
  - the **definition of valid transformations** among the input and output messages of the Enterprise Services and the EMPOWER Ontology
    - facilitating the exchange of ontological individuals between the Interoperable Enterprise Services
    - enabling dynamic data mediation among the collaborative services

- **the publication and storage of the developed Semantic Profiles in a semantically-enriched business services registry**
  - supporting **ontology-assisted categorization, search and discovery** of the registered (grounded) Semantic Web Services based on functional semantics
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Semantic Adaptation Layer Conceptual Architecture

Semantic Services Registry
- publishes the semantic profile
- refers to executable mediator services

Interoperable Enterprise Service Wrapper
- Semantic Profile
- Selects and visualizes the WSDL descriptions of the native Web Services

Services Semantic Annotator
- Selects and visualizes the WSDL descriptions of the native Web Services
- Navigates, selects, and uses ontological concepts for WSDL descriptions annotation

Mediator Services Web Server
- Deploys the generated service package
- Provides the data annotations for transformations generation

Transformations Creator
- Provides the data annotations for transformations generation

Ontology Handling Utilities
- Handles, edits, and manages the EMPOWER Ontology

System Interoperability Layer Components

Web Services Repository
- Stores and deploys transformations for service execution
- Communicates

Semantic Adaptation Layer
- Utilizes predefined data transformations for service execution
**SAL: Services Semantic Annotator**

- **allows the user to graphically select, visualize and annotate** (using drag and drop utilities) the native Web Services
- **extends their WSDL description** with functional and data semantics (from the EMPOWER Ontology)
- **generates a SA-WSDL file** (Semantic Profile) for each “Interoperable Enterprise Service”
- **publishes and stores the generated Semantic Profiles** at the Semantic Registry module
SAL: Ontology Handling Utilities

- allows the user to **visualize and navigate** through the EMPOWER Ontology
- facilitates the selection and **utilization of specific ontological concepts** in the semantic annotation process
- supports **ontology editing capabilities** (extensions & restrictions)

- publishes the semantic profile
- provides the data annotations for transformations generation
- navigates, selects and uses ontological concepts for WSDL descriptions annotation
- communicates
- handles, edits and manages the EMPOWER Ontology
- selects and visualizes the WSDL descriptions of the native Web Services

**System Interoperability Layer Components**

**Web Services Repository**

**Ontology Handling Utilities**

- [Semantic Services Registry](#)
  - refers to external mediator services
  - publishes the semantic profile

- [Interoperable Enterprise Service Wrapper](#)
  - provides the data annotations for transformations generation

- [Services Semantic Annotator](#)
  - navigates, selects and uses ontological concepts for WSDL descriptions annotation

- [EMPOWER Ontology Repository](#)
SAL: Transformations Creator

- allows the user to **graphically create up-casting** (XSD2OWL) and **down-casting** (OWL2XSD) XSLT transformations
- **utilises standard transformation functions** (string functions, math functions, logical expressions, etc.).
- **generates and deploys the XSLT code** into the Transformations Repository
- **extends the generated Semantic Profile** of the pre-selected service with the references to the XSLT transformations
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**SAL: Interoperable Enterprise Service Wrapper**

- **encapsulates the annotated services** into a **standard, executable Web Service** (described by a WSDL file)
  - which is **directly invokable** by a running process instance
- **generates**
  - the **description** of the (so-called) mediator service
  - the **code** of the mediator service
  - the **deployment package** for the mediator service, and deploys it into the Mediator Services Web Server
**SAL: Semantic Services Registry**

- constitutes a **semantically-enriched typical business services registry**
- supports the **registration, publication and storage of the Semantic Profiles**
- enables the **semantically-enhanced categorization, search and discovery of services**
Thank you