Semantic Annotation for Web Services and their Relevance to Environmental Models

~ Enabling Environmental Models as Services on the Web: The ENVISION Approach ~

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Dumitru Roman
University of Innsbruck / STI Innsbruck, Austria
dumitru.roman@sti2.at

(In collaboration with A. J. Berre, S. Schade, P. Maué, N. R. Bodsberg, J. Langlois, and J. Kopecky)
Outline

• Environmental models on the Web
  – The need for Model as a Service (MaaS)
  – MaaS Scenarios: Landslide and Oil Spill Risk Analysis

• ENVISION: An infrastructure for MaaS
  – Baseline framework: SWING
  – Emerging trends in semantic annotations for Web services

• Conclusions and outlook
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What are environmental models and what are their limitations? What do we need to overcome them?
Environmental Models

- Computer models that aim to re-create what occurs during some event in nature
- Increasingly significant in decision making
  - Diagnose and examine causes and precursor conditions of events that have taken place (i.e. what happened and why it happened)
  - Forecast outcomes and future events (i.e., what will happen).
- Models are being developed by a wide variety of scientific and engineering disciplines
  - Many types of models, e.g. economic, behavioral, physical, engineering design, health, ecological, transport
  - Good models come from an assortment of disciplines
    - Increased interoperability between models is needed!
Elements of Environmental Models

- **Application**: the scientific problem of interest
- **Algorithm**: the numerical/mathematical representation of that problem, the method used to solve the problem, and its materialization in a computer program
- **Architecture**: the computing platform and software tools used to compute a solution set for the algorithms developed
  - What kind of computer(s) will run the program?
  - What kind of programs will use the information?
  - Will the program be downloaded and loaded onto the permanent storage space of a computer, or will it be run over the Internet?
  - ...

*How can the architecture enable interoperability between models?*
Environmental Model – An Example

The HAPEM6 programs use twelve user-supplied input data files, and two or more parameter files. All are in ASCII format. A parameter file identifies the user-supplied input files, the output files available to the user, and specifies the parameter settings for a model run.
Characteristics of Environmental Models

- Static, centralized, and closed systems
- Tightly coupled components
  - Integration of components requires significant work
  - Low level of reuse and sharing
- Isolated systems with limited audience (i.e. experts)
  - The growth of the system is planned
  - Limited possibilities for wider community involvement in model reuse and development

=> There is a clear need for a dynamic, open, distributed and shared environmental modeling infrastructure that enables a high level of model reuse and is easily accessible for both experts and non-experts!
Relevant Computing Trends for Environmental Models

• Software as a Service (SaaS)
  – Evolution of applications that are delivered at runtime over the Internet

• Semantic Web Services (SWS)
  – Automated discovery, composition, mediation of Web services, based on their semantic annotations

=> Model as a Service (MaaS) = Models + SaaS + SWS
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What kind of scenarios does MaaS target?
How to set up Web services that can be manipulated by non-technical operators and can simulate damage under different climatic and/or another potential trigger (e.g. earthquake) for landslides scenarios?
How to set up Web services that can be manipulated by non-technical operators and can enable a quick and adequate response in order to minimize biological consequences of oil spills at sea?
A General Scenario for MaaS – User Operations

- **Design time**
  (provide on-the-shelf modeling solutions)
  - Discover existing resources
  - Build the modeling workflow
  - Register/Annotate the new Service

- **Set-up time**
  (connect the appropriate sources of information to feed the modeling service)
  - Discover existing Modeling Services
  - Select a region of interest
  - Discover existing data sources
  - Select the data sources
  - Set the parameters
  - Play the scenario

- **Execution time**
  (interact with the information provided by the models and monitor the system)
  - Discover existing Modeling Services
  - Select a region of interest
  - Discover existing data sources
  - Select the appropriate sensors data streams
  - Select functional parameters for the alerting system

*Semantic Annotations are a key enabler for discovery of services!*
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What kind of components are needed to realize MaaS?
ENVISION – An Infrastructure for MaaS

- **Environmental Services Infrastructure with Ontologies**
  - Portal with a pluggable decision support framework
    - Visual service chaining
    - Migration of existing models to MaaS
  - Semantic annotation infrastructure
    - Visual semantic annotation mechanism
    - Multilanguage ontology management
  - Execution space
    - Semantic discovery catalogue
    - Semantic service mediator
    - Adaptive service chaining execution
ENVISION Architecture
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*What framework can be reused for ENVISION?*
SWING: A baseline framework for ENVISION

- **Semantic Web Services Interoperability in Geospatial decision making**
- A framework for *semantic discovery and composition* of geospatial services
- Prototyped in the area of Mineral Resources Management

http://www.swing-project.org/
SWING components and tools

- **MiMS**: Environment for domain expert. Convenient semantic annotation & discovery; use composed services like standard OGC services
- **WSMX**: Semantic web services platform. Geospatial semantic discovery; execution of composed services
- **Concept Repository**: Ontologies for semantic annotation. Used throughout components
- **Visual OntoBridge**: Annotation tool. Semi-automatic annotation of services and queries; provides user with most plausible annotations
- **Catalogue**: OGC Catalogue. Semantic discovery in interaction with WSMX; also provides adapter OGC ↔ WSMX execution
- **Composition Studio**: Environment for IT expert. Convenient semantic annotation & discovery; graphically compose services; automatic export into WSMX service execution

*To be reused and enhanced in ENVISION!*
SWING – High-level Architecture

See demo at http://www.swing-project.org/showcase.html
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Which semantic annotation framework is appropriate for ENVISION’s models as services?
Web Services – State of the Art

• Numbers of WSDL services
  – Number of unique public WSDL-based services < 30,000
  – Large, but unknown, number of Intranet and enterprise services

• WSDL growth stagnates:

• Significant growth of Web APIs
  > 1,100 Web APIs on ProgrammableWeb.com
  > 3,700 Mashups on ProgrammableWeb.com
  (combining Web APIs from one or more sources)

Most service interfaces are proprietary Web sites, or FTP downloads of ASCII files
⇒ More than 90% of the services on the Web are not described with machine-readable service interfaces!
Semantic Web Services – State of the Art

• Existing approaches: OWL-S, WSMO
• They are (perceived as) complex
  – Little adoption, coming slowly
• More pragmatic solution needed
  – Scale down, modularize
  – Encompass RESTful services
=> SWS-Lite
WSMO-based annotation mechanism for WSDL and RESTful services

WSMO-Lite Ontology

SAWSDL

MicroWSMO

WSDL

hRESTS

extension

layer of semantic annotations

service description layer

simple service semantics

SAWSDL for hRESTS

WSDL in HTML
Types of Service Semantics

• **Functional**
  – What the service does

• **Behavioral**
  – How the client talks to the service

• **Information model**
  – For handling data
  – Incl. lifting/lowering

• **Nonfunctional**
  – Policies, QoS, price, location etc.
Semantic Annotations

Web service

Operation 1

Operation 2

Operation N

input, output, faults

input, output, faults

input, output, faults
Functional and Nonfunctional Semantics

- **Functional Semantics**
  - For service discovery, composition
  - **Category**
    - Functionality categorization
    - E.g. eCl@ss
  - **Capability**
    - \( w_l:Precondition, w_l:Effect \)
    - Using WSML rule languages

- **Nonfunctional Semantics**
  - For ranking and selection
  - Not constrained, any ontologies
  - Example: \( ex:\text{PriceSpecification} \)
    - \( rdfs:subClassOf w_l:NonFunctionalParameter . \)
    - \( ex:\text{ReservationFee} \)
      - \( rdf:type ex:\text{PriceSpecification} ; \)
      - \( rdf:value "15"^\text{ex:euroAmount} . \)
Behavioral and Information Semantics

- **Behavioral Semantics**
  - For invocation, composition, process mediation
  - Functionalities on operations
    - Capabilities, categories
  - Client selects operation to invoke next
    - Instead of being strictly guided by an explicit process

- **Information Semantics**
  - For invocation, composition, data mediation
  - Not constrained, any ontologies
  - Marked as *wl:Ontology*
WSMO-Lite – Service Semantics

- WSMO-Lite elements
  - \texttt{wl:Ontology}
  - \texttt{wl:FunctionalityClassificationRoot}
  - \texttt{wl:Precondition}
  - \texttt{wl:Effect}
  - \texttt{wl:NonFunctionalParameter}

- WSMO-Lite
  - Identifies the types and a \textit{simple vocabulary} for semantic descriptions of services (a service ontology) as well as languages used to define these descriptions.
  - Defines an \textit{annotation mechanism} for WSDL and RESTful services using a simple service ontology.
  - Provides the \textit{bridge} between WSDL, SAWSDL RESTful services, and (existing) domain-specific ontologies such as classification schemas, domain ontology models.
Conclusions and Outlook

• Environmental models are **important** for decision making
  – Models’ current limitations hinder their reuse and interoperability
  – A platform of **interoperating models** is needed
• **MaaS** aims to combine SaaS and SWS to overcome the existing limitations of environmental models
• **ENVISION**: An emerging infrastructure for realizing MaaS
  – SWING provides a set of components and tools to be reused and enhanced
  – A pragmatic approach to service annotations is needed: WSMO-based **SWS-Lite**
Thank you!
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