Introduction to Open Services for Lifecycle Collaboration (OSLC)

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• Background in aerospace engineering and in UML/SysML-based integration solutions

• **Activities performed by Koneksys**
  • **OSLC solutions** including OSLC adapters, clients, synchronization middleware, RDF triplestores, SPARQL endpoints, analytics, web-based OSLC data viewers
  • **Open-source OSLC solutions** at Eclipse Lyo
  • **Consulting** for developing OSLC solutions
  • **OSLC training**

• Chair of the INCOSE Tool Integration and Interoperability Working Group
• Co-Chair of the OMG OSLC4MBSE Working Group to apply OSLC beyond software engineering
Models for Architectural Design

Many Relationships between Models

System Architecture

Dynamic system models

Computer-Aided Design (CAD)
(e.g. 3D models, 2D drawings)

Meshed Analysis Models (e.g. FE, CFD, Thermo)

Requirements

And more...

ISO/IEC/IEEE 15288-Based SE Process V-Model

Stakeholder Requirements Definition

Validation

Requirements Analysis

Verification

Architectural Design

Integration

Implementation

Only the core SE Technical Processes are shown. Omitted are the Transition, Operations, Maintenance, and Disposal Processes.
Problem: Rollover Risk of SUVs

- Higher center of gravity -> higher risk of rollover
- More than a third of all *fatal* crashes in the US are rollovers!

Static Stability Factor Test

System Engineer defines SSF Test Case

Mechanical Engineer computes center of gravity height of new vehicle through geometric model
**Fishhook Maneuver Simulation**

System Engineer defines simulation test case

http://www.mathworks.com/tagteam/49380_2008-01-0579_Cherian_Final_1.10.08.pdf

Mechanical Engineer performs simulation with dynamic system model
Link between COG Parameter of Geometric Model and Simulation Model

Center of Gravity + Moments of Inertia

Center of gravity in geometric model

Center of gravity in simulation model
Relationships between Engineering Data

Requirements
- Static Stability Factor (SSF)
  - Id = "1.1"
  - Text = "SSF shall be higher than 1.3. SSF is a factor based on a vehicle's track width and center of gravity height."
- Vehicle in motion rollover test
  - Id = "1.2"
  - Text = "The vehicle shall not "tip-up" during fishhook maneuver. If the vehicle lifts two wheels off the ground during a quick left-right turn at 50 mph, it's considered a "tip-up" and the test failed."

Test Cases
- SSF Test
- Vehicle Fishhook Maneuver Simulation

Simulation Model

Geometric Model
Reality in Complex System Design: (Too Many) Relationships between Engineering Data

Requirements

- Static Stability Factor (SSF)
  - Id = "1.1"
  - Text = "SSF shall be higher than 1.3. SSF is a factor based on a vehicle's track width and center of gravity height."

- Vehicle in motion rollover test
  - Id = "1.2"
  - Text = "The vehicle shall not "tip-up" during fishhook maneuver. If the vehicle lifts two wheels off the ground during a quick left-right turn at 50 mph, it's considered a "tip-up" and the test failed."

Test Cases

- SSF Test
  - "testCase"

- Vehicle fishhook maneuver simulation
  - "testCase"

Simulation Model

- Geometric Model
- Software

"NX7-HD3D-car-300dpi" by Jsarfati - Own work. Licensed under Creative Commons Attribution 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:NX7-HD3D-car-300dpi.jpg#mediaviewer/File:NX7-HD3D-car-300dpi.jpg
Why do we need Traceability Links?

- Queries
- Impact Analysis
- Analytics
- Better Overview => Better Decisions
Overview of Relationships

Good Overview => Better Decisions
Status Quo

- **Proprietary data formats, data access protocols**
  - Vendor lock-in

- **Relational databases**
  - No easily adaptable solution for capturing additional unanticipated data relationships

No big picture overview of the data, too many isolated data silos, traceability gaps, wrong decisions
Game Changers

• **World Wide Web** = set of open standards for data representation and access protocols
  
  No Vendor lock-in

• **Graph databases**
  
  Easily adaptable solution for capturing additional unanticipated data relationships

*OSLC approach based on open W3C standards and compatible with graph databases*
Relationships on the Web

Linked Web Pages
(Unstructured Data)

- http://www.wikipedia.org/
- https://www.google.com/
- http://www.cnn.com/
- http://espnc.com/

Linked Data
(Structured Data)

"Lod-datasets 2010-09-22 colored" by Anjeve, Richard Cyganiak - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Lod-datasets_2010-09-22_colored.png#mediaviewer/File:Lod-datasets_2010-09-22_colored.png
Google’s Knowledge Graph

- Engineers also need a Knowledge Graph
- Knowledge Graph currently used by Google to improve search results

Kobe Bryant
Basketball player

Kobe Bean Bryant is an American professional basketball player who currently plays for the Los Angeles Lakers of the National Basketball Association. Wikipedia

- Born: August 23, 1978 (age 37), Philadelphia, PA
- Height: 6'6"
- Spouse: Vanessa Laine Bryant (m. 2001)
- Current team: Los Angeles Lakers (#24 / Shooting guard)
- Parents: Joe Bryant, Pam Bryant

Profiles
- Twitter
- Instagram
- Facebook
- YouTube
- Myspace

People also search for
- LeBron James
  Olympic teammate
- Michael Jordan
- Vanessa Laine Bryant
  Spouse
- Kevin Durant
  Olympic teammate
- Carmelo Anthony
  Olympic teammate
Linked Data Example

Example DBPedia Query: Cities in Germany with population larger than 1Mio?

```
SELECT ?City ?Population
WHERE {
  ?City dbpedia:country dbpedia-res:Germany.
  ?City rdf:type dbpedia:City.
  FILTER (?Population > 1000000)
} order by ?Population
```

<table>
<thead>
<tr>
<th>City</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cologne</td>
<td>1010269</td>
</tr>
<tr>
<td>Munich</td>
<td>1420000</td>
</tr>
<tr>
<td>Hamburg</td>
<td>1796077</td>
</tr>
<tr>
<td>Berlin</td>
<td>3499879</td>
</tr>
</tbody>
</table>

http://liris.cnrs.fr/~pchampin/spark/gmapv3.html
Open Services for Lifecycle Collaboration

- OSLC = Reusing the Web for tool integration
- Based on Web standards *(Linked Data and RESTful Web Services)*
- Initiated by IBM
- Adopted by many tool vendors
- Managed by OASIS
Status Quo of OSLC Solutions

• OSLC Solutions for point-to-point integration
  – Several engineering software applications already support OSLC
  – Traditional point-to-point integration, many offered by tool vendors

• OSLC Solutions for data management
  – Graph-based data integration, and data analytics, mostly developed by organizations internally
  – No PLM-based OSLC integration platform (yet)
Overview of Operations on OSLC Resources

- **Publishing** OSLC resources
- **Retrieving** OSLC resources
- **Linking** OSLC resources across tools
- **Adding/Updating/Deleting** OSLC Resources
- **UI Dialogs to find/create** OSLC resources of other tools
- **Interchanging** OSLC resources between tools
- **Tracking changes** to OSLC resources
Publishing OSLC Resources

OSLC Adapter

Data

Data on the Web
Linked Data Principle 1

Use URIs to denote things

Requirement in Systems Engineering Tool

URI of Requirement

http://myDomain/myTool/myProject/requirements/S5.4.1
Use **HTTP URIs** so that these things can be referred to and looked up.

```
<requirement>
 Master Cylinder Efficacy

Id = "S5.4.1"
Text = "A master cylinder shall have a reservoir compartment for each service brake subsystem serviced by the master cylinder. Loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment."
</requirement>
```

**URI of Requirement**

http://myDomain/myTool/myProject/requirements/S5.4.1

**Requirement in Systems Engineering Tool**
Linked Data Principle 3

Provide useful information about the thing when its URI is dereferenced, leveraging standards such as RDF, SPARQL.

**Requirement in Systems Engineering Tool**

```
«requirement»
Master Cylinder Efficacy

Id = "S5.4.1"
Text = "A master cylinder shall have a reservoir compartment for each service brake subsystem serviced by the master cylinder. Loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment."
```

**URI of Requirement**

http://myDomain/myTool/myProject/requirements/S5.4.1

**HTTP**

**W3C standard for data interchange on the Web**
Resource Description Framework (RDF)

- Statements in the form of **subject-predicate-object expressions (triples)**
- **W3C standard** for data interchange on the Web
- Used for semantic reasoning
- Variety of serialization formats (e.g. JSON-LD)

Subject = URI  
Predicate = URI  
Object = URI or literal

```
http://.../requirements/S5.4.1  →  http://.../Requirement/elaboratedBy  →  http://.../usecases/Decelerate_Car
```
**RDF Example**

**RDF = subject-predicate-object statements (triples)**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement „Master Cylinder Efficacy“</td>
<td>refinedBy</td>
<td>Use Case „Decelerate Car“</td>
</tr>
<tr>
<td>Requirement „Master Cylinder Efficacy“</td>
<td>satisfiedBy</td>
<td>Block „Brake System“</td>
</tr>
<tr>
<td>Requirement „Master Cylinder Efficacy“</td>
<td>derivedRqt</td>
<td>Requirement „Loss of Fluid“</td>
</tr>
<tr>
<td>Requirement „Master Cylinder Efficacy“</td>
<td>derivedRqt</td>
<td>Requirement „Reservoir“</td>
</tr>
</tbody>
</table>
RDF Graph Representation

- **Requirement** „Master Cylinder Efficacy“
- **Requirement** „Loss of Fluid“
- **Requirement** „Reservoir“
- **Use Case** „Decelerate Car“
- **Block** „Brake System“

- **refinedBy**
- **satisfiedBy**
- **derivedRqt**
Include links to other related things (using their URIs) when publishing data on the Web.
Retrieving Resources

HTTP Request
URL: http://.../requirements/S5.4.1
GET Method
Accept: application/rdf+xml
Id = "S5.4.1"
Text = "A master cylinder shall have a reservoir compartment for each service brake subsystem serviced by the master cylinder. Loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment."

MagicDraw Requirement S5.4.1

Description: A master cylinder shall have a reservoir compartment for each service brake subsystem serviced by the master cylinder. Loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment.

Hyperlink: http://en.wikipedia.org/wiki/Master_cylinder

Derived Elements
S5.4.1b
S5.4.1a

Satisfied By
Blocks::BrakeSystem

This document: http://localhost:8080/oslc4magicdraw/services/SUV_Example/requirements/S5.4.1
Adapter Publisher: Georgia Institute of Technology OSLC Tools Project
Adapter Identity: org.eclipse.lyo.adapter.magicdraw

OSLC MagicDraw Adapter 0.1 brought to you by Eclipse Lyo
Tool-specific Examples

RDF Representation Examples

```
<rdf:Description rdf:nodeID="A1">
  <rdfs:node rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#XMLLiteral">
    A master cylinder shall have a reservoir compartment for each service brake subsystem serviced by the master cylinder. Loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment.
  </rdfs:node>
</rdf:Description>
```
Linking Resources Across Tools

- Tool A
  - OSLC Adapter for tool A

- Tool B
  - OSLC Adapter for tool B

- Tool C
  - OSLC Adapter for tool C

Diagram showing connections between tools and adapters.
Defining Links Between OSLC Resources of Different Tools

Tool A
OSLC Adapter for tool A

Link Tool

Tool B
OSLC Adapter for tool B

Tool C
OSLC Adapter for tool C
Adding/Updating/Deleting Resources Through RESTful OSLC Web Services

- Publishing, Querying, Creating, Updating, Deleting Resources
- Aligned with W3C Linked Data Platform

Client

HTTP

OSLC Adapter for Tool C

Tool C

Koneksys
Overview of Operations on OSLC Resources

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Use Case Scenario of OSLC Tutorial

**OSLC Service Provider**

**Bugzilla**: web-based bug tracking tool

**OSLC Service Consumer**

**CRM system**: lists bugs/defects associated with an incident reported by a customer

A user needs to list bugs that correspond to an incident of a customer. The listed bugs of the CRM should correspond to the Bugzilla bugs.
Delegated UI for Resource Selection

Search Field

Tool A

OSLC Adapter for tool A

Search Results

Find a specific bug by entering words that describe it.

water

581: Salt has floatable impurities when mixed in water
3028: How to use the ACME water gun
3266: Moon changes water level
9541: Salt Water
15893: The water level control overreacts
16048: Sprinkler gets clogged with water
16129: Salt taste like the ocean water.
Delegated UI for Resource **Creation**

Tool A

OSLC Adapter for tool A
A user would like to hover over a bug with the mouse and get a small UI preview from Bugzilla.

Example:

**Status:** RESOLVED  
**Assignee:** cyeh@bluemartini.com  
**Component:** EconomicControl  
**Priority:** P2  
**Version:** 1.0  
**Reported:** 16.06.00 20:53  
**Modified:** 09.07.10 09:26
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Data Interoperability

Tool A
OSLC Adapter for tool A

Tool C
OSLC Adapter for tool C
RDF Example

RDF = subject-predicate-object statements (triples)

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</tr>
</tbody>
</table>
### Interoperability Through Standardized Resource Properties and Resource Types

<table>
<thead>
<tr>
<th>Subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requirement „Master Cylinder Efficacy“</strong></td>
<td>type</td>
<td><strong>Requirement</strong></td>
</tr>
<tr>
<td>Any HTTP URI</td>
<td><a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a></td>
<td><a href="http://open-services.net/ns/rm#Requirement">http://open-services.net/ns/rm#Requirement</a></td>
</tr>
<tr>
<td><strong>Requirement „Master Cylinder Efficacy“</strong></td>
<td>description</td>
<td>„A master cylinder shall...“</td>
</tr>
</tbody>
</table>
## Snapshot of the OSLC Requirements Management Specification

**Name:** Requirement

**Type URI:** http://open-services.net/ns/rm#Requirement

### Standardized OSLC Requirement Type

<table>
<thead>
<tr>
<th>Prefixed Name</th>
<th>Occurs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>oslc_rm:elaboratedBy</td>
<td>zero-or-many</td>
<td>The subject is elaborated by the object. For example, a user requirement is elaborated by use case.</td>
</tr>
<tr>
<td>oslc_rm:elaborates</td>
<td>zero-or-many</td>
<td>The object is elaborated by the subject.</td>
</tr>
<tr>
<td>oslc_rm:specifiedBy</td>
<td>zero-or-many</td>
<td>The subject is specified by the object. For example, a requirement is elaborated by a model element.</td>
</tr>
<tr>
<td>oslc_rm:specifies</td>
<td>zero-or-many</td>
<td>The object is specified by the subject.</td>
</tr>
</tbody>
</table>

### Standardized OSLC Requirement Properties
Summary - OSLC Specification

**OSLC Specification**

- RDF Vocabulary
  - Resource Type URIs
  - Predicate (Property) URIs
- OSLC Resource Shapes

Example:
- Requirement: http://open-services.net/ns/rm#Requirement
- satisfiedBy: http://open-services.net/ns/rm#satisfiedBy

Example:
```
<oslc:Property>
  <oslc:name>satisfiedBy</oslc:name>
  <oslc:propertyDefinition rdf:resource="http://open-service.net/ns/rm#satisfiedBy"/>
  <oslc:occurs rdf:resource="http://open-service.net/ns/core#Zero-or-many"/>
  <oslc:range rdf:resource="http://open-services.net/ns/core#Any"/>
</oslc:Property>
```
## OSLC Specifications for Interoperability and Information Discovery

<table>
<thead>
<tr>
<th>Domain</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>2.0</td>
</tr>
<tr>
<td>Architecture Management</td>
<td>2.0</td>
</tr>
<tr>
<td>Asset Management</td>
<td>2.0</td>
</tr>
<tr>
<td>Automation</td>
<td>2.0</td>
</tr>
<tr>
<td>Change Management</td>
<td>2.0</td>
</tr>
<tr>
<td>Performance Monitoring</td>
<td>2.0</td>
</tr>
<tr>
<td>Quality Management</td>
<td>2.0</td>
</tr>
<tr>
<td>Reconciliation</td>
<td>2.0</td>
</tr>
<tr>
<td>Requirements Management</td>
<td>2.0</td>
</tr>
<tr>
<td>Reporting</td>
<td>Converge</td>
</tr>
<tr>
<td>Estimation and Measurement</td>
<td>Converge</td>
</tr>
<tr>
<td>ALM/PLM Interoperability</td>
<td>Draft</td>
</tr>
<tr>
<td>Configuration Management</td>
<td>Scope</td>
</tr>
</tbody>
</table>
Relationship URIs
(http://www.omg.org/SysML/1.3/Requirement_satisfiedBy) need to be
standardized. Otherwise traceability links will not be queriable, and value of
traceability links will largely be diminished
Advantages of Minimalistic Standards over „Universal“ Standards

<table>
<thead>
<tr>
<th></th>
<th>„Closed world“ Standards</th>
<th>„Open world“ Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example</strong></td>
<td>UML/SysML + STEP</td>
<td>OSLC Specifications</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Large</td>
<td>Minimalistic</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Large</td>
<td>Minimalistic</td>
</tr>
<tr>
<td><strong>Effort until release</strong></td>
<td>High</td>
<td>Small</td>
</tr>
<tr>
<td><strong>Time until release</strong></td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td><strong>Ease of implementation</strong></td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td><strong>Ease of adoption</strong></td>
<td>Difficult</td>
<td>Easy</td>
</tr>
</tbody>
</table>
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Tracking Changes to a Base Resource Set

Resource Set
Version 1

Resource Set
Version 2

Resource Set
Version 3

Base

Change Event

Change Event

Base

Change Event

Change Event

Base
Retrieving ChangeEvents Through OSLC TRS Protocol

Client

HTTP

OSLC Adapter for tool C supporting Tracked Resource Set Protocol

Only Change Events
OSLC-Based Ecosystem

- **Single Point of Entry** to OSLC Resources
- **Editors** to define Relationships between OSLC Resources
- **Views** for seeing Relationships between OSLC Resources
- **Synchronization** of OSLC Resources
Full-Text Search of OSLC Resources
### Link Editor

**Linking Table**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>S5.4.1</td>
<td>oslc_rm:satisfiedBy</td>
<td>Desired::Position Desired::RTWMemSecFunc Execute</td>
</tr>
</tbody>
</table>

- **Resource Url**: http://localhost:8080/oslc4jmagicdraw/services/SUV_Example/requirements/S5.4.1
- **Resource Url**: http://open-services.net/ns/oslc#satisfiedBy
- **Resource Url**: http://localhost:8181/oslc4jsimulink/services/TwoDOFRobotDynCon.slx--TwoDOFRobotDynCon/parameters/Desired::Position Desired::RTWMemSecFuncExecute
OSLC Resource Importer

Import RDF Resources from OSLC Adapter

Please enter OSLC Service Provider Catalog URI

Import Logs

Filter import logs

Reload

Service Provider Catalog URI: http://localhost:8181/oslc4j simulink/services/catalog/singleton

OSLC Service Providers:
1. sldemo_househeat.xlsx---sldemo_househeat
   http://localhost:8181/oslc4j simulink/services/serviceProviders/sldemo_househeat.xlsx---sldemo_househeat
2. TwoDOFRobotDynCon.xlsx---TwoDOFRobotDynCon
   http://localhost:8181/oslc4j simulink/services/serviceProviders/TwoDOFRobotDynCon.xlsx---TwoDOFRobotDynCon
3. model11.xlsx---model11
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model11.xlsx---model11
4. model11AfterRT.xlsx---model11AfterRT
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model11AfterRT.xlsx---model11AfterRT
5. model2.xlsx---model2
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model2.xlsx---model2
6. model4.xlsx---model4
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model4.xlsx---model4
7. model11AfterRT4.xlsx---model11AfterRT4
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model11AfterRT4.xlsx---model11AfterRT4
8. model1.xlsx---model1
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model1.xlsx---model1
9. model3.xlsx---model3
   http://localhost:8181/oslc4j simulink/services/serviceProviders/model3.xlsx---model3

Download
Summary

- **World Wide Web** = set of open standards for data representation and access protocols
  - No Vendor lock-in

- **Graph databases**
  - Easily adaptable solution for capturing additional unanticipated data relationships

*OSLC approach based on open W3C standards and compatible with graph databases*
Be Part of the OSLC Community

Become a member on http://open-services.net/

Join us on Social Media
- Add @OSLCNews to any integration tweets
- Join the OSLC - Open Services for Lifecycle Collaboration on Linkedin
- Leverage the forums and mailing lists on open-services.net

Join a User Group
- NEW Human Factors Group
- Communication Group
- ALM-PLM Interoperability
- .... and many more - http://open-services.net/workgroups/

Contact webmaster@open-services.net or open an issue https://github.com/OSLC/SiteContent

if you find any issues with the website or have content to contribute.