Requirements Management

A knowledge-centric approach

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Sometimes...

Engineering fails...
Final Product
and causing...

loss of human life

A major problem and concern!
Requirements to the rescue...

"A requirement is a need or a property that whatever human invention must be able to perform or fulfill."
How can you identify needs from humans?

Requirements Engineering
The context...

It does not matter conditions...

SAFETY is a MUST!
The need of a **holistic view** of a system...

It is the first time that the world's largest train arrives in this city.

The best travelling experience must consider **ALL** the aspects!
The process...
To reach...

OBJECTIVES

CERTIFICATION

SAFETY

"... for any system"
What is a requirement?

A requirement defines how a system must be or must operate.

The requirement must exist because of a reason, and this reason is “owned” by a human or other system.

### Requirements Attributes...

<table>
<thead>
<tr>
<th>Id</th>
<th>COMP-01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>The saddle shall be able to resist a weight of 200 kg (440 Pound) without bending.</td>
</tr>
<tr>
<td>Type</td>
<td>System Property</td>
</tr>
<tr>
<td>Description</td>
<td>...</td>
</tr>
<tr>
<td>Author</td>
<td>Juan Llorens</td>
</tr>
<tr>
<td>Other attributes</td>
<td>...</td>
</tr>
</tbody>
</table>
Types of requirements

**Stakeholder Requirements**

Representing the point of view, in form of needs, of the related agents around the system to be built.

**Functional Requirements**

Describing capabilities, functions, or tasks that a system must have.

**System Properties Requirements**

They are usually called NON-FUNCTIONAL REQUIREMENTS or liabilities because they state non-functional properties about the system; for example, quality, security, maintainability, reusability, portability, etc.

**Interface Requirements**

Describing how the system must interact with external systems.

**Performance Requirements**

Describing how well or in which conditions the system must perform a function.

**Operational Requirements**

The interface requirements between the system and the humans (users).
Representation of requirements

INFORMAL METHODS
Using textual language supported by diagrams

FORMAL METHODS
Based on rigorous mathematical notation, that ensures the requirements correctness

SEMI-FORMAL METHODS
Combines formal and informal methods, like UML/SYSML, DARTS etc
How can we manage requirements?
Requirement Management System (RMS)
and the **quality**?

**S** - SPECIFIC

**M** - MEASURABLE

**A** - ACHIEVABLE

**R** - REALISTIC

**T** - TIME-BOUND

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**Correctness**

Every single requirement is correct

**Completeness**

The set of requirements represents a complete definition of the product (ISO 24766)

**Consistency**

Not a single requirement conflicts with another one in the set
Challenges

Interoperability

Quality metrics

Representation
Interoperability

Open Services for Life-cycle Collaboration

Source: http://open-services.net/
The **CRYSTAL** use cases

Requirements

Quality Checking

Knowledge Management
Contributions

OSLC KPIs -> OSLC EMS*

OSLC KM
Knowledge Management
OSLC Overview

Situating contributions...

Core
(Configuration Management, Reporting )

Others
- Reconciliation
- Mobile

ALM-PLM

Architecture Management

Asset Management

Automation

Change Management

Estimation & Measurement

Performance Monitoring

Quality Management

Tracked Resource Set

Requirements Management
OSLC Overview

Situated contributions...

Core
(Configuration Management, Reporting)

- ALM-PLM
- Architecture Management
- Automation
- Change Management
- Requirements Management
- Others
  - Reconciliation
  - Mobile

OSLC KPIs
(W3C RDF Data Cube)

- Quality Management
- Performance Monitoring
- Estimation & Measurement

KM
Knowledge Management

- Asset Mgmt.
- Tracked Resource Set
OSLC KPIs

Application to requirements quality management

KPIs

- Indicators for requirements quality
- +56
- Compile: dimensions, units of measurement, etc.

Observations

- Observations linked to a KPI
- A value under a context
  - Time
  - ...

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OSLC Defined Resources

- Based on qb:Dataset and qb:Observation
  - W3C Recommendation RDF Data Cube
- ios_kpi:KPI & ios_kpi:Observation
Scenarios...
1-Checking the quality of a text-based requirement

1. A third-party looks for checking the quality of a text-based requirement.
2. The Web client performs a request to the OSLC KPI service with the input text.
3. The OSLC KPI service takes the input text and returns a list of metrics for every KPI (RDF Data Cube vocabulary).
4. The Web Client shows the list of KPIs and metrics in a table.
2-Checking the quality of an OSLC-based requirement

1. A third-party looks for checking the quality of an OSLC-based requirement (URI).
2. The Web client performs a request to the OSLC KPI service with URI of the OSLC-based requirement.
3. The OSLC KPI service takes the OSLC-based requirement (extract the content) and returns a list of metrics for every KPI (RDF Data Cube vocabulary).
4. The OSLC KPI service returns the list of metrics.
5. The Web Client shows the list of KPIs and metrics in a table.
3-Checking the **quality** of an **OSLC-based requirement** and a **Jazz Widget**

1. A Jazz DRM user selects a requirement.

2. The RQA Widget installed in the Jazz platform performs a request to the OSLC KPI service with the selected requirement.

3. The OSLC KPI service takes the OSLC-based requirement (extract the content) and returns a list of metrics for every KPI (RDF Data Cube vocabulary).

4. The RQA Widget shows the list of indicators and metrics for the selected requirement.
Summary

OSLC KPIs—Key Performance Indicators

- Use of the W3C RDF Data Cube Vocabulary
- KPIs and Observations are the entities to be exchanged
- Exposing as OSLC-EMS provider.

KPIs + Observation

Artifact
Context for OSLC KM

- **Multiple domains**
  - Different types of artifacts
- Need of **intra-operability**
  - Intra-domain
- Need of **interoperability**
  - Inter-domain
Real Situation

Point to point connections --> Combinatorial explosion
OSLC

Preliminary Evaluation

- Great effort on interoperability
- Community (industry) effort
- Different types of artifacts (resource shapes)
- OASIS standards (Core, Change Management, etc.)
- ...

Challenges (among others)

- Increase of interoperability complexity when new domains are defined
- Provision of services to all the resource shapes

which leads to the need of a more universal approach
KCSE

Knowledge-centric

Systems Engineering
KCSE: notion of an **OSLC** bus
Representation

COMMON

Services
Representation

How many different types of artifacts are generated during the development life-cycle?

tools, formats, protocols, query languages, etc.
Needs and Challenges

- A common representation model
- Interoperability
- ...

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Services

• Language Uniformity
• Quality checking
• Visualization
• Traceability
• Human machine interface
• ...

Diagram: Workflow of Management, People, and Application with processes including Capture/Acquire, Organize/Store, Create, Share/Learn, Access/Search/Disseminate, and Use/Discover/Trace/Exploit.
Needs and Challenges

- A common representation model
- Interoperability
- Knowledge Management processes
- Natural language to express queries
- ...


OSLC-KM

New domain

New resource shape
RDF

Resource Description Framework

- Common & shared Data model
- Triples
  - (subject, object, predicate)
- Binary relationships
- Underlying Directed Graph
- W3C Recommendation (2004)
- Query languages

RDFS

RDF Schema

- Data modeling for RDF data
- Classes
- Properties (domain & ranges)
- RDF serialization
- W3C Recommendation (2004)
OWL
Ontology Web Language

- Vocabulary for defining formal ontologies
- Logic-oriented
- RDF serialization
- Flavours (2.0): EL, QL, RL
- W3C Recommendation (2012, v2.0)

RIF
Rule Interchange Format

- Exchange of business rules
- Rule-oriented
- Flavours: Core, PRD, BLD, etc.
- XML serialization
- W3C Recommendation (2013, v2.0)
RSHP

Relationship *"arship"*

- **Property Graph**
- Any kind of *relationship*
  - Arity and Cardinality
- **Industry-oriented**
- **Native tool support**
- Queries based on **natural language**
- First publication 2004

Others

- **SBVR**
  - Semantics of Business Vocabulary and Rules
- **ODM**
  - Ontology Definition Metamodel
- **RAS**
  - Reusable Asset Specification
Preliminary Evaluation

- **RDF** good option for *exchange data on the web*
  - Restrictions: arity and cardinality of relationships, lack of native tools, logics, etc.

- **RDFS and OWL**
  - Oriented to define formal ontologies

- **RSHP**
  - High level of Expressivity
  - Native tool support
  - ...

http://trc-research.github.io/spec/km/
The approach

OSLC
(Data Exchange)

+ 

RSHP*
(Internal representation: metadata+contents and services)
The Specification

Shape for KM resources

Metadata + Contents
Resource Shape

Based on the W3C SKOS Recommendation

Simple Knowledge Organization System
Summary of Properties

OSLC Core

Provenance*  
Access  (W3C HTTP Access)

Metadata  (Dublin Core, traces, etc.)

Contents  (resource shape)

Visualization  (SVG)
OSLC Defined Resources

- Based on skos:Concept
  - W3C Recommendation SKOS (Simple Knowledge Organization System)
- ios_Km:Concept
Knowledge Management

Application to requirements authoring and requirements quality management

Vocabulary & Conceptual Model

- Normalization
- Standardization
- Suggestions
- X Breakdown Structures
- ...

Patterns

- Restrictions
- Examples
- Suggestions
Scenarios...
1- Listing the concepts of a domain vocabulary

1. The Web Client requests to the OSLCKM service the vocabulary set.

2. The OSLC KM service retrieves all concepts in the ontology and returns a set of SKOS concepts.

3. The Web Client shows the result in a table.
2- **Standardize a term or text-based description**

1. A third-party needs to standardize a term or a text-based description.

2. The Web client performs a request to the OSLC KM service with the input text.

3. The OSLC KM service retrieves all concepts in the ontology and returns a set of SKOS concepts.

4. The Web Client shows the result in a table.
3-Get **synonyms** for a **term** or a **text-based description**
4-Get the **list of patterns** to guide the **writing** of requirements
Real Example

SKOS Concepts through OSLC in CKEditor
Summary

OSLC KM - Knowledge management

- Use of the **W3C SKOS vocabulary**
- **Concepts and relationships** are the entities to be exchanged
- **Services** for: search, trace, naming, visualize, etc.

**Metadata + Contents**

**Artifact**
An Example...

Process any kind of **OSLC Resource** or **RDF data** ...

E.g. **Modelica**
One implementation
OSLC KM

Knowledge Centric Systems Engineering to govern the development lifecycle

Inputs

Representa- tion

Outputs

Common services
OSLC KM

Not a dream!

Inputs

Outputs

Representations

Common services
Advantages

- Standard exchange of data: **OSLC**
- Enhance **expressiveness** (**RSHP**)  
- Reuse of **existing standards** and vocabularies
- **Native Tool support** (Knowledge Manager)
- **Cross-cutting services** (**semantic-based**)  
- Elastic approach
- ...

Drawbacks

- **Scope** of knowledge management (**needs**)  
- **Potential overlapping** with other tools and specs
- Need of **spread the approach**
Evaluation of OSLC KM

- Knowledge Management: a key process
  - REUSE!

- Need of:
  - Reuse of **standards and service-oriented** functionalities (OSLC)
  - Take the most for **data exchange** (OSLC) and **representation** (RSHP)
  - Bring technology to a **human-oriented environment** (NLP)

- Technical issues
  - **Completeness** of the specification?
  - Implementation
Conclusions

OSLC Domains

- Two main action lines
  - Requirements
  - Quality Metrics
  - Knowledge Management
- Keypoints:
  - Re-use of existing RDF vocabularies

Technical issues

- Good experience with OSLC4Net
  - Change in the JSON Serializer
- JSON format->better performance for large responses
Future work

- **Merge and extend** the spec with other knowledge standards
  - E.g. STEP, Industrial Internet activities
- **Refine** of the resource shape
- **Full implementation** and support to all services
- **Integration patterns** governed by knowledge
- ...

Industrial Linked Data
Industrial Knowledge Graph

"A multimode and multilayered graph"

- **Explicit** relationships

- **Implicit** relationships

  - **Intra-layer**
  - **Inter-layer**

  Layer 1
  Layer n

  Term  Requirement  Model  Test
  Any other artifact...
Thank You
Credits

- https://www.edx.org/course/software-architect-code-building-digital-uc3mx-inf-1x
Speakers

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Data modeling

- Need of **logic formalism**?
- **Requirements quality metrics** match OSLC EMS
- **Multilingual data** in OSLC APIs
- **On-line vs Reference vs Proxy** resources
- ...

Infrastructure & Data integration

- Convergence **OSLC** and **RDF Data Shapes**, W3C LDP, etc.
- Joint efforts in **OSLC** specs. and **new domains**
- OSLC APIs in other languages
  - Microservices
- ...

  - Federated queries and stream processing
  - Trust and Privacy