Multi-Level Modelling for Interoperability

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Overview

• Motivation: Modelling complex domains (OGI Pilot)
• Modelling extensions
• Example
• Evaluation
Engineering Lifecycle

• A key concern: same component in a real system can be subject to multiple classifications.

• Contribution: set of modelling extensions to overcome limitations of existing approaches (heterogeneous level)
Oil & Gas Interoperability Pilot

• Goal: Interoperability in the Oil & Gas Industry
• Automated Data Translation between different “software ecosystems”
• Based on the standards landscape:
  – “Reference Environment” (EPC): ISO 15926
  – “Execution Environment” (O&M): MIMOSA
• Multi-standards-organisation/multi-partner effort under ISO TC184/WG6
• Incrementally covering multiple use cases
• Youtube live demo video
Data Exchange in a Production Enterprise

- System Stability And Reliability Issues
- No Single Version Of The Truth
- System Maintenance Issues
- Difficult Access To Multiple Systems/Applications

(courtesy of Emerson Process Management)
**Service Bus Approach – Adapters still needed**

*“Adapters” are listeners that integrate a given system to the integration platform making it “visible” to the enterprise.*

**Federation NOT Replication**
Challenges

• Provision of a set of modelling mechanisms to allow other standards to be mapped to ISO 15926
Challenges

• Representing multiple levels of classification:

1. **Business level** which consists of complex taxonomies relevant from the business/ERP perspective
2. **Specification level** which provides the specifications of the physical entities.
3. **Physical entity level** where both designs and the physical entities of a product catalogue must be represented and have their own life-cycles which forms the physical entity level.
Modelling Extensions for Specialisation

• Specialisation by extension:
  – Adopts standard monotonic specialisation semantics
  – Extends a class by adding attributes, associations or behaviour
  – Introduces a new model level

• Specification by refinement:
  – Allows the introduction of subtypes that restrict the domain of the specialised class (e.g., by restricting the domains of properties and associations, or adding domain constraints on properties)
  – Does not introduce additional model levels
  – Allows for an arbitrary number of subtypes that simply refine the level of granularity
Modelling Extensions for Instantiation and Subset by Specification

• **Instantiation with extension:**
  – Allows for additional attributes, behaviour, etc. to be added to the concept that can then be instantiated or inherited further to lower model levels

• **Subset by specification:**
  – Represents the existence of a class of specification construct that identifies particular subtypes of another type
  – The specification exists at the same level as the type it refers to
  – Combined with *instantiation with extension*, this relationship can be used to construct the powertype pattern
Modelling Extensions to Associations

• **Member:**
  – Member associations can cross level boundaries
  – Requires the existence of a “primary” instantiation relation
  – Basic set membership relation that allows us to deal with multiple inheritance

• **Specification by enumeration:**
  – Represents a relationship between concepts A and B that describes how the extensions of the sets of entities that they represent are related i.e. the members of A are instances of B
Example

- Product catalogue modelled in plain UML, using generalisation, instantiation and aggregation (adapted from Neymayr et al. [5])
Example: Problems

- Enactment not supported (Henderson-Sellers et al. [6])
- Redundant classes (Neumayr et al. [5])
- Misuse of aggregation to represent membership and classification
- Multi-levels are forced into two levels

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Example Modelled in our Framework
Evaluation

• Criteria introduced by Neumayr et al. [5]:
  – Compactness: encompasses modularity and redundancy-free
  – Query Flexibility: queries can be performed to access the model elements at the different levels of abstraction.
  – Heterogeneous Level-Hierarchies: Introducing new levels without causing changes to other levels.
  – Multiple Relationship Abstractions: Whether an approach supports multi-level abstraction of relationships.

• Additional criteria:
  – Locality of Attributes & Relationships: Attributes/relationships are defined locally if they are defined on the model elements closest to where they are used.
  – Clarity of Relations’ Semantics: Relations have clearly delineated semantics from other relations.
Ongoing Work

• An Ontological Core for Conformance Checking
• Currently the ontology is not “live” in the transformation
  – Different computational environment
  – Map to ontology from the transformation model
• Extension to process ontology for complex use cases
Conclusion

• Effective exchange of information about processes and industrial plants, their design, construction, operation, and maintenance requires sophisticated information modelling and exchange mechanisms.

• Need increases with the growing tendency for direct interaction of information systems from the sensor level to corporate boardroom level.

• Introduction of modelling primitives that support the multilevel level modelling paradigm for information integration in heterogeneous information systems.
Questions?