Industrial Operations / Information Processing Convergence

Control Chain Management Body Of Knowledge

MI - Enable and Develop Intelligence Language

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Agenda

- Introduction
- Enabling Interactions
- Interoperability
- Semantic levels
- Modeling approaches
- Enterprise language
- Practical implementation

Introduction

- **The Enterprise organism keeps morphing itself**
  - Achieving the Darwinian process of its existence by developing objective knowledge to its advantage
  - Fighting entropy, securing survival, enabling progress
  - Ensuring that thinking people and machines understand each other and the system they live in
- **Hypercritical complexity**
  - quantity and quality of interactions
  - spouts “emerging properties”, Culture, Intelligence, Auto-organization
  - Developing new, higher ranking behavior
  - Not deductible from their individual components
- **The Syntropic Factory focuses on becoming a smarter organism**
  - Developing its “intelligence”

Conditions of intelligence

- **A product of complexity, Intelligence raises from**
  - Ability to develop knowledge
    - Enabling cycling between subjective experience and objective knowledge
  - Ability to share knowledge
    - Enabling seamless storage and access to relevant knowledge
  - Ability to interact
    - Enabling understandable communications between components
  - Individual intelligence
    - Sophisticated components performing locally
    - At the advantage of the whole system
- **Secondary level behavior**
  - Creativity
  - Risk assessment and management
    - Securing actions against uncertainty

Language

- **Objective knowledge is out of reach**
  - It exists independently of its actual understanding – by human, machines
- **Language is the means for handling knowledge**
  - Language defines basic concepts (vocabulary) and rules (grammar) for expressing knowledge
- **Existence of language is a pre-condition for intelligence**

Enterprise knowledge

- **Covers many domains**
- **Addresses tangible and intangible information.**

For Industrial facilities operations

- Tangible knowledge
  - Resources and capabilities (equipment, people, material, energy…)
- Intangible knowledge
  - Know-how not formalized

- **Enterprise knowledge covers**
  - Public knowledge
    - Readily available
  - Private knowledge
    - Represents the enterprise essence
    - Might need to be protected from competitors' eyes

Information technology

- **IT purpose**
  - Serving most aspects of the enterprise
  - Powering interactions between machines and people
  - Providing memorization and access to knowledge
- **IT development**
  - Growing erratically (on demand) by small and big spots
    - On demand for addressing business needs
    - Planned for technology upgrades
  - Following multiple, asynchronous lifecycles
    - Weakly coupled between them and the enterprise globally

Information technology

- **IT is widely diversified**
  - despite large scope global solutions
    - such as ERPs, MES, Control systems (This ordering matching increasing specialization)
  - Each solution is a system on its own
    - Though not a complex one, offering deterministic features and capabilities (not taking bugs into account…)
    - Applying and exposing concepts
      - *taken from a public knowledge space*
      - *Or implemented from local projects private knowledge space*
- **Interactions between IT solutions**
  - Are a major factor of enterprise intelligence
- **Interoperability is the search of interaction effectiveness**

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Interoperability

- **There is no such a thing as an Enterprise Information System**
  - But a large set of IT solutions with their own ontological background
  - Addressing part of the enterprise informational aspects
- **Enabling Enterprise intelligence implies**
  - Alignment of the IT solutions concepts with the enterprise conceptual domain
  - Unconstrained interactions between IT solutions
  - Supporting efficient human, machines interactions
- **Interoperability conditions interactions,**
  - Directly impacts enterprise intelligence
  - A critical “asset” that cannot be neglected nor delegated
  - A major enterprise responsibility

Context of interoperability

- **Each enterprise department is concerned**
  - Concerned by part of the enterprise knowledge
  - Shared with others
- **Each IT solution is (more and more) conceptually and lexically independent, embedding knowledge from**
  - Vendor external expertise
  - Implementation and integration
  - Actual operations

Adhoc interfaces

- **« Interfaces » between IT solutions can be hastily realized from the specific context of the IT solution:**
  - Only aims a proper functioning according to the specific project specs
  - Concepts are linked together at their logical level
    - Not formally identified,
    - expressed only as bit and bytes streams
  - Gluing of linked solutions leads to bigger solutions
  - Bigger solutions are less fit to evolution
    - Changes compromise the compound solution’s integrity
  - Solutions do not understand the Enterprise
    - They just understand each other in the restricted context of a project
    - They do not efficiently share the enterprise knowledge

Conditions for interoperability

- **Respect the local knowledge and ontologies**
  - From vendor solutions and enterprise entities
  - Implies many local ontological domains – generally not explicited
- **Availability of an enterprise language**
  - Covering the part of knowledge that needs to be exchanged
  - Enriched from the needs as they arise
  - Translatable into local idioms
- **Use of this language in all non-local interactions**
  - Solutions connect to each other using exclusively the enterprise language – regardless the respective languages of the communication partners

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About modeling

- **Difference between**
  - vocabulary,
  - taxonomy,
  - thesaurus,
  - ontology,
  - meta-model,
  - meta-meta-model
  - Model

(arranged from www.metamodel.com)

(controlled) vocabulary

- **A list of terms**
  - enumerated explicitly.
  - controlled by and available from a vocabulary registration authority.
- **Terms have unambiguous, non-redundant definition.**
  - Implicit understanding or detailed definition
  - Namespacing: If the same term is commonly used to mean different concepts in different contexts, then its name is explicitly qualified to resolve this ambiguity.
  - Synonyms: If multiple terms are used to mean the same thing, one of the terms is identified as the preferred term in the controlled vocabulary and the other terms are listed as synonyms or aliases.

Taxonomy

- **A collection of controlled vocabulary terms organized into a hierarchical structure.**
  - parent-child relationships between terms in the taxonomy.
  - Different relationships e.g., whole-part, genus-species, type-instance
- **Possibly poly-hierarchical,**
  - a term can have multiple parents.
  - if such a term appears in multiple places in a taxonomy, then it is the same term (with the same children if any).
- **Bring additional meaning to vocabulary**
  - The links can be typed (e.g., part of, broader topic than, instance of)
  - Close to onlology

Thesaurus

- **A networked collection of controlled vocabulary terms.**
  - uses associative relationships in addition to parent-child relationships.
  - The expressiveness of the associative relationships in a thesaurus vary and can be as simple as “related to term” as in term A is related to term B.
- **Taxonomies and Thesauri**
  - may relate terms in a controlled vocabulary via parent-child and associative relationships,
  - but do not contain explicit grammar rules to constrain how to use controlled vocabulary terms to express (model) something meaningful within a domain of interest.
- **Thesaurus is equivalent to sophisticated taxonomy**

ontology

- **A controlled vocabulary expressed in an ontology language**
- **Includes a grammar**
  - for using vocabulary terms to express something meaningful within a specified domain of interest.
  - defining formal constraints on how terms in the ontology's controlled vocabulary can be used together.
- **Enforcement of an ontology's grammar**
  - may be rigorous or lax.
  - Frequently, the grammar for a "light-weight" ontology is not completely specified,
  - i.e., it has implicit rules that are not explicitly documented.
- **Taxonomy/Thesaurus+grammar = Ontology**
- **Can be equivalent to a UML description**
  - Fuzzy line between classical modelling and ontology

meta-model

- **A an explicit model of the constructs and rules needed to build specific models within a domain of interest.**
- **A meta-model can be viewed from three different perspectives:**
  1. as a set of building blocks and rules used to build models
     - Or meta-models: meta-meta-models
  2. as a model of a domain of interest
     - Comparing meta-models to ontologies, meta-models are models
  3. as an instance of another model.
- **A valid meta-model is an ontology,**
  - but not all ontologies are modeled explicitly as meta-models (2)
- **Note:**
  - a modeling tool imposes its own ontology to construct models,
  - This model making ontology is usually called a meta-model, with "model making" as its domain of interest.
  - A meta-model is an ontology used by modelers.

From Meta-Models to Real World

Meta-meta-model

Relational data model:
Tables, attributes, records

«instance-of»

Meta-model
Ontology

Database schema:
Student, Section, Year…

Model

«instance-of»

Database tables of records:
(Paul, SY20, 2010, …

«represented-by»

Real world:
…

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Modelling levels

1. **Contextual representation = Models**
   - Describe the reality fitting the nedds of the observer
     - Example : Physical model describing the location within a facility
       - *Station1/Compressor6/PT104 = hierarchical model*
2. **Consistent models = Meta-models**
   - Or ontologies / canonical models… defining the structure of models describing similar entities
     - Examples: ISA-95, PODS
3. **Consistent meta-models = Meta-meta-models**
   - Or « Upper-level ontologies » defining abstract « building blocks » (a grammar) to build up meta-models
     - Examples : ISO15926, APDM)

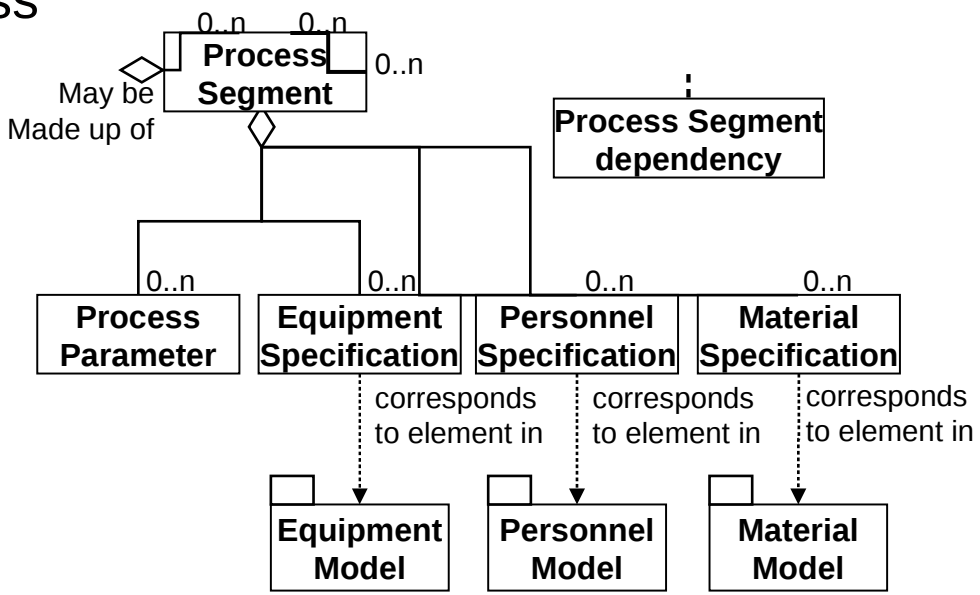
Direct « ad hoc » Models

- **Ad hoc data structures build without references**
  - Make use of terminology and hierarchies to address the different situations and contexts
    - Reference data
    - Data storage
    - Analysis dimensions
    - Data exchange between applications
- **Pros**
  - Variety is preserved at the data level
- **Cons**
  - Subsequent effort to pull meaning from data
  - No variety filtering at the meaning level: needs further interpretation

Meta-modelling

- **Usage of canonical meta-models**
  - Common, predefined and consistent structures and terminologies
- **Pros**
  - Variety filtering with limited loss
- **Cons**
  - May increase variety when canonical forms do not match well the real world

Exemple ISA-95

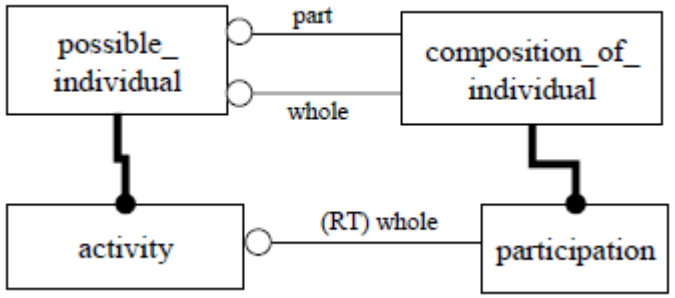


Meta-Meta-modelling

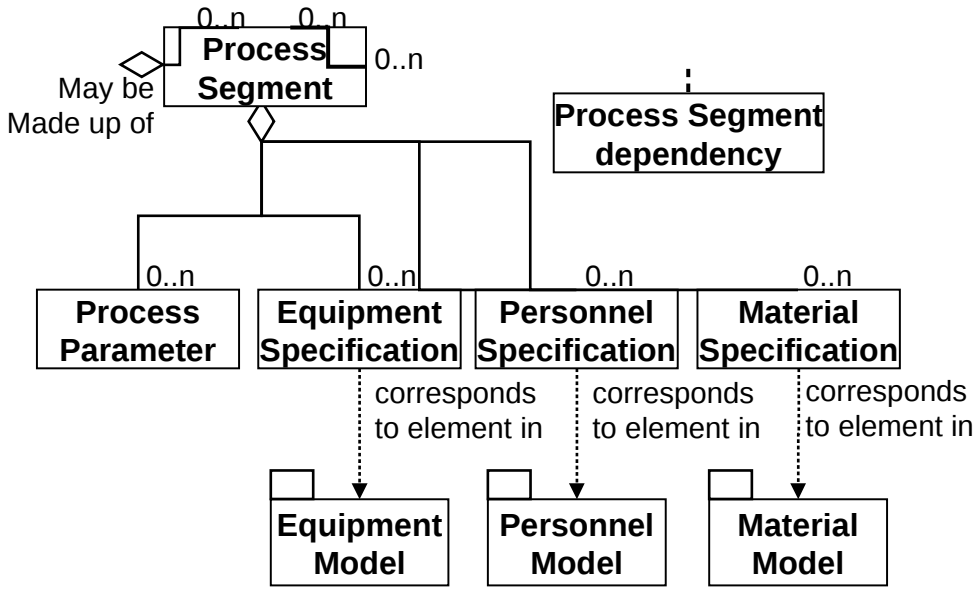
- **The real world is represented by abstract concepts corresponding to individuals, activities, events…**
  - A specific ontology can then be developed consistently for a specific domain.
- **Example (next page)**
  - ISO 15926 defines an abstract, generic model
    - Activity / participation / individual
  - ISA-95 defines a more explicit meta-model for a specific type of activity
    - Segment / Equipments, material, people
    - An ISA95 meta model can be described using ISO 1526 abstract element:
      - *Segment = Activity*
      - *EquipmentSpecification = Participation*

Representation of an activity

ISO 15926



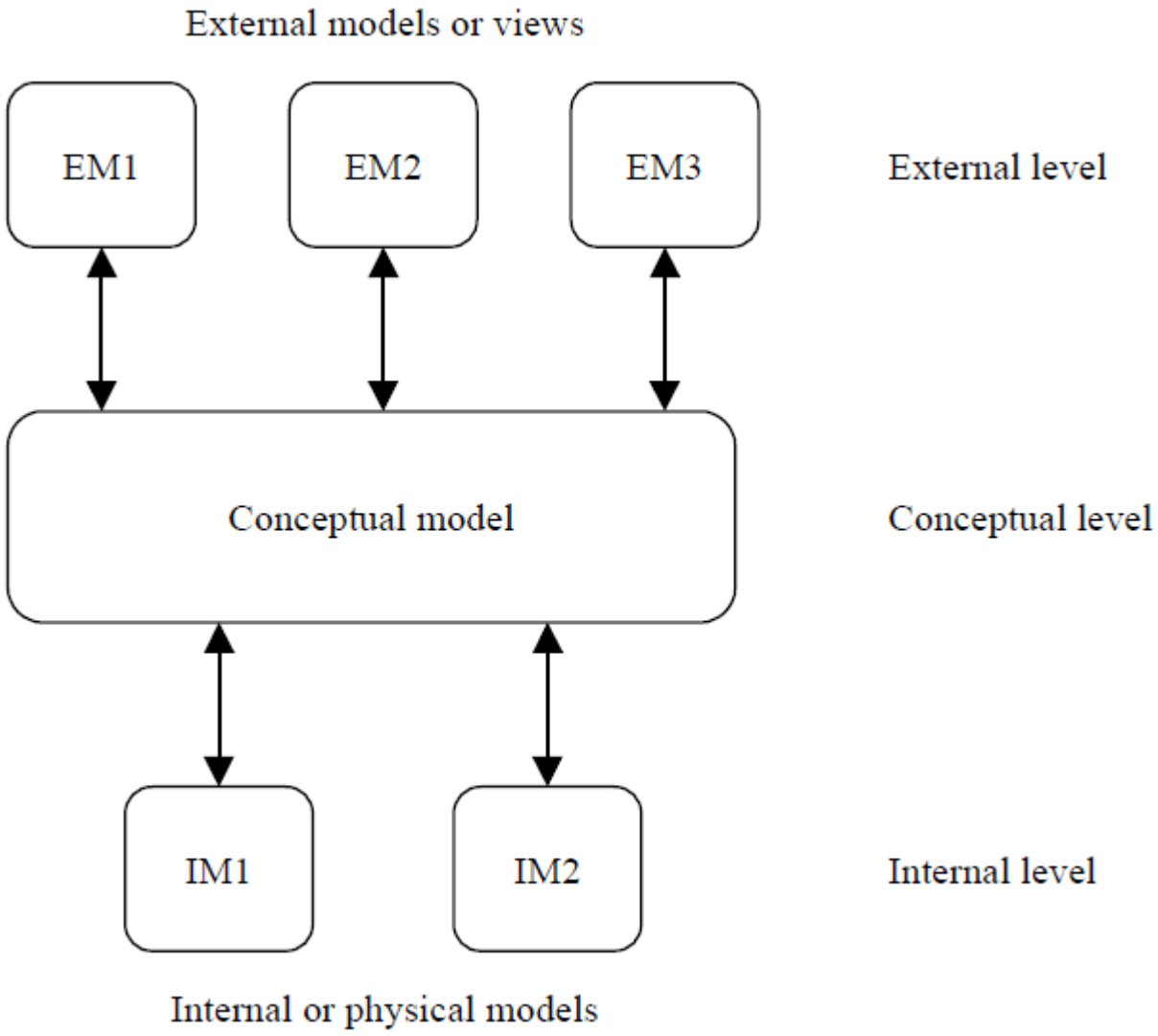
ISA-95



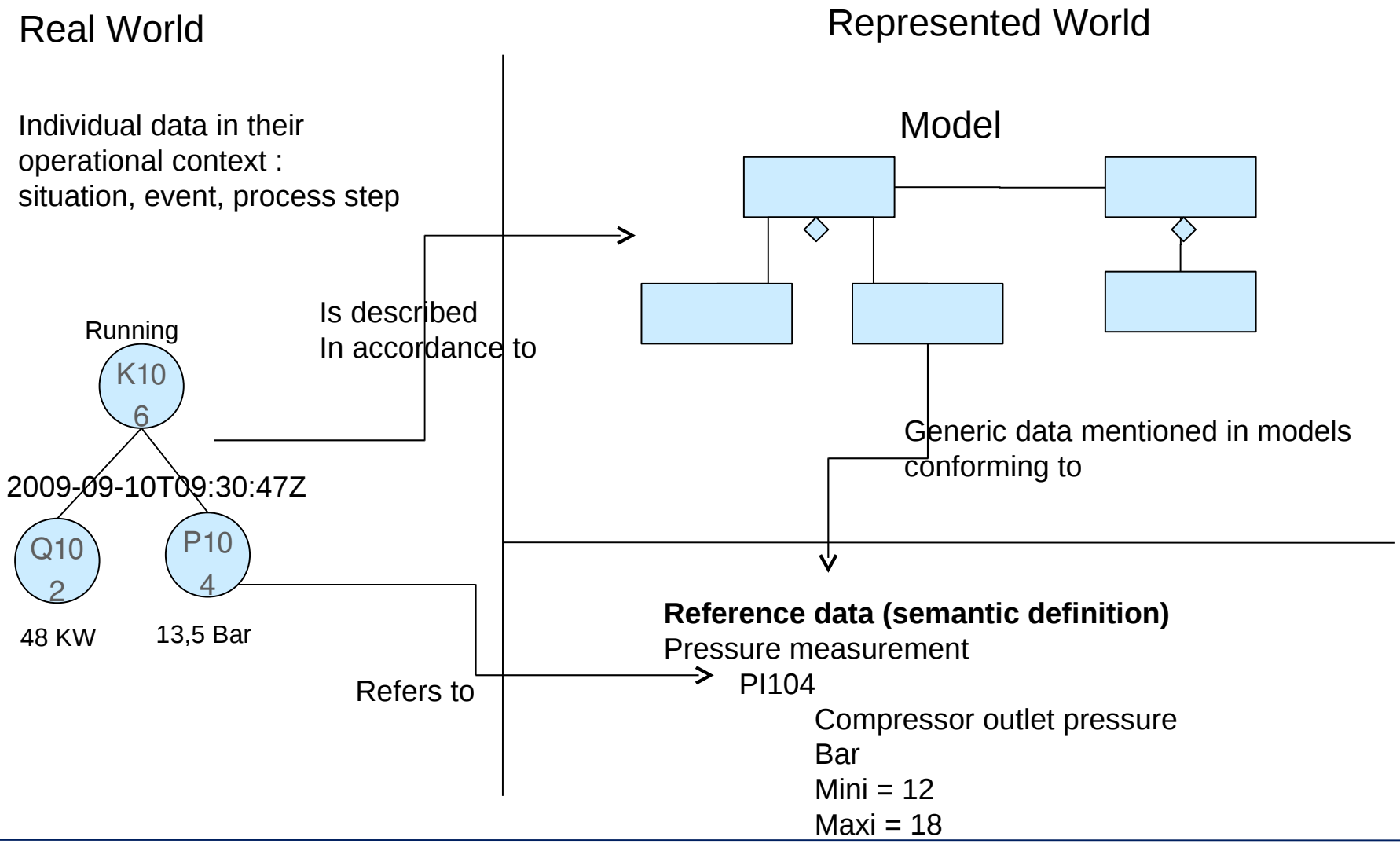
ISO modelling levels

- **External model / View (= level 1 “Model”)**
  - Data structure, applicable rules
    - View of the system for a given purpose
- **Conceptual model (= level 2-3 “Meta-model” and “Meta-meta-model”)**
  - Neutral model capable of handling any valid type of view
  - Universal time/space rules
- **Physical model (internal)**
  - Defines the way data are stored
    - Example: xsd ISA-95 (B2MML), owl ISO15926, DDL PODS …

ISO modelling levels



Reality => Semantics => Models



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Enterprise language

- **Tangible outcome of the language:**
  - meaningful, non ambiguous messages for knowledge exchange, storage, retrieval
  - Support the description of enterprise structural and behavioral aspects on the time scale
- **Must serve both Human and IT relationship**
  - Understandable by people and machines
  - Machine, being notably stupid, need extended, precise formalism to understand

Elements of the enterprise language

- **Natural language accommodate most of human interactions**
- **Machines need more formalism**
- **The enterprise language is a formal ontology**
  - A semantic tree
  - Defining concepts associated with lexicon (translations, synonyms,)
  - Structured successively in
    - simple abstract concepts i.e. « Identifier » « Description »
    - General concepts i.e. « « activity », « Resource »
    - business concepts as references for actual business entities mentioned in messages
  - Describing relationships and value domains

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Practical implementation

- **Semantic registry**
  - Identifies and manage concepts semantically
  - Associates concepts with local / logical representations
  - ISO11179 provides a meta model for managing concepts semantics
- **Language specification**
  - Defines concepts with attributes and relationships with other concepts
    - ISO62264, ISO 15926, ISO19440 provide possible basis for estblishing and structuring concepts
  - Defines logical data structures for message language enforcement
    - XML schemas is a possible technology
  - Database structures for ontology persistence (reference data)
- **Interface implementation**
  - Based on logical data structure (i.e. XML schemas)

Practical implementation

	Semantic registry	Ontology and Schemas	Interface
Scope	Whole entreprise	Conceptual domains within enterprise	Specific Projects
IT solution	MDM solutions	Ontology editors XML schema authoring tools	EAI/SOA plateforms
Lifecycle	Continuous, event base resgistration	On demand to address new interoperability needs	IT Projects
Responsibility	Enterprise Linguist	Enterprise Linguist	IT

Thank You !