The Language of Complexity: Ontology in Systems Design and Engineering

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The Problem

Toilet Out of Order

Use Floor Below
The Problem (cont’d)

During Systems Development, how do we ensure we **consistently communicate** the **correct meaning** in language used between:

- humans & humans  
  - across domains / disciplines
- humans & machines
- machines & machines

Without clear communication, we get cost overruns, delays, and rework.
What is an Ontology?

A formal specification of things, concepts, and the relationships between them, within some knowledge domain.

Describes:
- classes: abstractions of things
- individuals: the actual things themselves
- properties: relationships between individuals
  - includes constraints / restrictions on relationships
Written Works Ontology
Why Ontologies?

- Language disambiguation
- Well established technology
- Can model any system
- Formal relationships between objects
- Machine and human readable
- Reasoning / Inferencing engines
- Complex queries
- Information model to complement physics-based models
Industry Application

▪ Ford
  – Started developing ontologies to capture their manufacturing process in 1989 (Rychtyckyj, 1999)³
  – Digitized and standardized “process sheets”: vehicle assembly work instructions
  – Improved labor time estimation accuracy
  – Invested effort to rewrite ontology in a newer language, even with impact to production (Rychtyckyj, 2016)⁴
Design Process with Ontologies

Requirements

Component Selection

Analysis

System Architecture

Trade Space Definition

Ontologies

Modeling & Simulation

V & V
Domain Ontology
Value Proposition to the DoD

- Improve acquisition process
  - Design products faster (Better Buying Power\textsuperscript{5}).
  - Improve ability to compare competitive product proposals.
  - Evaluate a broader assessment of alternatives.

- Consistency among stakeholders
  - Ensure that the DoD’s interpretation of requirements equals manufacturer’s interpretation.

- Traceability
  - Allow for traceability of design decisions back to the requirements
References

2. IBM developerWorks, 2012, Reification and Trust: Ontology-driven NLP.
5. Better Buying Power
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