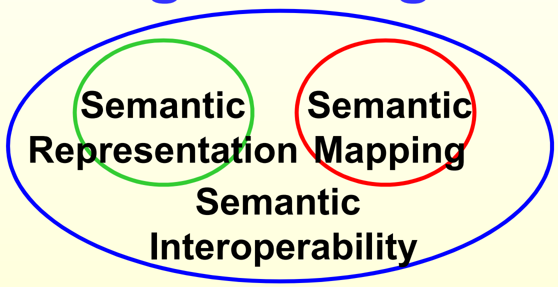
Ontologies for Big Systems: Aspects of Semantic Interoperability

Track 1&2 **Ontology for Big Systems & Systems Engineering II**



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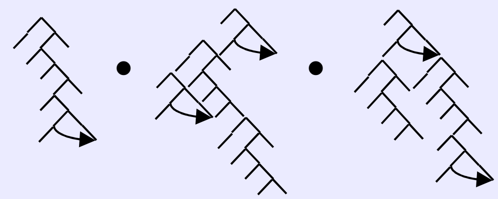
Semantic Integration Implies Semantic Composition

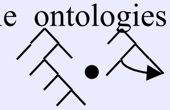
Complexity

Complex Semantic Model, Knowledge, System Integration & Composition

Unification of complex networks of graph Structures, with complex reasoning, complex ontologies:



Simple Semantic Model, Knowledge Integration & Composition
Unification of tree or graph structures, with reasoning, simple ontologies:



Simple Syntactic Object Integration & Composition
Alignment of embedded interface definition language statements mapping two CORBA, Javabean objects

Simple Procedure Integration & Composition
Concatenation, alignment of calling Procedure with called procedure:

Caller: Do_this (integer: 5, string: “sales”)
Called: Do_this (integer: X, string: Y)

1960

1998

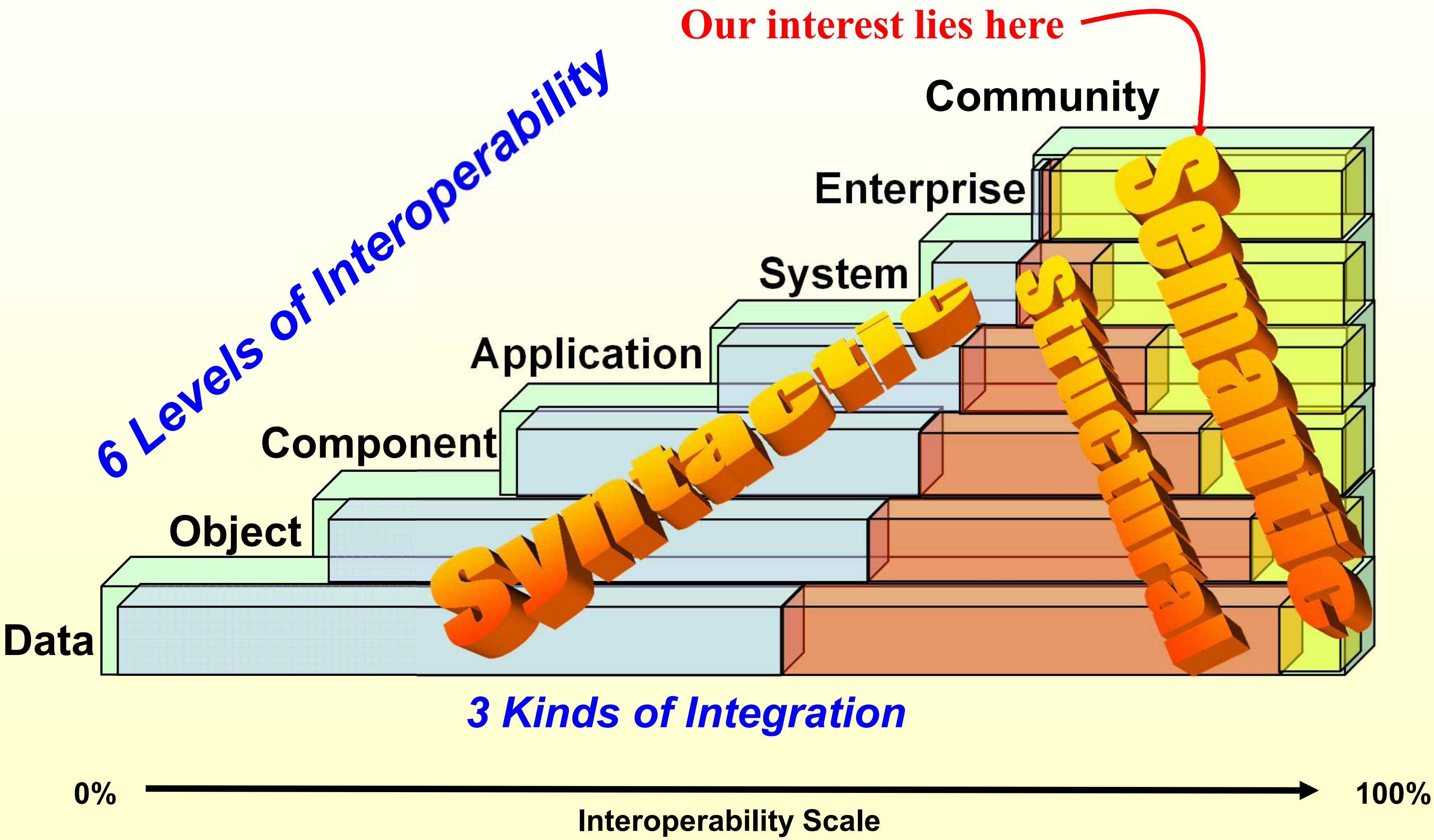
2005

2020

Time

● - signifies the composition operation

Dimensions of Interoperability & Integration



Semantic Interoperability, Integration Definition

- To *interoperate* is to participate in a *common purpose*
  - Operation sets the context
  - Purpose is the intention, the end to which activity is directed
- Semantics is fundamentally *interpretation*
  - Within a particular context
  - From a particular point of view
- Semantic Interoperability/Integration is fundamentally driven by *communication of purpose*
  - Participants determined by interpreting capacity to meet operational objectives
  - Service obligations and responsibilities explicitly contracted

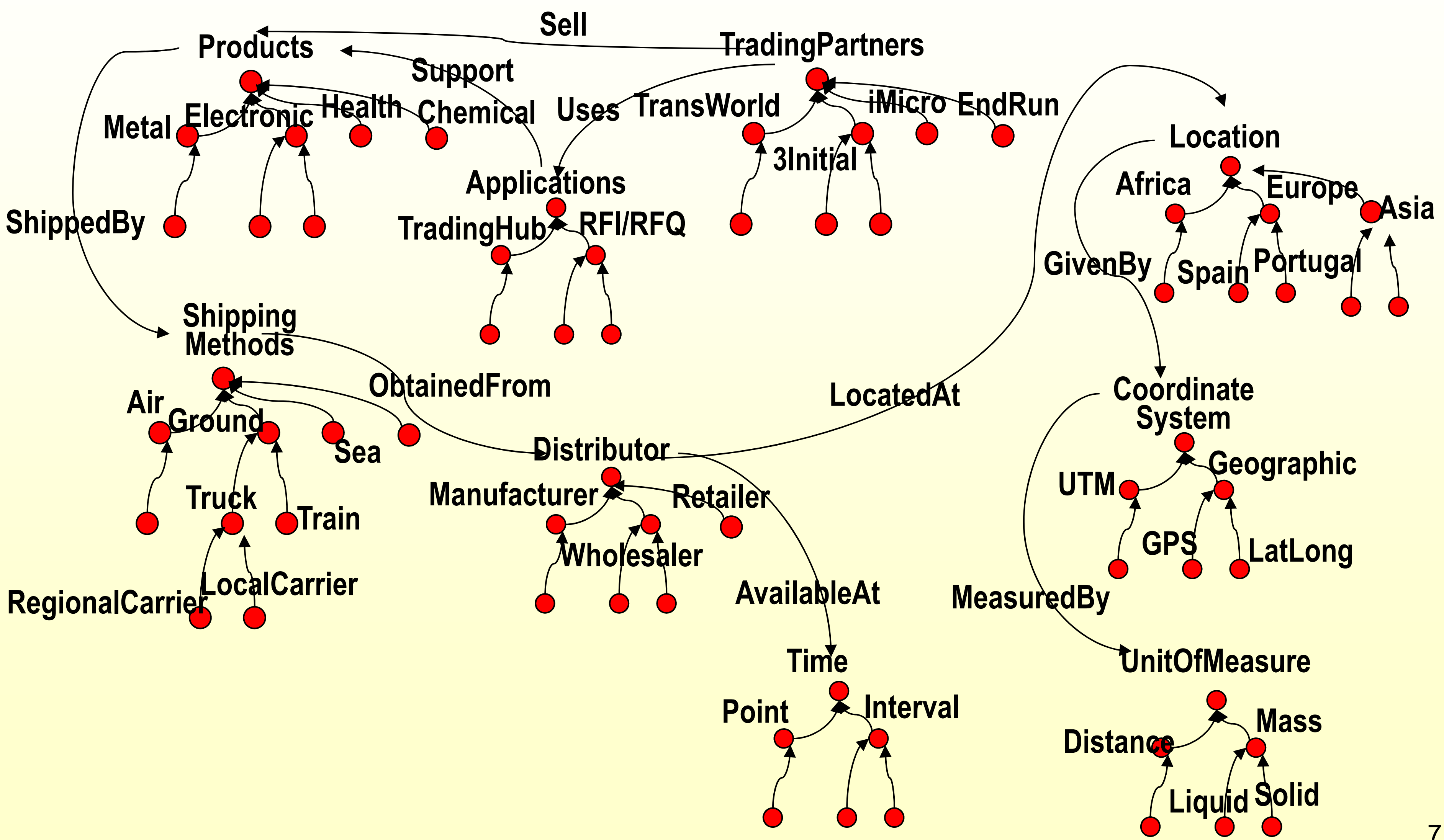
Enabling Semantic Interoperability

- Semantic Interoperability is enabled through:
  - Establishing base semantic representation via ontologies (class level) and their knowledge bases (instance level)
  - Defining semantic mappings & transformations among ontologies (and treating these mappings as individual theories just like ontologies)
  - Defining algorithms that can determine semantic similarity and employing their output in a semantic mapping facility that uses ontologies
- The use of ontologies & semantic mapping software can reduce the loss of semantics (meaning) in information exchange among heterogeneous applications, such as:
  - Web Services
  - E-Commerce, E-Business
  - Enterprise architectures, infrastructures, and applications
  - Complex systems-of-systems
  - Integrated collective intelligence

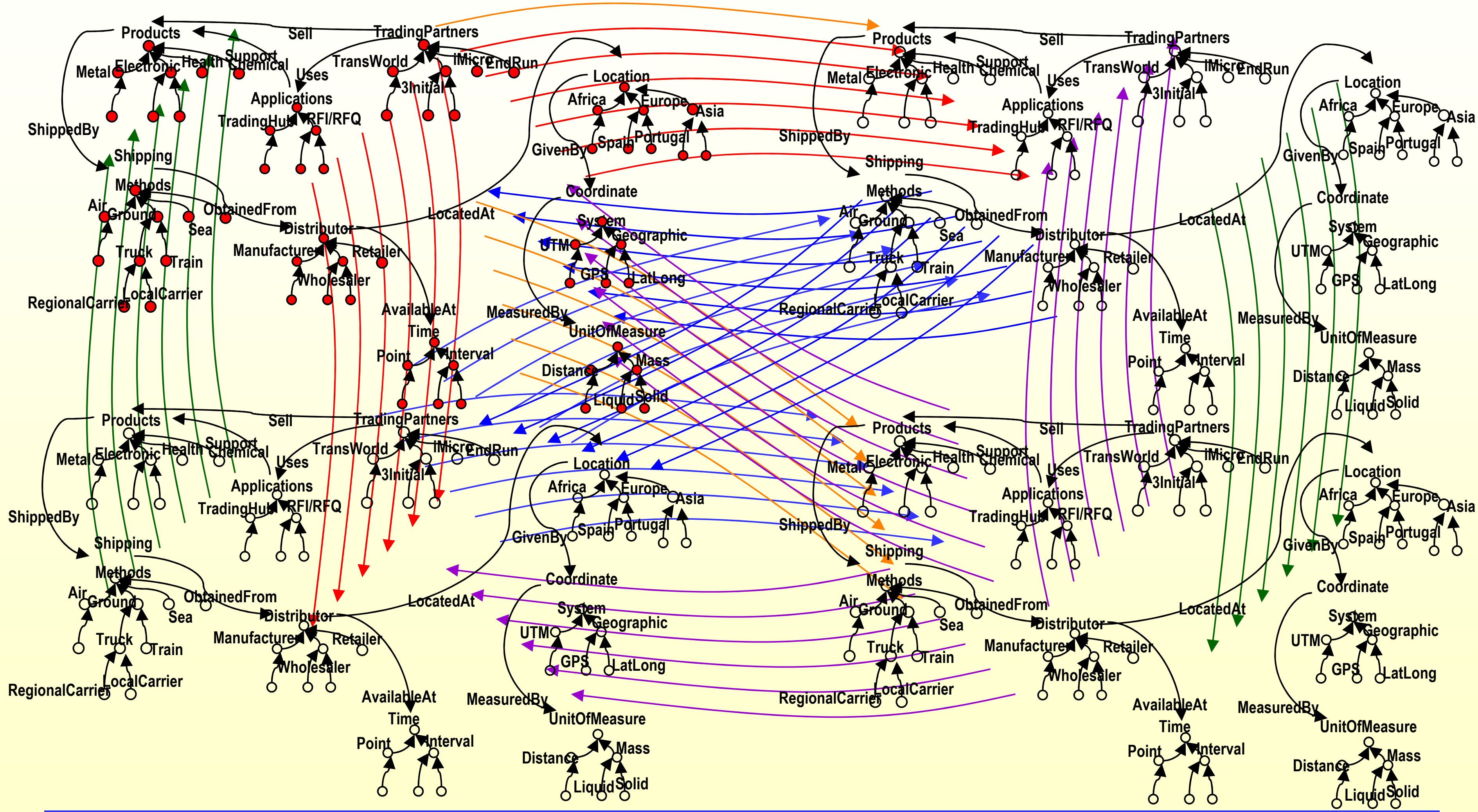
Semantic Interoperability, Integration: Multiple Semantics

- Multiple contexts, views, application & user perspectives
- Multiple levels of precision, specification, definiteness required
- Multiple levels of semantic model verisimilitude, fidelity, granularity, dynamicity
- Multiple kinds of semantic mappings, transformations needed:
  - Entities, Relations, Properties, Ontologies, Model Modules, Namespaces, Meta-Levels, Facets (i.e., properties of properties), Units of Measure, Conversions, Theories, Interpretations, etc.
- Upper & Middle Ontologies are important
  - To be able to interrelate domain ontologies

Electronic Commerce Example: One Company, Many Systems



Now Assume Each Company Has Separate Enterprise Semantics, Multiply by the Number of Companies, & Have Them Interoperate and Preserve Semantics: Many Systems!



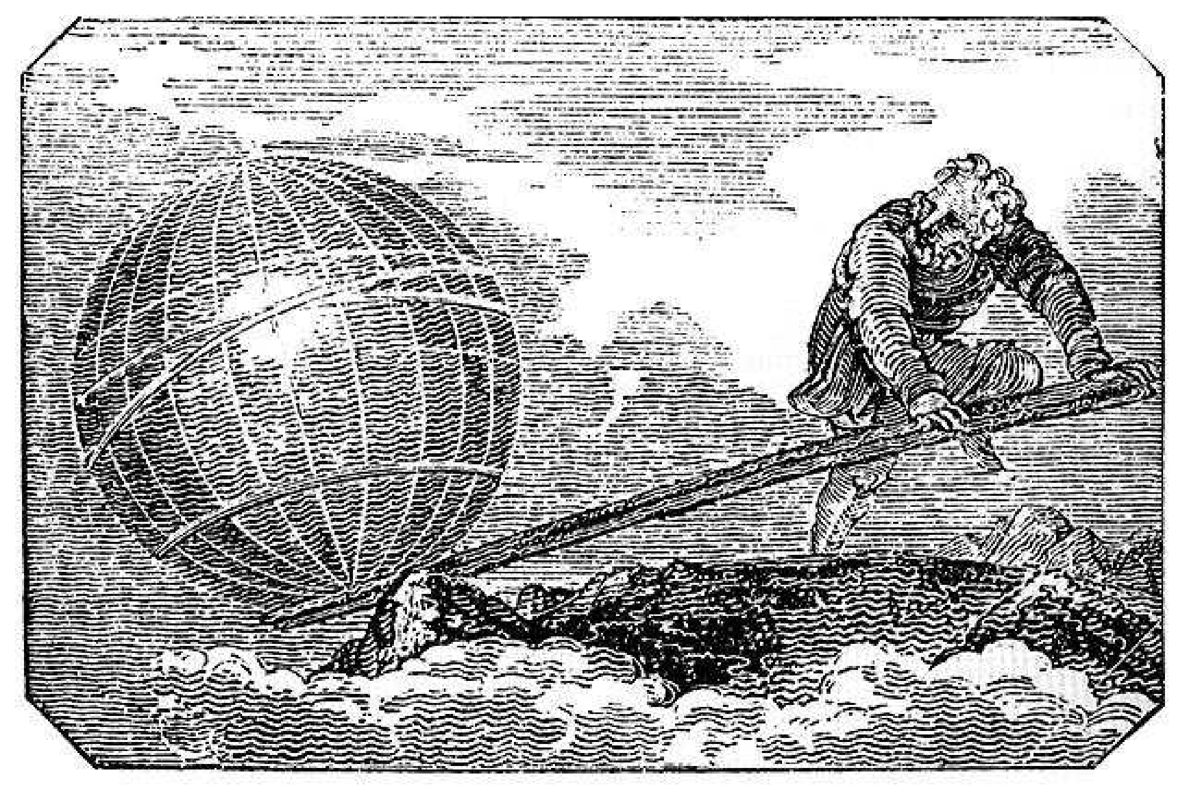
Try doing this without Ontologies! You can, but it's a Nightmare, and it COSTS: Now & Later!

Mainstream Systems Engineering and Information Technology cannot adequately address these issues

- Service-Oriented Architecture, database technology (including Big Data), programming technology (including OO, genetic programming, "swarm" agents), parallel distributed technologies (Cloud, Grid) cannot address
- Ontology can address these issues:
  - **Formal ontological analysis**
  - **Theory of Parts and Wholes**
  - **Theory of Essence and Identity**
  - **Theory of Dependence**
  - **Theory of Qualities**
  - **Theory of Composition and Constitution**
  - **Theory of Function (teleology)**
  - **Formal Pragmatic Intent and Use**
  - **Theory of Social/Organizational Roles**
  - **Relations between Semantics and Ontology for Systems**
  - **Theory of Dynamics: Change and Time**

Conclusion

- Ontology can contribute much to Systems Engineering and Engineered Systems
- Semantic complexity will only increase: Ontology is the lever



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