TOWARDS AN EFFECTIVE METHODOLOGY FOR RAPIDLY DEVELOPING COMPONENT-BASED DOMAIN ONTOLOGIES

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Today's Talk

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- Why Composite Domain Ontologies?
- Software Engineering vs Ontology Engineering
- Ontology Engineering Methodology
- Compositeness Metric
  - Desirable Properties
  - Definition
  - Examples
- Going Forward

Composite Domain Ontology Engineering

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- Problem
  - Existing research into ontology engineering focuses on:
    - Creating new ontologies
    - Aligning existing, redundant ontologies
    - Interacting with ontologies using software tools
  - No real effort spent on high-level engineering of cohesive ontologies
- Goal
  - Develop a methodology for linking and re-purposing ontologies in an agile manner to enable better interoperability between ontology-based applications and services

Composite Domain Ontologies

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- Definition
  - Domain ontology developed by linking multiple ontologies about various topics through imports
  - Analogue to component-based software development or Service-Oriented Architecture (SOA)

Software Engineering

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- As the amount and complexity of software systems has increased, so has the amount of effort dedicated to the study of software engineering
  - More time and effort are spent attempting to make software reusable
  - Metrics have been developed to track the quality of software in many different ways
  - These techniques enhance the understanding of the process and reduce cost and risk
- As ontologies become more widely used, the same changes will happen

Composite Domain Ontologies

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- Ontologies and Software Components share some common attributes:
  - Used in multitude of applications, including some unanticipated by designer
  - Likely to evolve after initial creation
  - Cost to replicate is minimal compared to the cost to develop
  - Reuse has potential to save considerable engineering resources
  - Must be specific enough to be useful, yet general enough to be reusable

Software Metrics vs. Ontology Metrics

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Software		Ontology
• Cyclomatic Complexity	→	▫ Level of Expressiveness?
• # of classes and interfaces	→	▫ # of classes and properties
• Program Size	→	▫ # of statements, axioms
• Coupling	→	▫ Compositeness?
• Cohesion	→	▫ ?

Composite Domain Ontologies

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- Why/when to use composite ontologies?
  - Time savings
  - Leverage existing software
  - Take advantage of existing reasoning and translation
  - Scope vs Applicability

Building a Composite Domain Ontology

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- Start With the Application Domain
  - What questions need to be asked?
  - What does the instance data look like?
  - What type of inferences are required?
- Divide application domain into reusable subsections
- Identify existing ontologies to fulfill section requirements
- Create new ontologies when necessary

Compositeness Metric Goals

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- We have developed a new compositeness metric for ontologies
- This metric should indicate:
  - How much an ontology's creators were able to reuse existing ontologies
  - How usable an ontology is in different situations with different pieces of software
  - A relative idea of how long an ontology should take to develop

Compositeness Metric Definitions

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- *Compositeness* as a metric
  - Degree to which an ontology is made up primarily of other ontologies, and the compositeness of those ontologies.
- Definitions

C(X) : Compositeness of ontology, X.

S(X) : Size of ontology, X.

I(X,Y) : Ontology(X) imports Ontology(Y).

Compositeness Metric Properties

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- Properties of *Compositeness* Metric (1)
  - If X imports Y, then X is more composite than Y.
    - $I(X, Y) \rightarrow C(X) > C(Y)$
  - If X and Y both import Z and X is smaller than Y, then X is more composite than Y.
    - $I(X, Z) \wedge I(Y, Z) \wedge S(X) < S(Y) \rightarrow C(X) > C(Y)$

Compositeness Metric Properties

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- Properties of *Compositeness* Metric (2)
  - If X and X' are identical except that they import 2 separate ontologies, then the one that imports the more composite ontology has a higher compositeness.
    - $I(X, Y) \wedge I(X', Z) \wedge C(Y) > C(Z) \rightarrow C(X) > C(X')$
  - If X and X' are identical except that X imports an extra ontology, then X has higher compositeness.
    - $(I(A, B) \wedge I(A', B) \wedge I(A', C) \wedge \exists X: (I(A,X) \&\& X = B)) \rightarrow C(A') > C(A)$

Compositeness Metric

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- Compositeness Metric

$$C(X) = \sum_{y \in I(X)} C(y) + \frac{\sum_{y \in I(X)} S(y)}{S(X)}$$

- An ontology that imports no other ontologies will have a compositeness score of 0

GARCON-F Ontologies

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- We have used the ontologies developed on the GARCON-F to evaluate the metric
  - **Air Defense** ontology defines the domain of air defense
  - **Foundational** ontology defines spatial annotations
  - **BFO** (OWL version)
  - **OWL-Time** standard temporal information
  - **GeoRSS** defines simple spatial locations
  - **RAID** defines the domain of Marine raid missions
  - **Transportation** defines vehicles, cargo, etc
  - **Movement** defines simple movements
  - **SAULTE** defines the contents of a simple report

Composite Domain Ontologies

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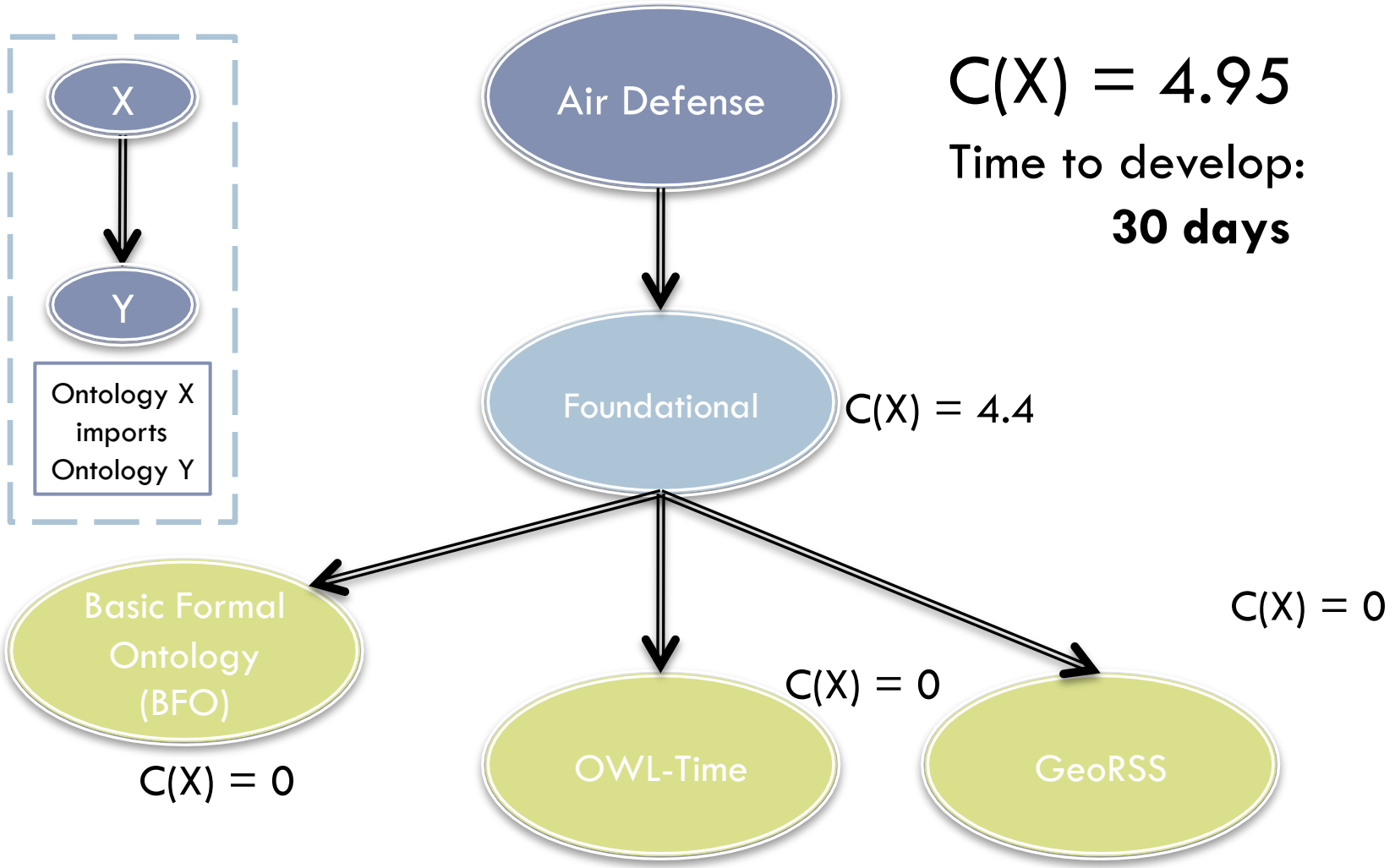

Composite Domain Ontologies

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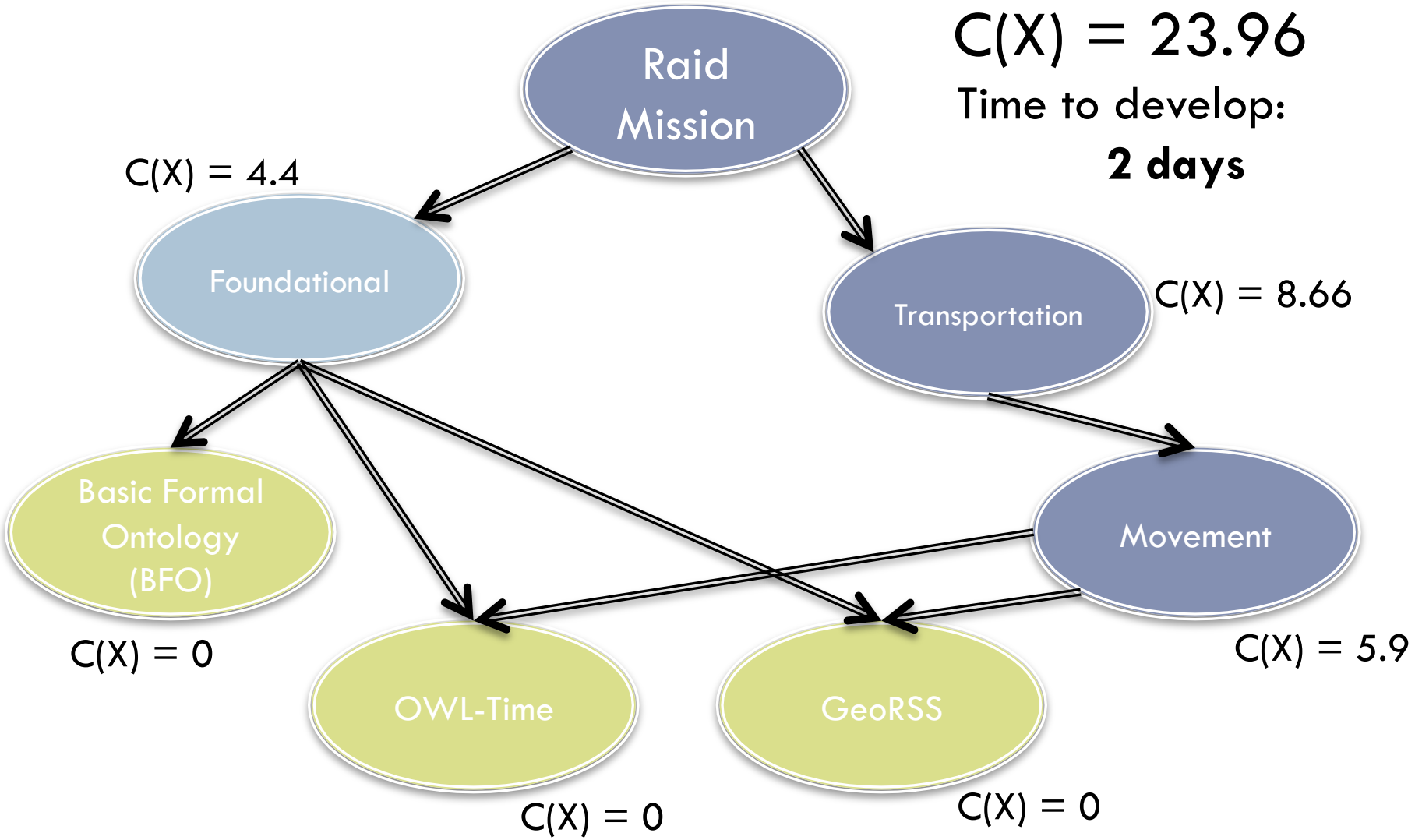

Composite Domain Ontologies

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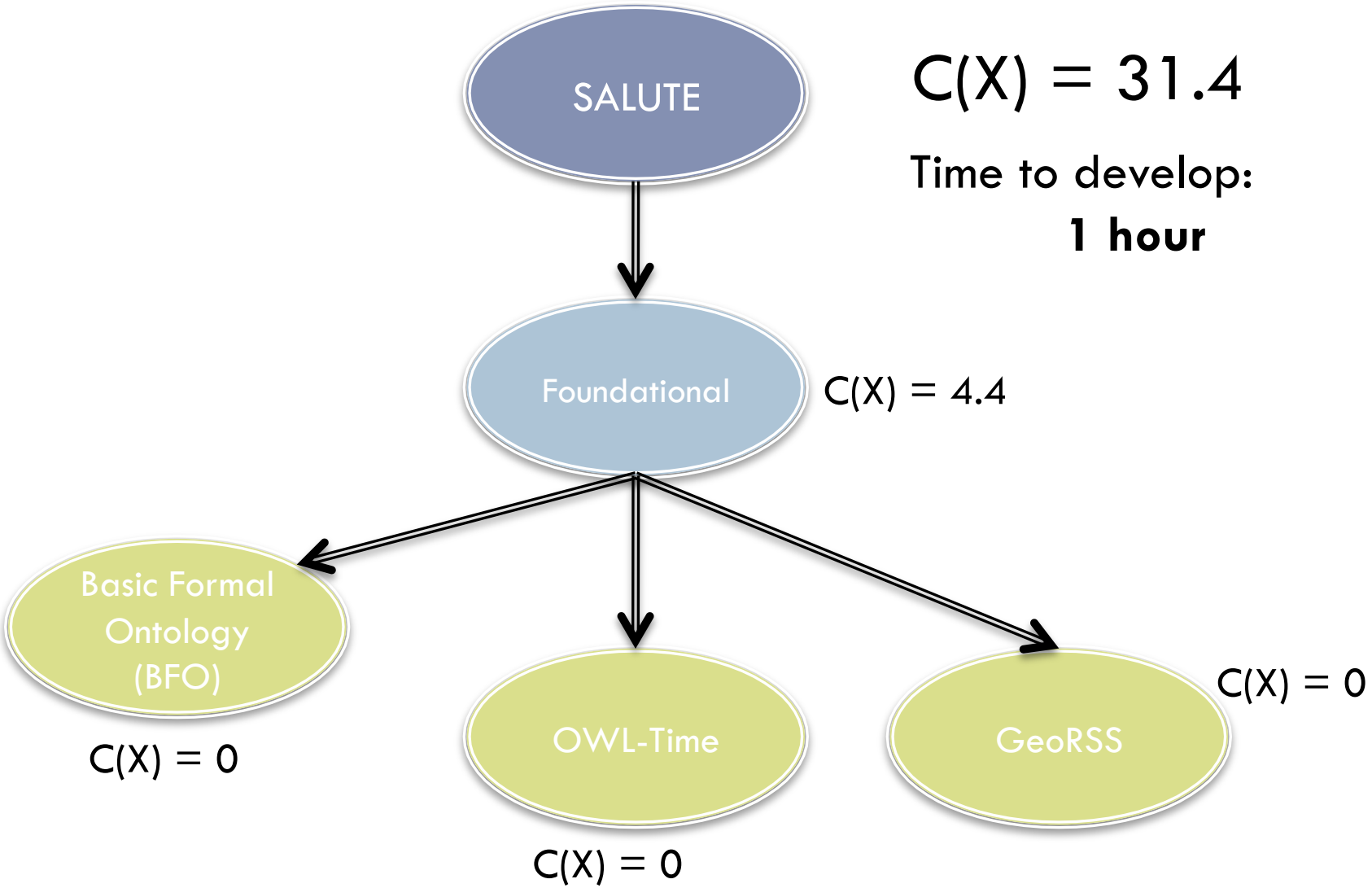

Going Forward

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- This is only a small start…
  - How can we improve/further validate compositeness metric?
  - What is the ontology equivalent of "cohesion"?
  - What useful ontology metrics exist that do not have software analogs?

Thank You

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Questions?