Opportunities for Next Generation BML: Semantic C-BML

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Outline

- Introduction
- Current state of C-BML
- Need for a semantic C-BML
- Enhancements provided by a semantic layer
- Elements in a Semantic C-BML
- Reasoning through a Knowledge representation
- Future Work and Conclusions

Introduction- BML

- Battle Management Language is an unambiguous language to facilitate the command and control of forces and equipment in a military environment and to provide information for situational awareness.
- BML has a accompanying grammar- Command and Control Lexical grammar (C2LG)
- *One of the goals of BML is to provide "**Shared Semantics** between C2 and M&S via a Common Tasking Description"*
- BML is based on work initiated by the C4I Center outlined in [*Carey, S., M. Kleiner, M. Hieb, and R. Brown, "Standardizing Battle Management Language – A Vital Move Towards the Army Transformation," IEEE Fall Simulation Interoperability Workshop, September 2001]*

Introduction: C-BML

- C-BML is applying BML to a coalition context
- A standard has been approved following a SISO balloting process
  - Based on a specification provided by the C-BML product development group (*Blais, Curtis, et al; SISO Fall 2011 SIW)*
  - My work provides insight into the use of OWL in phase 2 standardization
- Phase 1 focused on formalizing syntax in terms of a XML schema
  - Vocabulary based on the JC3IEDM data model
  - Sought to provide full expressivity of the data model

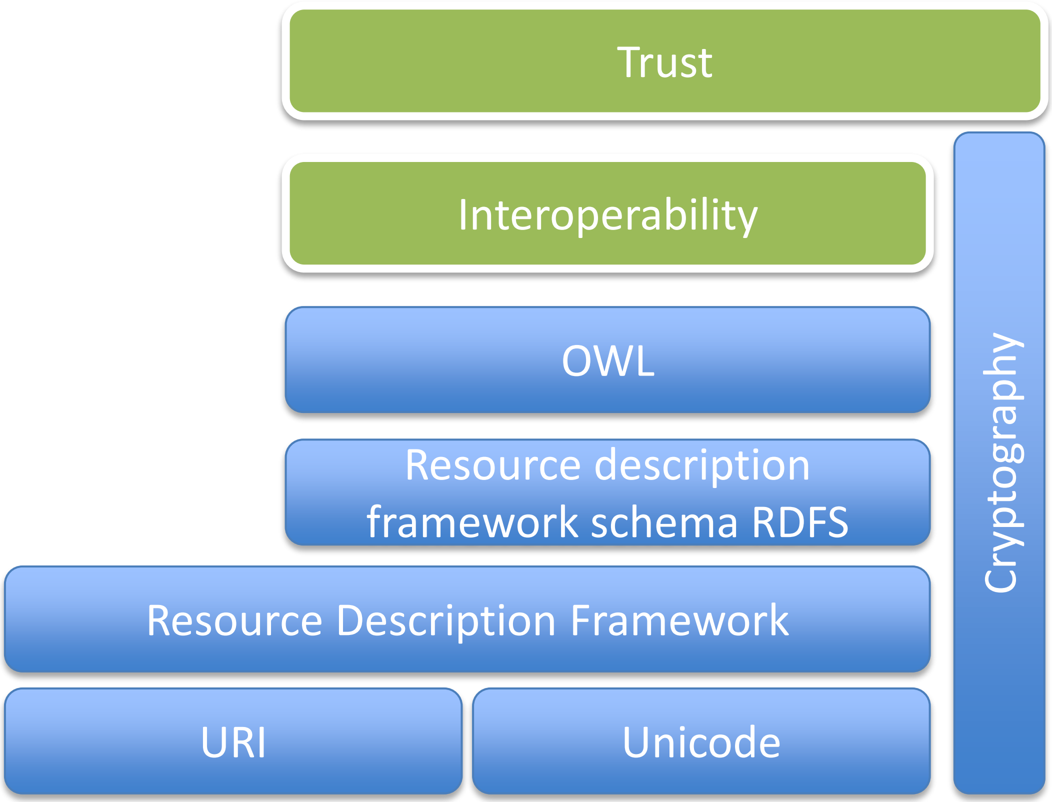
Limitations in the current standard

- An XML based system built on the full expressivity of the JC3IEDM limits the speed of
  - Development/extensions
  - Integration
  - Testing
- Interoperability in Phase 1 is on the syntax level
- The need for a semantic C-BML has been suggested by Blais, Turnitsa, and Gustavsson (SISO Fall SIW 2006); my work provides:
  - A path forward in using upper level ontologies
  - A context for the use of reasoning in semantic C-BML

Introduction: Semantic Web

- The semantic web is a framework of linked web data in a shared machine-readable knowledge representation
  - Shared semantics
  - Linked data
  - Machine readable
- Based on W3C standards
- Semantic representation enables:
  - Formalization of shared semantics
  - The ability to infer knowledge
  - The use of a reasoner to check for semantic inconsistencies

The Semantic Stack



Current standards in ontology creation

- Resource Description Framework
  - Based on Uniform Resource Identifier (URI)
  - Any element can be defined (and disambiguated) using a URI
  - Knowledge is represented using a <subject> <predicate> <object> triplet

An example of a semantic representation(in C-BML context)

- Representation of a Unit using URI: http://urlNamespaceOfUnit:UnitA
- Representation of a relationship: http://urlNamespaceOfUnitRelationship:UnitHasAsCommander
- An RDF axiom (asserted knowledge in the ontology):

<http://urlNamespaceOfUnit:UnitA>
<http://urlNamespaceOfUnitRelationship:UnitHasAsCommander>
< http://urlNamespaceOfUnit:UnitA >

- RDFS is:
  - Flexible
  - Easily scalable

Introduction: OWL

- Web Ontology Language is a current standard to model and represent knowledge in the form of an ontology
  - The goal is to model and represent knowledge in a machine readable fashion
  - Based on RDFS, can be serialized to XML
  - Compliant to description logic, which makes it computationally decidable and has adequate logical expressivity
  - Available reasoners can be used to derive inferred knowledge
- OWL is a W3C standard (*http://www.w3.org/TR/owl-features/*);

Why does C-BML need an ontology?

- It formalizes the definition and **meaning** of common terms
- It formalizes the **doctrinal** rules for Orders and Reports
- It eases **interoperability** because of a shared vocabulary and defined meaning
- It allows performing powerful **reasoning** on operational semantics
- A model driven(ontology-driven) framework facilitates easy extensions
  - Gupton, Blais and Heffner (International Journal for Intelligent Decision Support Systems, October 2011) suggest model based data engineering as a development approach; my work lays a foundation for OWL as a central data model.

A path to creating semantic C-BML

- Evaluate relevant upper level ontologies
- Extract semantic pieces from existing Phase 1 work
  – Entities recognition (XSD elements, XSD types)
  – Taxonomy classification (subsumption relation, IS-A relationships)
  – C-BML specific relationships
  – Doctrine based axioms

Upper Level Ontologies

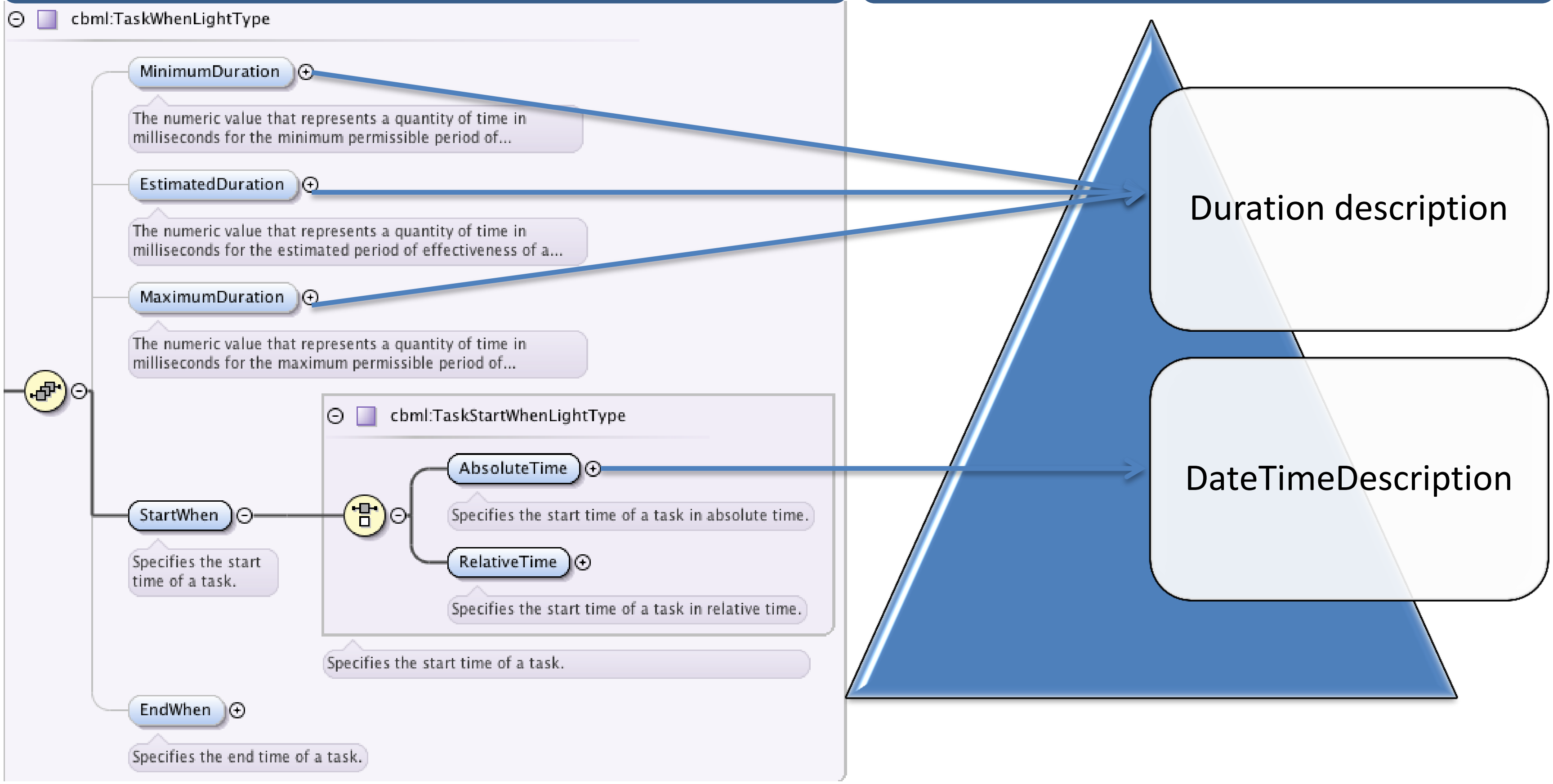
- General purpose ontologies that define entities in a particular domain (time, geography, …)
- Why use upper level ontologies?
  - Reusability
  - Easier extension management
  - Easier mapping between systems that use the same upper level ontology
- Gupton, Blais and Heffner (IJIDSS, October 2011) have proposed the use of upper level ontologies; my work:
  - Identifies applicable upper level ontologies and their alignment with C-BML
  - Provides a context for reasoning on semantic C-BML

Upper level ontologies relevant to C-BML

- C-BML vocabulary is based on the 5Ws(‘Who’, ‘What’, ‘When’, ‘Where’ and ‘Why’)
- OWL-Time *(relevant to ‘When’)*
  – Upper level ontology that represents time in different forms, temporal constraints and axioms
  – The core class “TemporalEntity” has two sub classes: Instant and Interval
- Geo-OWL *(relevant to ‘Where’)*
  – Upper level ontology to represent geometric shapes
  – The top class geometry can be of type Point, LineString, Polygon…

Mapping between C-BML and OWL Time

Schema definition of C-BML 'When' | Entities in OWL Time

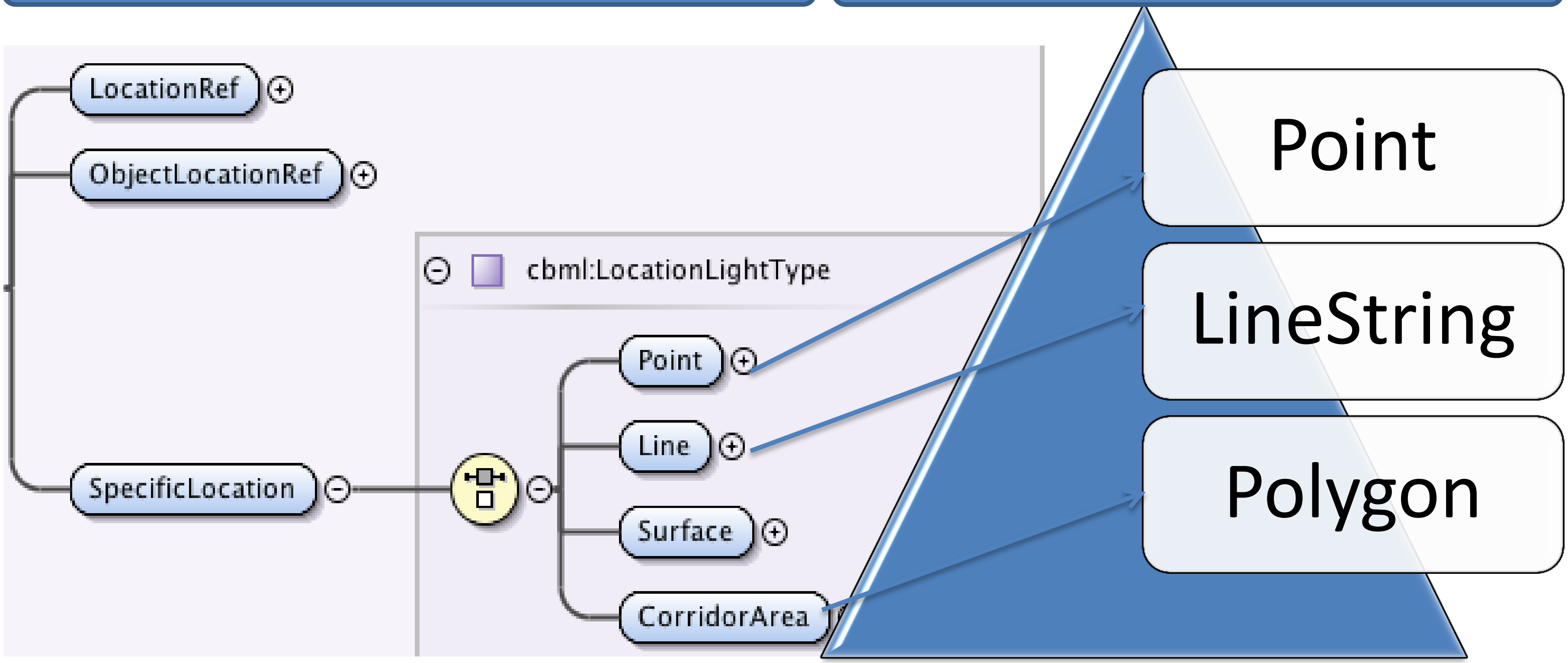


Advantages of using OWL-Time

- Rich expressiveness of time entities
  - Models both time instants and time intervals
  - Temporal constraints can be established
- Powerful reasoning over temporal concepts
  - Task1 after Task2 can be modeled
  - New temporal relationships can be inferred using a reasoner

Mapping between C-BML and Geo-OWL

Schema definition of C-BML ‘AtWhere’	Entities in Geo-OWL



Reasoning in semantic C-BML

- Reasoning has two main goals
  - Checking for semantic inconsistencies
  - Gaining inferred knowledge
- OWL captures knowledge in a way that existing reasoners (HermIT, Jena..etc) can automatically derive new knowledge
- OWL reasoners are based on First order predicate logic

Semantic C-BML reasoning example 1

- Checking for semantic inconsistencies
  - An example in the "reports" context: "*Executer(x), hasAsReportedTime(x,t1)∧Executer(x), hasAsReportedTime(x,t1)⟹(hasAsLocation(x,l1)=hasAsLocation(x,l2))*
    (SWRL syntax)

  Checks to make sure that multiple reports provide consistent reported data locations of a "Executer"

- A ontology provides a formal, machine understandable way to check for semantic inconsistencies

Semantic C-BML reasoning example 2

Deriving inferred knowledge:

Example asserted axioms:

Axiom 1: *ObjectProperty (a:isAUnit domain(a:Tasker) range(a:Unit))*

Axiom 2*: ObjectProperty (a:isAsubordinateOf domain(a:Taskee) (a:Tasker))*

The knowledge represented by these Object properties are:

1: A Tasker should be a Unit (as opposed to a Equipment)

2: A Taskee is subordinate to a Tasker

Semantic C-BML reasoning example 2 *continued*

Example Task:

Tasker:"1060: 1st Battalion Commander"

Taskee: "1062: Company A"

Using the two axioms, we can infer the knowledge:

"'1060: 1st Battalion Commander' is a Unit who is a commanding officer to '1062: Company A'"

Semantic C-BML reasoning example 3

Axiom: ObjectProperty(a:isAfterTask domain(a:Task) range(a:Task)

Note: Object Properties are transitive

Assertion1: Task1 isAfterTask Task2,

Assertion2: Task2 isAfterTask Task3

The inferred knowledge is:

Task1 isafterTask Task3

Note: *This inference can be derived in the Ontology even if the two tasks are in separate C-BML Orders/Tasks*

Conclusions

- Semantic C-BML can help in:
  - Model driven development and ease of scalability and extension management
  - Better interoperability with shared semantics and common, formal conceptualization
  - Formalization of doctrinal rules/axioms and semantic restrictions
  - Checking for semantic inconsistencies
- OWL is an adequate language to model C-BML

Future Work

- Development of C-BML in a model driven framework
  - OWL could be used as the central semantic model
  - Alignment with the MIP information Model and Change Proposals(CP)
- Abductive reasoning as a way to hypothesize knowledge based on reported data
- Explore ways to extract semantic elements from Phase 1 specification
  - How do XML schema schema elements relate to entities?
  - What relationships can be extracted from XML schemas?