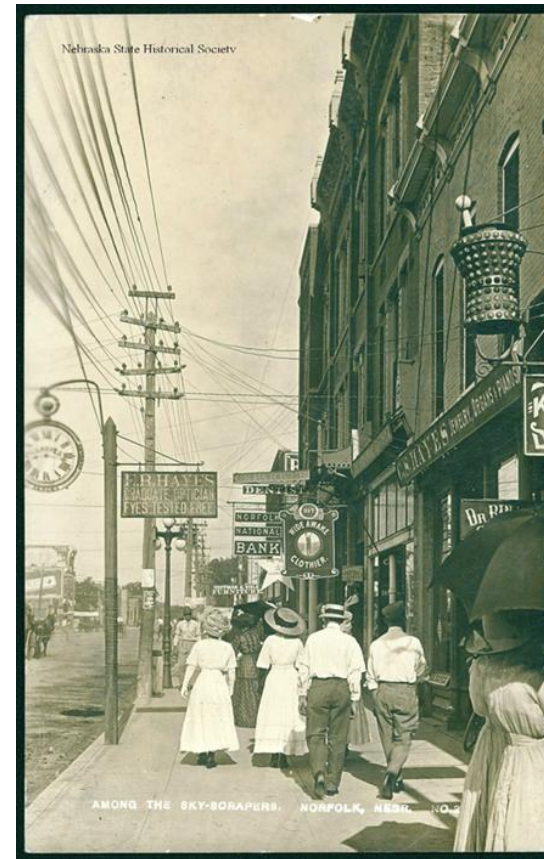


Knowledge Organization Systems for Semantic Models

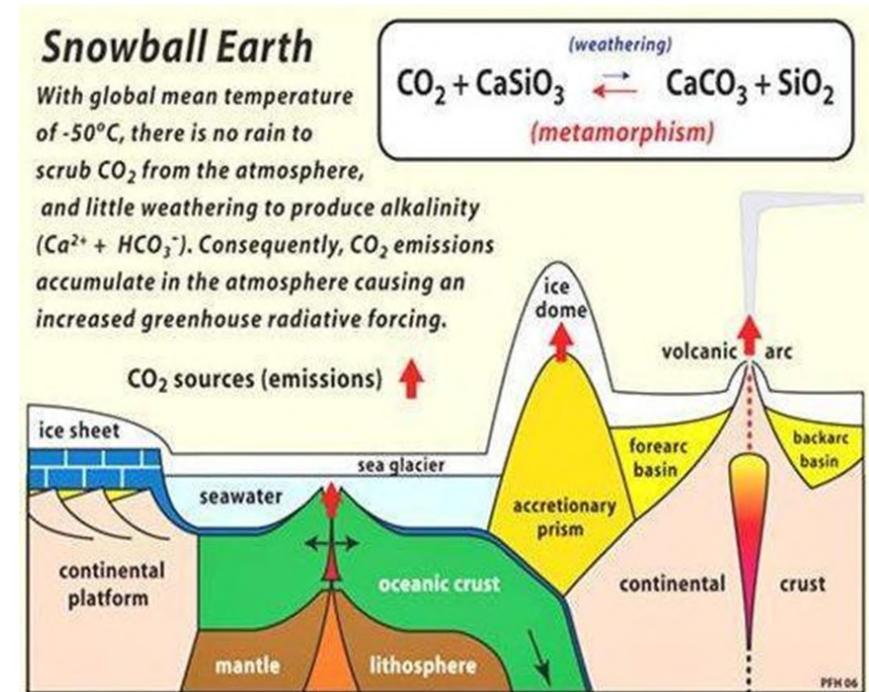
Bob Allen



- Models Rather than Ontologies
 - Indexing articles from historical newspapers
 - Traditional full-text indexing ineffective
 - Better to develop a community model

Direct Representation of Scientific Research Reports

- Models rather than Ontologies
 - Models are integral to research reports
 - Snowball Earth theory
 - Geological claim that the earth may have frozen over completely – an extreme ice age
 - Main question – how the earth escaped that extreme ice age
- In this talk, we will consider some issues for how to build these models
 - Specifically, the relationship of knowledge representation systems to object-oriented programming languages
 - These models have complex objects and systems (parts, states, mechanisms), microworlds, and context



From Upper Ontologies to Object-Oriented Models

- Upper Ontology (Basic Formal Ontology - BFO)
 - Establishes categories of entities allowed in application ontologies
 - Realist, Aristotelian, Universals/Particulars
 - Main distinctions:
 - Continuants/Occurrents
 - Independent Continuants/Dependent Continuants
- Programming Languages
 - Basic Features:
 - Data Types, State Machines, Guard Conditions, Threads, Concurrency, Conditionals
- Object-oriented Analysis, Models, and Programs
 - Smalltalk is a better example of object-oriented programming than Java.
 - Language Features: Inheritance, Classes and Methods
 - Typical Applications: Microworlds

Representation of Semantics of Complex Objects (#1)

- Transitionals (implement state changes)
 - BFO focuses on Processes, but state changes seem equally important
 - Conditions on whether a transition will occur
 - Sequences of Transitionals are common
 - Mechanisms, Workflows, Other sequences
 - Natural language verbs have semantic roles, which should be applied in semantic modeling.
- Relationships
 - BFO Core relationships (“inheres in”).
 - Increasingly, BFO applications include ad hoc relationships.
 - Many ad hoc relationships are actually events
 - If there is a person, there is necessarily a birth event
 - Rules/Axioms
 - Rules are like ad hoc relationships about the world we are trying to model.
 - Example: “Predators eat Prey”
- Definitions
 - Describe what implied about the relationship of the given object to other objects
 - A waterfall must have water and a stream with a drop.
 - A bakery must have a baker, an oven, and baked goods, and be a commercial establishment.
 - For modeling, we need a structure to describe these connections.

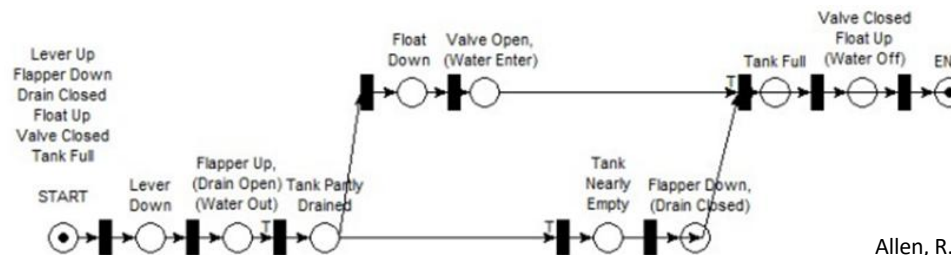
Representation of Semantics of Complex Objects (#2)

Parts: Different senses of Part_of (Winston, et al., 1987)

- *Component/Integral object (handle/cup, punchline/joke)*
 - Parts associated with activities
 - Distinct functional units or structural parts.
- *Feature/Activity (paying/shopping)*
 - Subprocess/Process.
 - Segments of an activity may be modeled with states and threads.
- *Portion/Mass (slice/pie, grain/salt)*
 - If a portion is distinct, it may be a fiat-object part
- *Place/Area (Everglades/Florida, oasis/desert)*
 - Nested spatial regions or nested sites
- *Member/Collection: (tree/forest, card/deck)*
 - Object aggregates, such as “a heap of stones” and “a symphony orchestra”
- *Stuff/Object: (gin/martini, steel/bike)*
 - A material and an object made from it.

Representation of Semantics of Complex Objects (#3)

- States and Stages
 - Simple states attach dependent continuants
 - Complex states are more difficult. Is ice a different entity than liquid water?
 - Representation issues
 - Perhaps it is the state of an aggregate of water molecules, but the details are not clear.



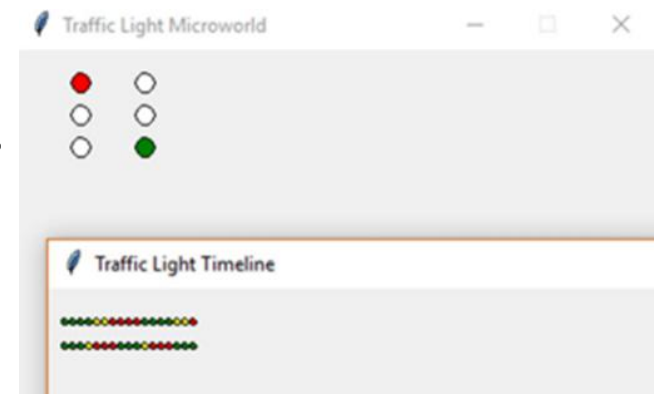
Allen, R.B. Issues for Using Semantic Modeling to Represent Mechanisms, arXiv: 1812.11431

- Configurations of Components and Scenarios
 - A person and the shirt they are wearing
 - Meta-operators, Yoked material entities

Representation of Semantics of Complex Objects (#4)

- Functions
 - In BFO, Functions are Realizable Dispositions
 - For example: “the function of amylase is to break down starch into sugar”
 - Depends on context
- Systems
 - A foundation of programming languages
 - Composed of interacting mechanisms
 - Many complex objects can be considered as systems
- Microworld
 - Environment for interacting objects
 - Can include gravity, temperature, pressure, etc
 - Focus on specific issues by nesting microworlds
 - Could be conceptualized as a type of system

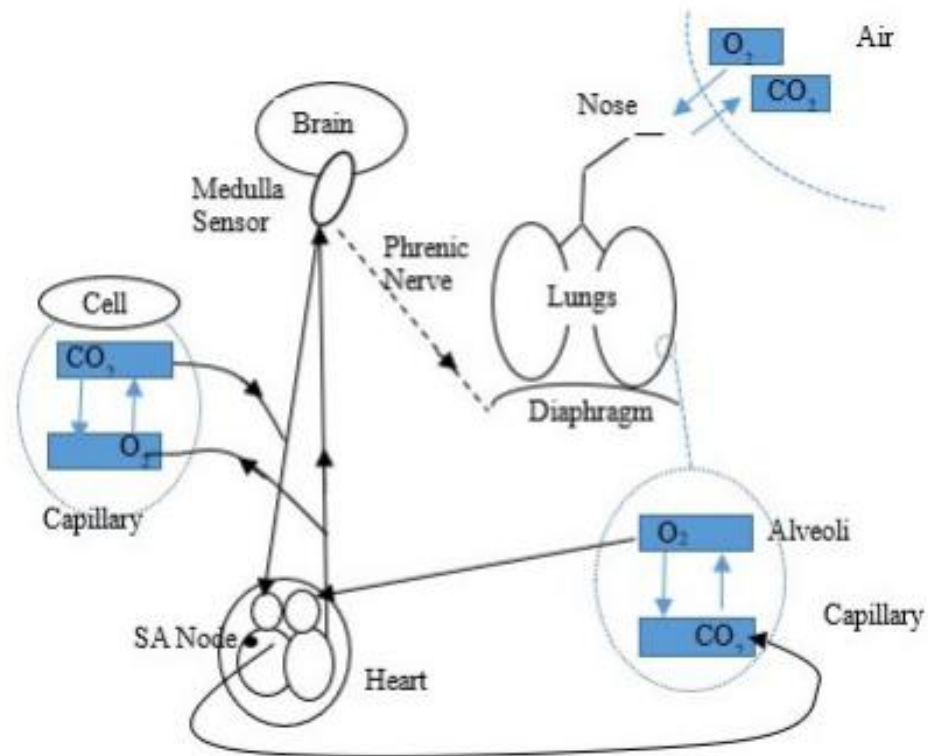
Microworld programmed with semantic modeling framework.



Allen, R.B. and Jones, T.K., XFO: Toward Programming Rich Semantic Models (April2018), arXiv:1805.11050

Example: Semantic Model of Cardio-Pulmonary System

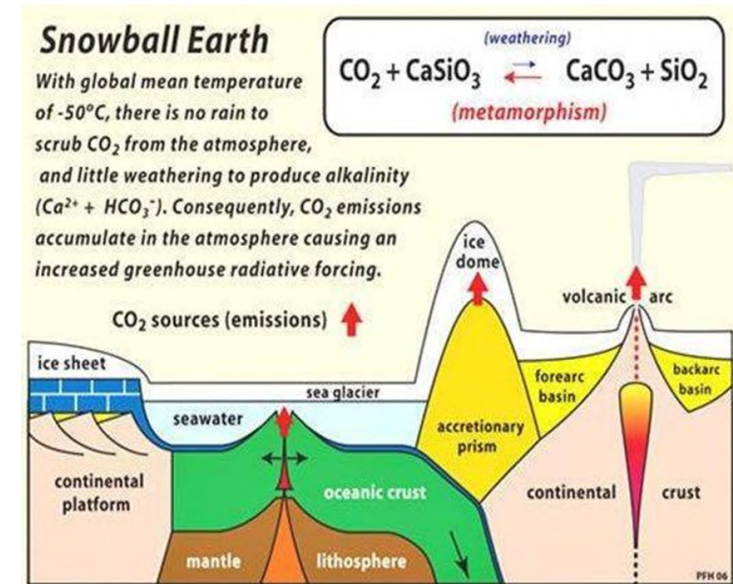
Constructed purely from local interaction (message passing) between material entities.



Allen, R.B., Definitions and Semantic Simulations Based on Object-Oriented Analysis and Modeling, 2019, ARXIV 1912.13186

Evidence and Discourse

- Evidence
 - Snowball Earth model is based on a lot of details geological evidence.
 - Evidence has its own model that needs to be related to the broader model.
 - Collecting evidence
 - Workflows for the collection of evidence
 - Measurement procedures
- Style of presentation in a research report
 - One approach: Tracking the emergence and synergies of the model and the evidence
 - A second approach: Direct Model descriptions
 - Follow the mechanisms of the model.
 - Ideally, one framework could support both approaches.



Conclusion

- We describe a modeling framework that is centered on complex objects.
- We have discussed solutions to several modeling puzzles.
- Future work can include more advanced Object-oriented modeling techniques such as:
 - Actors model (can include timing of interactions)
 - Object-oriented system dynamics
- Overall, modeling is a useful perspective.