Architecting Digital Twins for Model-Centric Engineering: Semantic and Machine Learning Approach

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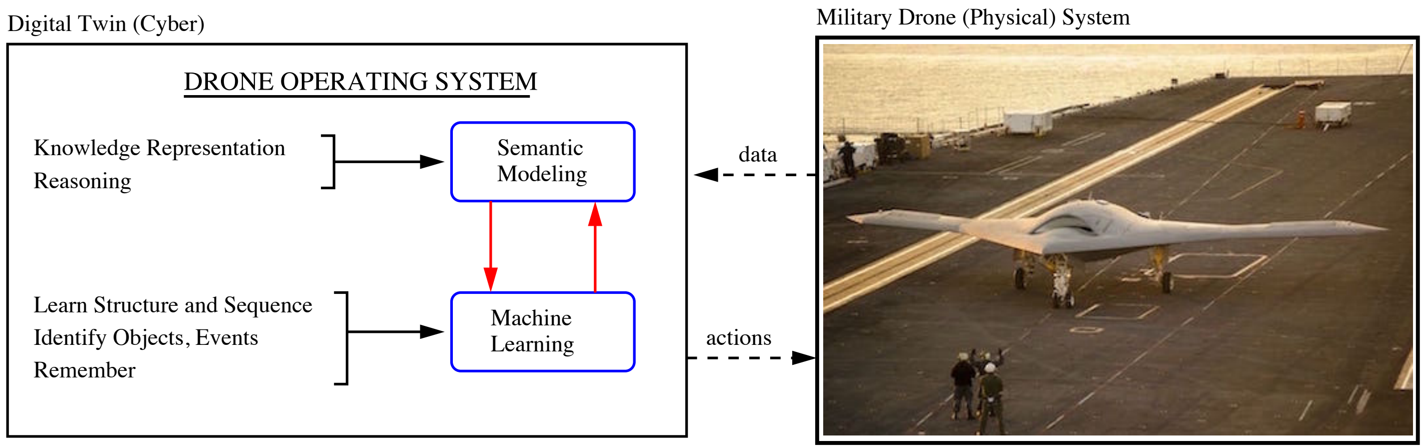
Incubator Project

Basic Idea: Explore design of digital twin architectures that support AI and ML formalisms working side-by-side as a team, providing complementary and supportive roles in collection of data, identification of events, and automated decision making.

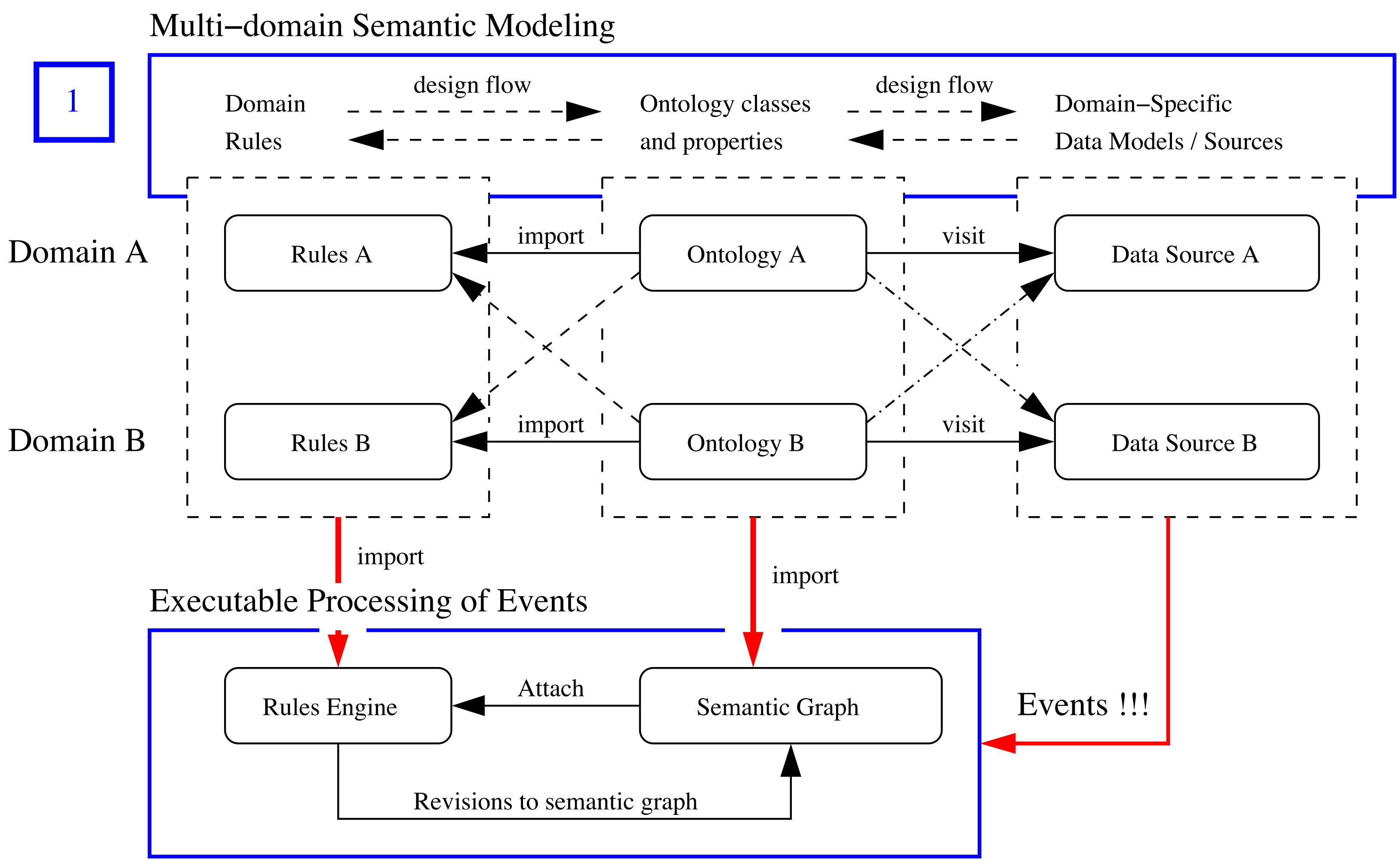


Research Challenge: How to design digital twin elements and their interactions so that collectively they can support a wide variety of systems engineering methods and processes?

Incubator Goals: Understand the range of possibilities for which machine learning of large-scale graphs and their attributes support activities in model-centric engineering.

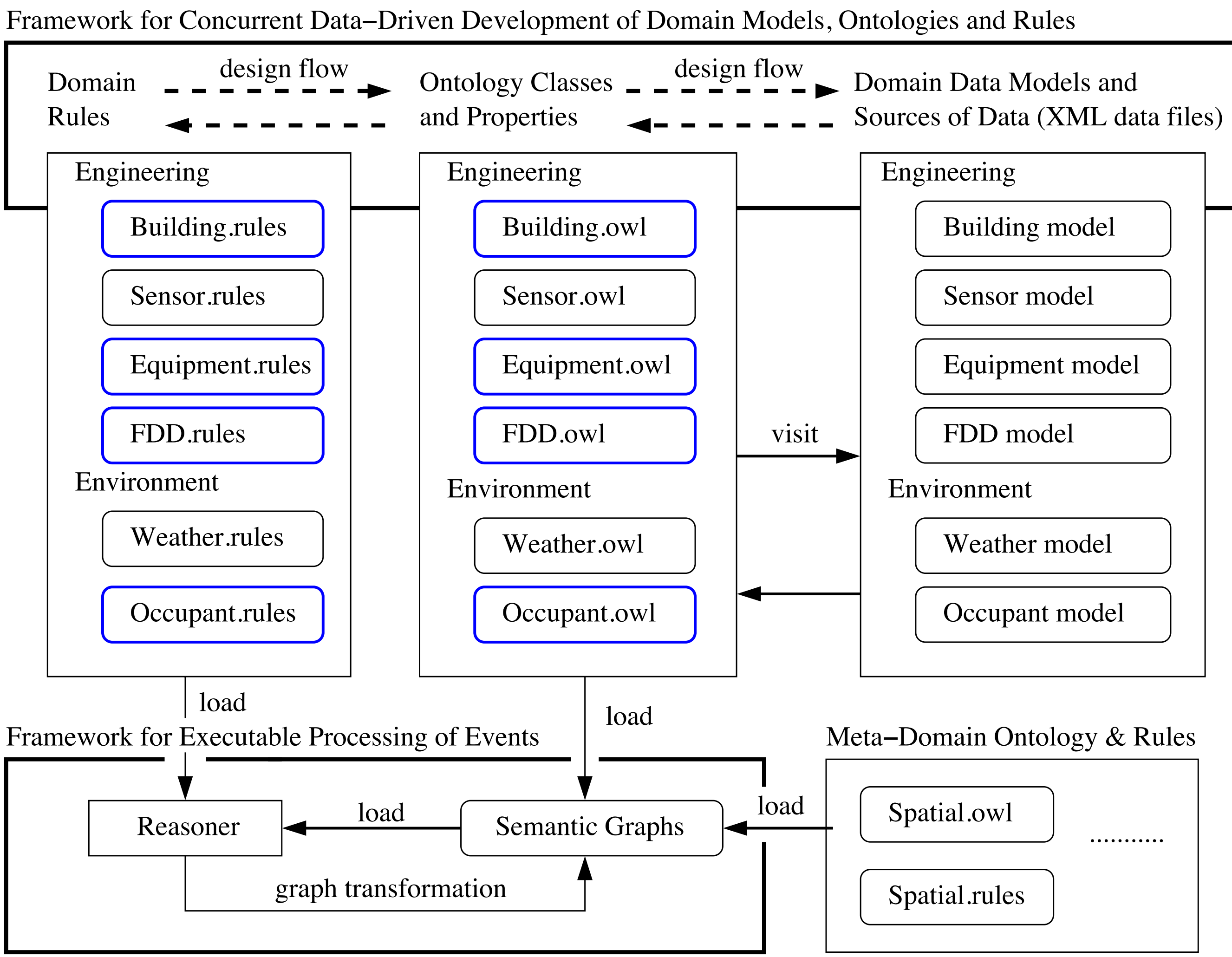
Architecture for Multi-Domain Semantic Modeling

Step 1: Data-Ontology-Rule Footing (Work at UMD / NIST / SERC in 2017).

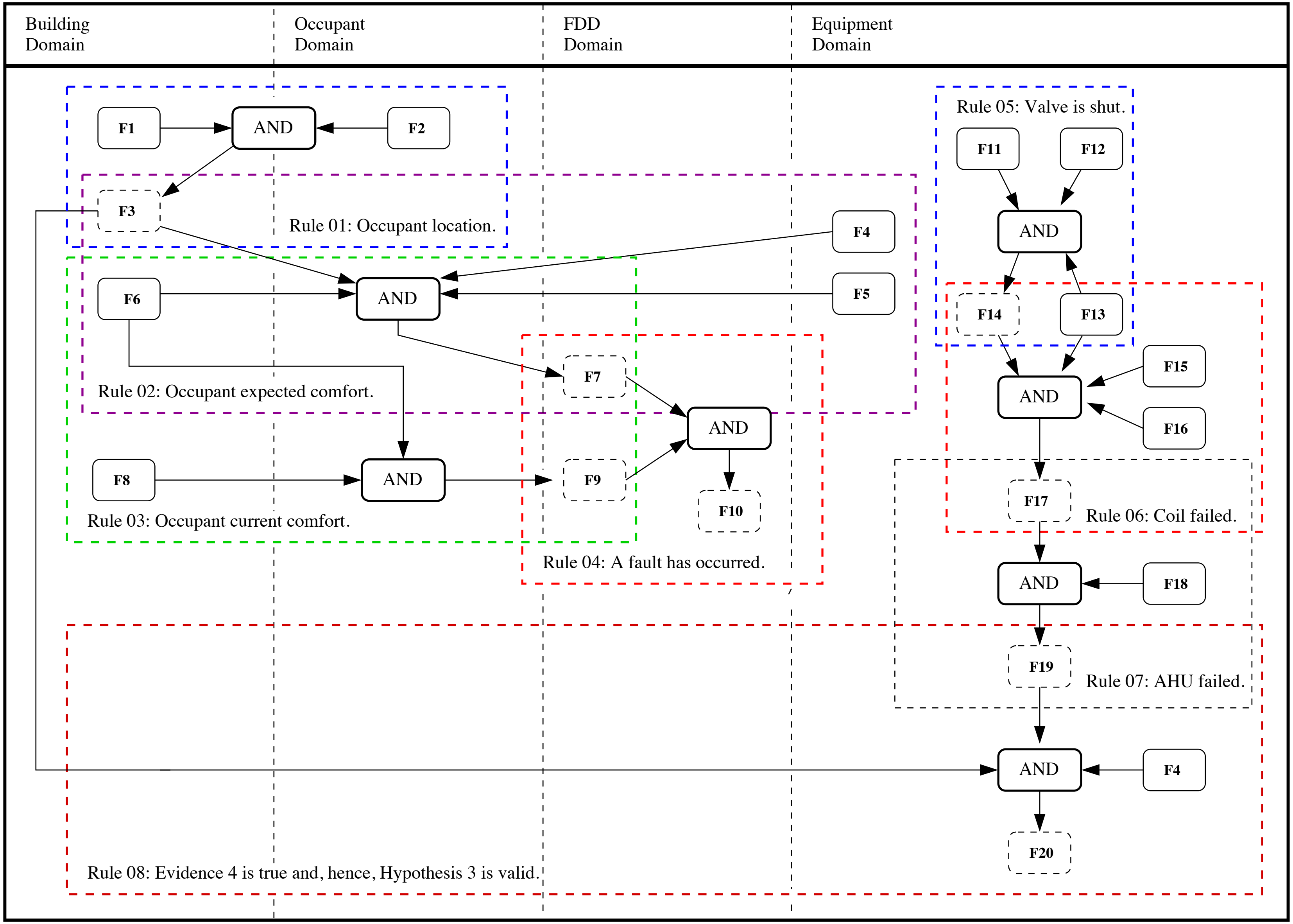


Multi-Domain Semantic Modeling

Example: Detection and Diagnostic Analysis of Faults in HVAC Equipment.

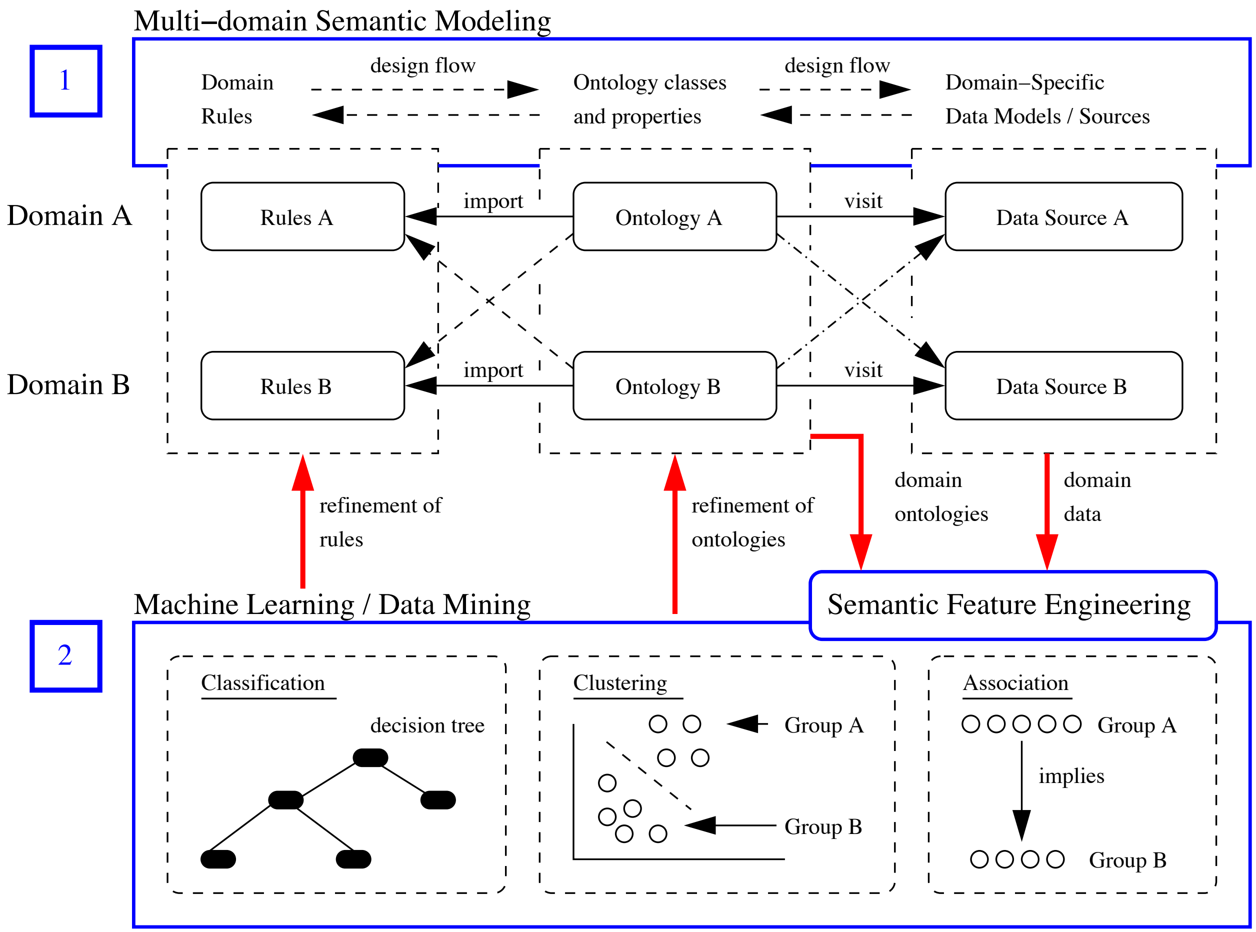


Multi-Domain Semantic Modeling



Combined Semantics + Data Mining

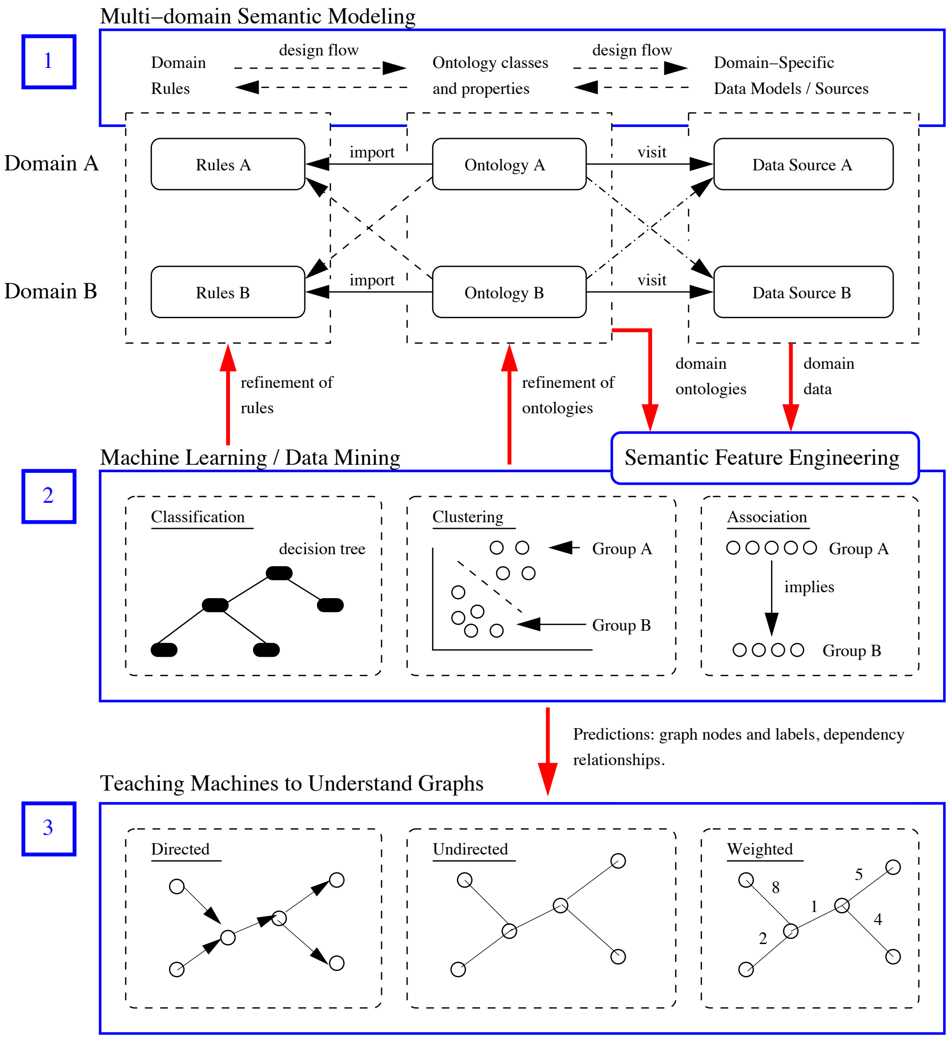
Step 2: Work at UMD / Building Energy Group at NIST / NCI, 2018-2019



Research Question: How can semantic modeling + machine learning / data mining work together as a team?

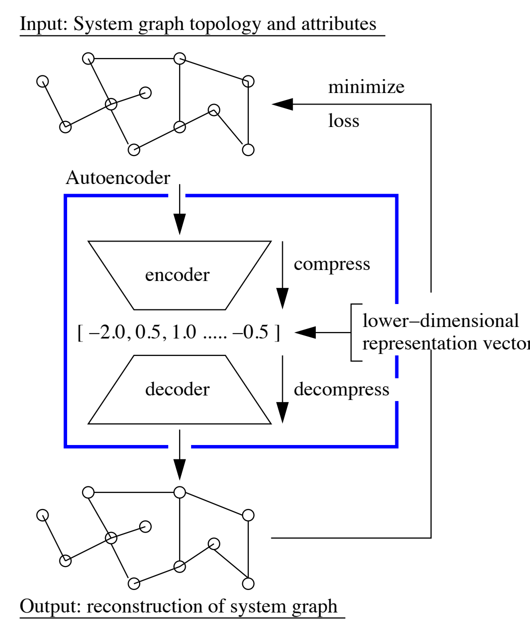
Incubator Project

Step 3: Focus on Machine Learning of Graphs and Model-Centric Engineering.



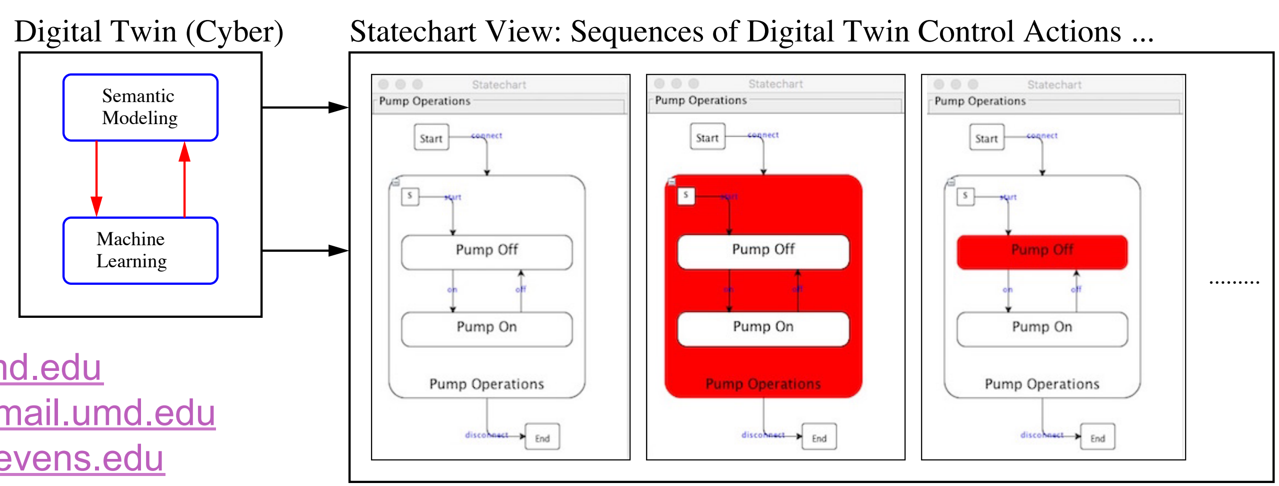
Observation: A lot of model-centric engineering boils down to representation of systems as graphs and sequences of graph transformations punctuated by decision making and work / actions.

Hence: Explore opportunities for teaching machines to understand graphs.



Incubator Research Questions

- What types of graphs (e.g., undirected, directed, weighted, multi-graph) are easy for the ML to learn?
- How well do these techniques work with graph topology and attributes that are dynamic?
- What can the ML do that is outside the capability of semantic modeling? And vice-versa?
- How can the ML improve the semantic modeling? And vice-versa?
- How to design the red arrows connecting layers 1, 2 and 3?
- How to represent and reason with uncertainties?
- How does the difficulty of these challenges increase with graph size?
- How to map AI-ML capability to state-of-the-art engineering views?



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