PROGNOS: Applying Probabilistic Ontologies to Distributed Predictive Situation Assessment in Naval Operations

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Case Study - Arabian Sea MSO

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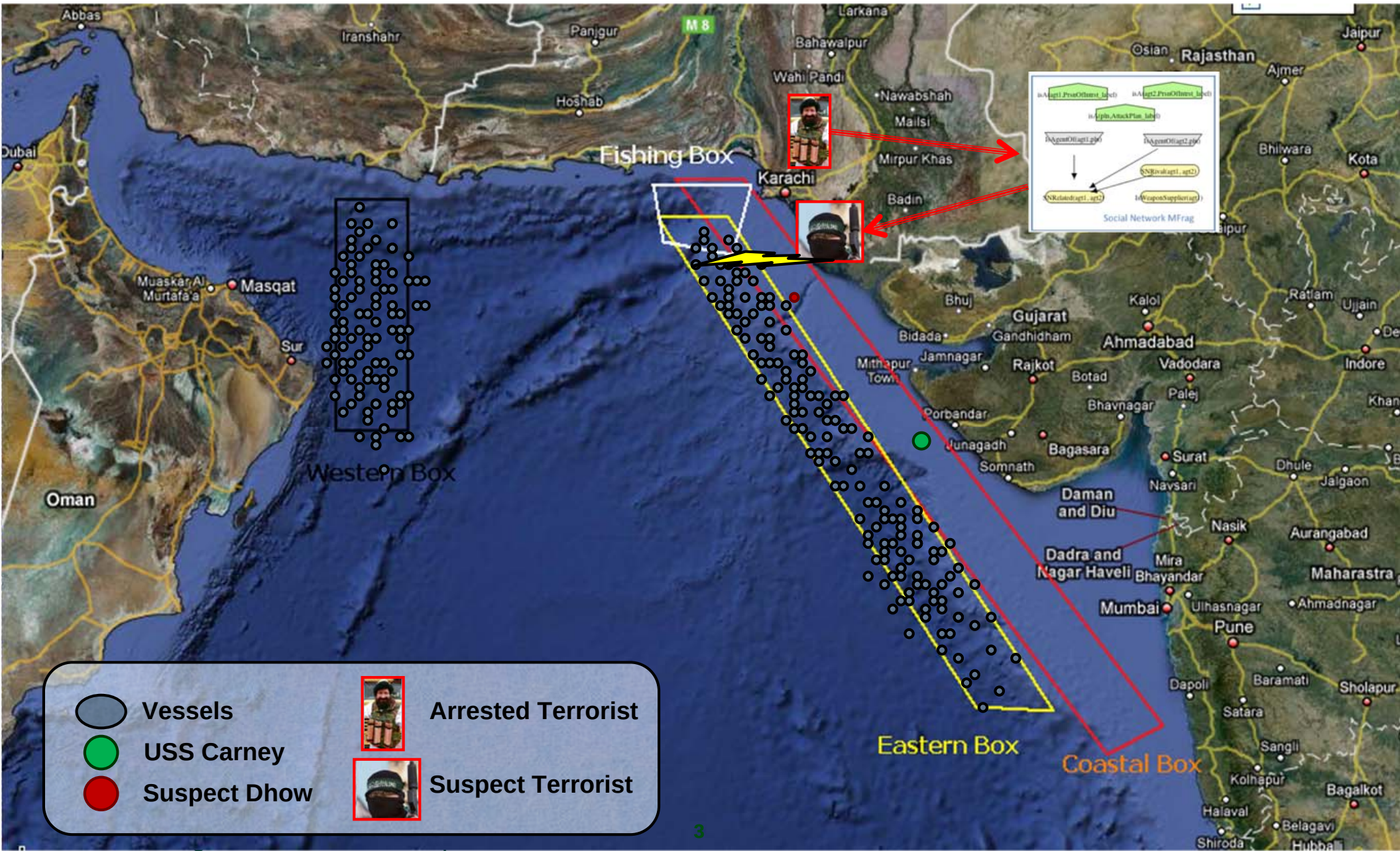
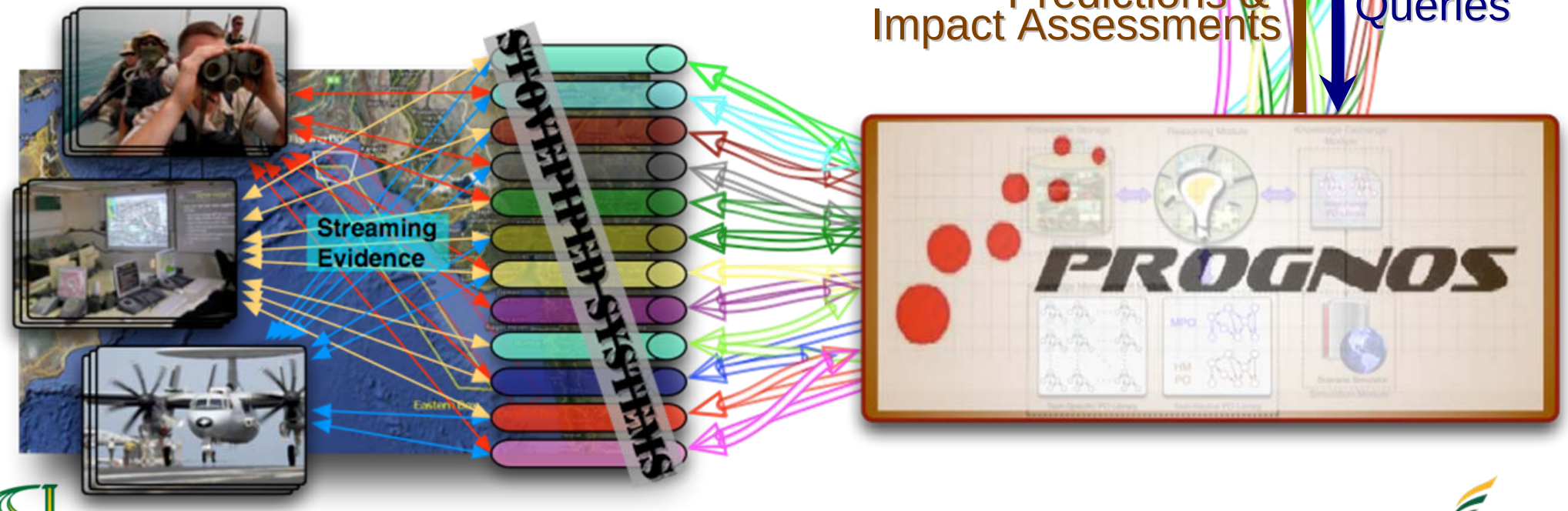


Problem Statement

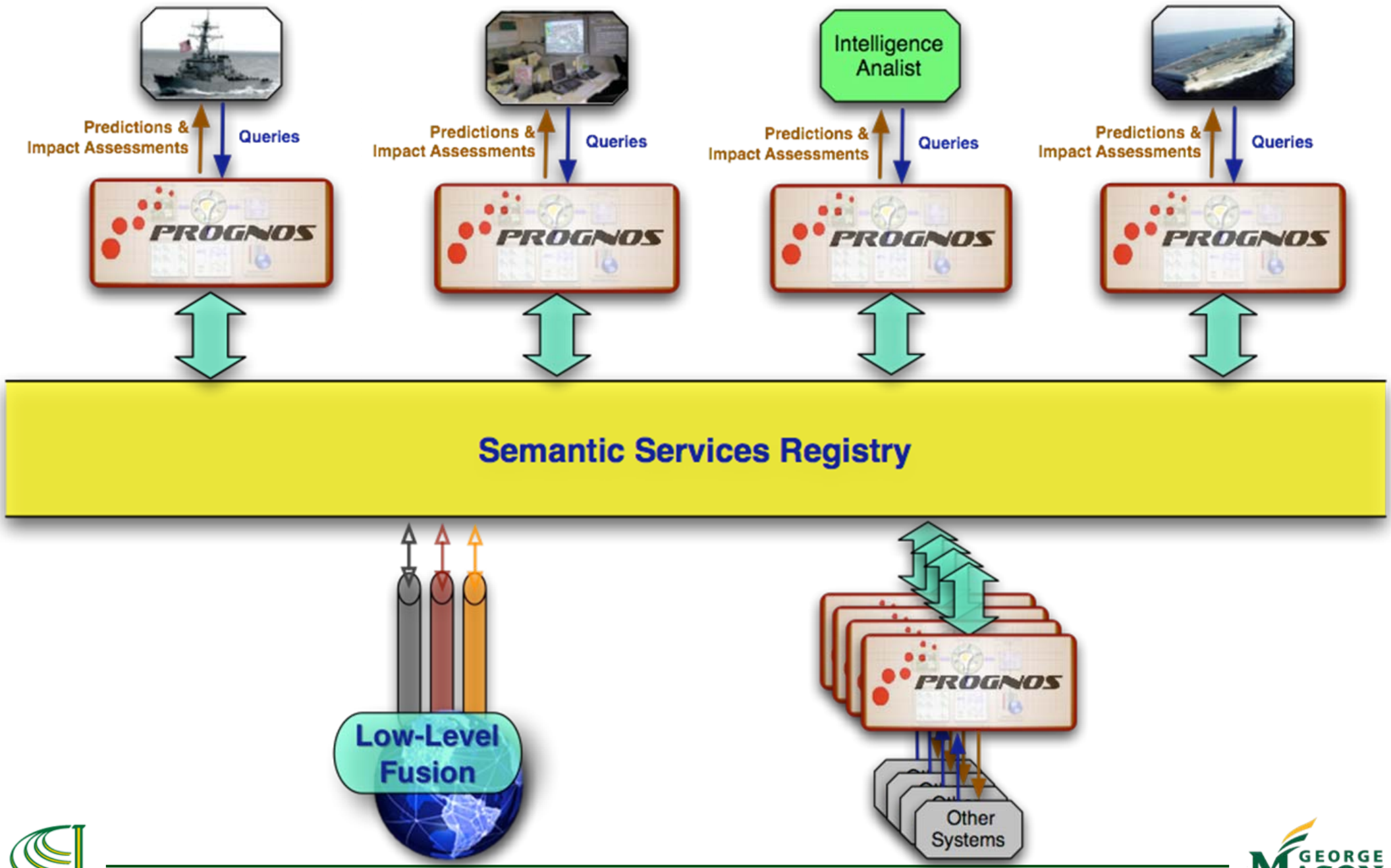
- Current technology provides lower-level multi-sensor data fusion through stove-piped systems
- High Bandwidth Net-Centric systems such as FORCENet can manage thousands of tracks through many and diverse sensors.
- Humans are responsible for the higher-level fusion, creating a situational awareness and performing their own predictive analysis
- Cognitive overflow, among other issues, hamper this process, preventing optimal decision-making

Prognos Purpose

- Provide consistent higher-level fusion through state-of-the-art knowledge representation and reasoning
- Enable predictive analysis with principled hypothesis management

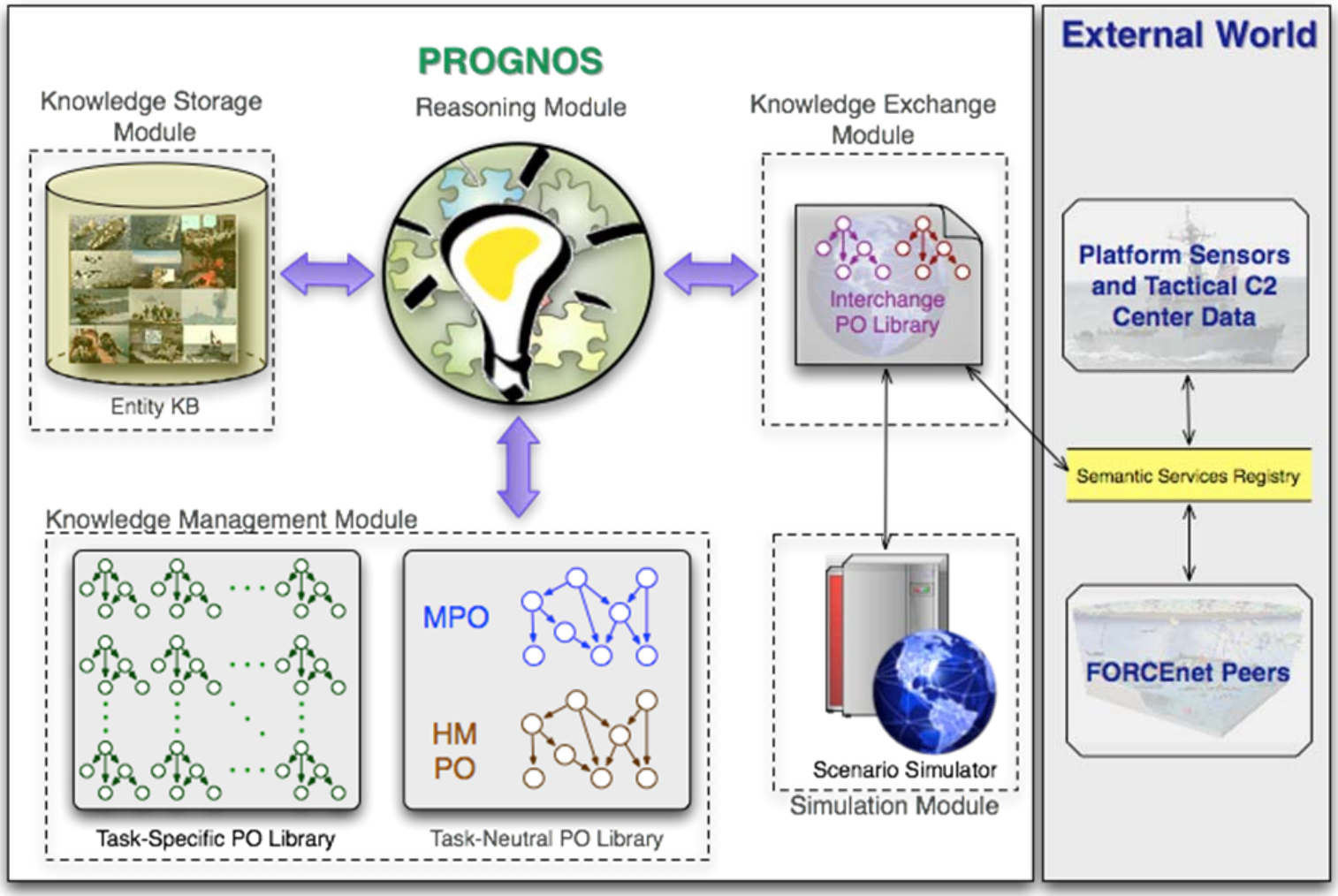


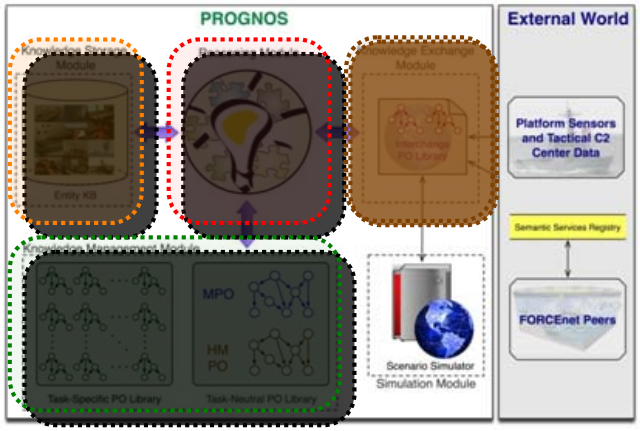
High-Level Fusion Architecture



Architecture Components

- Interoperability with FORCENet and external systems via a set of interchange POs
- Hybrid reasoning in support for a Hypothesis Management engine
- Internal entity storage module in FORCENet formatting
- Task-specific POs for optimal mission-based inferences
- Domain-agnostic PO library in support to general reasoning and HMng.
- Simulation module for both system training and evaluation



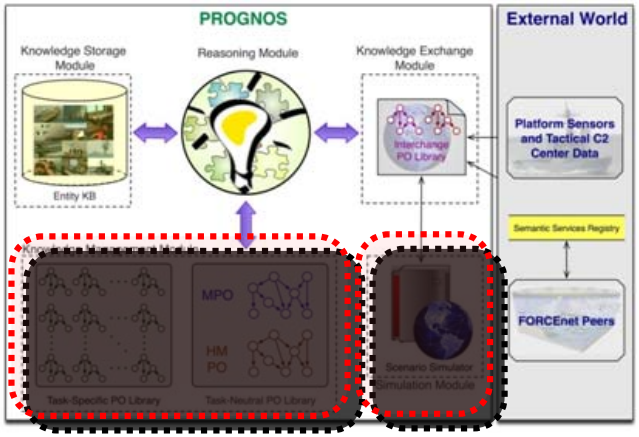


Hypothesis Management in PROGNOS

- Incoming data or new queries trigger a new cycle of the hypothesis management process.
- Both are assessed with respect to relevance and impact to existing hypothesis, either creating a new hypothesis or extending an existing one.
- In conjunction with the knowledge management POs, they can also trigger the hypothesis discovery engine.

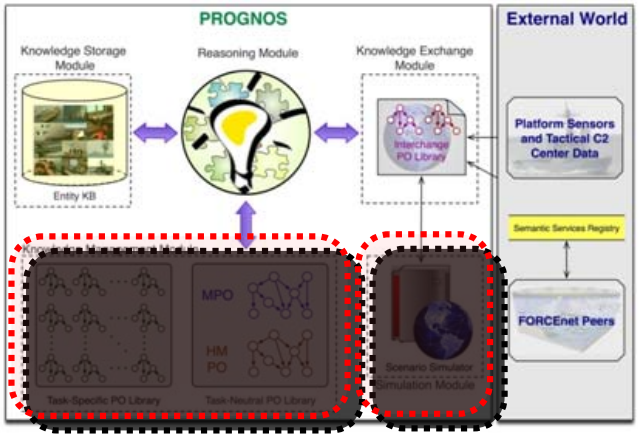
Enabling Technologies

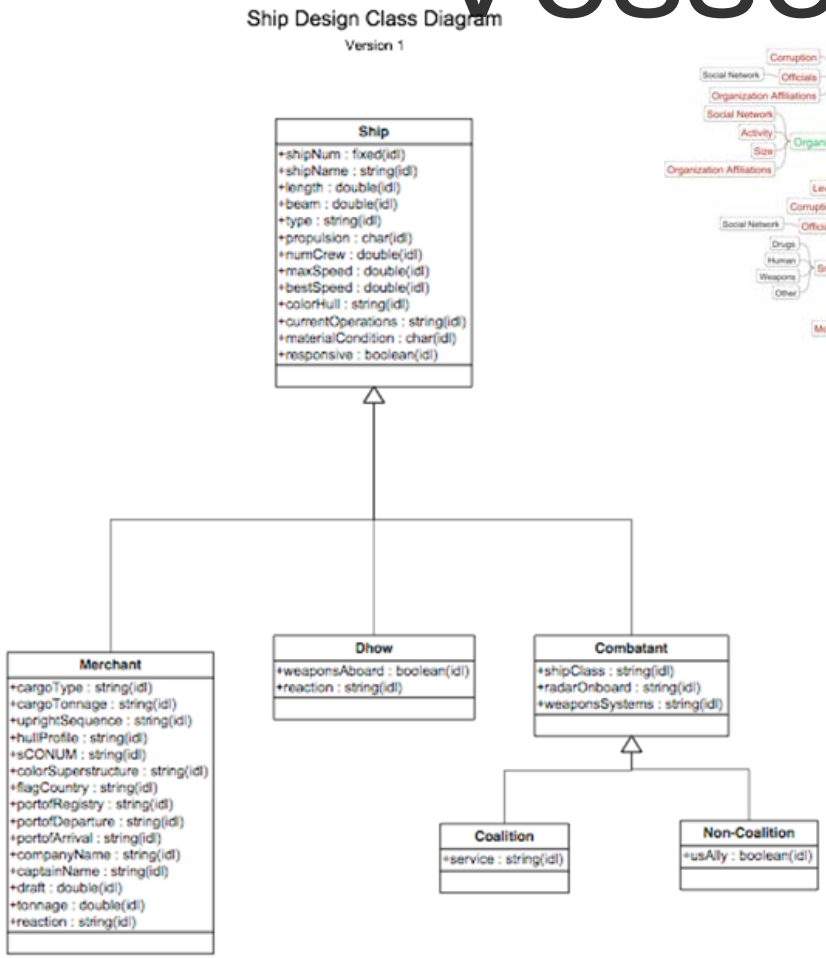
- Multi-Entity Bayesian Networks
  - Combine the expressivity of FOL with the inferential power of Bayesian Networks
  - Built on a rigorous mathematical foundation
- PR-OWL Probabilistic Ontology Language
  - Combine the advantages of semantic-enabled approaches with support for principled uncertainty representation and reasoning.
- Spatio-Temporal Hypothesis Management
  - Extends current HM techniques to a higher level of expressivity, enabling sophisticated analyses over very large numbers of hypotheses.
- Efficient Distributed Hybrid Inference
  - Addresses both discrete and continuous random variables
  - Unscented transformation has been shown to be more accurate than traditional linearization methods

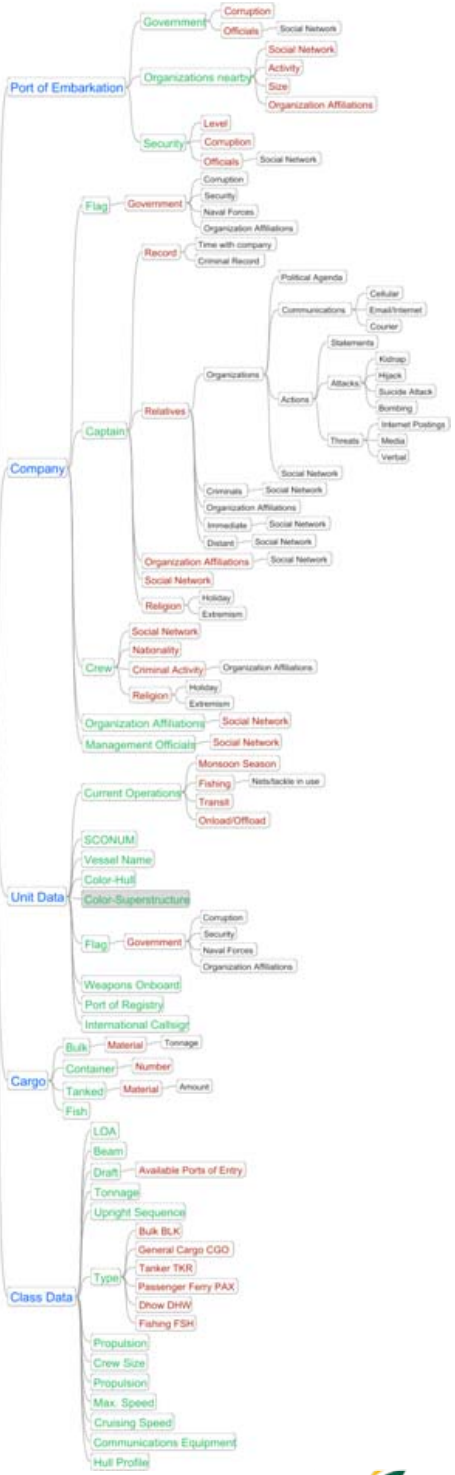


Behavior of a Surface Vessel

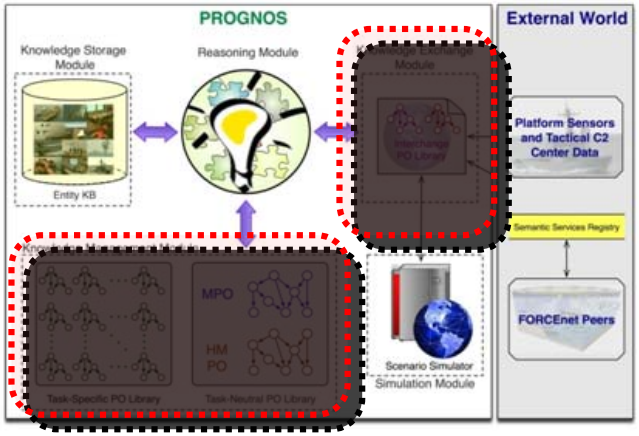
Modeling TOI of a Vessel

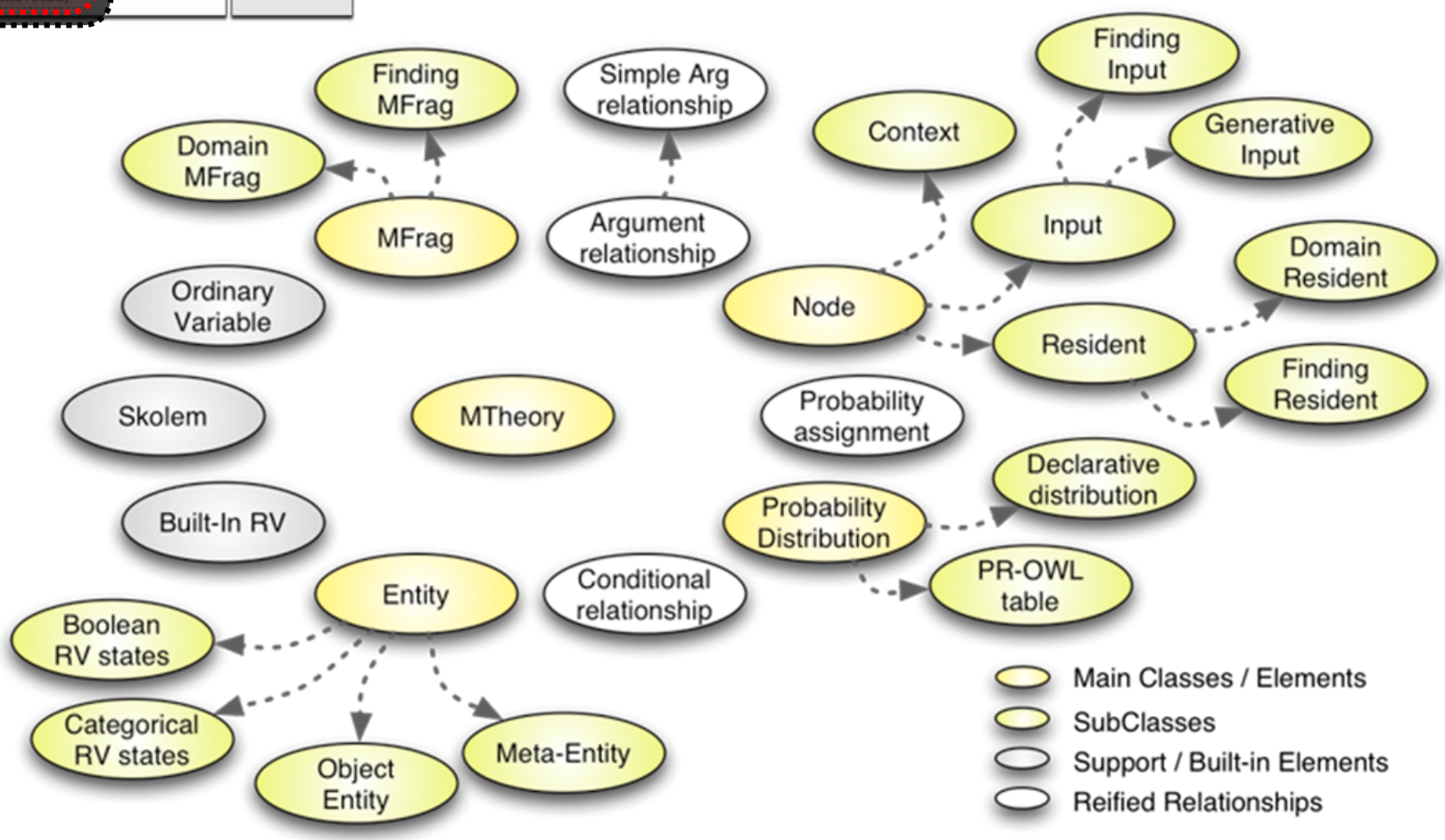


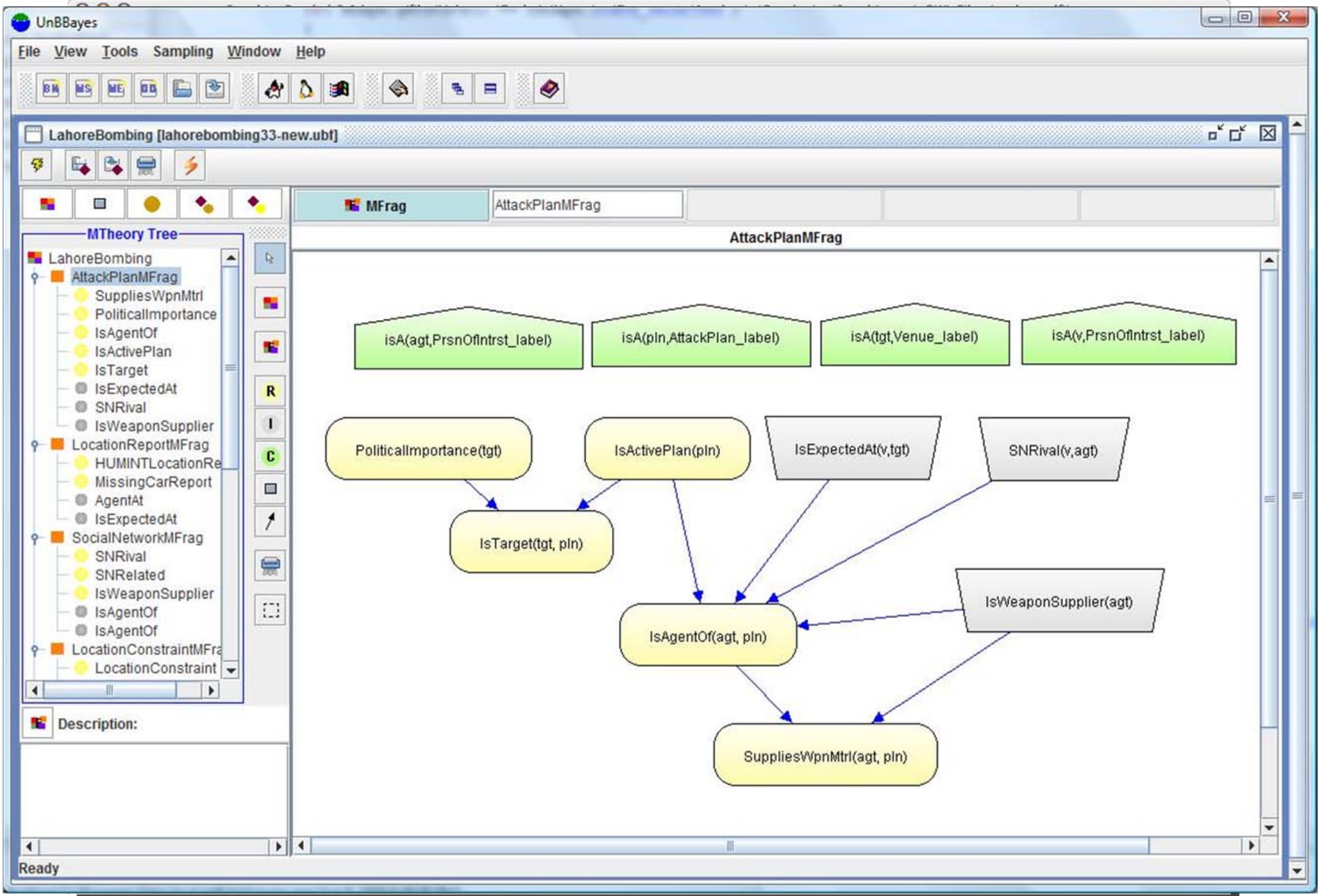




PR-OWL


PROGNOS
External World
Knowledge Storage Module
Reasoning Module
Entity KB
Platform Sensors and Tactical C2 Center Data
Semantic Services Registry
FORCEnet Peers
MPO
HM PO
Scenario Simulator
Simulation Module


Finding MFrag
Simple Arg relationship
Finding Input
Context
Generative Input
Domain MFrag
MFrag
Argument relationship
Input
Domain Resident
Ordinary Variable
Node
Resident
Finding Resident
Skolem
MTheory
Probability assignment
Declarative distribution
Built-In RV
Probability Distribution
PR-OWL table
Entity
Conditional relationship
Boolean RV states
Categorical RV states
Object Entity
Meta-Entity
Main Classes / Elements
SubClasses
Support / Built-in Elements
Reified Relationships


UnBBayes
File View Tools Sampling Window Help
LahoreBombing [lahorebombing33-new.ubf]
MFrag
AttackPlanMFrag
MTheory Tree
LahoreBombing
AttackPlanMFrag
SuppliesWpnMtrl
PoliticalImportance
IsAgentOf
IsActivePlan
IsTarget
IsExpectedAt
SNRival
IsWeaponSupplier
LocationReportMFrag
HUMINTLocationRe
MissingCarReport
AgentAt
IsExpectedAt
SocialNetworkMFrag
SNRival
SNRelated
IsWeaponSupplier
IsAgentOf
IsAgentOf
LocationConstraintMFra
LocationConstraint
Description:
AttackPlanMFrag
isA(agt,PrsnOfIntrst_label)
isA(pln,AttackPlan_label)
isA(tgt,Venue_label)
isA(v,PrsnOfIntrst_label)
PoliticalImportance(tgt)
IsActivePlan(pln)
IsExpectedAt(v,tgt)
SNRival(v,agt)
IsTarget(tgt, pln)
IsWeaponSupplier(agt)
IsAgentOf(agt, pln)
SuppliesWpnMtrl(agt, pln)
Ready

Resources – PR-OWL Website

PR-OWL Home

http://www.pr-owl.org/

PR-OWL: A Bayesian extension to the OWL Ontology Language

PR-OWL | MEBN | Bayesian Networks | UnBBayes

Background Material

Probabilistic Ontologies

PR-OWL Guide

PR-OWL Semantics

PR-OWL Ontologies

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Related Links

URSW 2005
URSW 2006
URSW 2007
URSW 2008
URW3 XG Group
URW3 Charter
GMU C4I Center
UnB

Search pr-owl.org

Go

Match:

Any word
All words
Exact phrase
Sound-alike matching

PR-OWL

A Bayesian Framework for Probabilistic Ontologies

What is PR-OWL?

PR-OWL is an open research work aimed to extend the OWL ontology Web language so it can represent probabilistic ontologies. In other words, it is a probabilistic extension to OWL that provides a framework for authoring probabilistic ontologies and is based on the Bayesian first-order logic called Multi-Entity Bayesian Networks (MEBN).

A More Detailed Explanation

Uncertainty is ubiquitous. Any representation scheme intended to model real-world actions and processes must be able to cope with the effects of uncertain phenomena.

A major shortcoming of existing Semantic Web technologies is their inability to represent and reason about uncertainty in a sound and principled manner. This not only hinders the realization of the original vision for the Semantic Web, but also raises an unnecessary barrier to the development of new, powerful features for general knowledge applications.

The overall goal of our research is to establish a Bayesian framework for probabilistic ontologies, providing a basis for plausible reasoning services in the Semantic Web. As an initial effort towards this broad objective, this dissertation introduces a probabilistic extension to the Web ontology language OWL, thereby creating a crucial enabling technology for the development of probabilistic ontologies.

The extended language, PR-OWL (pronounced as "prowl"), adds new definitions to current OWL while retaining backward compatibility with its base language. Thus, OWL-built legacy ontologies will be able to interoperate with newly developed probabilistic ontologies. PR-OWL moves beyond deterministic classical logic (Frege, 1879; Peirce, 1885), having its formal semantics based on MEBN probabilistic

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