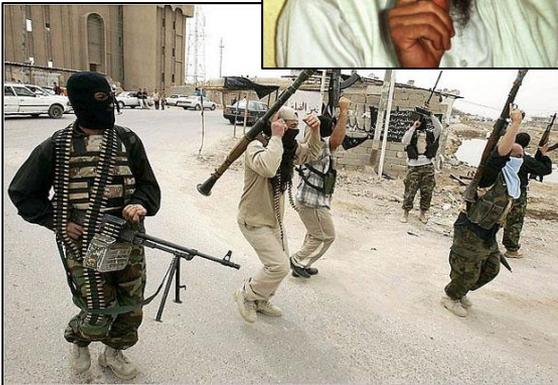


# Probabilistic Ontology Architecture for a Terrorist Identification Decision Support System

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*International Command & Control Research &  
Technology Symposium  
June 16-19, 2014*

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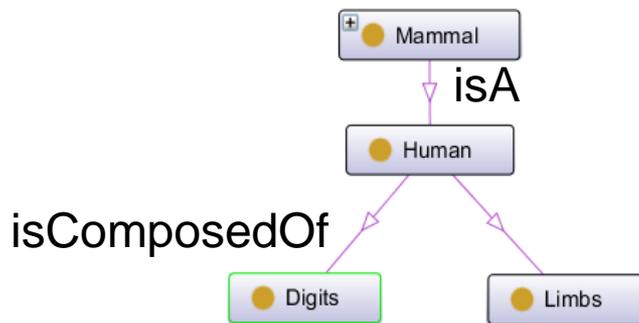


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Kathryn B. Laskey (George Mason University)*

# Background

# Why Probabilistic Ontologies?

- Suppose an ontology of organisms contains the following classes and relationships:

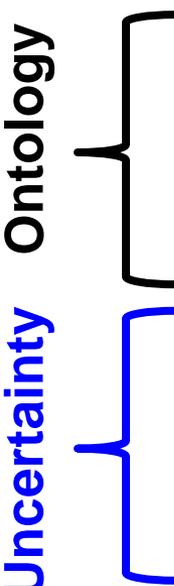


- Humans *usually* have:
  - 2 arms & 2 legs
  - 10 fingers & 10 toes
- However, if a man loses a limb....
  - Is he no longer human?

*Premise of an argument can be uncertain (e.g. Humans have 2 legs): (in)validity of the argument imposes no condition on the certainty of the conclusion (an amputee is Human).*

# Probabilistic Ontology Defined

A *probabilistic ontology* is an explicit, formal representation of knowledge about a domain of application. This includes

- 
- Types of entities that exist in the domain;
  - Properties of those entities;
  - Relationships among entities;
  - Processes and events that happen with those entities;
  - **Statistical regularities that characterize the domain;**
  - **Inconclusive, ambiguous, incomplete, unreliable, and dissonant knowledge related to entities of the domain;**
  - **Uncertainty about all the above forms of knowledge;**

where the term entity refers to any concept that can be described and reasoned about within the domain of application [Costa, 2005].

*An ontology is an explicit specification of a conceptualization* [Gruber, 95].

*A probabilistic ontology extends a traditional ontology to represent uncertainty.*

- A systematic approach to probabilistic ontology development
  - Facilitated through a reference architecture
    - Formalizes the application of the methodology
    - Extensible to various domains
- Reference Architecture for Probabilistic Ontology Development (RAPOD)
  - A generalized reference architecture designed to collect, catalogue, and define the components required for development of probabilistic ontologies and establish the criteria to be satisfied by any set of selected tools and methods

*RAPOD provides a flexible solution*

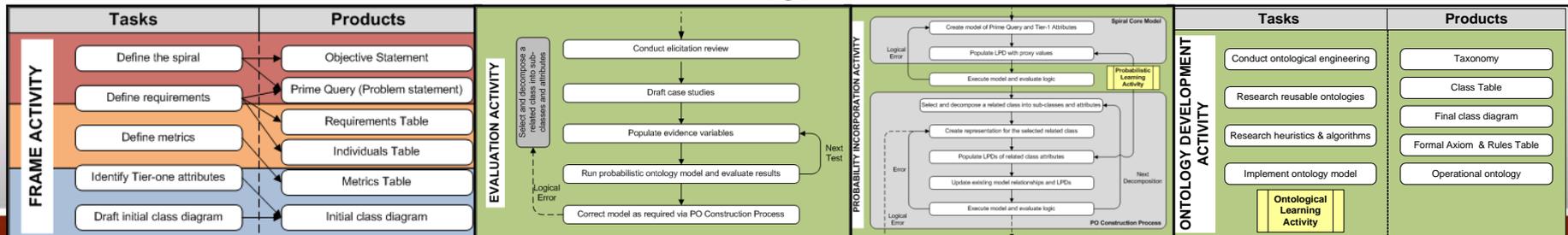
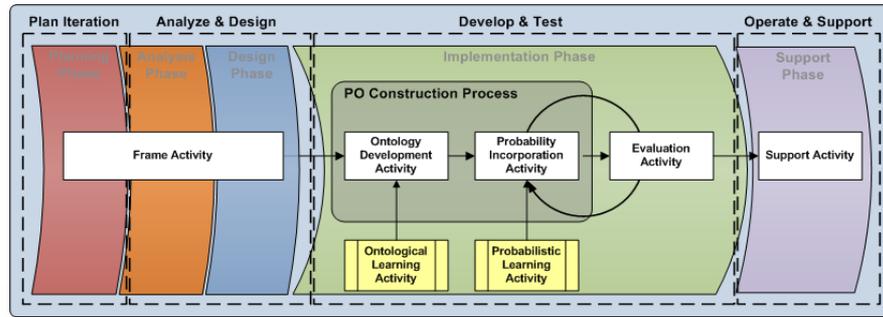
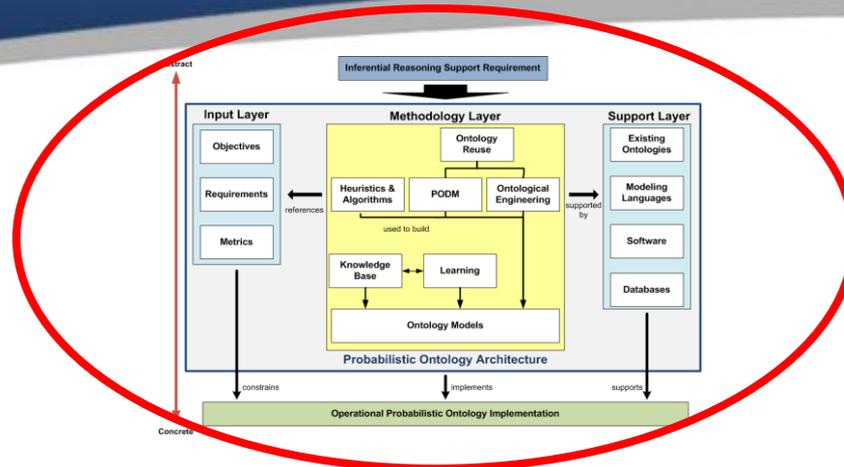
- Provides a blueprint for architects to develop specific solution architectures within a defined domain.
  - Template for development
  - Defines integral components and their relationships
  - Reduces development time and project risk
- Standardizes language among participants
- Provides consistency of development within a domain
- Provides a reference for evaluation
- Establishes specifications and patterns

*[A Reference Architecture is] "... an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions [OASD/NII, 2010]."*

- Provides synergy of effort within the ST community
  - Identifies concepts, processes, languages, theories and tools
  - Synergizes effort of probabilists, logicians, decision analysts, computer scientists
- Spans knowledge, processes, models and tools necessary to engineer POs at a high level of abstraction
- Output defines a domain specific architecture that may be used to produce probabilistic ontologies in similar domain contexts

*RAPOD output is an architecture*

# The RAPOD in Probabilistic Ontology Development



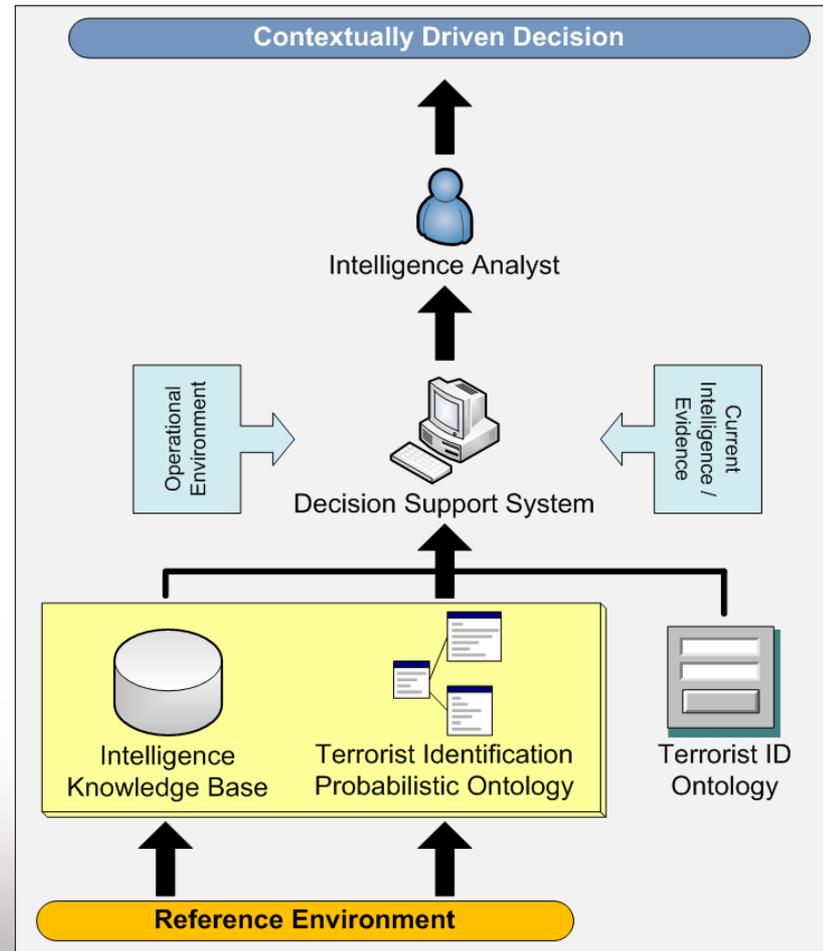
# Architecture for the Terrorist Identification Probabilistic Ontology (TIDPO)

## Objective

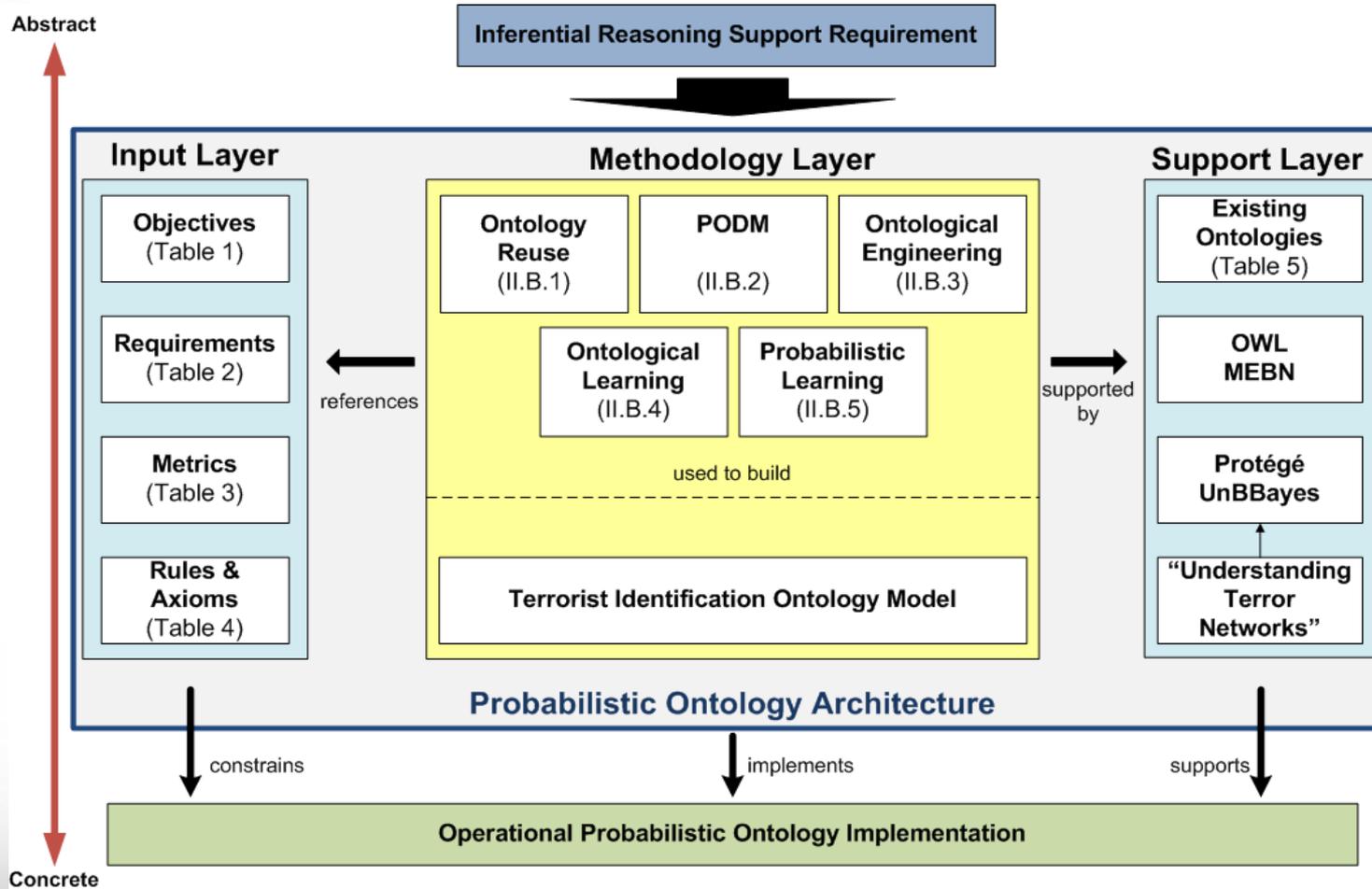
Develop a DSS that assists in determining if an individual is associated with terrorism.

*“A DSS is a system under control of one or more decision makers that assists in the activity of decision making by providing an organized set of tools intended to impose structure on portions of the decision-making situation and to improve the ultimate effectiveness of the decision outcome [Marakas, 2003].”*

## Concept Diagram

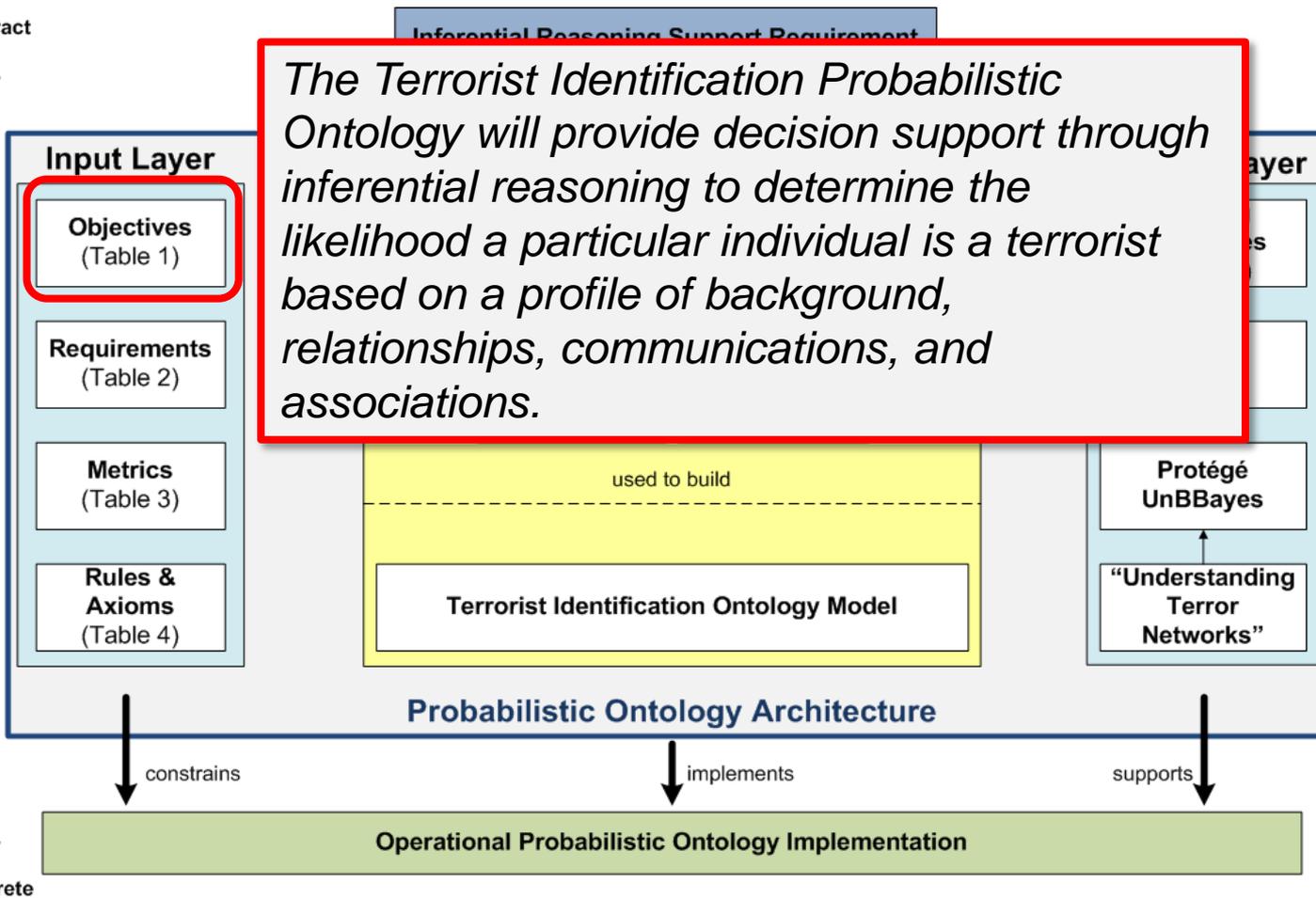


# Architecture for Terrorist Identification Probabilistic Ontology



# Architecture for Terrorist Identification Probabilistic Ontology

Abstract

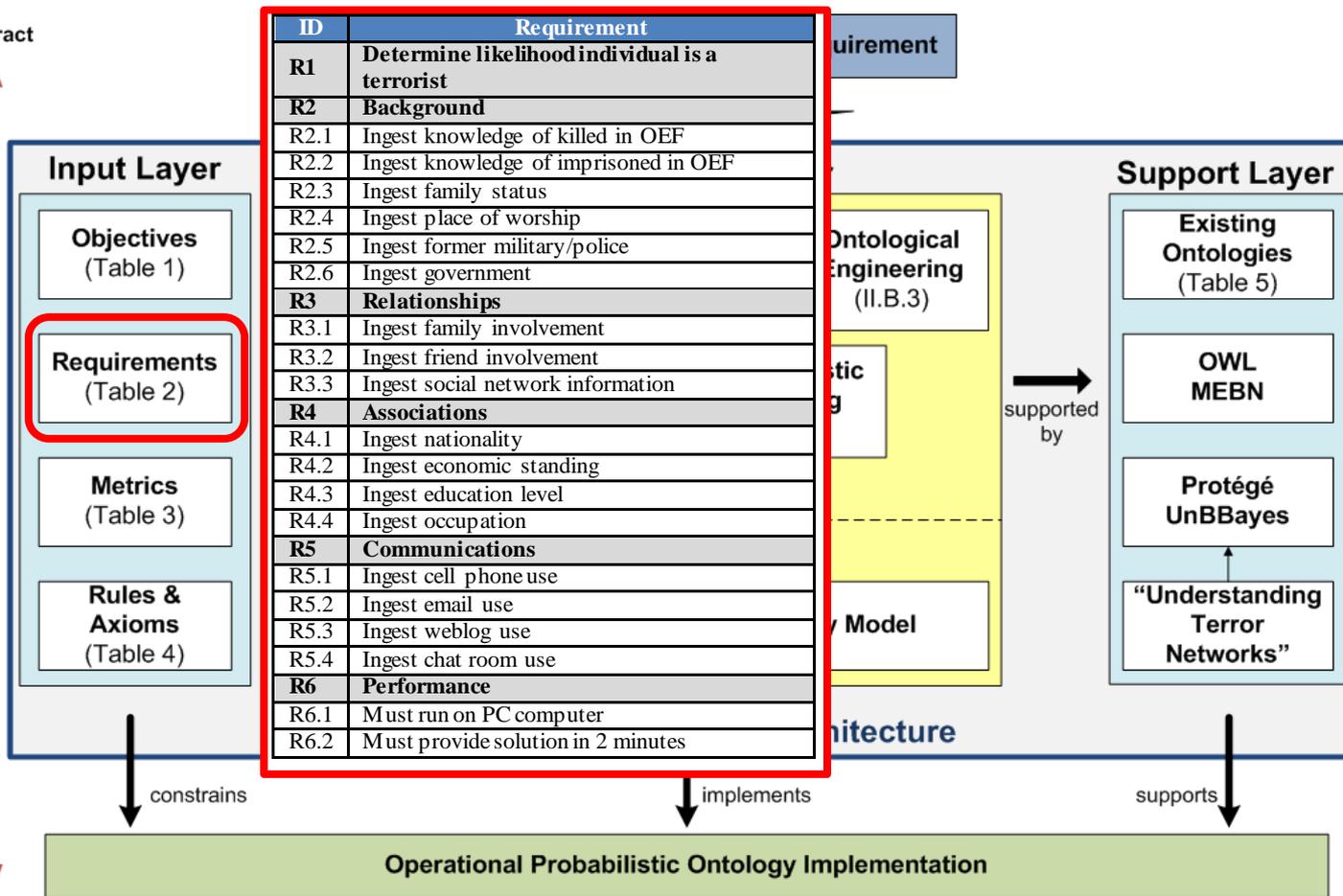


*The Terrorist Identification Probabilistic Ontology will provide decision support through inferential reasoning to determine the likelihood a particular individual is a terrorist based on a profile of background, relationships, communications, and associations.*

# Architecture for Terrorist Identification Probabilistic Ontology

Abstract

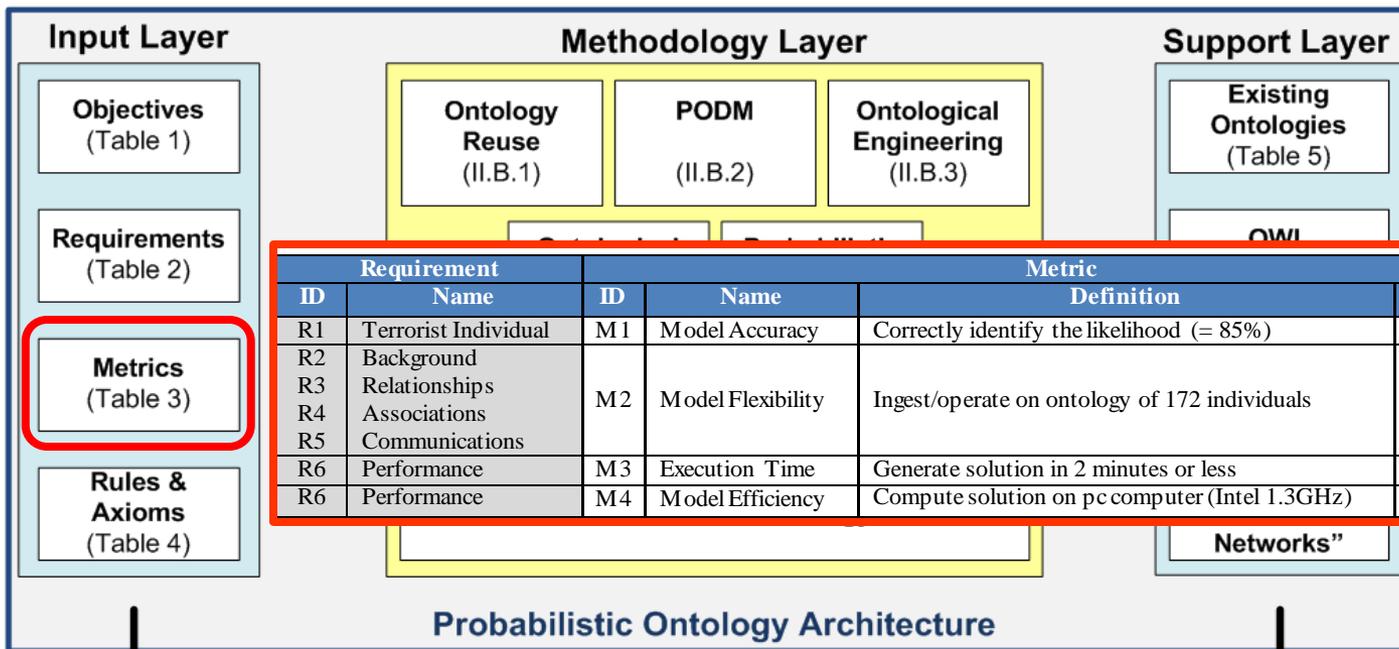
Concrete



# Architecture for Terrorist Identification Probabilistic Ontology

Abstract

Inferential Reasoning Support Requirement



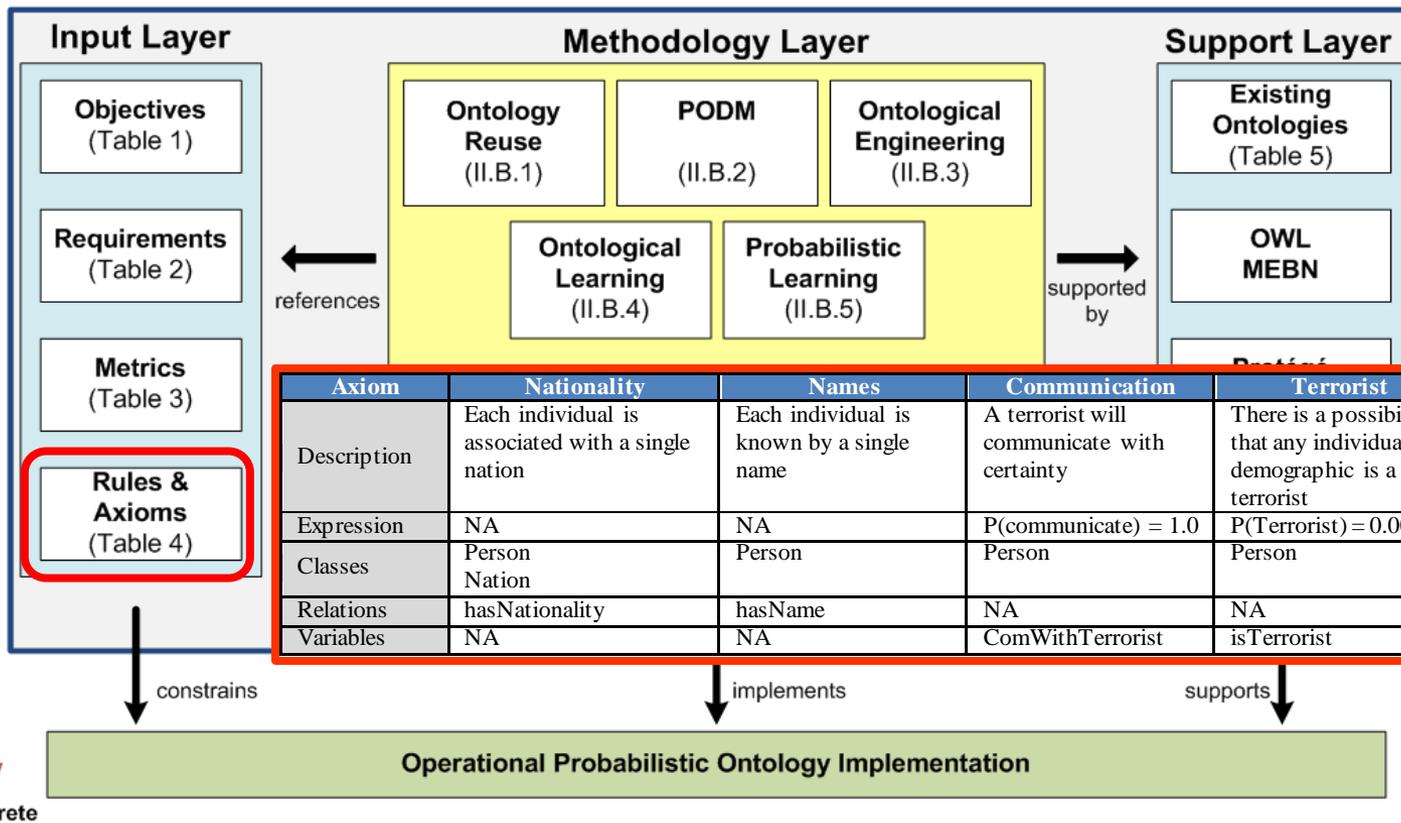
Concrete

Operational Probabilistic Ontology Implementation

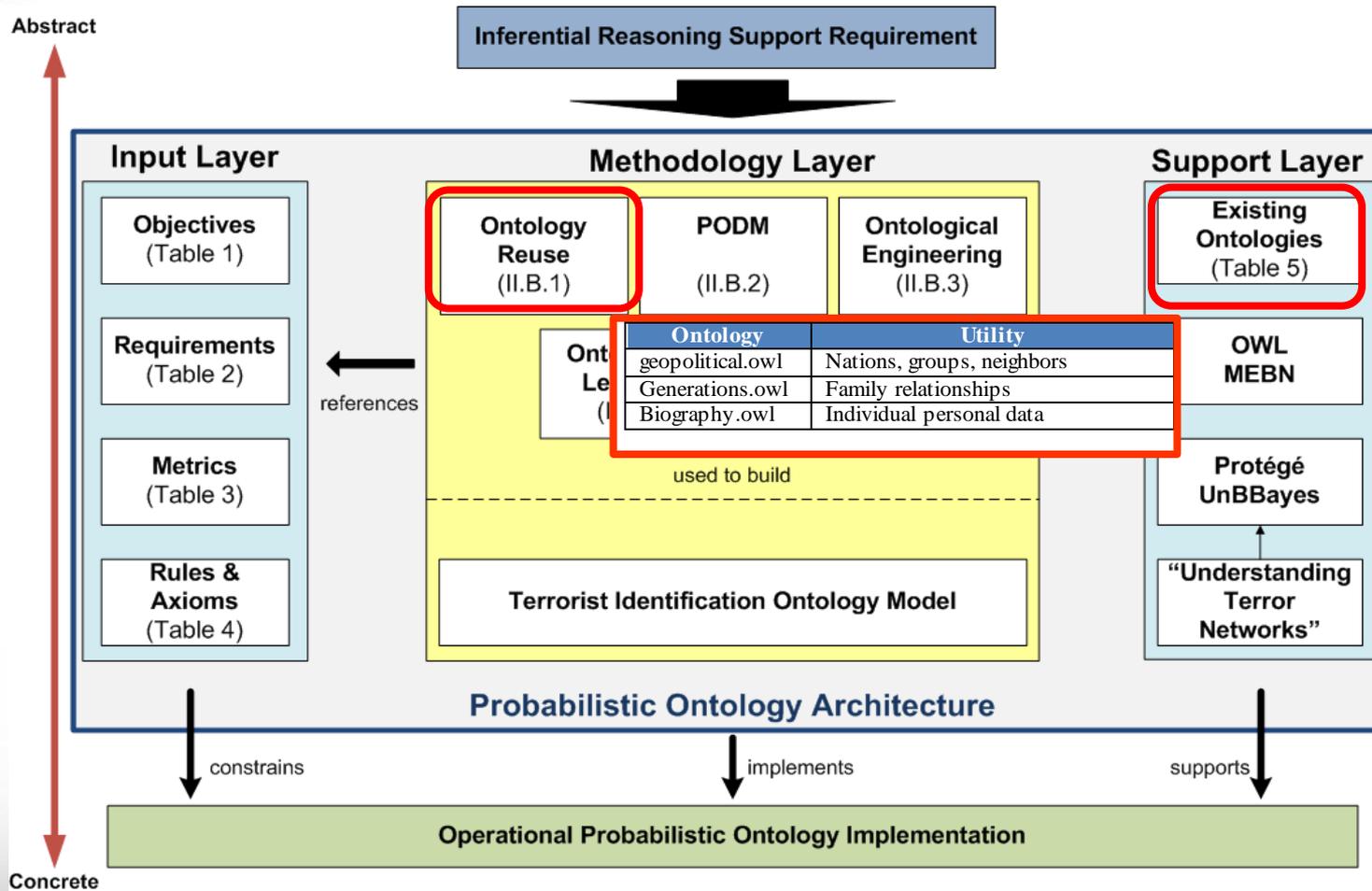
# Architecture for Terrorist Identification Probabilistic Ontology

Abstract

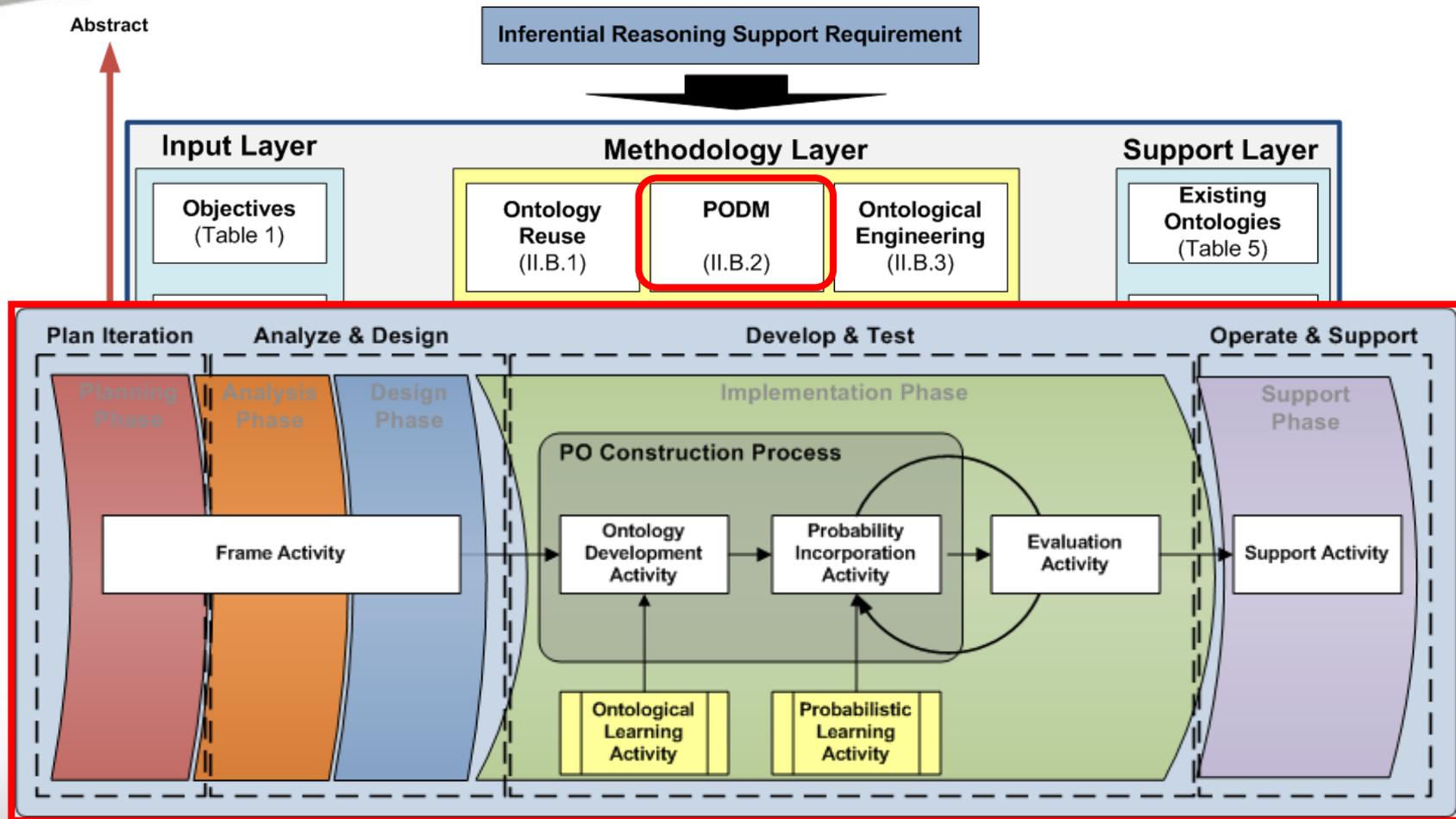
Inferential Reasoning Support Requirement



# Architecture for Terrorist Identification Probabilistic Ontology



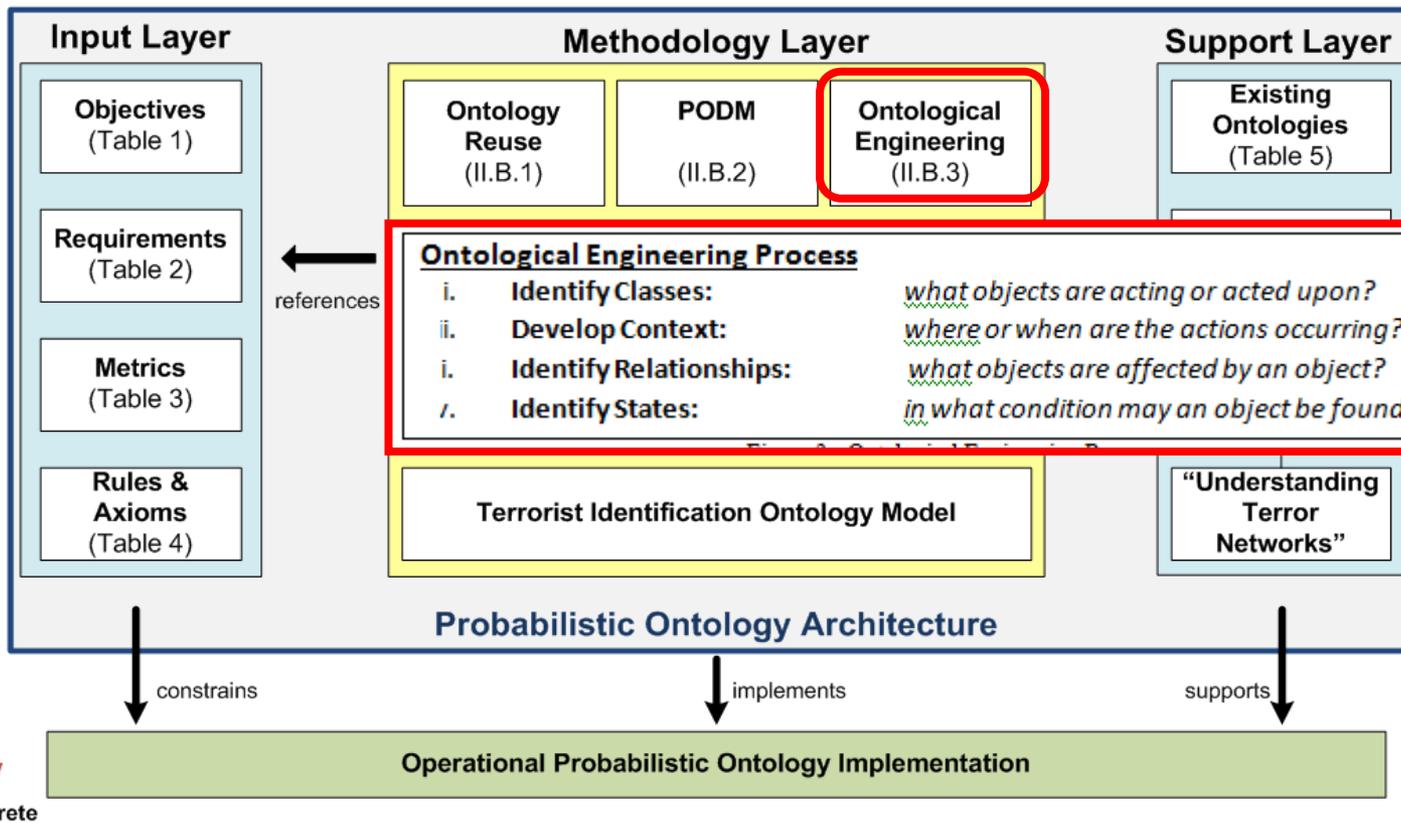
# Architecture for Terrorist Identification Probabilistic Ontology



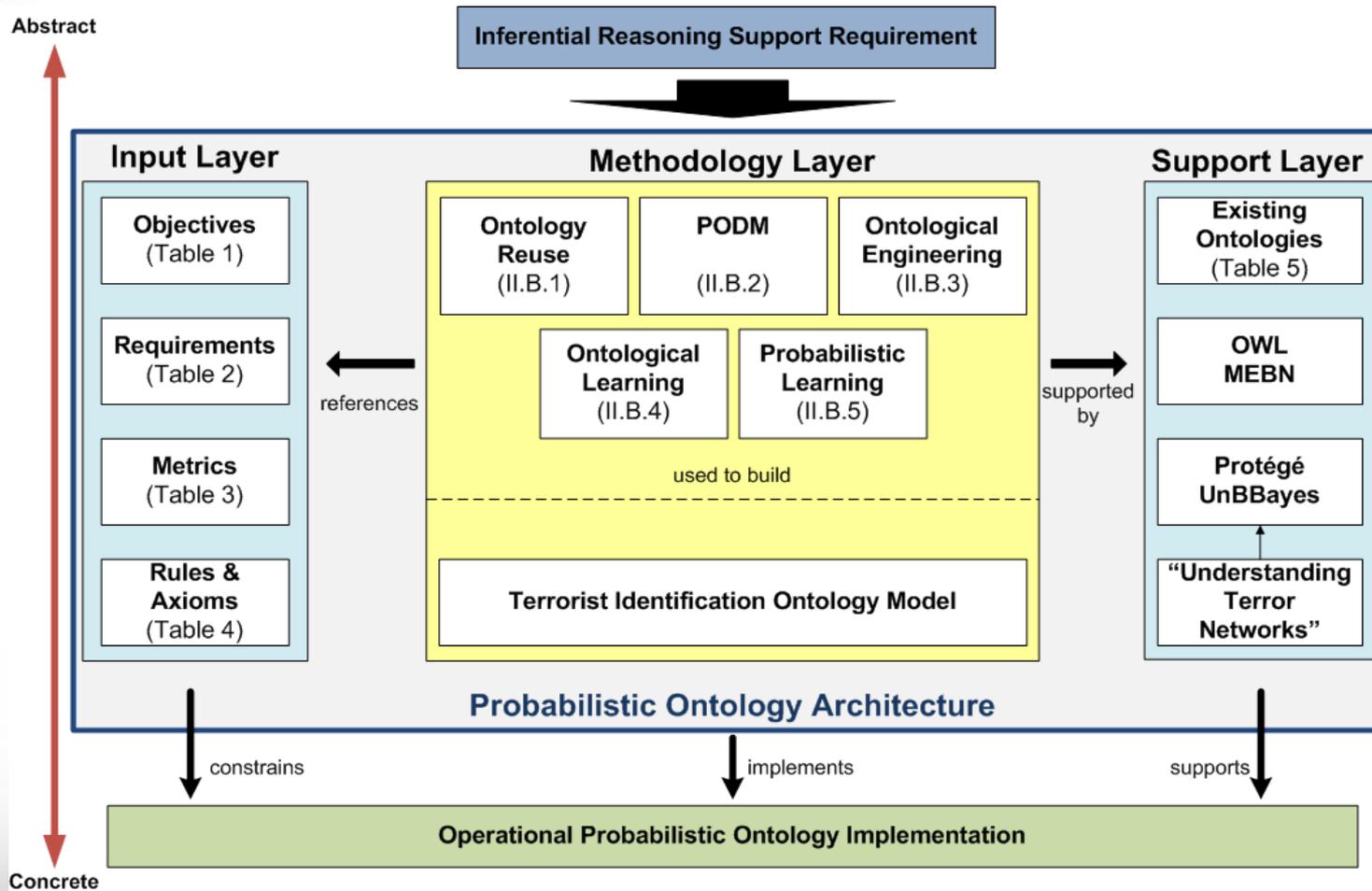
# Architecture for Terrorist Identification Probabilistic Ontology

Abstract

Inferential Reasoning Support Requirement



# Architecture for Terrorist Identification Probabilistic Ontology



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