

# 5th International Workshop on Independent Verification and Validation of Software



## SEMANTIC-BASED KNOWLEDGE REPRESENTATION

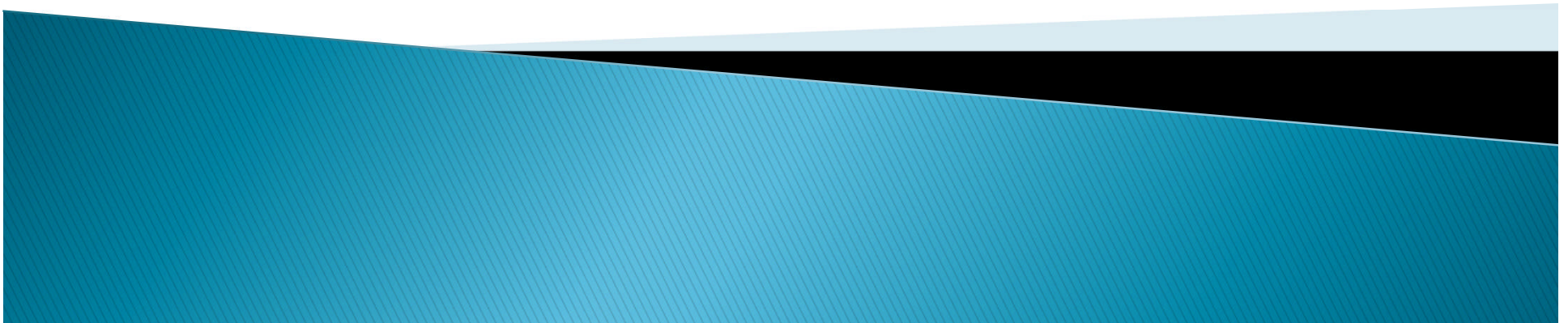
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# Semantic-Based Knowledge Representation

- ▶ Introduction – What is Semantics?
- ▶ How does Semantics relate to knowledge representation?
- ▶ How would Semantics be used in the context of IV&V?
  - Tracking and mining of findings/issues/risks
  - Tracking and mining of IV&V evidence
  - Assurance statement development
- ▶ What are other uses of Semantic-Based Knowledge Representation?
- ▶ What's next for IV&V?

# Introduction – What is Semantics?

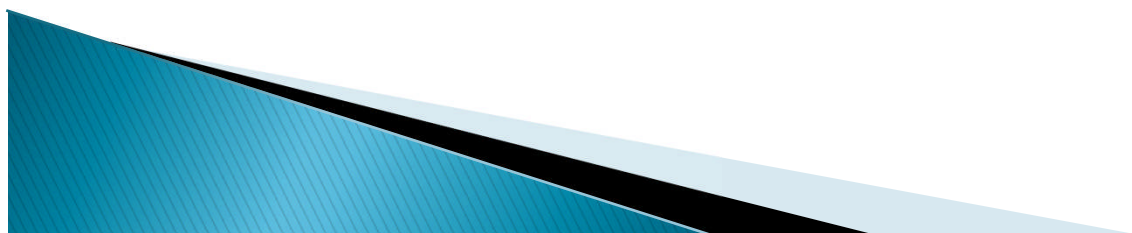
- ▶ (as the lawyers say) *It Depends*
  - The literal meaning of the Greek word σημαντικός – signifiers – signs or symbols
  - If you're a philosopher
    - The study of meanings – context
  - If you're a Linguist
    - Linguistic semantics is the study of meaning that is used for understanding human expression through language
  - If you're a computer scientist
    - The processes a computer follows when executing a program – the model of computation in a particular programming language
  - If you're an IV&V analyst (a little of all of these)
    - Finding the meaning of evidence in its context

# Semantic-Based Knowledge Representation

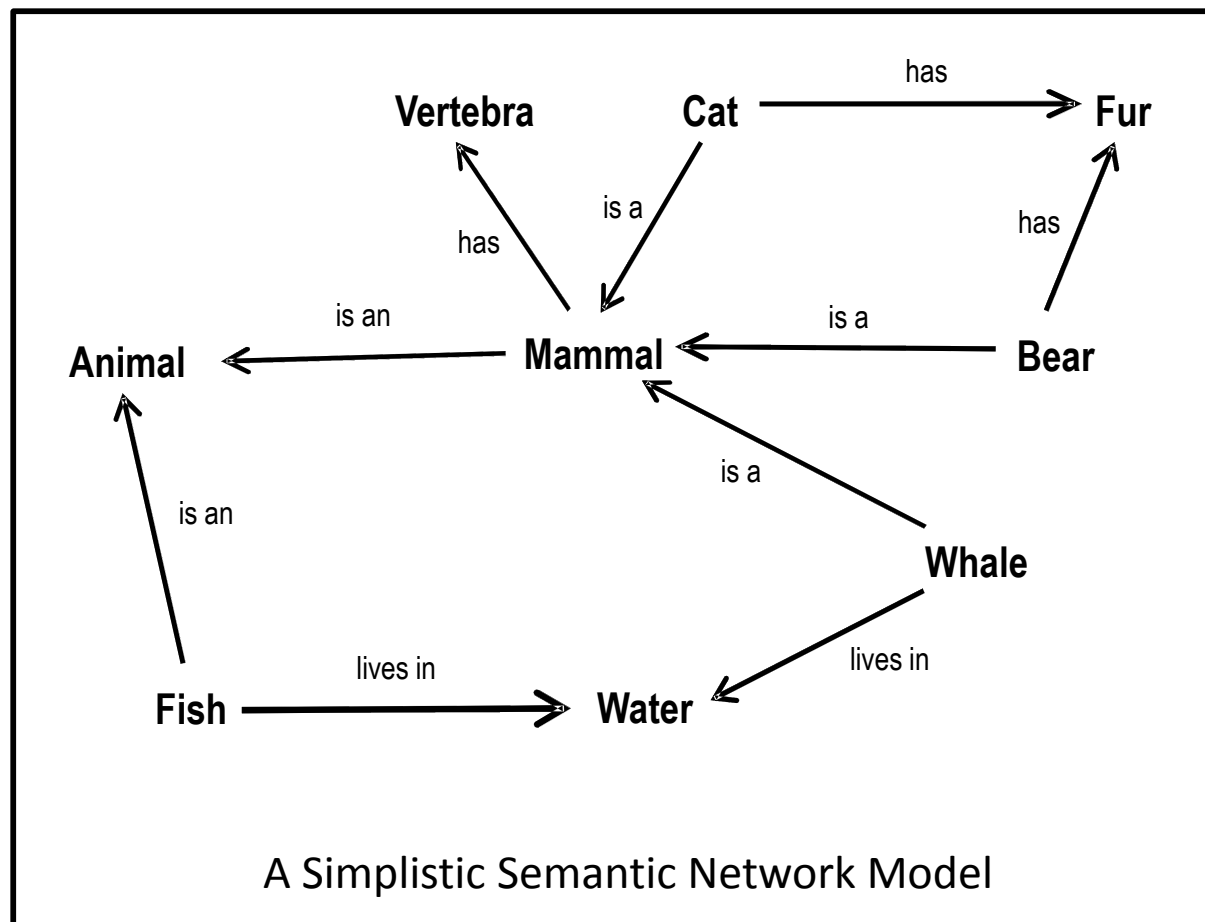
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# Semantics and Knowledge Representation

- ▶ Used when knowledge best understood as a set of concepts that are related to one another
- ▶ Context is everything
- ▶ **NOT** a new concept
- ▶ Extended Ontological/Taxonomic structure makes it derivable, searchable and mineable
- ▶ Stored relationships provide the data needed to automatically generate visual network diagrams and to later mine for significances of subtle relationships



# Semantics and Knowledge Representation



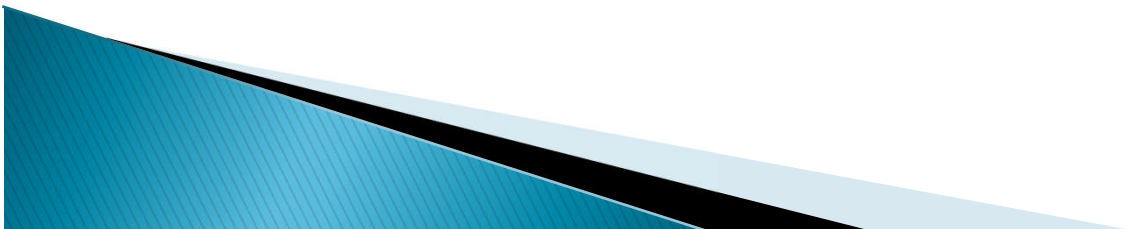
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# Tracking and Mining of Findings/Issues/Risks

- ▶ Reported anomalies (findings/issues/risks) are inherently contextual (e.g., a software error which would cause a hypergolic propellant valve to open when it is not supposed to):
  - Catastrophic when the vehicle is being fueled (loss of life and mission assets)
  - Merely an annoyance when the vehicle is unfueled and being processed
- ▶ A semantic-based knowledge system can suggest appropriate scoring of anomalous findings based on context and a pre-determined “bar”

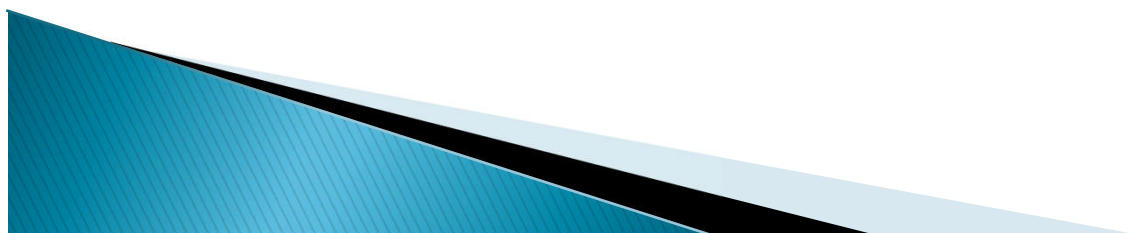




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- ▶ A semantic-based knowledge system can describe evidence element relationships and derive their significance
- ▶ A semantic-based knowledge system can suggest additional evidence that must be acquired in order to complete an analysis
- ▶ *A knowledge-based system always generates a decision path which can be evaluated and learned from*

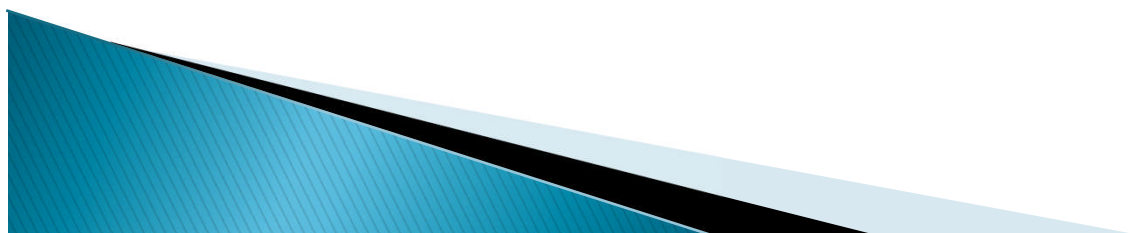


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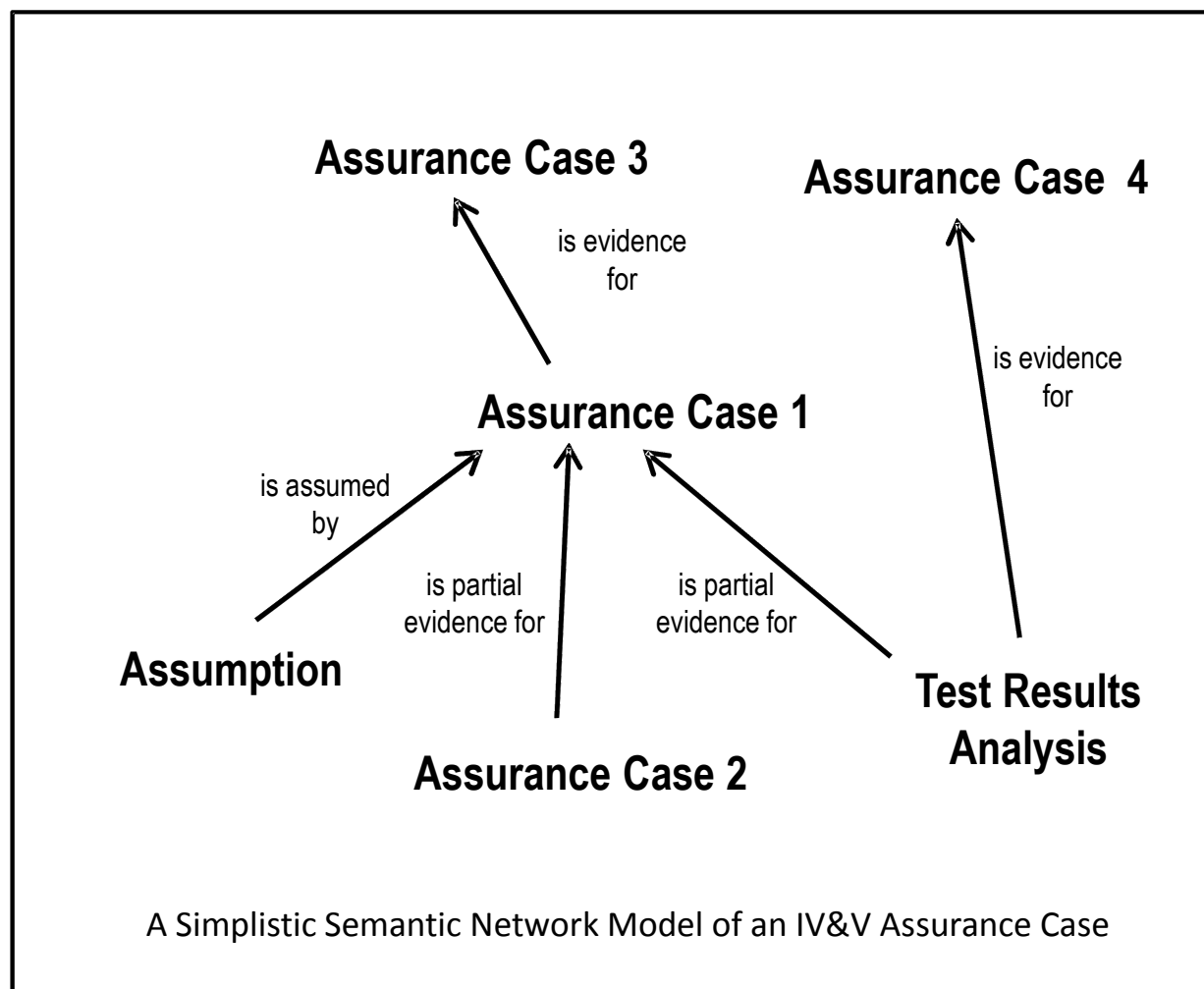
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# Assurance Statement Development

- ▶ A semantic-based knowledge system can suggest assurances that can be made for captured assurance element relationships
- ▶ A semantic-based knowledge system can suggest caveats that must be attached to assurances that are desired to be made, based on missing assurance element relationships
- ▶ *A knowledge-based system always generates a decision path which can be evaluated and learned from*



# Assurance Statement Development



# Semantic-Based Knowledge Representation

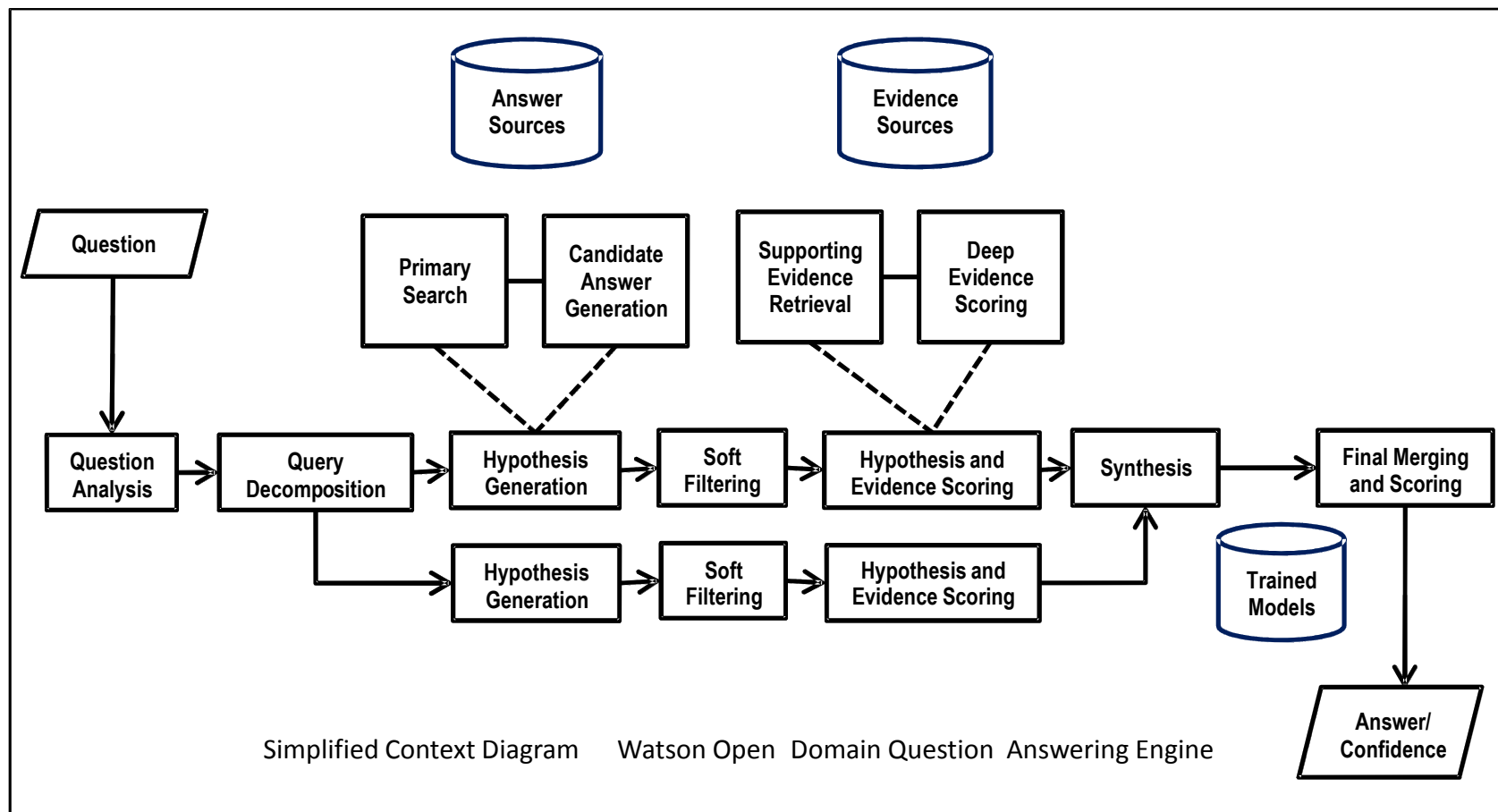
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- ▶ What's next for IV&V?

# What are other uses of Semantic-Based Knowledge Representation?

- ▶ IBM's Watson computer system
  - Showcased on the Jeopardy network television program
  - Used as an open-domain question answering system using natural language input
  - An example of a semantic-based knowledge representation and retrieval system
  - Competitors – two other semantic-based knowledge representation and retrieval systems:  
*two well-read humans*



# What are other uses of Semantic-Based Knowledge Representation?



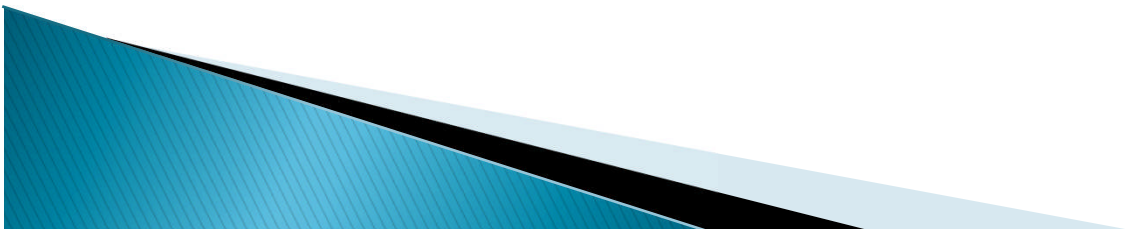
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# What's next for IV&V?

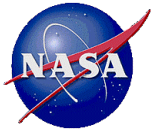
## ► Conclusions

- Several semantic-based knowledge systems show promise for documenting and mining aspects of the Independent Verification and Validation of software
- Semantic-based knowledge systems show promise for documenting and mining aspects of other areas outside of the Independent Verification and Validation of software



# What's next for IV&V?

- ▶ Suggestions for the future of IV&V
  - Development of a self-populating database tool for entering entities and relationships in multiple functionalities/domains (e.g., requirements quality in a spacecraft guidance, navigation and control [GN&C] domain)
  - Development of a self-populating database tool for entering ISO/IEC 15026-2 assurance elements and their relationships
  - Development of a customizable common notation for ISO/IEC 15026-2 (for display)
  - Development of display, report generation, analysis and mining tools to make the databases useful
  - Using the tools to analyze patterns and trends to improve the IV&V process



# Questions?