Intelligence Analysis Ontology for Cognitive Assistants

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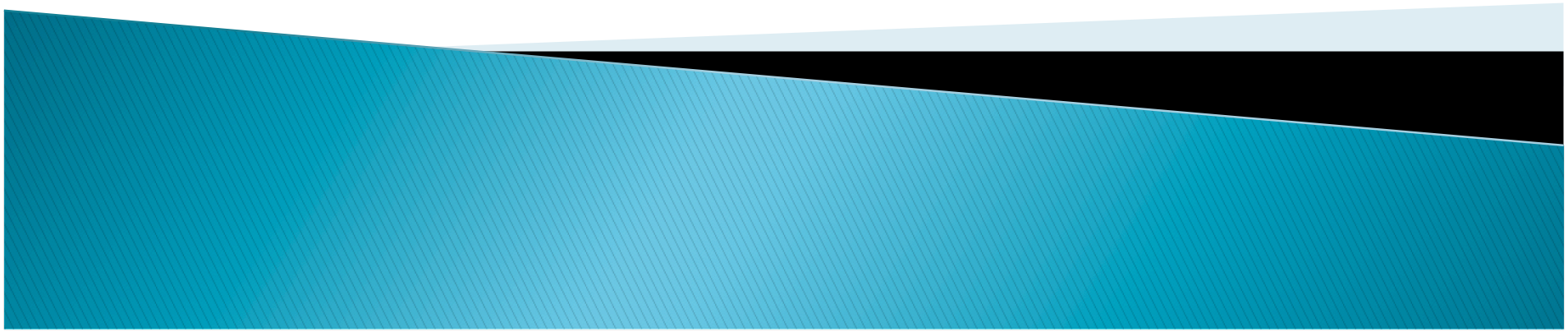


Disciple-LTA Overview

Disciple-LTA is a new type of personal cognitive assistant that:

- can rapidly acquire expertise in intelligence analysis,
- can train new intelligence analysts, and
- can help analysts analyze complex hypotheses

- through mixed-initiative reasoning,
- allowing a synergistic integration of a human's experience and creativity with an agent's knowledge and speed, and
- facilitating collaboration with complementary experts and their agents.

- Rapid and systematic hypothesis analysis
- Assumption-based reasoning
- Evidence retrieval and representation
- Automatic report generation
- Collaboration and information sharing

- Rapid acquisition of analytic expertise
- Learning to analyze based on source's culture
- Tutoring new analysts
- Automatic test generation
- Easy integration with other tools and services

Disciple Approach to Agent Development

Develop learning and problem solving agents that can be taught by subject matter experts to become knowledge-based assistants.

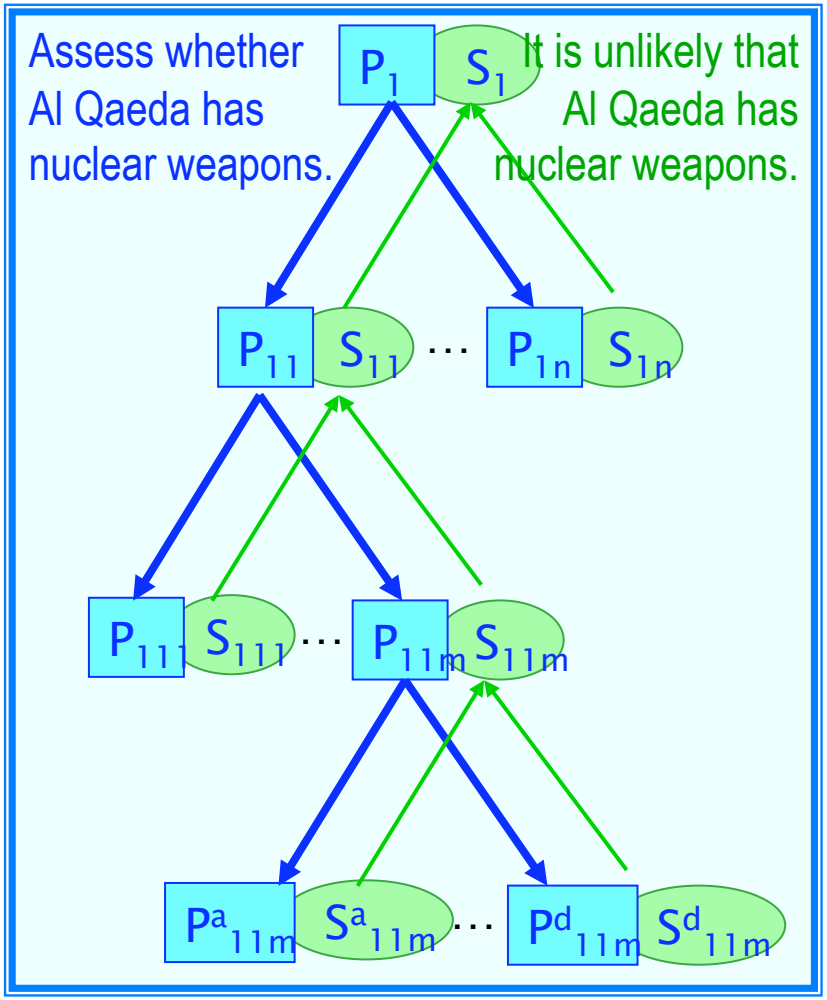
The expert teaches Disciple how to solve problems in a way that resembles how the expert would teach a student, an apprentice or a collaborator.

Disciple continuously develops and refines its knowledge base to capture and better represent expert's knowledge and problem solving strategies.

There is no longer a distinction between knowledge base development and its maintenance.

Hypothesis Analysis through Problem Reduction

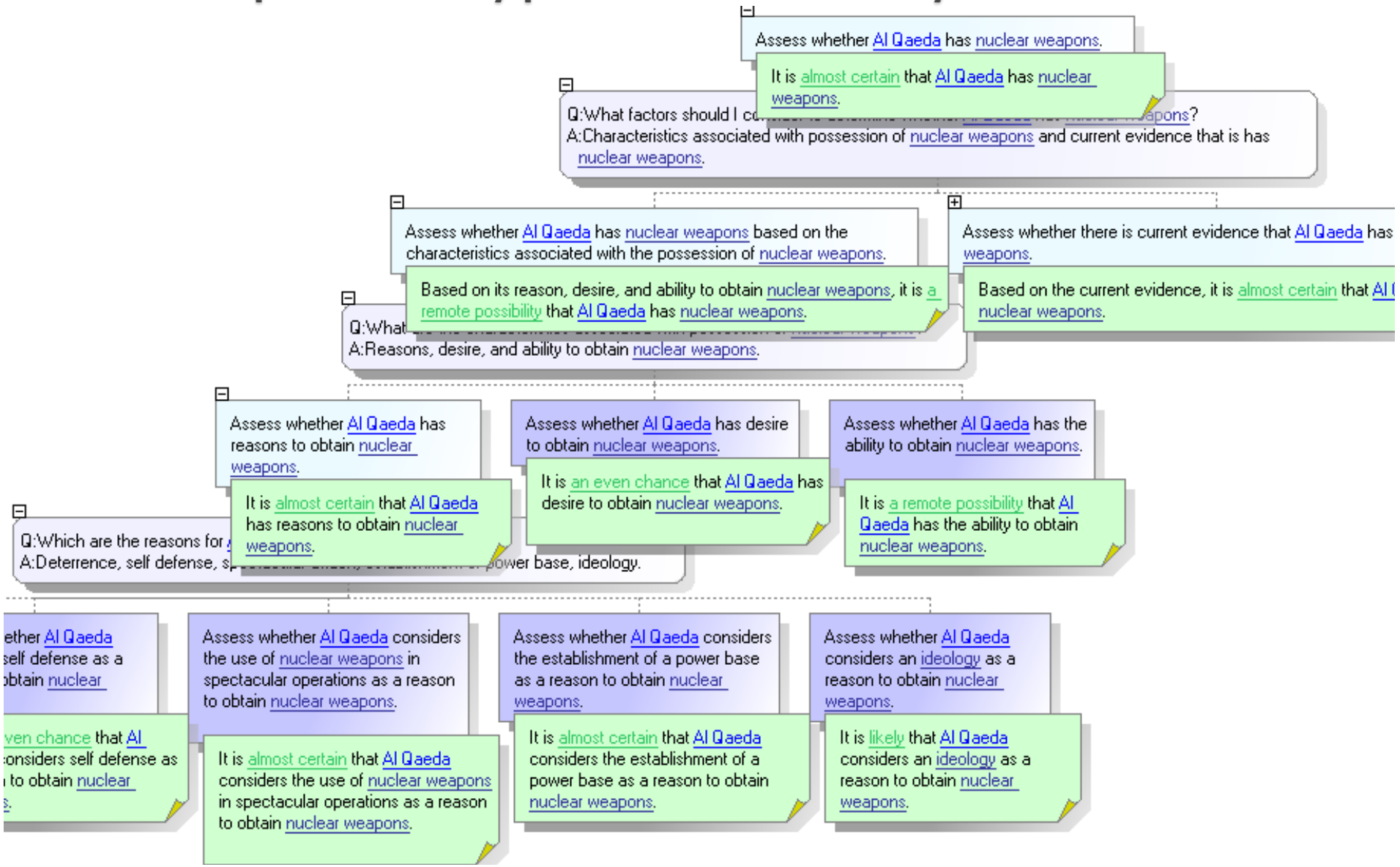
1. A complex hypothesis analysis problem is successively reduced to simpler problems that either have known solutions or can be solved through evidence analysis.
2. Potentially relevant pieces of evidence for the unsolved problems are identified.
3. The pieces of evidence are analyzed to obtain solutions for the unsolved problems.
4. The solutions of the simplest problems are successively combined to obtain the solution of the initial problem.



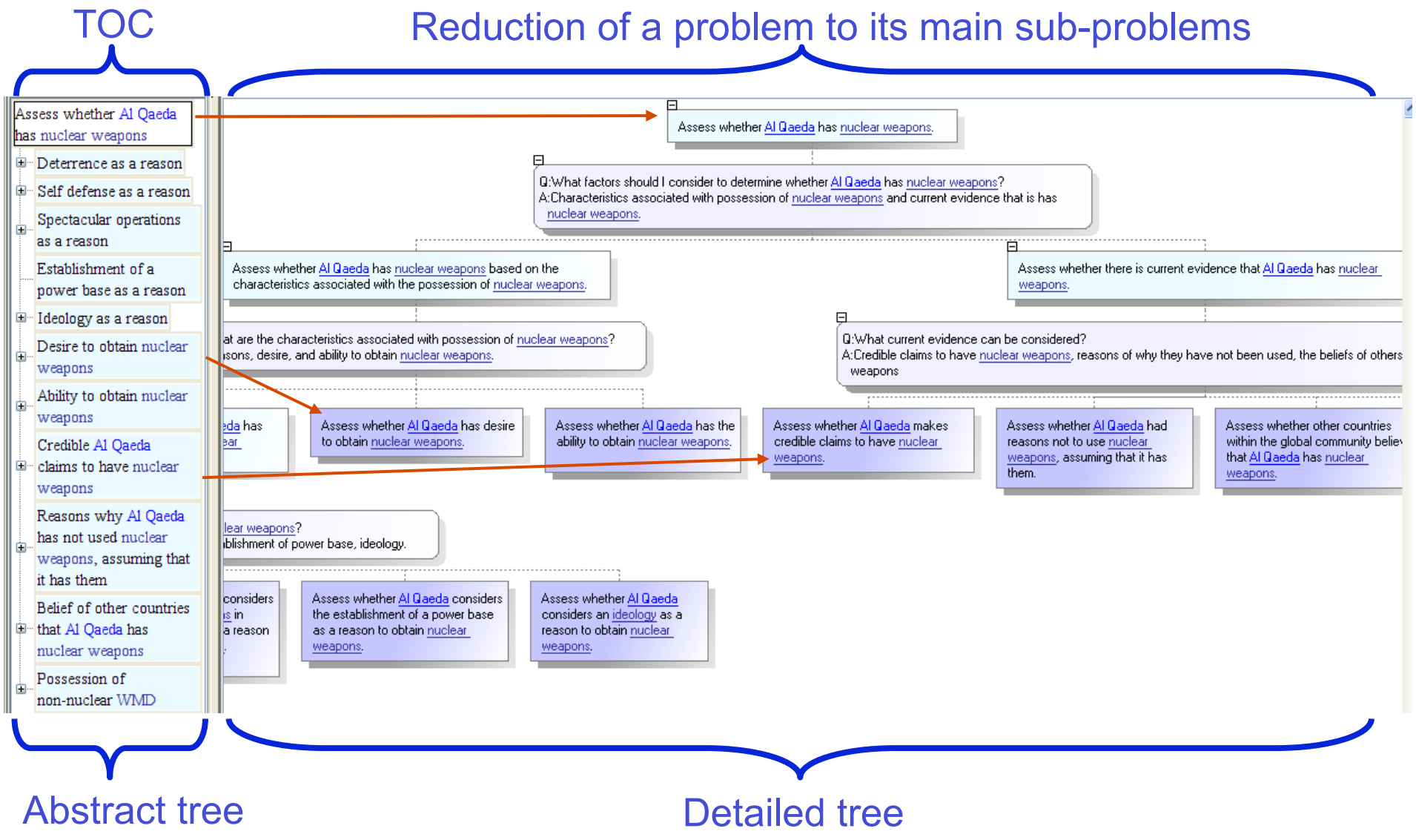
Remote	Unlikely	Even chance	Probably, Likely	Almost certainly

National Intelligence Council's standard estimative language

Example of Hypothesis Analysis

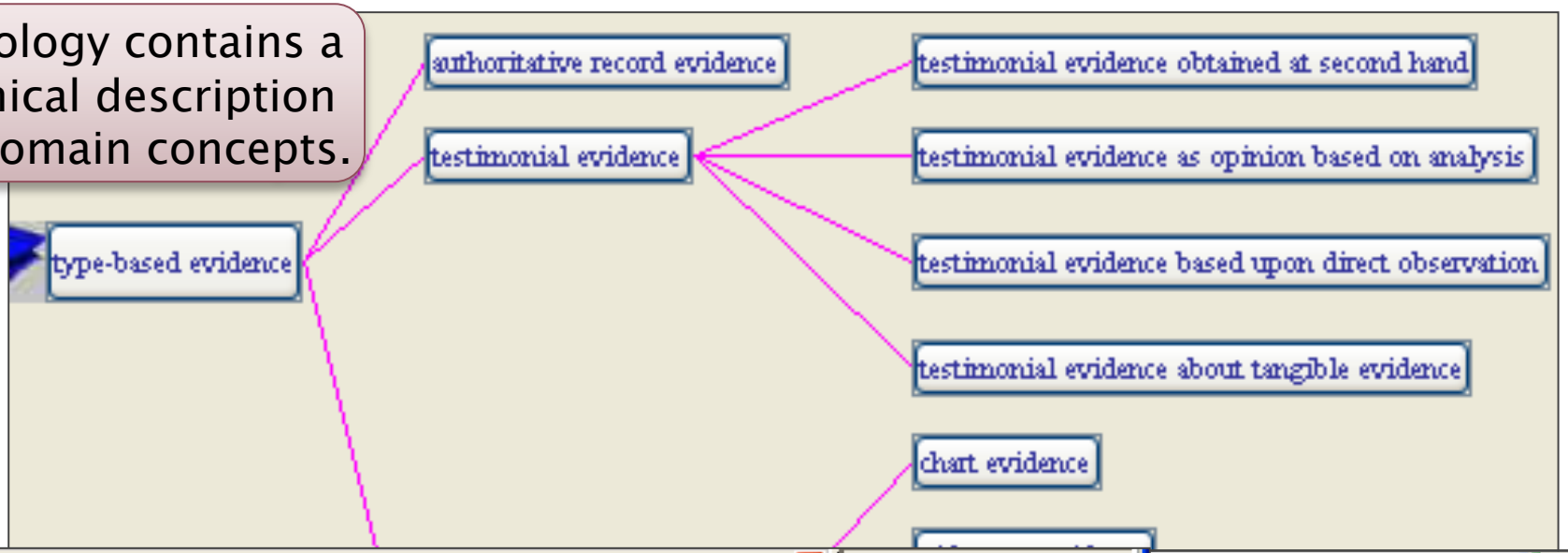


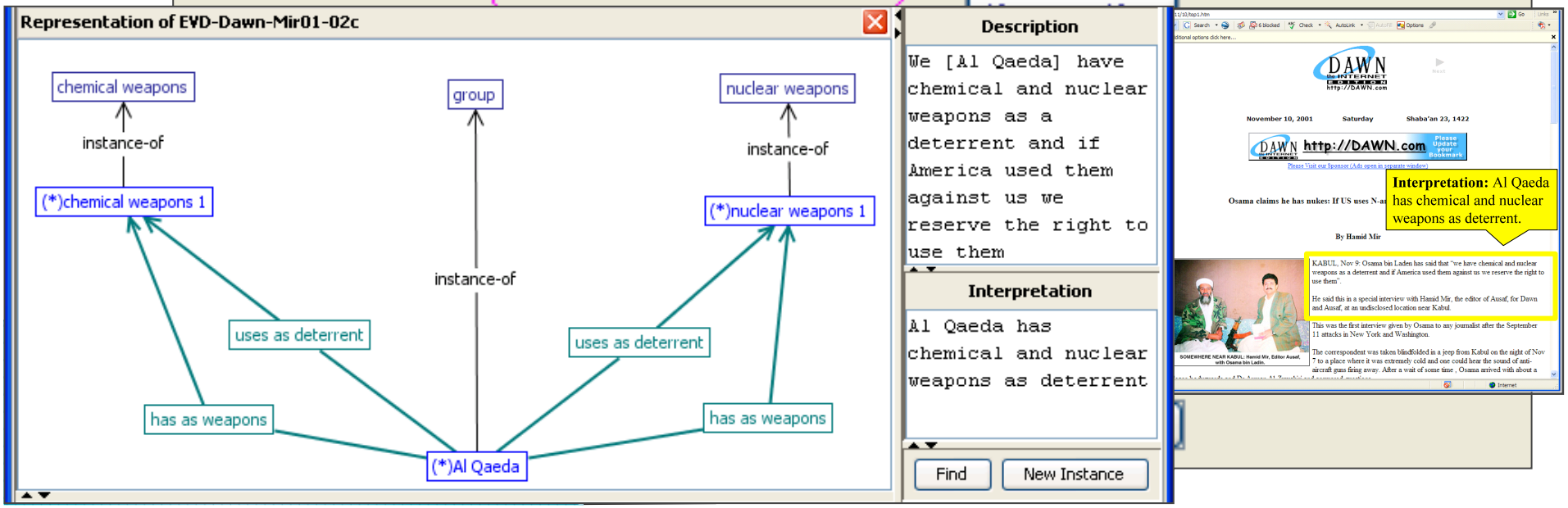
Abstract and Concrete Reduction Tree



Knowledge Base = Ontology + Rules

The ontology contains a hierarchical description of the domain concepts.

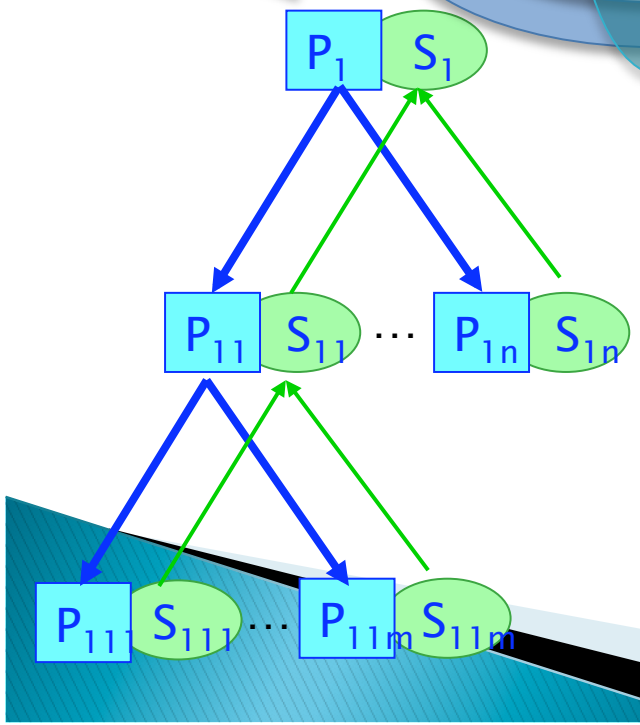


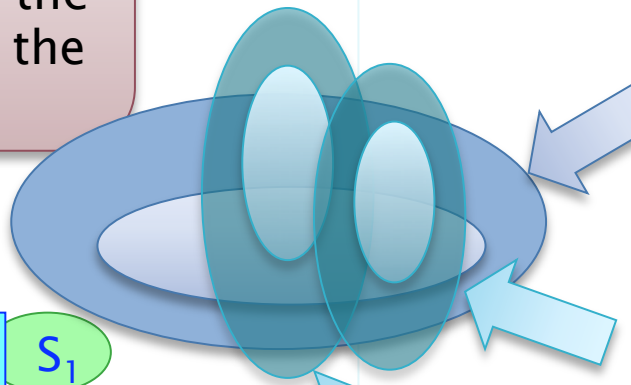


Knowledge Base = Ontology + Rules

The rules specify general reduction or synthesis steps described with the concepts from the ontology.

ANALYSIS TREE





Partially learned rule

IF:	Assess whether there are states with nuclear weapons willing to sell nuclear weapons to *?O1*.

Q:	Which is a nuclear state which is not an enemy of *?O1* and does not oppose the proliferation of nuclear weapons?
A:	*?O2*

MAIN CONDITION

Var	Lower Bound	Upper Bound
?O1	(terrorist group)	(actor)
?O2	(nuclear state)	(nuclear state)

EXCEPT WHEN CONDITION 1

Var	Lower Bound	Upper Bound
?O1	(terrorist group)	(actor)
?O2	(superpower, nuclear state)	(actor)

Var	Relationship	Var
?O2	perceives as enemy	*?O1*

EXCEPT WHEN CONDITION 2

Var	Lower Bound	Upper Bound
?SI1	[medium - medium]	[very low - very high]
?O2	(nuclear state)	(actor)

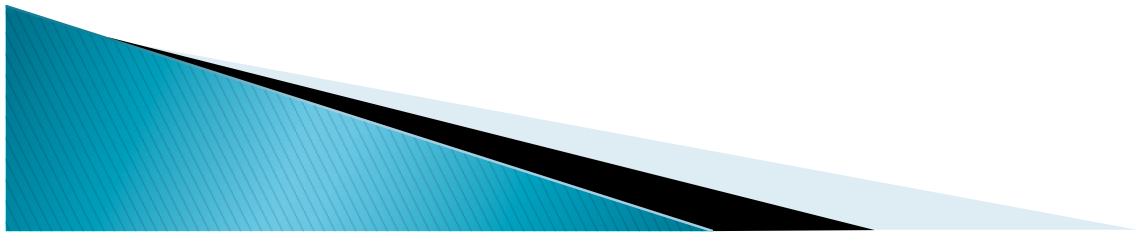
Var	Relationship	
?O2	degree of opposition to nuclear weapons proliferation	*?SI1*

THEN:	Assess whether *?O2* is willing to sell nuclear weapons to *?O1*.

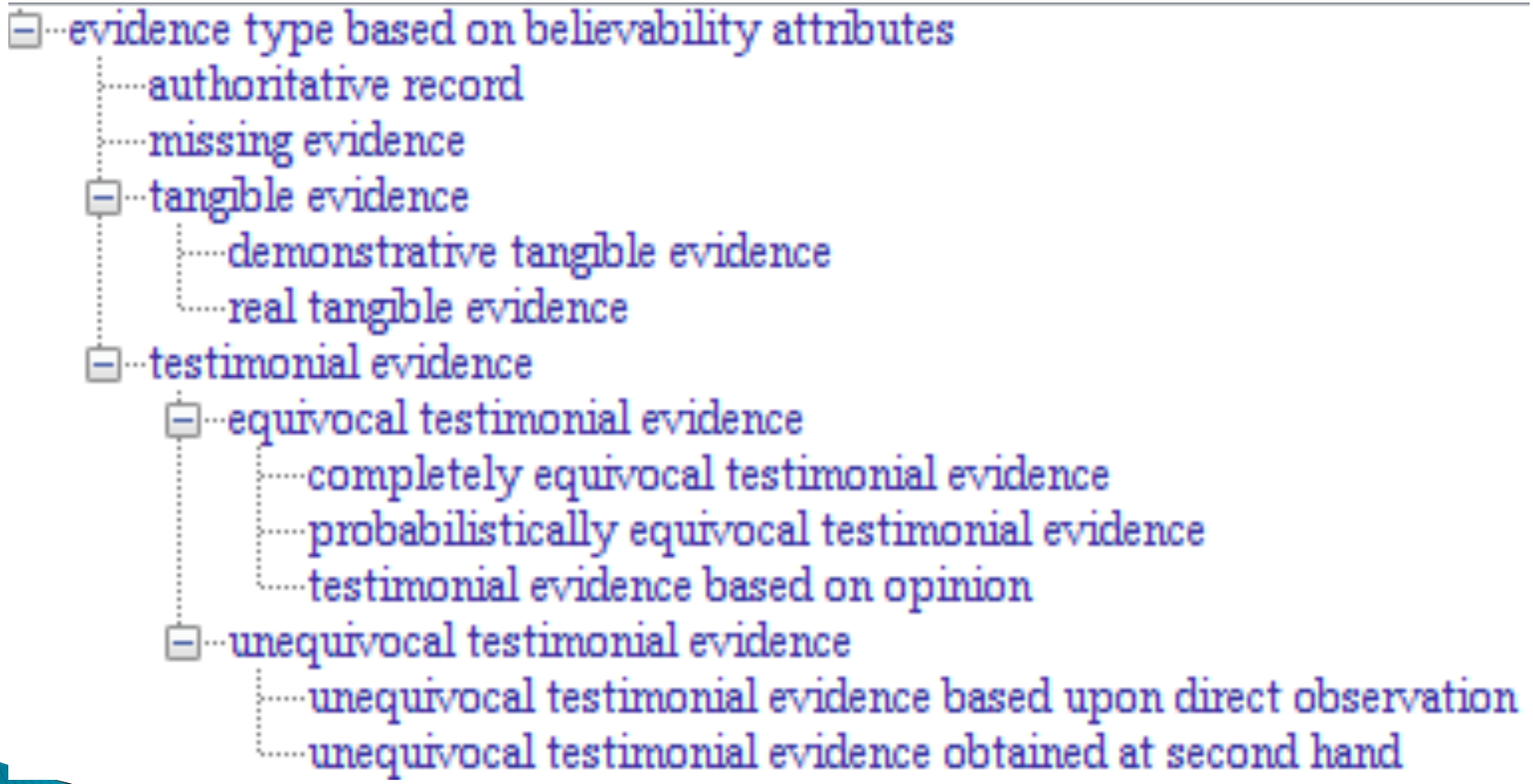
To assess whether there are states that may be willing to sell nuclear weapons to an actor, one has to consider each nuclear state which is not an enemy of that actor and does not oppose the proliferation of nuclear weapons, and determine whether that state may be willing to sell nuclear weapons to that actor.

Multiple Roles of the Ontology

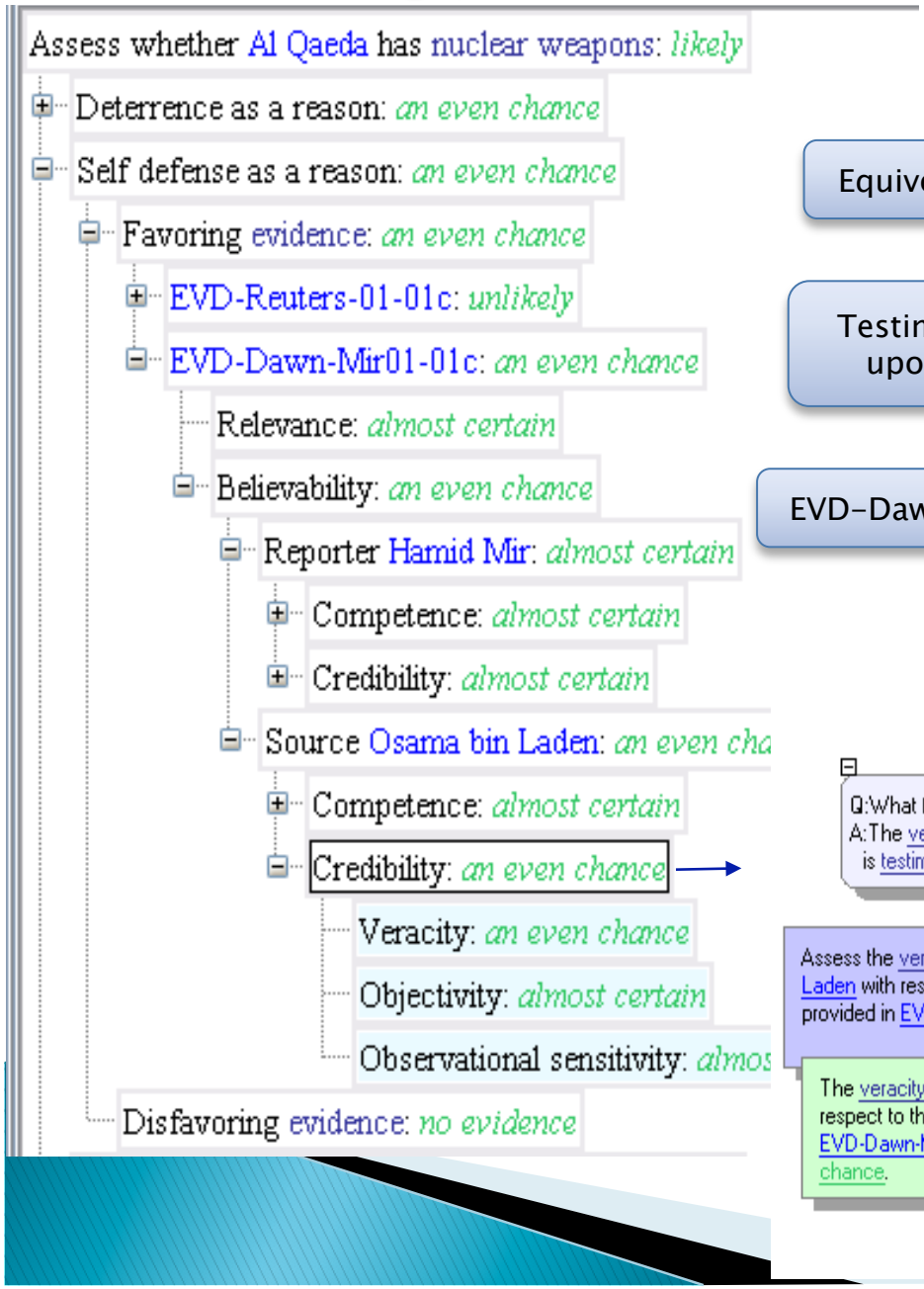
- knowledge representation
- user-agent communication
- problem solving
- knowledge acquisition and learning

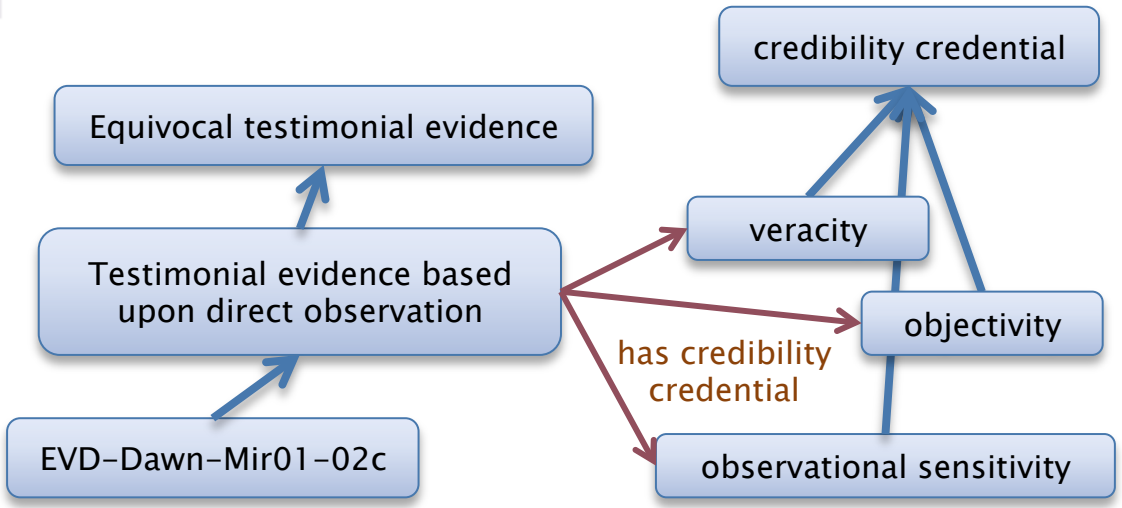


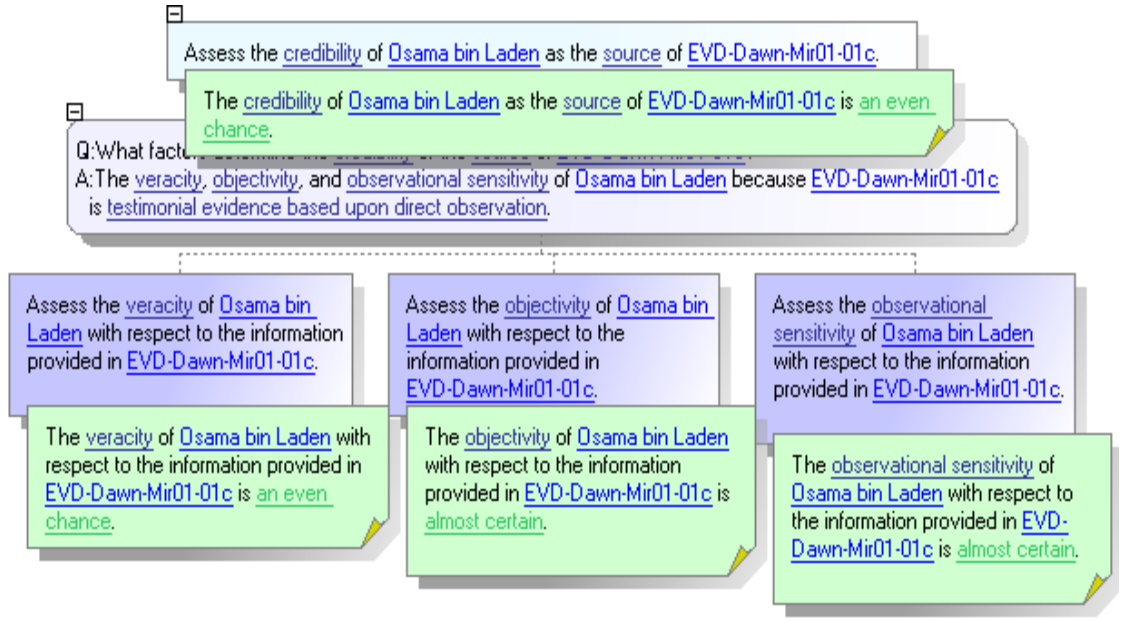
Ontology of Substance Blind Classes of Items of Evidence



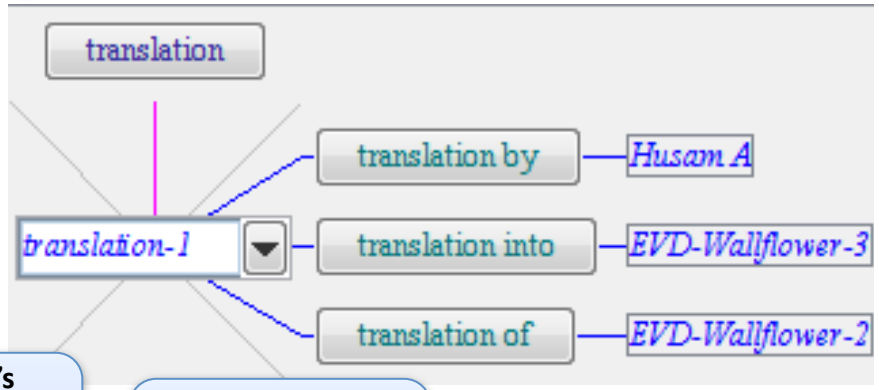
Ontology of Believability Credentials







Ontology of Actions for Chains of Custody



Wallflower's received testimony about Emir Z in English.

Wallflower's reported testimony about Emir Z in English.

Wallflower's translated testimony about Emir Z in English.

Wallflower's recorded testimony about Emir Z in Farsi.

Wallflower's testimony about Emir Z in Farsi.

EVD-Wallflower-5

EVD-Wallflower-4

EVD-Wallflower-3

EVD-Wallflower-2

EVD-Wallflower-1

Clyde

transmission

editing

translation

recording

Marsha
- Competence
- Veracity

SN 247
- Fidelity
- Reliability
- Security

Marsha
- Competence
- Credibility

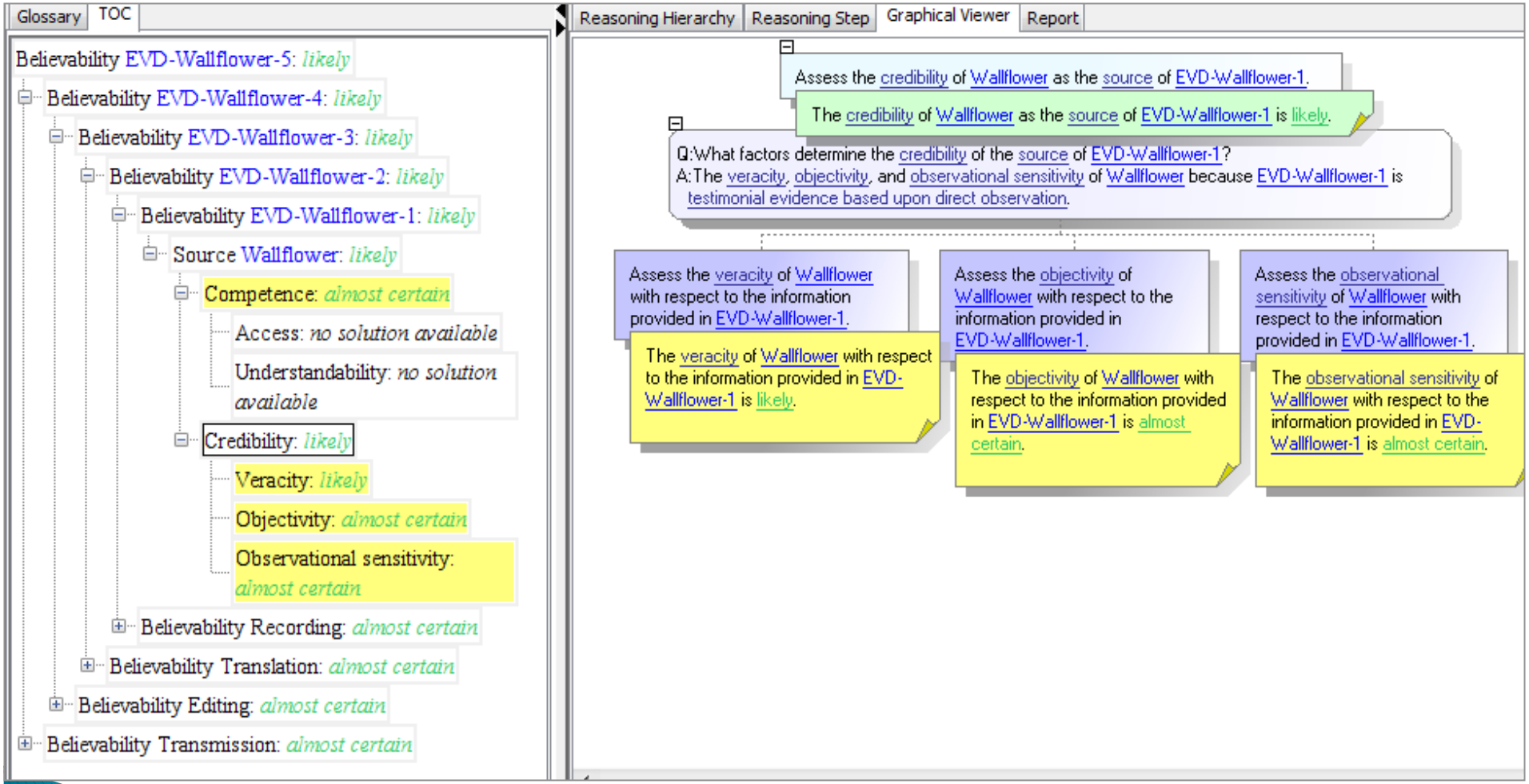
Husam A.
- Competence
- Credibility

Bob
- Competence
- Veracity

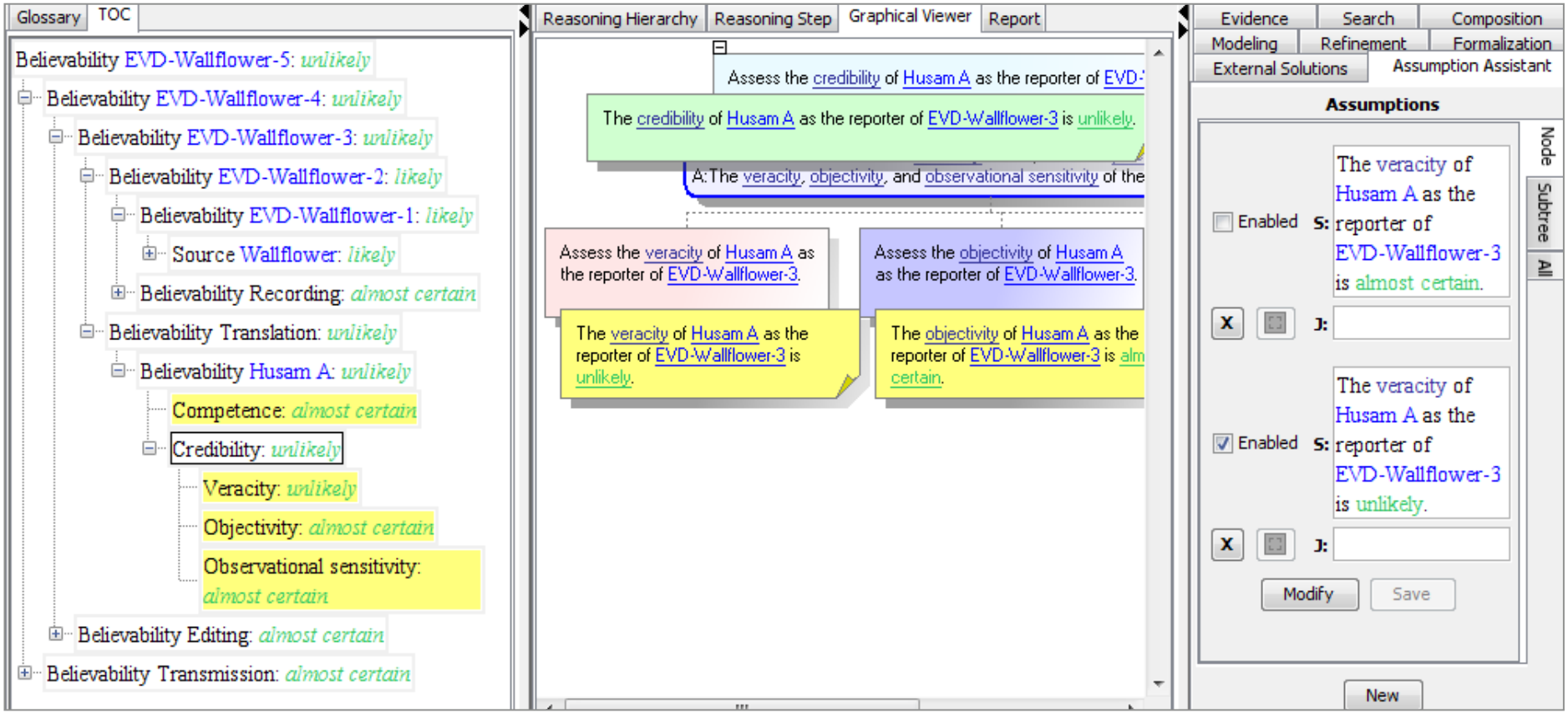
Sony Recorder
- Fidelity
- Reliability

Wallflower
- Competence
- Credibility

Analyzing the Chain of Custody



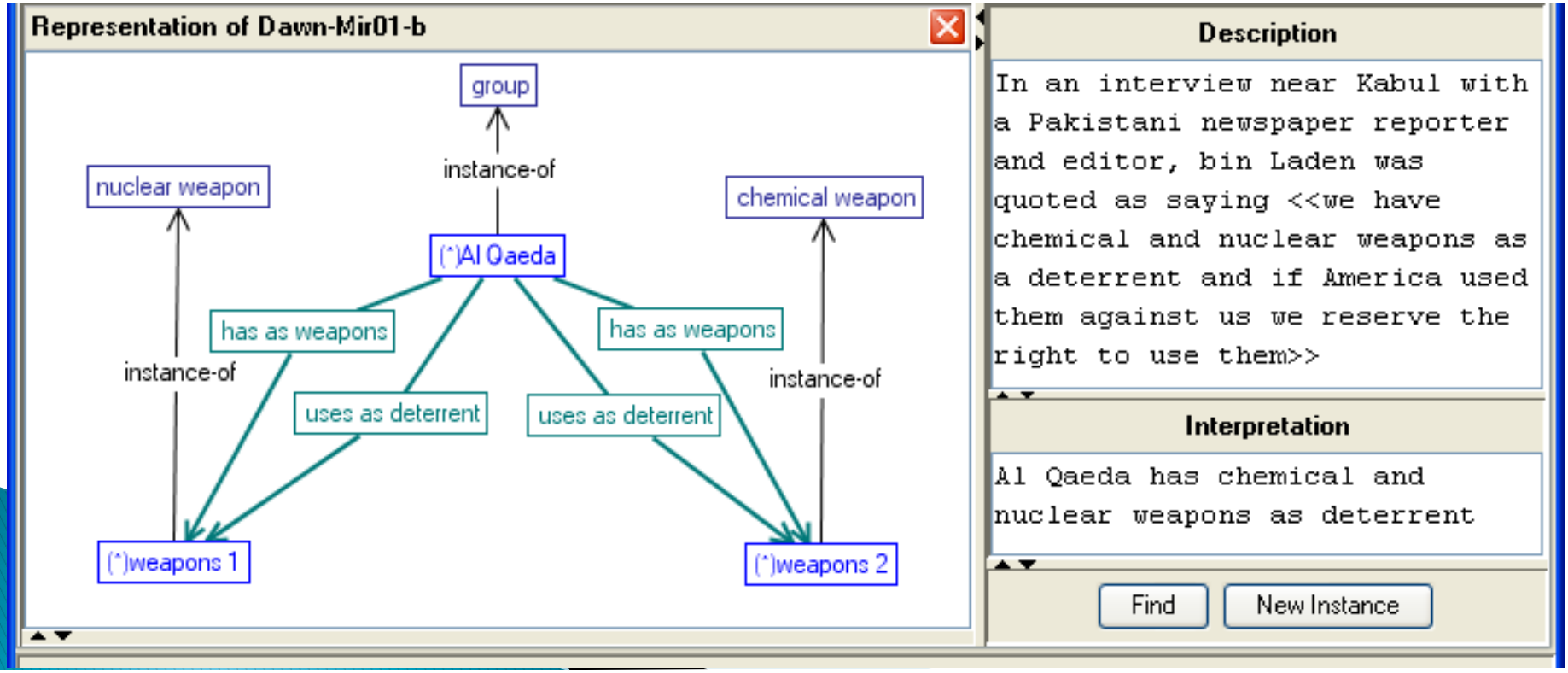
Assumption-based Reasoning



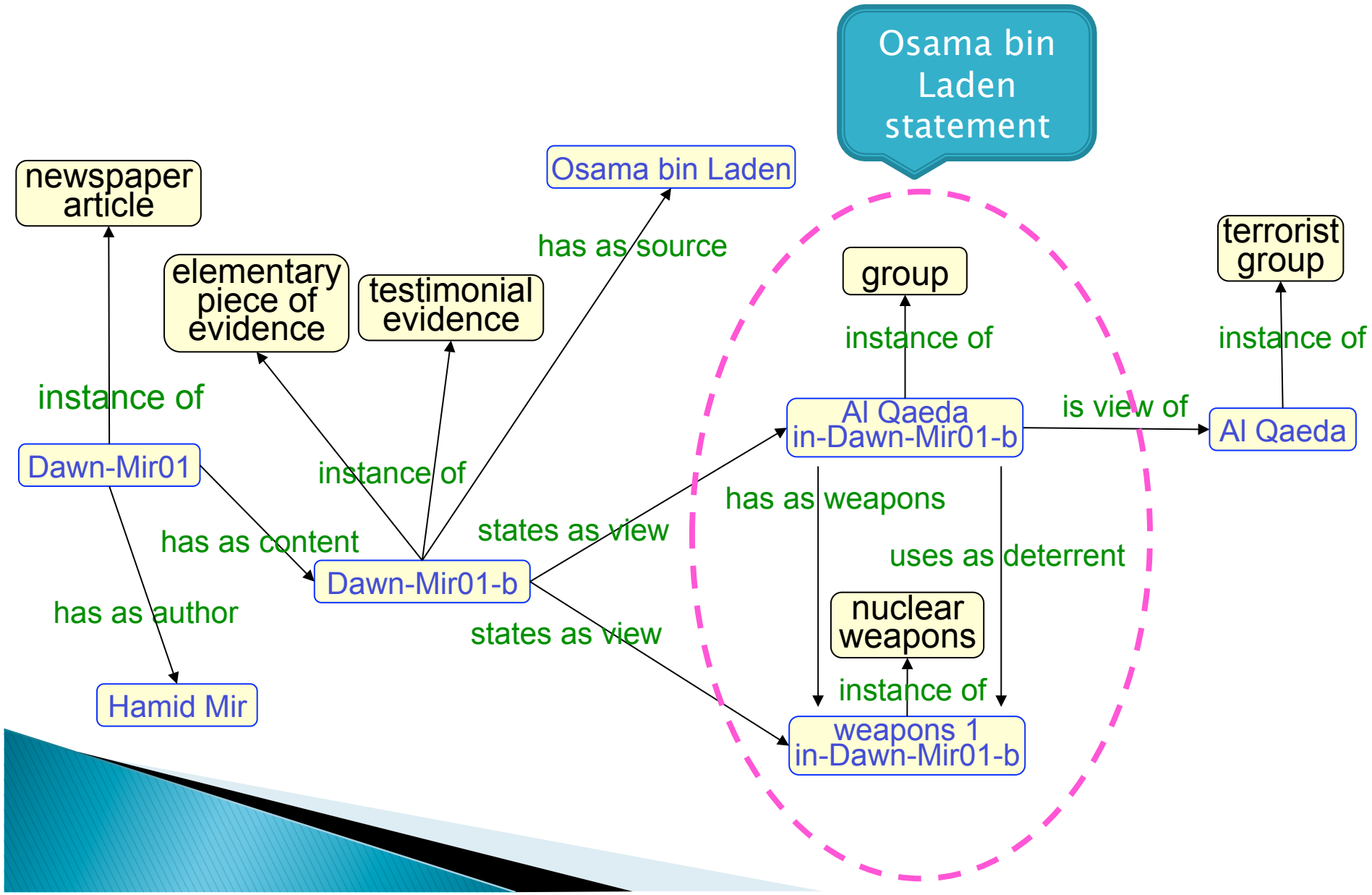
Representing the view of a human source

A statement made by Osama bin Laden

- represents his view
- should not interfere with other (maybe contradictory) statements made by other sources, or by the analyst who taught Disciple.



View representation



Tutoring: Lessons and …

Lesson Fragment: Hypothesis support from a piece of evidence

Tutoring

Lesson: Hypothesis support from piece of evidence.

Assess to what extent the piece of evide

The information provided by the piece of evidence and the extent to which it is believable.

Assess to what extent the piece of evidence favors the hypothesis, assuming that we believe the information provided by the piece of evidence.

Assess the extent to which the information provided by the piece of evidence is believable.

The piece of evidence is testimonial evidence obtained at second hand.

The piece of evidence is testimonial evidence about tangible evidence.

Assess the believability the reporter of the piece of evidence.

Assess the believability the source of the piece of evidence.

Assess the believability the reporter of the piece of evidence.

Assess the credibility of the tangible evidence.

Assess the believability the source of the piece of evidence.

Abstract reduction strategy

Illustrations: Previous Next **Select Example:** EVD-Dawn-Mir01-02c and Al Qaeda

Assess to what extent the piece of evidence EVD-Dawn-Mir01-02c favors the hypothesis that Al Qaeda considers deterrence as a reason to obtain nuclear weapons.

Q:What factors determine how a piece of evidence favors a hypothesis?
A:The information provided by the piece of evidence and the extent to which it is believable.

Assess to what extent EVD-Dawn-Mir01-02c favors the hypothesis that Al Qaeda considers deterrence as a reason to obtain nuclear weapons, assuming that we believe the information provided by EVD-Dawn-Mir01-02c.

Assess the extent to which the information provided by EVD-Dawn-Mir01-02c is believable.

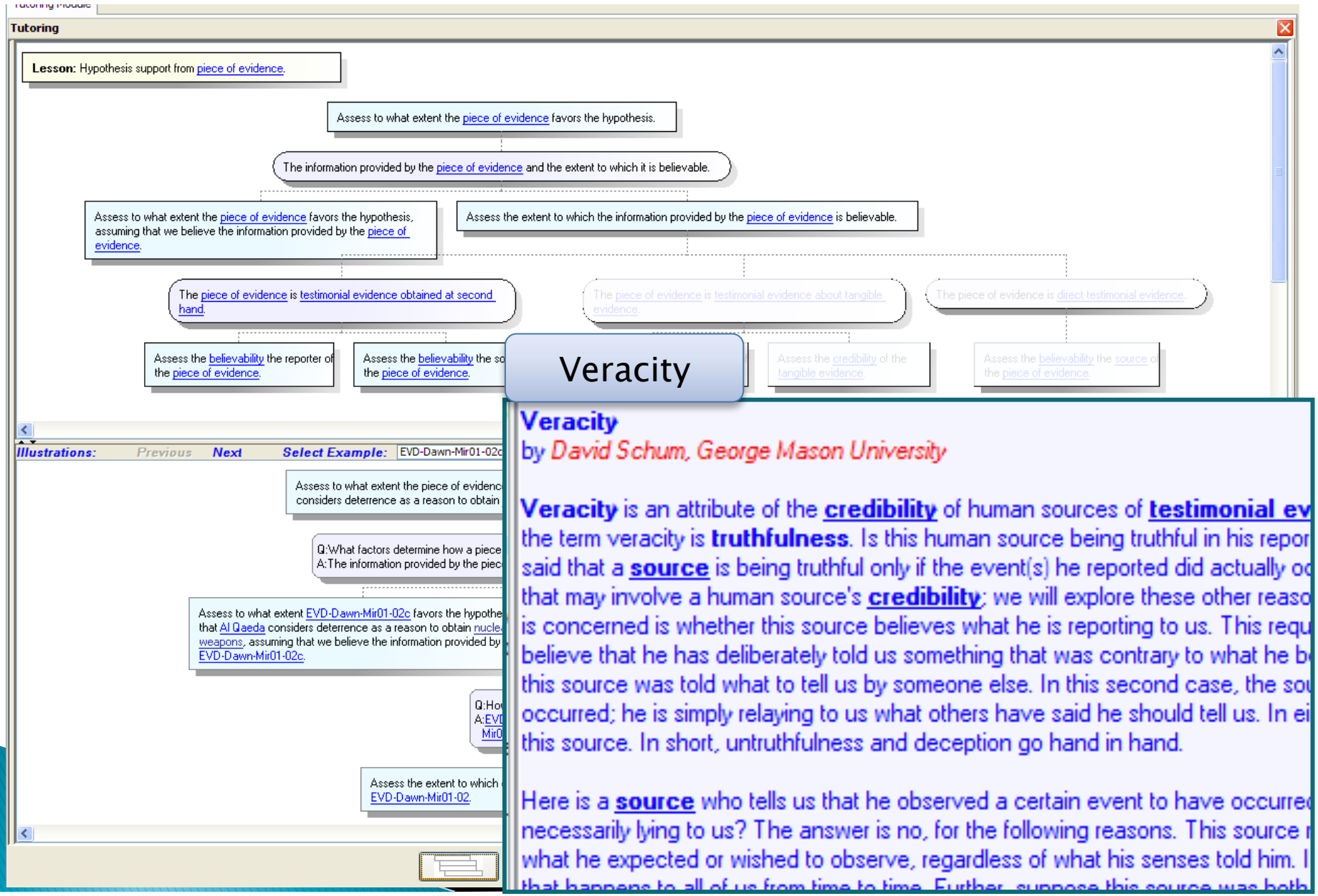
Q:How was EVD-Dawn-Mir01-02c obtained?
A:EVD-Dawn-Mir01-02c was obtained as testimonial evidence of Osama bin Laden cited in EVD-Dawn-Mir01-02 by Hamid Mir.

Assess the extent to which one can believe Hamid Mir as the reporter of EVD-Dawn-Mir01-02.

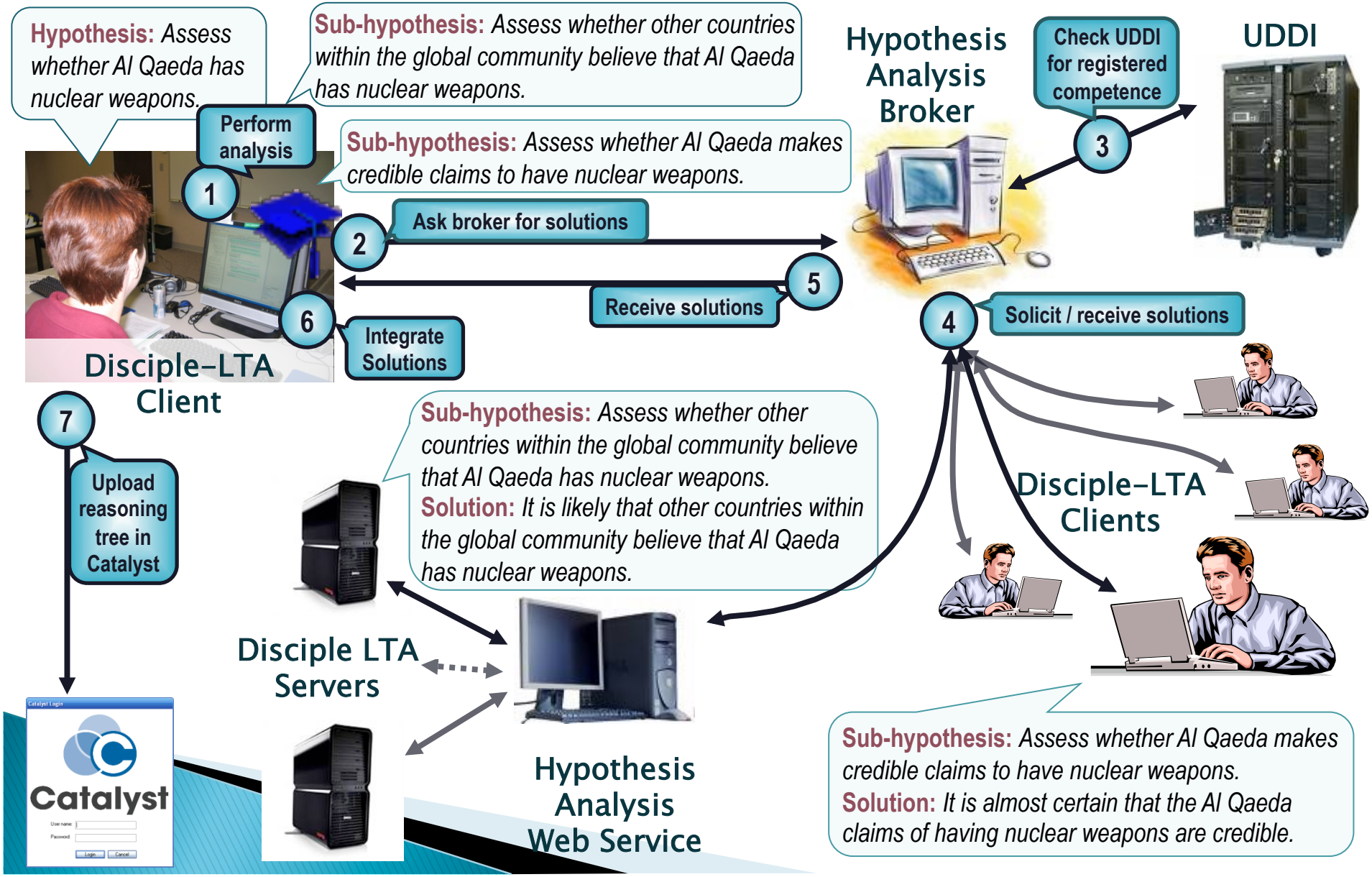
Assess the extent to which one can believe Osama bin Laden as the source of EVD-Dawn-Mir01-02c.

Automatically generated illustration of the abstract strategy

Tutoring: … and Stories



Ontology in Service Oriented Architecture



Support for Learning Expert Analysis

1. The analyst extends the analysis logic

- Assess whether there are states with nuclear weapons that may be willing to sell nuclear weapons to Al Qaeda.
  - Which is a nuclear state? North Korea
    - Assess whether North Korea may be willing to sell nuclear weapons to Al Qaeda.
      - What might be a possible reason for North Korea to sell nuclear weapons to Al Qaeda? United States is perceived as a common enemy of North Korea and Al Qaeda.
        - Assess to what extent the perception that United States is a common enemy of North Korea and Al Qaeda might be a good reason for North Korea to sell nuclear weapons to Al Qaeda.

2. Disciple learns reasoning rules

Disciple Agent KB

Learned Rule

DECOMPOSITION RULE

IF:	Assess whether there are states with nuclear weapons that may be willing to sell nuclear weapons to *?O1*.
Q:	Which is a nuclear state?
A:	*?O2*

MAIN CONDITION

Var	Lower Bound	Upper B
?O1	(terrorist group)	(ac
?O2	(nuclear state)	(nuclea

THEN:	Assess whether *?O2* may be willing to s

Learned Rule

DECOMPOSITION RULE DDR.

IF:	Assess whether *?O1* may
Q:	What might be a weapons to *?O*
A:	*?O3* is perceive

Var	
?O1	
?O2	
?O3	(supe

Var	Relationship	Var
?O1	perceives as enemy	*?O3*
?O2	perceives as enemy	*?O3*

THEN:	Assess to what extent the perception that *?O3* is a common enemy of *?O1* and *?O2* might be a good reason for *?O1* to sell nuclear weapons to *?O2*.

To assess whether there are states that may be willing to sell nuclear weapons to an actor, one has to consider each nuclear state and assess whether that state may be willing to sell nuclear weapons to that actor.

Support for Problem Solving

Reasoning type: Reduction | Reasoning mode: Modeling | Plausibility: medium

Reasoning Hierarchy | Reasoning Step | Graphical Viewer | Report

- Assess whether there are states with nuclear weapons willing to sell nu… weapons to Al Qaeda.
  - Which is a nuclear state? North Korea
    - Assess whether North Korea is willing to sell nuclear weapons t…
  - Which is a nuclear state? France
    - Assess whether France is willing to sell nuclear weapons to Al …
  - Which is a nuclear state? India
    - Assess whether India is willing to sell nuclear weapons to Al Qaeda.
  - Which is a nuclear state? Iran
    - Assess whether Iran is willing to sell nuclear weapons to Al Qaeda.
  - Which is a nuclear state? Israel
    - Assess whether Israel is willing to sell nuclear weapons to Al Qaeda.
  - Which is a nuclear state? Pakistan
    - Assess whether Pakistan is willing to sell nuclear weapons to Al Qaeda.

Disciple Agent KB

Rule Viewer

DECOMPOSITION RULE DDR.00104 FORMAL DESCRIPTION

IF:	Assess whether there are states with nuclear weapons that may be willing to sell nuclear weapons to *?O1*.

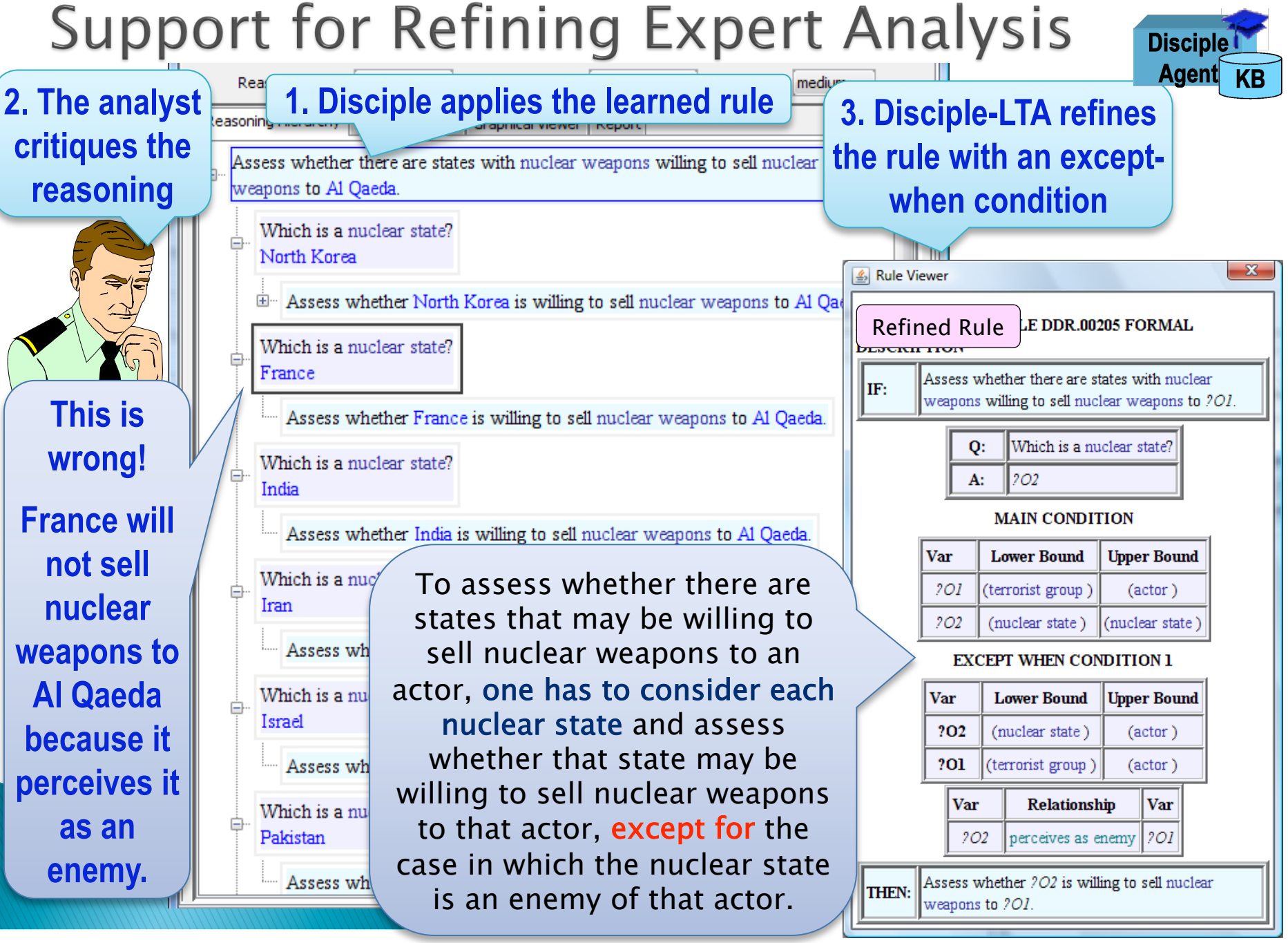
Q:	Which is a nuclear state?
A:	*?O2*

MAIN CONDITION

Var	Lower Bound	Upper Bound
?O1	(terrorist group)	(actor)
?O2	(nuclear state)	(nuclear state)

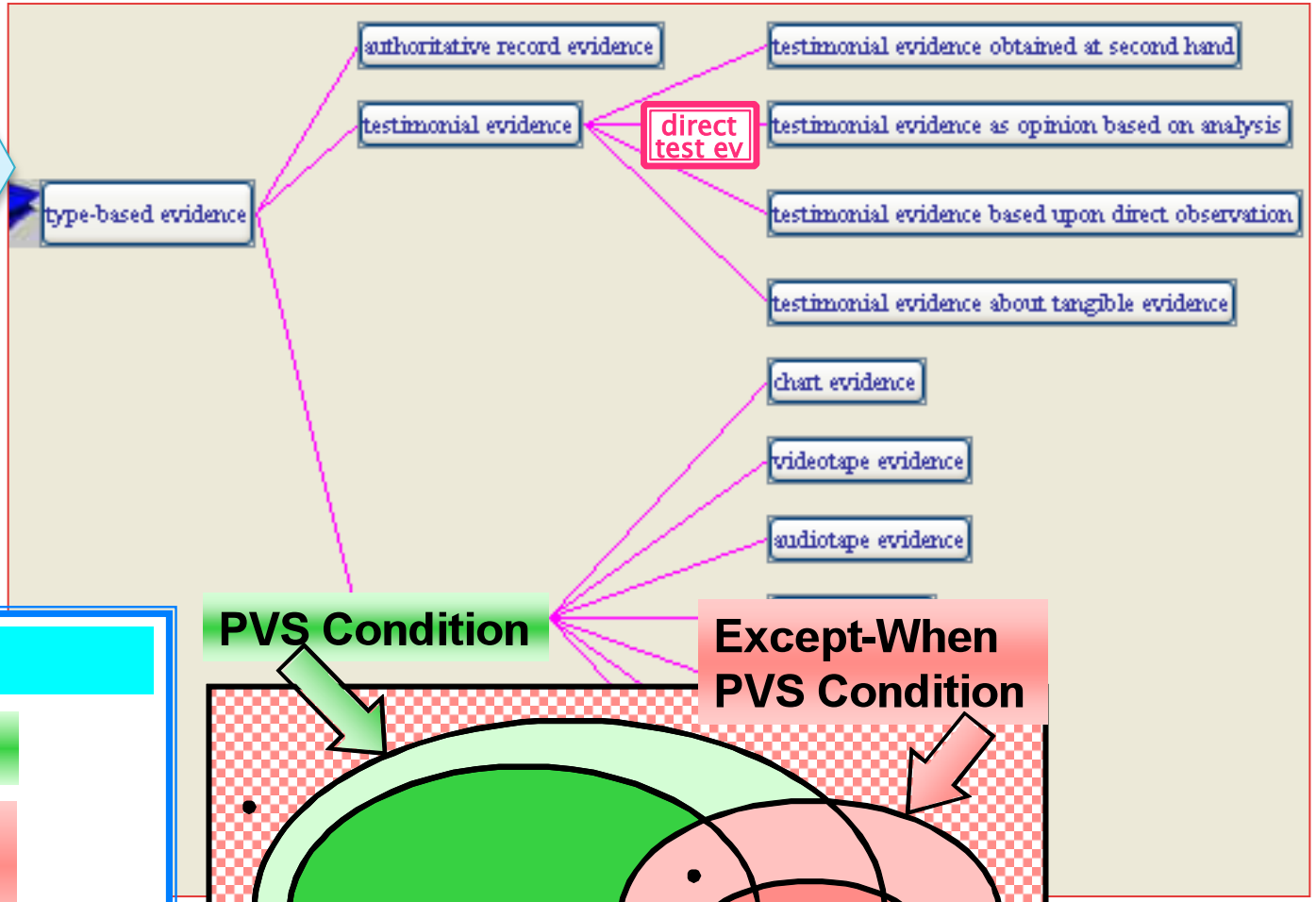
THEN:	Assess whether *?O2* may be willing to sell nuclear weapons to *?O1*.

Support for Refining Expert Analysis



Evolving representation space

Continuous adaptation of the previously learned rules to the evolution of the ontology.



IF <Problem>

PVS Condition

Except-When PVS Condition

THEN <Subproblem 1>
…
<Subproblem m>

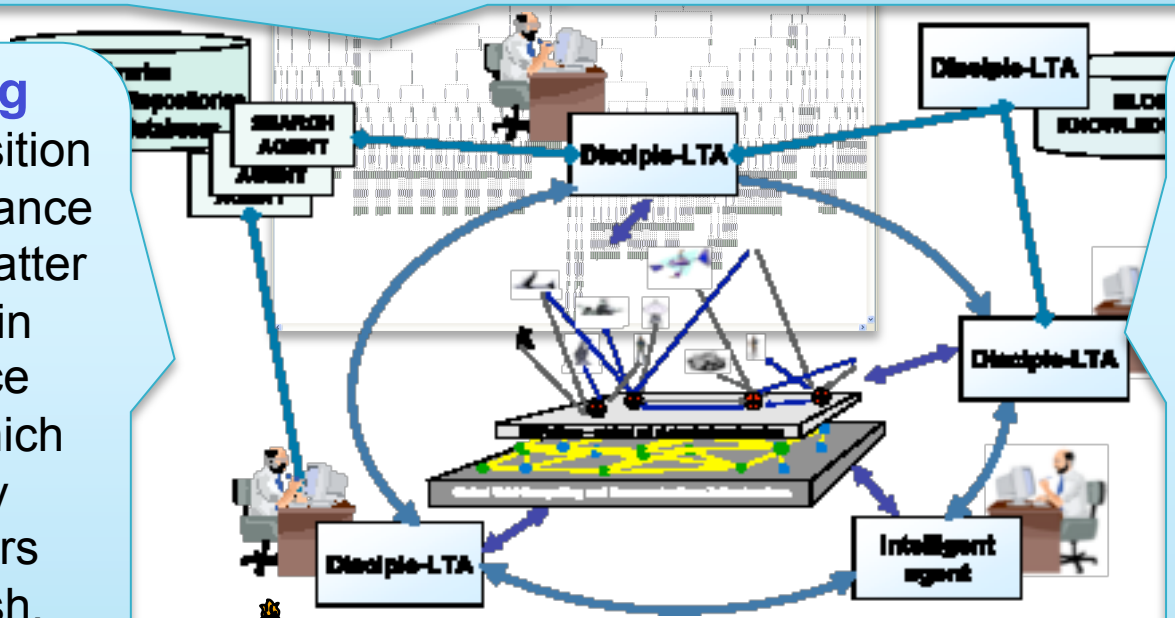
Summary and experimentation remarks

Analytic Assistance

Empowers the analysts through mixed-initiative reasoning for hypotheses analysis, collaboration with other analysts and experts, and sharing of information.

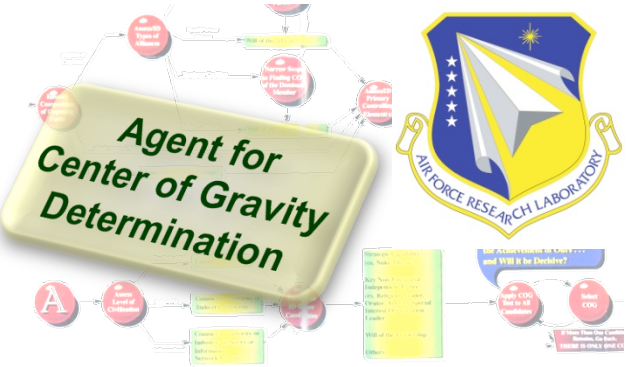
Learning

Rapid acquisition and maintenance of subject matter expertise in intelligence analysis which currently takes years to establish, is lost when experts separate from service, and is costly to replace.



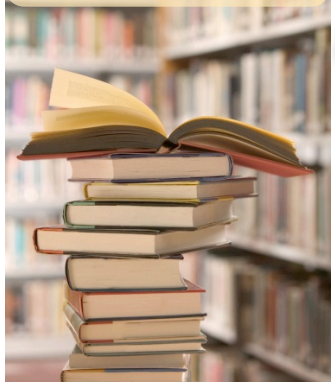
Tutoring

Helps new intelligence analysts learn the reasoning processes involved in making intelligence judgments and solving intelligence analysis problems.



Agent for Hypothesis Analysis

Agent Learning Theory



Critical requirement for a new generation of cognitive assistants

Disciple Learning and Tutoring Shell

- Problem Solving Engines
- Learning Engines
- Tutoring Engines

Domain Knowledge Base

Tutoring Knowledge Base

- Expertise modeling
- Multistrategy learning
- Mixed-initiative reasoning
- Reasoning with uncertainty

Agent for PhD Advisor Assessment

Agent for Web Believability Assessment

GEORGE MASON UNIVERSITY

Agent for Financial Regulations

NSF

STTR Phase II