

# Explanation-based E-Learning for Business Decision Making and Education

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Coherent Knowledge Systems\*

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# Introduction

- Core Technology approach: Textual Rulelog implemented in Ergo Suite – Reasoning with Explanations
- Case Study 1: Automated Decision Support for Financial Regulatory and Policy Compliance
- Case Study 2: Ergo Suite for Education Technology – Digital Socrates, an interactive tutor
- Conclusions and Lessons Learned from the Case Studies

# Coherent Knowledge: Company Overview

- Leverages over a decade of major government and privately funded research advances in artificial intelligence (AI) and semantic technologies. Founded 7/2013.
- Company offers: platform software product Ergo Suite™ + custom dev / services
  - Current applications in compliance and e-learning. Other applications in plan.
- World-class founder team: created many industry-leading logic systems & standards
  - XSB Prolog, RuleML, W3C RIF, W3C OWL-RL, IBM Common Rules, SWRL, SweetRules
  - Extensive experience applying logic systems to numerous domains in govt. and biz.



**Michael Kifer, PhD**  
**Principal Engineer**

*Creator, Flora.  
Co-Architect, W3C RIF.  
Prof., Stonybrook Univ.*



**Benjamin Grosf, PhD**  
**CTO & CEO**

*Creator, IBM Common Rules.  
Co-Architect, RuleML.  
Prof., MIT.  
Advanced AI Prog. Mger.  
for Paul Allen.*



**Terrance Swift, PhD**  
**Principal Engineer**

*Co-Architect, XSB Prolog.  
Consultant, US CBP.*



**Paul Fodor, PhD**  
**Senior Engineer**

*IBM Watson team.  
Prof., Stonybrook Univ.*



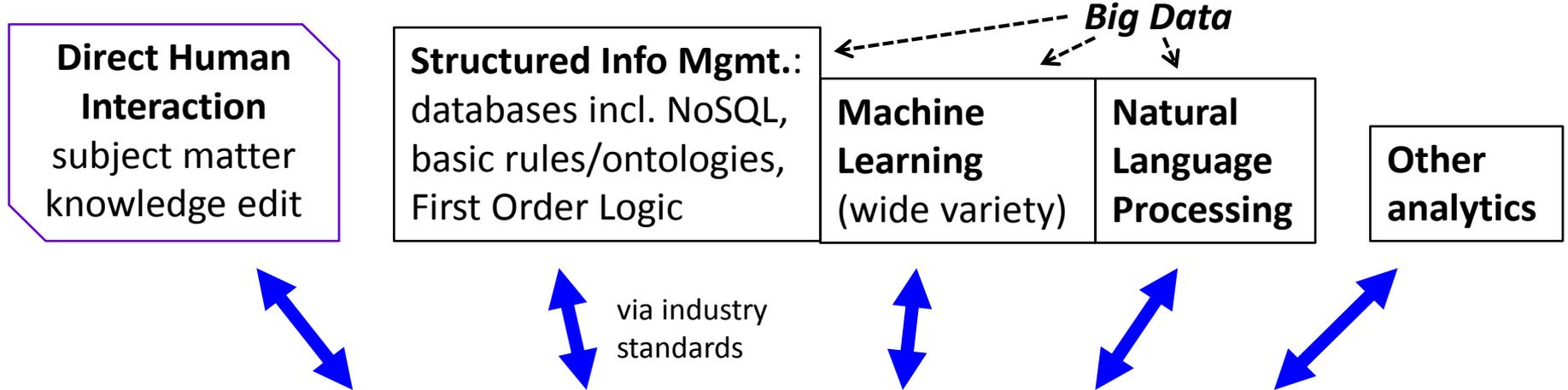
**Janine Bloomfield, PhD**  
**Dir., Marketing & Operations**

*Sr. Scientist, Climate Change,  
Environmental Defense Fund.  
Mindexplorekids.org.*

# Ergo Suite™ – The Coherent Knowledge Platform

- Dramatically expands the capabilities of database and reasoning systems
  - Adding or updating assertions, and posing queries, is much easier, faster, cheaper, and more under user control
  - An advanced logic engine operates under the covers. Handles probabilistic too.
  - Full explanations in English are provided, exposing the context and meaning behind the results
    - Every relevant assertion is a step in the chain of reasoning that leads to the final answer
- Benefits automation of:
  - Policies: organizational, compliance, and legal
  - Decision making: routine, exceptions, alerts
  - Learning: interactive tutor, in-depth explanation of solutions
  - Info Access: fine-grain control and tracking
  - Info Analysis: including collaboration and scenarios
  - Info Integration: from diverse sources, using structured info and text

# Bringing Coherence to Cognition & Integration



## **Textual Rulelog KRR** (KRR = Knowledge Representation & Reasoning)

- Orchestrates avail. Analytics and Info, via Flexible Semantics & Meta Knowledge
  - Weaves together into Deep Reasoning with Explanation
  - Includes: Probabilistic reasoning, Conflict handling, Schema Mapping

**Applications** in finance, legal/policy, education, security/defense, health care, life science, e-commerce/ads, intelligent/contextual assistants, ...

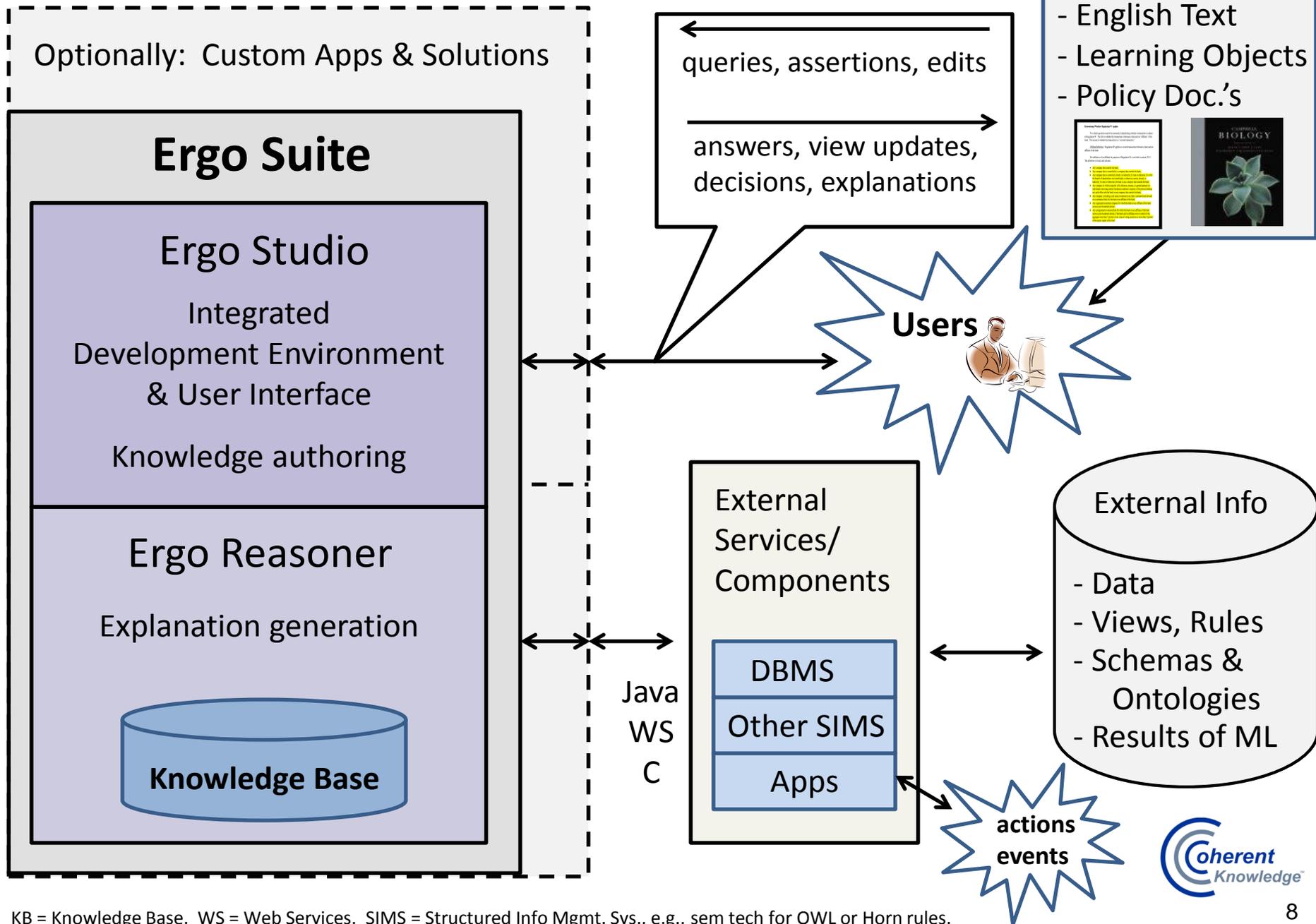
# Ergo Suite – Coherent Knowledge Management Platform

- Unprecedented flexibility in the kinds of complex info that can be stated as assertions, queries, and conclusions (highly expressive “knowledge” statements)
  - Almost anything you can say in English – concisely and directly
  - Just-in-time introduction of terminology
  - Statements about statements (meta knowledge)
  - State and view info at as fine a grain size as desired
- Probabilistic info combined in principled fashion, tightly combined with logical
  - Tears down the wall between probabilistic and non-probabilistic
- Unprecedented ease in updating knowledge
  - Map between terminologies as needed, including from multiple sources
- Conflict between statements is robustly handled (often arises during integration)
  - Resolved based on priority (e.g., authority), weighting, or else tolerated as an impasse
- Scalable and computationally well-behaved

# Ergo Reasoner & Ergo Studio (IDE/UI)

- Textual Rulelog: Implementation of major research advances in logic (Rulelog) and how to map between logic and English (Textual Logic )
  - The most complete & highly optimized implementation available
  - Rulelog significantly extends Datalog, the logic of databases, biz rule systems (production/ECA/Prolog), semantic web ontologies, and earlier-generation semantic web rules cf. SWRL and RIF and RuleML
- Ergo Reasoner component – with sophisticated algorithms
  - Reordering, caching, transformation, compilation, indexing, modularization
- Ergo Studio component – User Interface with array of advanced techniques
  - Integrated Development Environment (IDE). Visualizations of knowledge.
  - Fast edit-test loop with award-winning toolset
- Knowledge interchange with leading and legacy systems
  - SQL, RDF, RDF-Schema, OWL. Others in dev or easy to add. Fully automatic.
- Open, standards-based approach. Builds on open source components.
  - Supports Rulelog draft industry standard from RuleML (submission to W3C & Oasis)

# Coherent's Ergo Suite™ Platform



# Case Study 1: Automated Decision Support for Financial Regulatory/Policy Compliance

Problem: Current methods are expensive and unwieldy, often inaccurate

Solution Approach – using Textual Rulelog software technology:

- Encode regulations and related info as semantic rules and ontologies
- Fully, robustly automate run-time decisions and related querying
- Provide understandable full explanations in English
  - *Proof*: Electronic audit trail, with provenance
- Handles increasing complexity of real-world challenges
  - Data integration, system integration
  - Conflicting policies, special cases, exceptions
  - What-if scenarios to analyze impact of new regulations and policies

Business Benefits – compared to currently deployed methods:

- More Accurate
- More Cost Effective – less labor; subject matter experts in closer loop
- More Agile – faster to update
- More Overall Effectiveness: less exposure to risk of non-compliance



# Demo of Ergo Suite for Compliance Automation: US Federal Reserve Regulation W

- EDM Council Financial Industry Consortium  
Proof of Concept – **successful and touted pilot**
  - Enterprise Data Management Council (Trade Assoc.)
  - Coherent Knowledge Systems (USA, Technology)
  - SRI International (USA, Technology)
  - Wells Fargo (Financial Services)
  - Governance, Risk and Compliance Technology Centre (Ireland, Technology)
- Reg W regulates and limits \$ amount of transactions that can occur between banks and their affiliates. Designed to limit risks to each bank and to financial system.
- Must answer 3 key aspects:
  1. *Is the transaction's counterparty an affiliate of the bank?*
  2. *Is the transaction contemplated a covered transaction?*
  3. *Is the amount of the transaction permitted ?*

## Determining Whether Regulation W Applies

Two initial questions need to be answered in determining whether a transaction is subject to Regulation W. The first is whether the transaction is between a bank and an "affiliate" of the bank. The second is whether the transaction is a "covered transaction."

Affiliate Definition. Regulation W applies to covered transactions between a bank and an affiliate of the bank.

The definition of an affiliate for purposes of Regulation W is set forth in section 223.2. The definition is broad, and includes:

- Any company that controls the bank;
- Any company that is controlled by a company that controls the bank;
- Any company that is controlled, directly or indirectly, by trust or otherwise, by or for the benefit of shareholders who beneficially or otherwise control, directly or indirectly, by trust or otherwise, the bank or any company that controls the bank;
- Any company in which a majority of its directors, trustees, or general partners (or individuals exercising similar functions) constitute a majority of the persons holding any such office with the bank or any company that controls the bank;
- Any company, including a real estate investment trust, that is sponsored and advised on a contractual basis by the bank or an affiliate of the bank;
- Any registered investment company for which the bank or any affiliate of the bank serves as an investment adviser;
- Any unregistered investment fund for which the bank or any affiliate of the bank serves as an investment adviser, if the bank and its affiliates own or control in the aggregate more than 5 percent of any class of voting securities or more than 5 percent of the equity capital of the fund<sup>1</sup>;

## The Starting Point - Text of Regulation W

# Query is asked in English

The screenshot shows a software window titled "Coherent Query". The window has a menu bar with "Edit", "Restraint", "View", "Explain", "History", and "Windows". Below the menu bar are three buttons: "Execute", "Pause", and "Stop". The main text area contains the query: "What proposed transactions are prohibited by RegW? Show '(?Bank,?Company,?Amount).". Below the text area is a table with three columns: "?Bank", "?Company", and "?Amount". The first row of data contains the values "'Pacific Bank'", "'Maui Sunset'", and "23.0". A red circle highlights the cell containing "'Maui Sunset'", and a context menu is open over it with the following options: "Why?", "Explanation Game", and "See answer term as tree".

?Bank	?Company	?Amount
'Pacific Bank'	'Maui Sunset'	23.0

# User Clicks the handles to expand the Explanations



# Why is the proposed transaction prohibited by Regulation W?

1. *Is the transaction's counterparty an "affiliate" of the bank?*

YES.

Why 'What proposed transactions are prohibited by RegW? Show ('Pacific Bank','Maui Sunset',23.0) ?

Edit Operations

- RegW prohibits the proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million
  - The proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million is a RegW covered transaction
    - Maui Sunset is a RegW affiliate of Pacific Bank
      - Hawaii Bank is a RegW affiliate of Pacific Bank
        - There is common control of Hawaii Bank and Pacific Bank
          - Hawaii Bank is controlled by Americas Bank
            - Hawaii Bank is a subsidiary of Americas Bank
            - Pacific Bank is controlled by Americas Bank
              - Pacific Bank is a subsidiary of Americas Bank
        - Maui Sunset is advised by Hawaii Bank
      - There is a proposed loan from Pacific Bank to Maui Sunset of \$23.0 million
    - There is a limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
    - The proposed transaction of \$23.0 million is greater than the RegW limit of \$10.0 million

And here's why ...

# Why is the proposed transaction prohibited by Regulation W?

2. *Is the transaction contemplated a “covered transaction”?*

YES.

And here's why ...

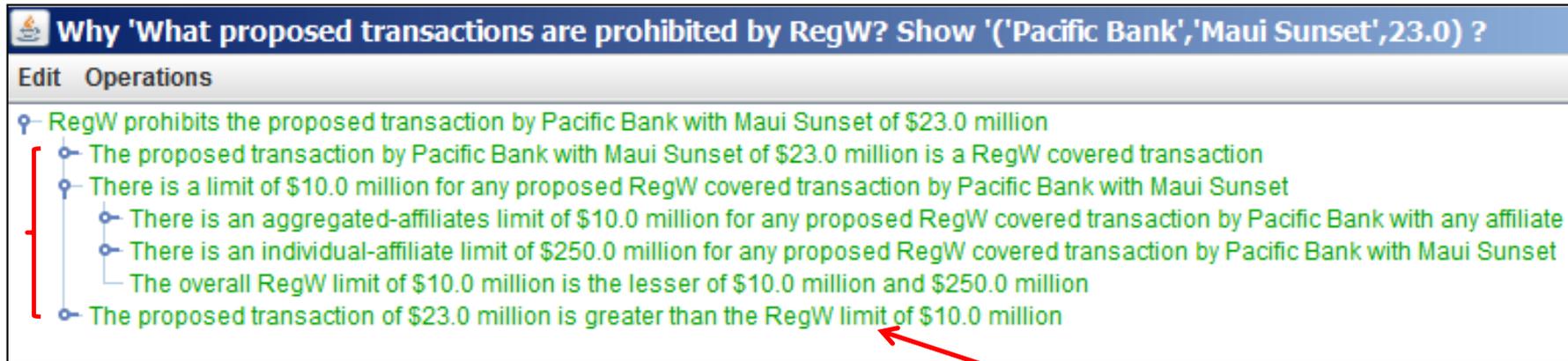
The screenshot displays a knowledge graph interface with a title bar that reads "Why 'What proposed transactions are prohibited by RegW? Show '(Pacific Bank', 'Maui Su...". Below the title bar is a menu with "Edit" and "Operations". The main content is a hierarchical list of nodes and edges, all in green text, explaining the prohibition:

- RegW prohibits the proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million
  - The proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million is a RegW covered transaction
    - Maui Sunset is a RegW affiliate of Pacific Bank
      - Hawaii Bank is a RegW affiliate of Pacific Bank
      - Maui Sunset is advised by Hawaii Bank
    - There is a proposed loan from Pacific Bank to Maui Sunset of \$23.0 million
  - There is a limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
  - The proposed transaction of \$23.0 million is greater than the RegW limit of \$10.0 million

Red arrows point from the text "And here's why ..." to the graph, and from "YES." to the top-level node of the graph.

# Why is the proposed transaction prohibited by Regulation W?

## 3. *Is the amount of the transaction permitted?*



The screenshot shows a knowledge base entry titled "Why 'What proposed transactions are prohibited by RegW? Show ('Pacific Bank','Maui Sunset',23.0) ?". The entry is structured as follows:

- RegW prohibits the proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million
  - The proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million is a RegW covered transaction
  - There is a limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
    - There is an aggregated-affiliates limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with any affiliate
    - There is an individual-affiliate limit of \$250.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
    - The overall RegW limit of \$10.0 million is the lesser of \$10.0 million and \$250.0 million
  - The proposed transaction of \$23.0 million is greater than the RegW limit of \$10.0 million

And here's why ...

NO.

It went over the limit.

# Why is the proposed transaction prohibited by Regulation W?

## 3. (continued) Why is the aggregate-affiliates limit \$10 million?

**Why 'What proposed transactions are prohibited by RegW? Show '(Pacific Bank','Maui Sunset',23.0) ?**

Edit Operations

- RegW prohibits the proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million
  - The proposed transaction by Pacific Bank with Maui Sunset of \$23.0 million is a RegW covered transaction
  - There is a limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
    - There is an aggregated-affiliates limit of \$10.0 million for any proposed RegW covered transaction by Pacific Bank with any affiliate
      - The aggregated total of previous RegW covered transactions by Pacific Bank with all affiliates is \$490.0 million
      - The maximum threshold for aggregate RegW covered transactions by Pacific Bank with all affiliates is \$500.0 million
        - The capital stock and surplus of Pacific Bank is \$2500.0 million
        - The RegW threshold percentage for aggregate affiliates is 20.0 percent
        - \$500.0 million is \$2500.0 million multiplied by 20.0 percent
      - The limit of \$10.0 million is the result of subtracting the previous RegW covered transactions total of \$490.0 million from the RegW threshold \$500.0 million
    - There is an individual-affiliate limit of \$250.0 million for any proposed RegW covered transaction by Pacific Bank with Maui Sunset
      - The overall RegW limit of \$10.0 million is the lesser of \$10.0 million and \$250.0 million
  - The proposed transaction of \$23.0 million is greater than the RegW limit of \$10.0 million

# Examples of the Underlying Textual Rulelog Executable **Fact** Assertions

- subsidiary(of)('Pacific Bank','Americas Bank').
- advised(by)('Maui Sunset','Hawaii Bank').
- bank('Hawaii Bank').
- company('Maui Sunset').
- capital(stock(and(surplus)))(('Pacific Bank',2500.0)).
- proposed(loan) (from('Pacific Bank'))(to('Maui Sunset')) (of(amount(23.0)))  
(having(id(1101))).
- previous(loan)(from('Pacific Bank'))(to('Hawaii Bank')) (of(amount(145.0)))  
(having(id(1001))).
- proposed(asset(purchase))(by('Pacific Bank'))  
(of(asset(common(stock)(of('Flixado'))))) (from('Maui Sunset'))  
(of(amount(90.0)))(having(id(1202))).

# Executable Assertions: non-fact Rules

```
/* A company is controlled by another company when the first company  
   is a subsidiary of a subsidiary of the second company. */
```

```
@!{rule103b} /* declares rule id */
```

```
@@{defeasible} /* indicates the rule can have exceptions */
```

```
controlled(by)(?x1,?x2)
```

```
:- /* if */
```

```
  subsidiary(of)(?x1,?x3) \and
```

```
  subsidiary(of)(?x3,?x2).
```

```
/*A case of an affiliate is: Any company that is advised on a contractual basis by  
   the bank or an affiliate of the bank. */
```

```
@!{rule102b} @@{defeasible}
```

```
affiliate(of)(?x1,?x2) :-
```

```
  ( advised(by)(?x1,?x2)
```

```
    \or
```

```
    (affiliate(of)(?x3,?x2) \and advised(by)(?x1,?x3))).
```

# Executable Assertions: **Exception Rule**

```
@!{rule104e}
@{'ready market exemption case for covered transaction'} /* tag for prioritizing */
\neg covered(transaction)(by(?x1))(with(?x2))
    (of(amount(?x3)))(having(id(?Id))) :-
    affiliate(of)(?x2,?x1) \and
    asset(purchase)(by(?x1))(of(asset(?x6)))(from(?x2))(of(amount(?x3)))
    (having(id(?Id))) \and
    asset(?x6)(has(ready(market))).

/* prioritization info, specified as one tag being higher than another */
\overrides('ready market exemption case for covered transaction',
    'general case of covered transaction').

/* If a company is listed on the New York Stock Exchange (NYSE), then the
    common stock of that company has a ready market. */
@!{rule201} @@{defeasible}
asset(common(stock)(of(?Company)))(has(ready(market))) :-
    exchange(listed(company))(?Company)(on('NYSE')).
```

# Executable Assertions: Import of OWL

```
- iriprefix fibof = /* declares an abbreviation */
    "http://www.omg.org/spec/FIBO/FIBO-Foundation/20120501/ontology/".

/* Imported OWL knowledge: from Financial Business Industry Ontology (FIBO) */
rdfs#subClassOf(fibob#BankingAffiliate, fibob#BodyCorporate).
rdfs#range(fibob#whollyOwnedAndControlledBy, fibob#FormalOrganization).
owl#disjointWith(edmc#Broad_Based_Index_Credit_Default_Swap_Contract,
    edmc#Narrow_Based_Index_Credit_Default_Swap_Contract).

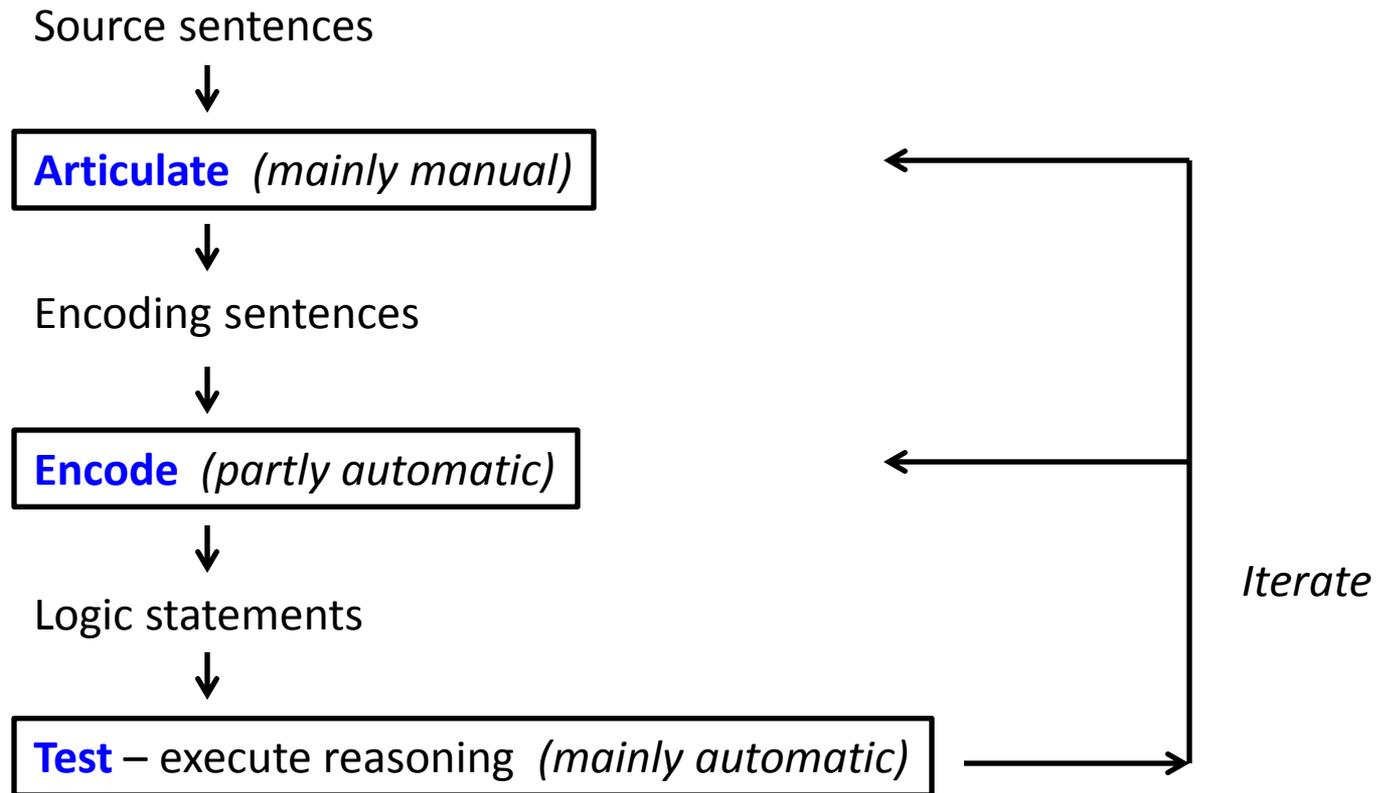
/* Ontology Mappings between textual terminology and FIBO OWL vocabulary */
company(?co) :- fibob#BodyCorporate(?co).
fibob#whollyOwnedAndControlledBy(?sub,?parent) :- subsidiary(of)(?sub,?parent).

/* Semantics of OWL - specified as general Rulelog axioms */
?r(?y) :- rdfs#range(?p,?r), ?p(?x,?y).
?p(?x,?y) :- owl#subPropertyOf(?q,?p), ?q(?x,?y).
```

# Knowledge Authoring Process using Ergo Suite

- Start with source text in English – e.g., textbook or policy guide
  - A sentence/statement can be an assertion or a query
- Articulate: create encoding sentences (text) in English.  
As necessary:
  - Clarify & simplify – be prosaic and grammatical, explicit and self-contained
  - State relevant background knowledge – that’s not stated directly in the source text
- Encode: create executable logic statements
  - Each encoding text sentence results in one executable logic statement (“rules”)
  - Ergo Suite has tools and methodology
- Test and debug, iteratively
  - Execute reasoning to answer queries, get explanations, perform other actions
  - Find and enter missing knowledge
  - Find and fix incorrect knowledge
  - Optionally: further optimize reasoning performance, where critical

# Knowledge Authoring Steps using Ergo Suite



*In-development: methods to greatly increase the degree of automation in encoding*

# Case Study 2: Ergo Suite for Education Technology

## *Digital Socrates, an interactive tutor*

Problem: Current automated tutors are expensive and time-consuming to encode, can't re-use knowledge well, can't teach critical thinking skills well

Solution Approach – using Textual Rulelog software technology:

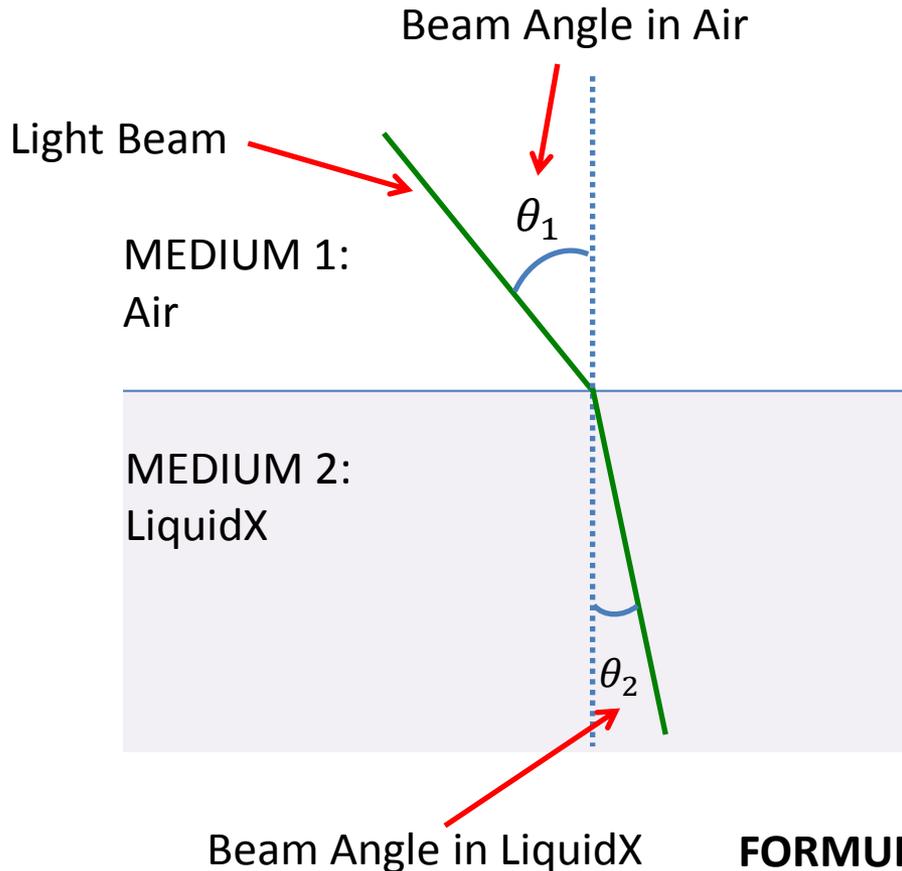
- Encode educational materials such as textbooks, policy and legal documents, and company intelligence, as semantic rules and ontologies
- Create question/answer/explanation triples for study and test preparation
- Automatically generate *fine-grained* explanations – in English
  - Show each step in the logical chain of reasoning - go beyond the right answer to teach the student *Why* it is correct
  - Provide links to the source material on a per-sentence level
- Personalized and Adaptive Learning guidance based on what the student knows and what the student needs to learn

Business Benefits – compared to currently deployed methods:

- Critical Thinking Skills are addressed much better
- Cost effective and Scalable
- Knowledge is much more reusable

# AP Physics Optics Problem

Question: “What is the Index of Refraction for a sample clear liquid given the Index of Refraction for air and the light beam angles in the two mediums?”



## KEY CONCEPTS:

Index of Refraction (IOR)

Snell's Law

## FACTS:

IOR of Air = 1.000277

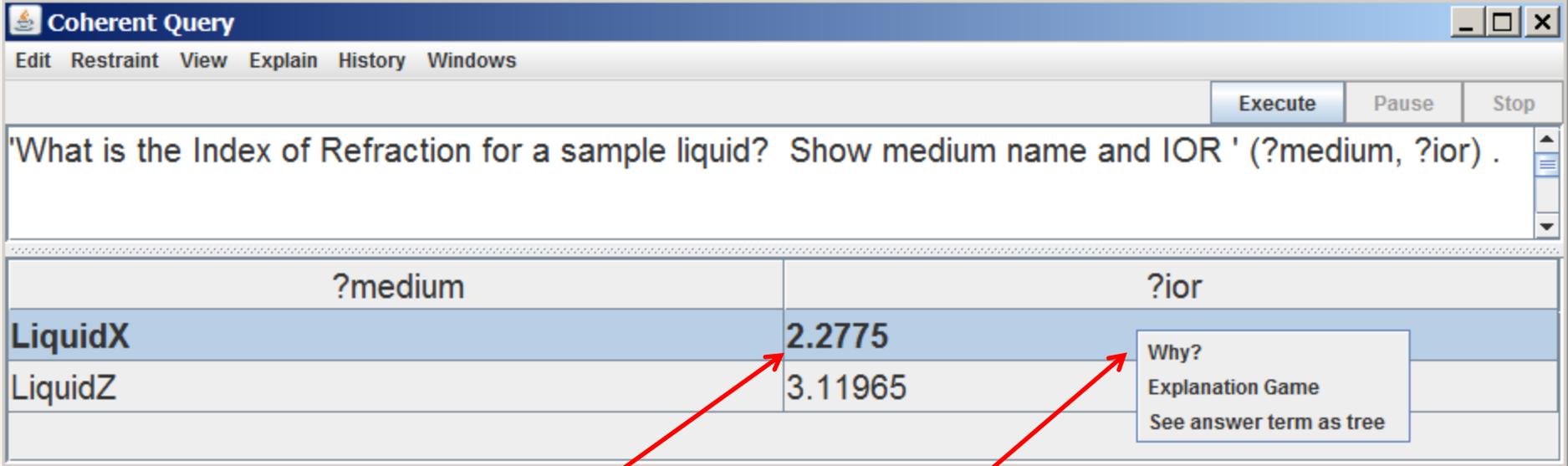
Beam Angle in Air = 0.52

Beam Angle in LiquidX = 0.22

## FORMULA for Snell's Law:

$$\begin{aligned} &(\text{IOR of Medium 2}) * \sin(\text{Beam Angle in Medium 2}) \\ &= (\text{IOR of Medium 1}) * \sin(\text{Beam Angle in Medium 1}) \end{aligned}$$

# The Index of Refraction for the unknown liquid is inferred using Snell's Law



The screenshot shows the Coherent Query application window. The title bar reads "Coherent Query". The menu bar includes "Edit", "Restraint", "View", "Explain", "History", and "Windows". On the right side of the window, there are three buttons: "Execute", "Pause", and "Stop". The main text area contains the query: "What is the Index of Refraction for a sample liquid? Show medium name and IOR ' (?medium, ?ior) .". Below the query is a table with two columns: "?medium" and "?ior". The table has two rows: "LiquidX" with a value of "2.2775" and "LiquidZ" with a value of "3.11965". A context menu is open over the "2.2775" cell, showing options: "Why?", "Explanation Game", and "See answer term as tree". Two red arrows point from the text below to the "2.2775" cell and the "Why?" option.

?medium	?ior
LiquidX	2.2775
LiquidZ	3.11965

The Answer

Click on 'Why' for the Explanation

# The Answer and Explanation are shown, including formula, facts, and concepts

ANSWER

The screenshot shows a software window titled "Why 'What is the Index of Refraction for a sample liquid? Show medium name and IOR '(LiquidX,2.2775) ?". The window contains the following text:

- 'What is the Index of Refraction for a sample liquid? Show medium name and IOR '(LiquidX,2.2775)
- The Index of Refraction for LiquidX is 2.2775 using Snells Law
- Snells Law states that the Index of Refraction for Medium 1 = Index of Refraction for Medium 2 \* sin(Beam Angle in Medium 2) / sin (Beam Angle in Medium 1)
- The sample medium is LiquidX
- The Index of Refraction for air is 1.00028
- The beam angle in air is 0.52
- The beam angle in LiquidX is 0.22
- $2.2775 = 1.00028 * (\sin(0.52) / \sin(0.22))$
- air is not LiquidX

Red arrows point from external labels to specific parts of the text: "ANSWER" points to the question, "CONCEPT" points to Snell's Law, "FORMULA" points to the equation, and "FACT" points to the refractive index of air.

CONCEPT

FORMULA

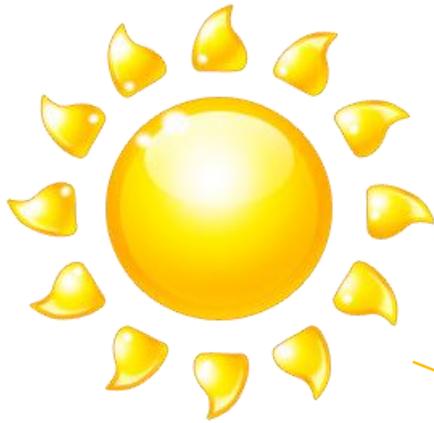
FACT

# Astronomy: Problem in Different Topic

## *Reuses* Knowledge from Optics

**Question: "The Sun is  $1.5 \times 10^8$  km from Earth. How many more minutes would it take light from the Sun to reach Earth if the space between them were filled with an unknown liquid instead of a vacuum. Why?"**

[Adapted from *Physics Principles and Problems*, Glencoe Science, McGraw Hill, 2009, p. 511]



### NEW FACTS:

Distance from Sun to Earth =  $1.5 \times 10^8$  km  
IOR of vacuum = 1.0

### NEW KEY CONCEPT:

Speed of Light

### **REUSED** KEY CONCEPTS and FACTS:

Index of Refraction  
Snell's Law

IOR of Air = 1.000277

Beam Angle in Air = 0.52

Beam Angle in LiquidX = 0.22

### NEW FORMULAS:

Rate \* Time = Distance

Speed of Light in a medium =  $\frac{\text{Speed of Light in a vacuum}}{\text{Index of Refraction in a medium}}$



# Query is asked in English

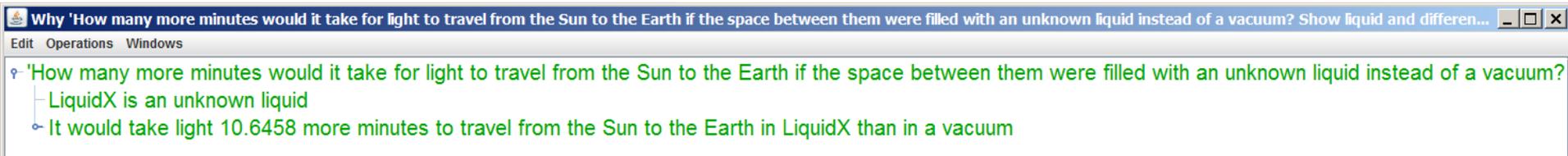
The screenshot shows the 'Coherent Query' application window. The title bar includes 'Coherent Query' and standard window controls. The menu bar contains 'Edit', 'Restraint', 'View', 'Explain', 'History', and 'Windows'. On the right side of the window, there are three buttons: 'Execute', 'Pause', and 'Stop'. The main text area contains the query: 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum? Show liquid and difference in minutes' (?liquid, ?difference). Below the query is a table with two columns: '?liquid' and '?difference'. The table has two rows: 'LiquidX' with a value of '10.6458' and 'LiquidZ' with a value of '17.6638'. A context menu is open over the '10.6458' value, with options: 'Why?', 'Explanation Game', and 'See answer term as tree'. Two red arrows point from the text below to the '10.6458' value and the 'Why?' option.

?liquid	?difference
LiquidX	10.6458
LiquidZ	17.6638

The answer is given in minutes.

Next, we can get the explanation by clicking on 'Why?'

# User Clicks the handles to Expand the Explanations

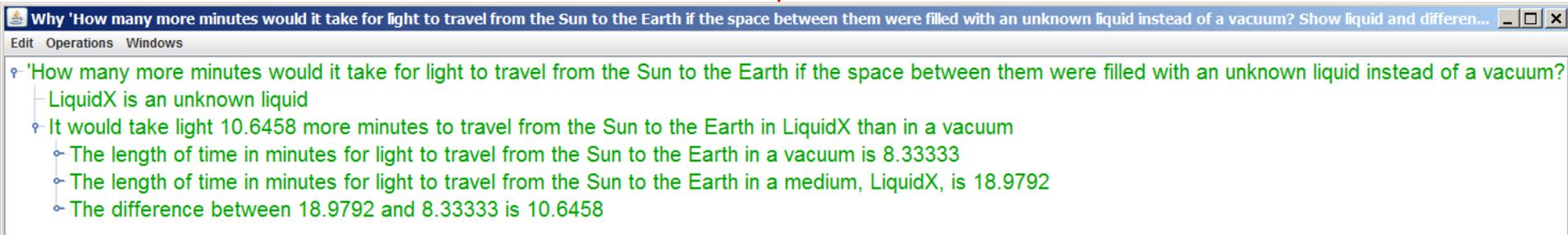


Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum? Show liquid and differen... \_ □ ×

Edit Operations Windows

Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum?'

- LiquidX is an unknown liquid
- It would take light 10.6458 more minutes to travel from the Sun to the Earth in LiquidX than in a vacuum

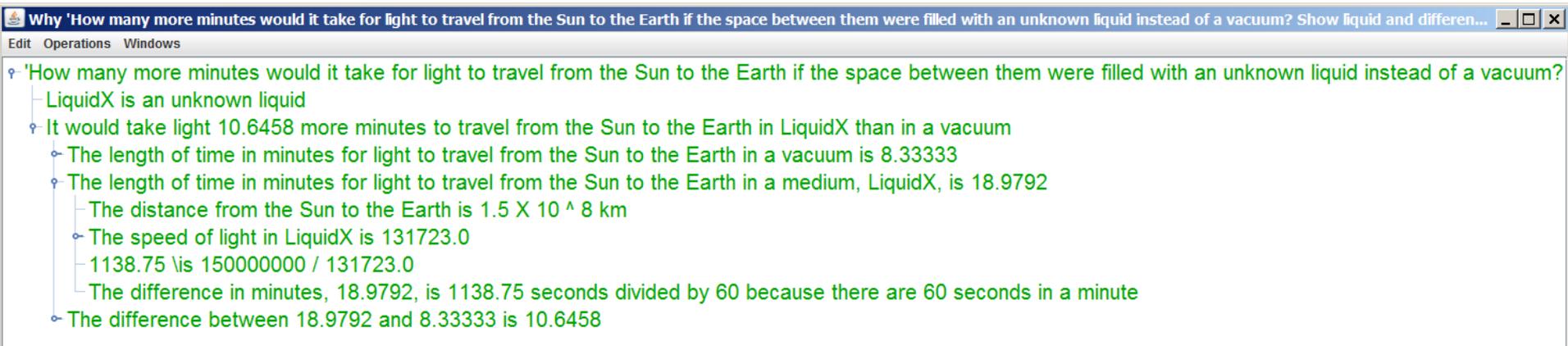


Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum? Show liquid and differen... \_ □ ×

Edit Operations Windows

Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum?'

- LiquidX is an unknown liquid
- It would take light 10.6458 more minutes to travel from the Sun to the Earth in LiquidX than in a vacuum
  - The length of time in minutes for light to travel from the Sun to the Earth in a vacuum is 8.33333
  - The length of time in minutes for light to travel from the Sun to the Earth in a medium, LiquidX, is 18.9792
  - The difference between 18.9792 and 8.33333 is 10.6458



Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum? Show liquid and differen... \_ □ ×

Edit Operations Windows

Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum?'

- LiquidX is an unknown liquid
- It would take light 10.6458 more minutes to travel from the Sun to the Earth in LiquidX than in a vacuum
  - The length of time in minutes for light to travel from the Sun to the Earth in a vacuum is 8.33333
  - The length of time in minutes for light to travel from the Sun to the Earth in a medium, LiquidX, is 18.9792
    - The distance from the Sun to the Earth is  $1.5 \times 10^8$  km
    - The speed of light in LiquidX is 131723.0
    - $1138.75$  is  $150000000 / 131723.0$
    - The difference in minutes, 18.9792, is 1138.75 seconds divided by 60 because there are 60 seconds in a minute
  - The difference between 18.9792 and 8.33333 is 10.6458

# The Answer *and* the Underlying Knowledge are all part of the Explanation in English

- Illustrates cumulative, modular character of the encoded knowledge. The reused knowledge needs no modification. This is key to scalability.

Why 'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum? Show liquid and differenc...

Edit Operations Windows

'How many more minutes would it take for light to travel from the Sun to the Earth if the space between them were filled with an unknown liquid instead of a vacuum?'

- LiquidX is an unknown liquid
- It would take light 10.6458 more minutes to travel from the Sun to the Earth in LiquidX than in a vacuum
  - The length of time in minutes for light to travel from the Sun to the Earth in a vacuum is 8.33333
  - The length of time in minutes for light to travel from the Sun to the Earth in a medium, LiquidX, is 18.9792
  - The distance from the Sun to the Earth is  $1.5 \times 10^8$  km
  - The speed of light in LiquidX is 131723.0
  - The index of refraction for LiquidX is 2.2775
    - The Index of Refraction for LiquidX is 2.2775 using Snells Law
      - Snells Law states that the Index of Refraction for Medium 1 = Index of Refraction for Medium 2 \* sin(Beam Angle in Medium 2) / sin (Beam Angle in M
      - The sample medium is LiquidX
      - The index of refraction of air is 1.00028
      - The beam angle in air is 0.52
      - The beam angle in LiquidX is 0.22
      - $2.2775 = 1.00028 * (\sin(0.52) / \sin(0.22))$
    - The speed of light in a medium is calculated by dividing the speed of light in a vacuum, 300000, by the index of refraction of the medium.
    - $131723.0$  is  $300000 / 2.2775$
    - $1138.75$  is  $150000000 / 131723.0$
    - The difference in minutes, 18.9792, is 1138.75 seconds divided by 60 because there are 60 seconds in a minute
  - The difference between 18.9792 and 8.33333 is 10.6458

NEW FACT

REUSED KNOWLEDGE:  
inferred IOR of LiquidX

NEW FORMULA

# Lessons Learned from Case Studies

- Coherent's Ergo Suite technology successfully automated Regulation W, demonstrating its utility for Regulatory and Policy Compliance
  - Highly Accurate on test data
  - Full Explanations – in English, with chain of reasoning and provenance
  - Reduces key elements of compliance risk
  - Cost Effective implementation – flexible; with electronic audit trail
- Textual Rulelog can be applied to Education via Digital Socrates tutor
  - Re-use of knowledge (complex concepts, facts, formulas)
  - Critical Thinking Skills addressed. Deepens the learning experience.
    - Answer *plus* Explanation incl. Concepts, Formulas, .... Why, not just what.
  - Content neutral platform. Fundamentally faster, cheaper, better.
  - Personalized based on what questions student asks, where (s)he drills down
- Concrete Business Benefits for Financial Compliance and Education
  - More Cost Effective – less labor, subject matter experts in closer loop
  - More Agile – faster to update
  - More Overall Effectiveness – firmer deeper understanding
    - Lower risk of non-compliance or confusion

# Case Study Lessons – Bigger Picture

- Knowledge work by professionals revolves largely around continuing education (a.k.a. training)
  - Need to cope with ever-growing info amounts, complexity, and expectations
- The customers were very excited by the availability of comprehensible detailed explanations
  - Compliance non-IT people could understand them – and validate decisions
  - Analytics without sufficient explanation/transparency is hard to trust, hard to use, and hard to learn from, individually and organizationally
- Knowledge work in turn revolves around orchestrating and integrating multiple knowledge sources and analysis components.
  - Coherence and synergistic power in combining are critical
- Textual Rulelog meets these requirements well
  - Flexible, expressive, semantic, open, transparent

# Thank You

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