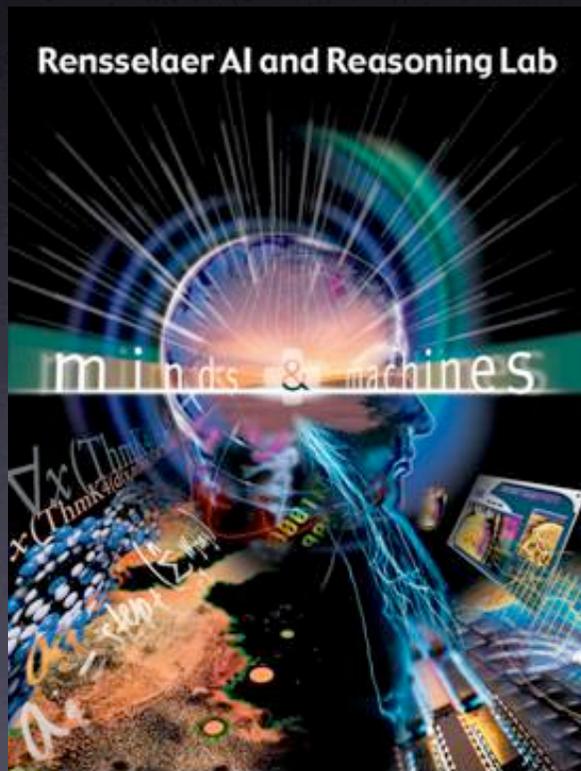


# Artificial Intelligence and the Future of Intelligence Analysis and Wargaming



## Selmer Bringsjord

Andrew Shilliday, Joshua Taylor, Bettina Schimanski  
Konstantine Arkoudas, Sangeet Khemlani, Eric Pratt,  
Gabe Mulley, Sunny Khemlani  
Rensselaer AI & Reasoning (RAIR) Laboratory  
Department of Cognitive Science  
Department of Computer Science  
Rensselaer Polytechnic Institute (RPI)  
Troy NY 12180 US  
@ PNNL 8.8.05



# Structure of Talk

- The RAIR Lab is...
- Brief remarks on wargaming R&D
- Slate (bulk of presentation)
- Three points in 2nd part (very brief; abstract a bit misleading :))
  - penetrating reasoning w/o invading personal privacy
  - depth vs breadth of reasoning
  - uncrackable communication

The RAIR Lab...



Rensselaer

DEPARTMENT OF COGNITIVE SCIENCE

Rensselaer Computer Science

Rensselaer > Department of Cognitive Science > Research > RAIR Lab

# Rensselaer Artificial Intelligence and Reasoning (RAIR) Laboratory

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The **Rensselaer Artificial Intelligence and Reasoning (RAIR) Laboratory** is located in rooms 1112 and 1201 of the Russell Sage Laboratory on the RPI campus.

Research and development in the RAIR Lab ranges across a number of applied projects, as well as across many of the fundamental questions AI raises (e.g., Are we machines ourselves? If so, what sort of machines?). Everything is to a high degree unified by the fact that the formalisms, tools, techniques, systems, etc. that underlie the lab's R&D are invariably based on reasoning.

Because of this, logic plays for us a central role (since, after all, logic is the science of reasoning), but reasoning can be implemented in many ways, and so to reach our goals we happily turn to whatever concretization of reasoning gets the job done.



## RAIR Lab News

**Artificially induced: Teaching computers to read first step in developing consciousness**

February 20, 2005

"RPI's work will investigate learning and reasoning, both areas that are key to achieving the vision of cognitive systems," said Jan Walker, with DARPA's external relations department. "In addition, while learning and reasoning are generally important, it is also important to be able to measure when a cognitive system has learned. The RPI project will develop ways to help measure when a system has truly learned something."

**Rensselaer Researchers Awarded DARPA Grant to Focus on Learning and Reading**

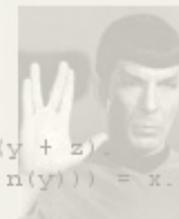
The sentence below is true  
The sentence above is false



$f(1) = 0. a_{(1,1)} a_{(1,2)} a_{(1,3)}$   
 $f(2) = 0. a_{(2,1)} a_{(2,2)} a_{(2,3)}$   
 $f(3) = 0. a_{(3,1)} a_{(3,2)} a_{(3,3)}$

end\_of\_list.

```
list(sos).  
x + y = y + x.  
(x + y) + z = x + (y + z).  
n(n(x + y) + n(x + n(y))) = x.  
n(C + D) = n(C).
```



# RAIR Lab Method

- Isolate and dissect human ingenuity.
- Formalize weak correlate to this ingenuity in advanced KR&R systems.
- Implement correlate in working computer programs.
- Augment correlate as needed with machine-specific power.

RAIR Laboratory - Projects

<http://www.cogsci.rpi.edu/research/rair/projects.php> Google

 **Rensselaer** DEPARTMENT OF COGNITIVE SCIENCE + Rensselaer Computer Science

[Rensselaer](#) > [Department of Cognitive Science](#) > [Research](#) > [RAIR Lab](#) > [Projects](#)

## Rensselaer Artificial Intelligence and Reasoning (RAIR) Laboratory

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### Projects



#### Psychometric Artificial Intelligence and PERI

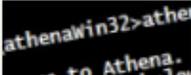
Psychometric AI is the field devoted to building information processing entities capable of at least solid performance on all established, validated tests of intelligence and mental ability - a class of tests that includes IQ tests, tests of reasoning, of creativity, mechanical ability, and so on.

PERI, a robot capable of perfect performance on the Block Design subtest of the Wechsler Adult Intelligent Scale, is our first step towards satisfying this goal.



#### Poised-For Learning

Can you ascertain if a human or machine has learned a domain solely by direct inspection of the brain, rather than testing for performance? This question is the driving idea behind our Poised-For Learning project, which seeks to concretely engineer a computational system that will learn by reading content *as it appears to humans*, something no previous system has been able to do. Since textual content read by humans is often supplemented with diagrams and pictures, we are also developing the system to have the ability to reason over diagrammatic and visual content.



#### Athena

Athena developed by Kostas Arkoudas is a programming

### RAIR Lab News

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#### Rensselaer Researchers Awarded DARPA Grant to Focus on Learning and Reading

January 24, 2005

Researchers at Rensselaer have been awarded a grant from the Defense Advanced Research Projects Agency (DARPA) to investigate key

# Wargaming...

(for details: AAAI Fall Symposium *Machine Ethics*; keynote paper & presentation; and technical paper & presentation)

# Oxy vs Jihad

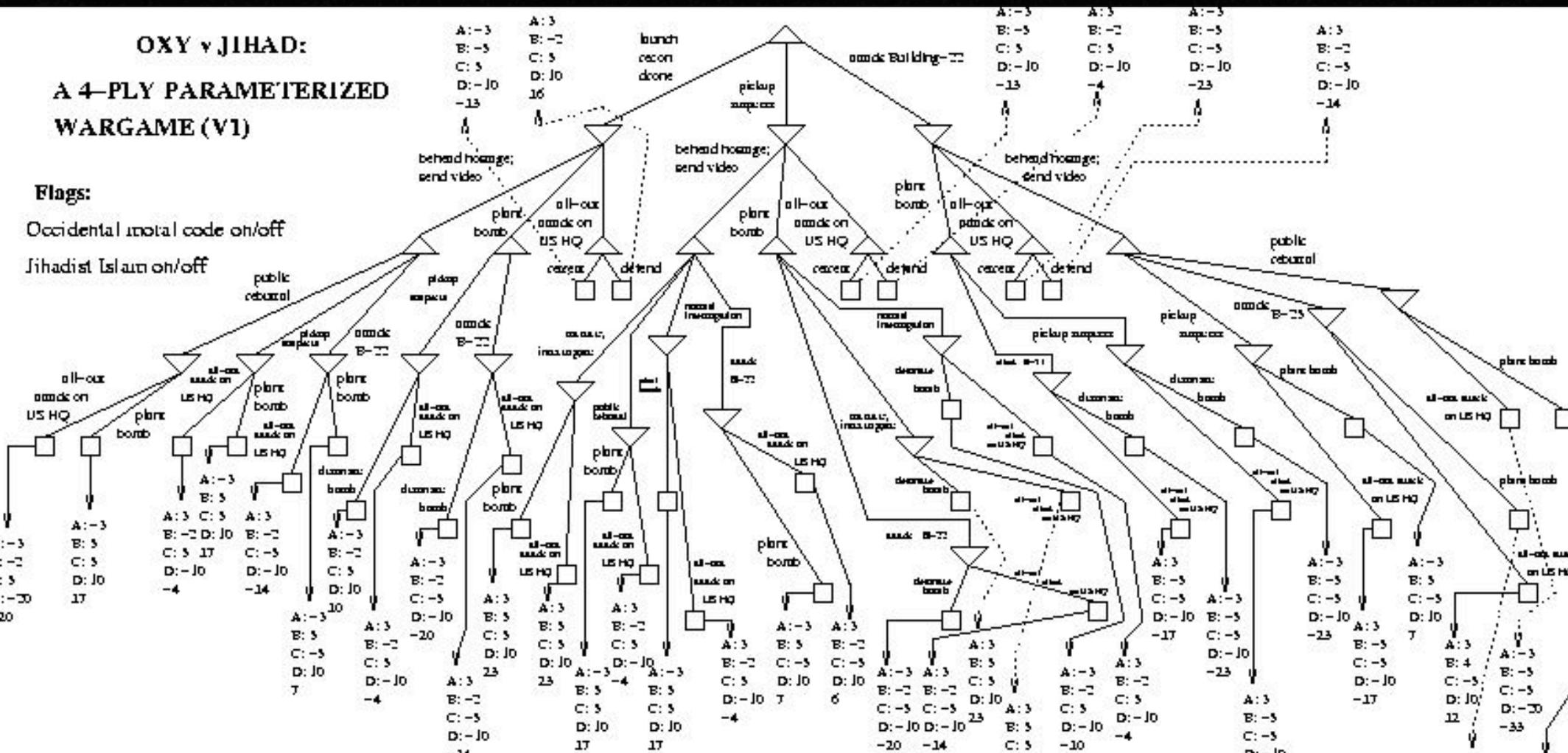
## OXY v JIHAD:

### A 4-PLY PARAMETERIZED WARGAME (V1)

#### Flags:

Occidental mortal code on/off

Jihadist Islam on/off



#### Outcomes Determining Utility:

##### Cluster A:

No terrorists are killed -3  
 All terrorists killed 10  
 Some terrorists killed 3

##### Cluster B:

HQ structure destroyed -5  
 HQ structure partially destroyed -2  
 HQ structure no damage 5

##### Cluster C:

No loss of innocent life 5  
 Some innocents killed by US -5

##### Cluster D:

All occupants of HQ killed -20  
 Some occupants of HQ killed -10  
 Occupants of HQ all saved 10

# Militaristic “Wise Man”

\*\* A L E R T \*\*

To: Special Forces Company D  
From: Central Command, Integrated Special Forces  
cc: Special Forces Companies A, B, C

Recent HUMINT and SIGINT reveals that at least one of you (A, B, C, D), at present, has been locked in as a target of MET's highly effective medium-range laser-guided missile system, the Azan+. Despite the threat this poses (launch could come at any moment), under no circumstances should you change your present location: Any movement could result in your being locked into the sites of the Azan+, if you aren't already. The last thing we want is for a group that isn't locked in to be successfully targeted.

As you know, and as the other companies know as well, you cannot determine through use of your EYE system whether your own company has been locked in by the Azan+'s targeting system. But the EYE *can* determine whether *another* company has been locked in (a signature laser tag is visible to the EYE when the Azan+ is aimed at units other than yours). All of you, as you know, can scan each other with the EYE. ...

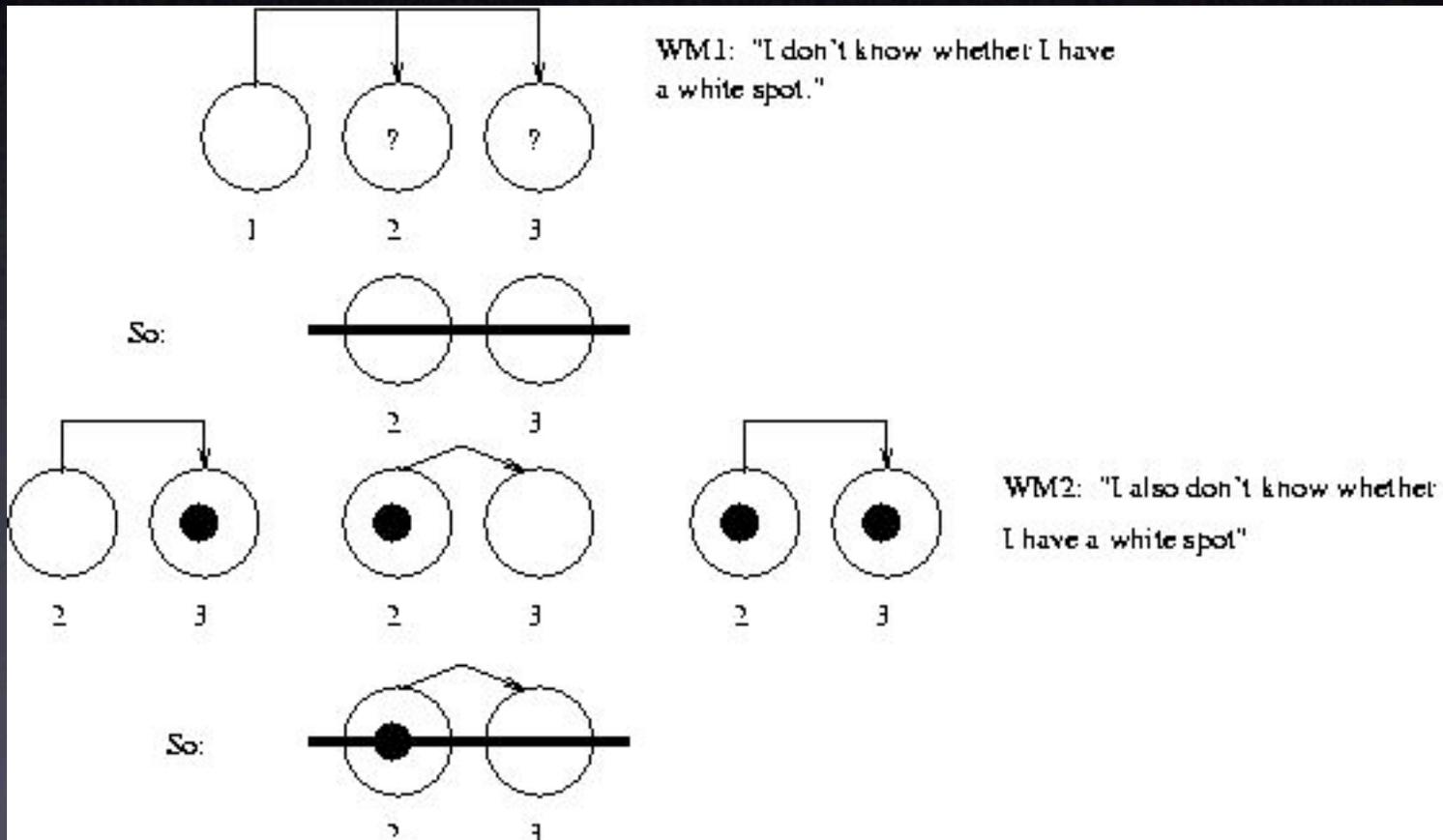
# Militaristic “WM” (con)

Company A, upon receiving an alert a few minutes ago informing it that at least one of A, B, C, and D is locked in, and asking it to respond as to whether or not it can infer that it is locked in, engaged its EYE and then sent out comm declaring that it does not know whether it is locked in. After this same comm, B issued the same message, and then C received the same comm and soon thereafter radioed the same message. Now the ball is in your court.

As you know, if a company is currently locked in by the Azan+, certain jamming techniques implemented from our location can cloak you once again -- but if these jamming techniques are used mistakenly, if they are used when you are *\*not\** already locked in by the Azan+, you will be immediately targeted, and launch will almost certainly ensue shortly thereafter.

We await your response.

# Wise Man Puzzle





```
# (load-file "/Users/shilla/milit.ath")  
█  
(load-file "/Users/shilla/fset.ath")  
  
# We define Company as an enumeration datatype: either A,  
# or B, or C, or D:  
  
(datatype Company  
  A B C D)  
  
# We introduce sentential propositions (atoms, negations,  
# conjunctions, etc.), as well as propositions stating  
# that a given company knows a given proposition:  
  
(datatype Prop  
  (Atom Boolean)  
  (Company Prop))  
--:-- milit.ath      Top L2      (Fundamental)-----  
Kokopelli:~ shilla$ █
```

Slate...

Slate overview...

# Slate (@ the highest level)

“Sci Fi” empowerment through entire IA process

Preclude bias/error in analytic reasoning

Develop rigorous theory of intelligence analysis

# A Bit More Precisely, what is Slate?

- System for Logical Analysis and Theorem Extraction (SLATE) — though that's a forbidding mouthful, confessedly.
- A workbench for visual reasoning
- A reasoning validity checker
- (intelligent) hypothesis generation system
- A proof finder \*
- and much more...

# Slate is Not...

a replacement for human reasoners

# For Slate, Two General Uses; Four Specific Ones

| Professional<br>“Laic” Reasoning               | Formal<br>Reasoning                                  |
|--|--|
| IAs, item writers, ...                         | Mathematicians, logicians,<br>technical philosophers |
| <i>Students</i> of IA, of item<br>writing, ... | <i>Students</i> of math, logic,<br>philosophy        |

# Parallel (Idealized) Processes?

IA tasked.

Reads, gathers data, etc.

Develops an argument-sketch in support of a hypothesis or recommendation.

Fills in gaps and refines the argument.

Issues a written report expressing/defending the argument.

Mathematician given problem.

Reads, gathers info on prior work, etc.

Develops a proof-sketch in support of a theorem.

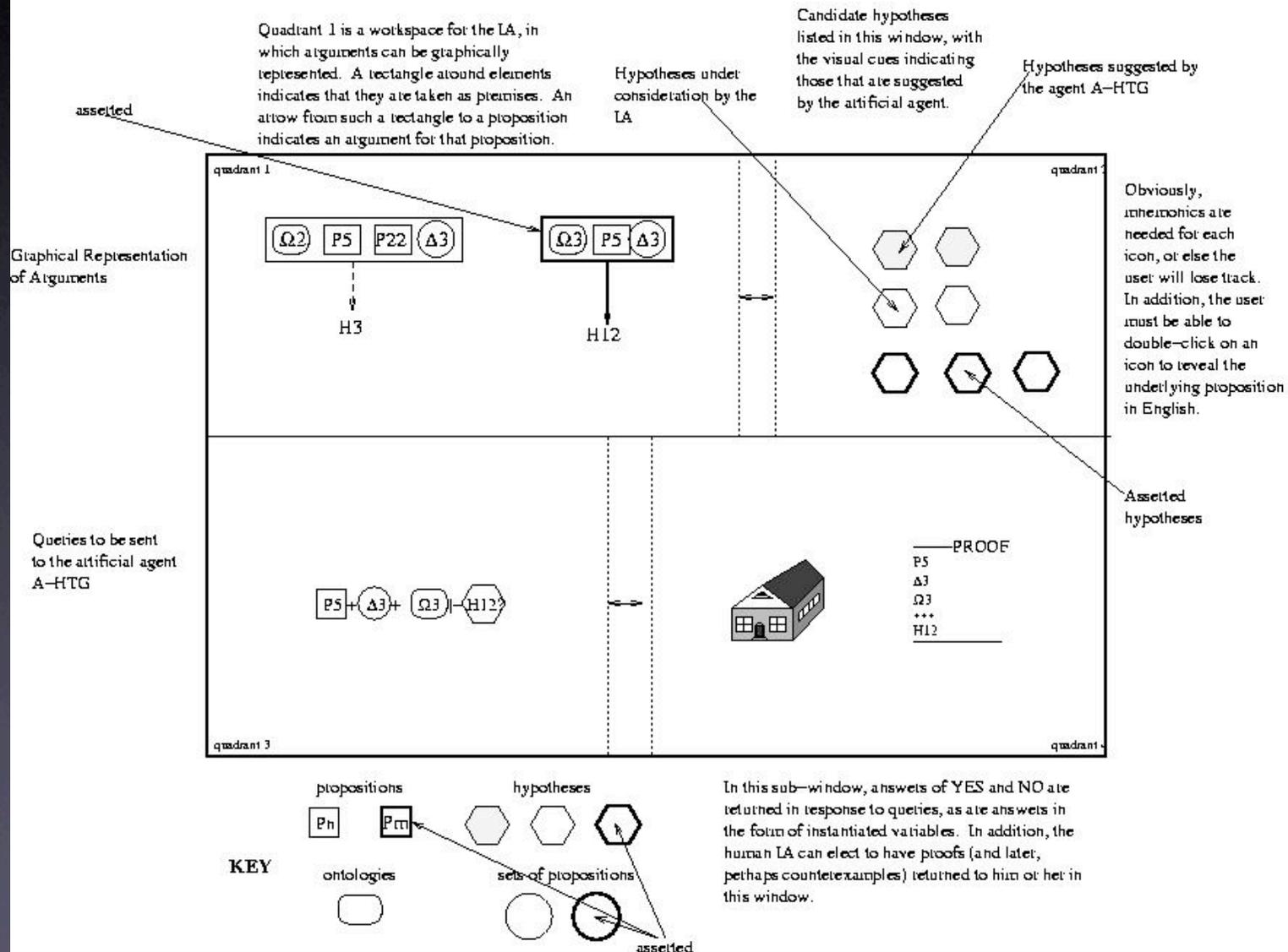
Fills in gaps in the sketch.

Releases an “informal” proof to the community.

# Original Concept

## THE HTG WINDOW IN SAGE, V2b

Selmer Blingsjod 4.23.03



# Current Release: v2.0

SLATE - Rips 1a

Single element selected:  
P1 -

Description:  
It's not true that: If John trained in Afghanistan, then Majed is an Al Qaeda sleeper.

Subproof 1 - Assumes: S(M)

Subproof 2 - Assumes: TA(J)

Subproof 3 - Assumes: -TA(J)

Subproof 4 - Assumes: TA(J)

Workspace Tools | Information Management | Model Building | Check Consistency | Generate Hypotheses | Validate / Invalidate Seq... | Generate Reports

Create: New Set, New Argument, New Subproof, Copy objects

Modify: Change Info, Remove Objects

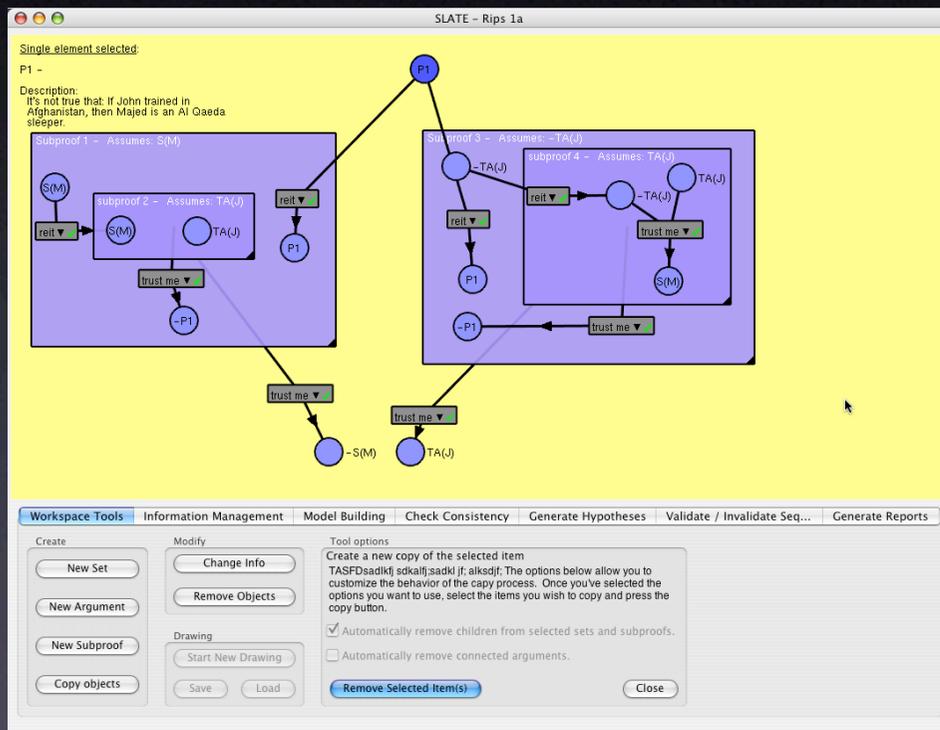
Drawing: Start New Drawing, Save, Load

Tool options: Create a new copy of the selected item. TASFDsadklkj sckalfj; sadkl jf; alksdjf; The options below allow you to customize the behavior of the copy process. Once you've selected the options you want to use, select the items you wish to copy and press the copy button.

- Automatically remove children from selected sets and subproofs.
- Automatically remove connected arguments.

Remove Selected Item(s) | Close

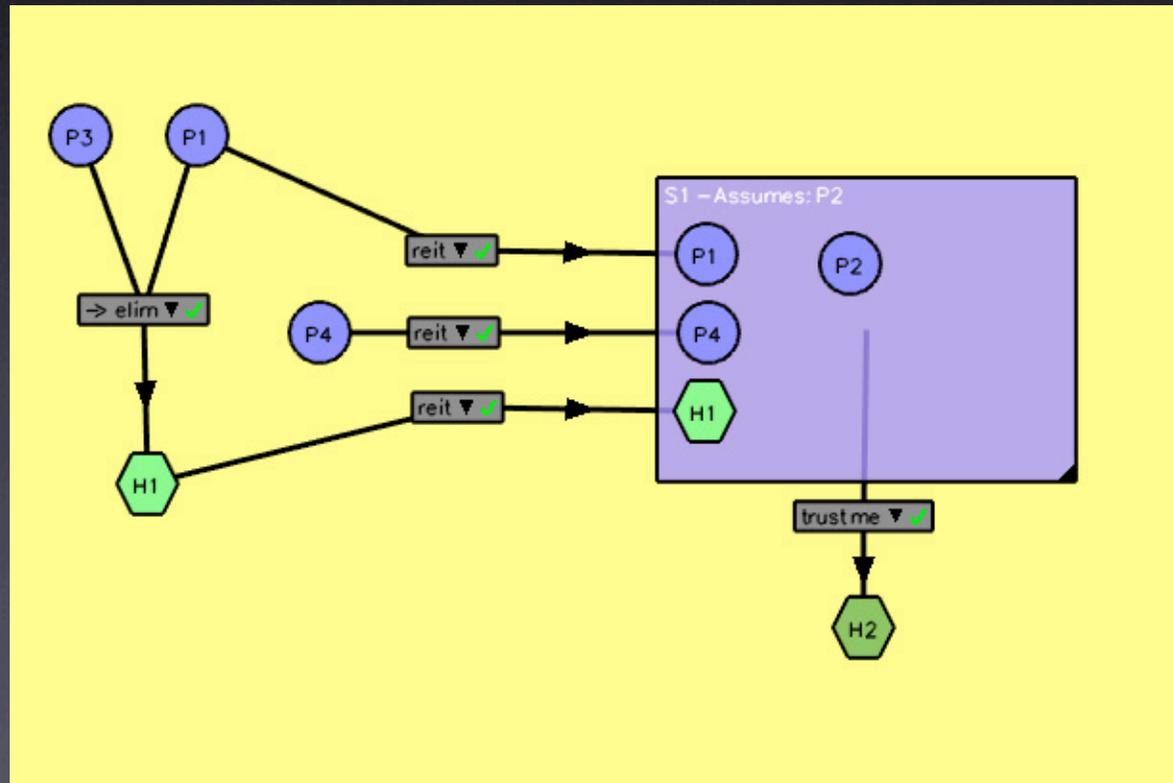
# Some Innovative Features



- Reflects new formal theories of hypothesis generation.
- E.g., retrospective and prospective *MMOI-based abduction*
- Automatic report generation (with DARPA support)
- Includes a system —  $S$  — for sketching out and checking *visual* natural reasoning-style arguments
- Designed to model not just deduction, but abduction, induction, and “mental model”-based reasoning.
- Seamless integration with machine reasoning & interactive proof systems (SNARK, OSCAR, ...; Athena, ...)
- New, unprecedentedly powerful machine reasoning under development (e.g., MARMML)

# System S

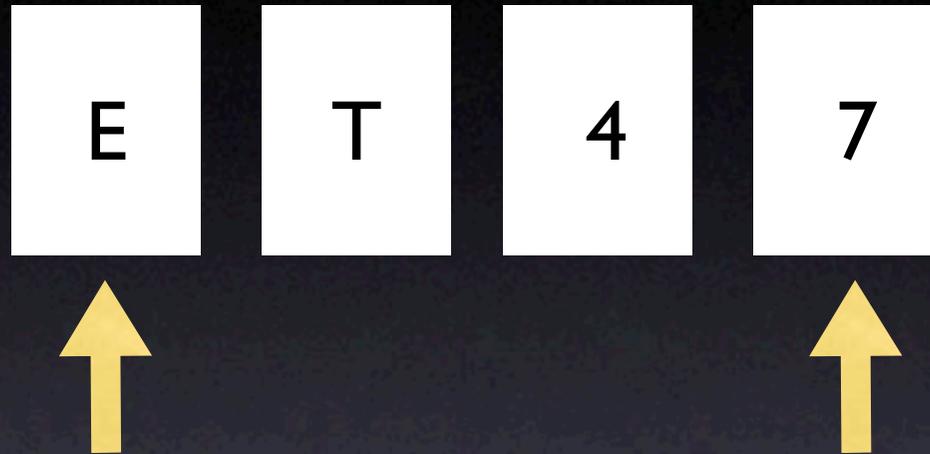
A proof creation / validation environment



# Three Desiderata

- Both teaches and (when on the job) encourages analysts to reason in context-independent fashion, so as to avoid bias.
- Brings to light interesting hypotheses the IA might not consider on his/her own.
- Reflects the empirically confirmed fact that humans reason not just sententially, but also in visual “mental model” fashion.

# Simple Selection Task



Suppose I claim the following rule is true:

If a card has a vowel on one side, it has an even number on the other side.

Which card or cards should you turn over to try to decide if the rule is true?

# Bringsjord #1

(1) The following three assertions are either all true or all false:

If Billy helped, Doreen helped.

If Doreen helped, Frank did as well.

If Frank helped, so did Emma.

(2) The following assertion is definitely true: Billy helped.

Can it be inferred from (1) and (2) that Emma helped?

Yup!

# Demo: MPIa

# Demo: New Order #1

And, a good IA tool automatically generates the first draft of reports (seen in passing in previous two demos)...

Single element selected:

O: P1 P2 P3 P4 P5 P6 P7 -&gt; H1

This is an undefeated argument of strength 1.0 for:

( Killed John John )  
 which is of ultimate interest.      $\vdash$

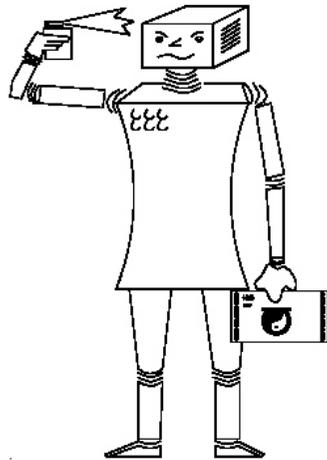
1. (( Killed John John ) v (( Killed Essid John ) v ( Killed Majed John)))    Given
26. (~( Killed John John ) -> (( Killed Essid John ) v ( Killed Majed John)))    disj-simp from { 1 }
6. (all X)(( Believes-Traitor John X ) -> ( Believes-Traitor Majed X))    Given
4. (( Believes-Traitor John Essid ) & (( Believes-Traitor John John ) & ~( Believes-Traitor John Majed)))    Given
31. (( Believes-Traitor John John ) & ~( Believes-Traitor John Majed))    simp from { 4 }
16. (( Believes-Traitor John x4 ) -> ( Believes-Traitor Majed x4))    UI from { 6 }
34. ( Believes-Traitor John John )    simp from { 31 }
37. ( Believes-Traitor Majed John )    modus-ponens2 from { 16 , 34 }
7. (all X)~(( Believes-Traitor X John ) & (( Believes-Traitor X Essid ) & ( Believes-Traitor X Majed)))    Given
28. ~( Believes-Traitor x22 John ) & (( Believes-Traitor x22 Essid ) & ( Believes-Traitor x22 Majed))    UI from { 7 }
29. ~( Believes-Traitor x22 John ) v ~( Believes-Traitor x22 Essid ) & ( Believes-Traitor x22 Majed))    DM from { 28 }
38. (( Believes-Traitor x22 John ) -> ~( Believes-Traitor x22 Essid ) & ( Believes-Traitor x22 Majed))    disj-simp from { 29 }
39. ~( Believes-Traitor Majed Essid ) & ( Believes-Traitor Majed Majed )    modus-ponens1 from { 38 , 37 }
41. ~( Believes-Traitor Majed Essid ) v ~( Believes-Traitor Majed Majed )    DM from { 39 }
30. ( Believes-Traitor John Essid )    simp from { 4 }
44. (( Believes-Traitor Majed Essid ) -> ~( Believes-Traitor Majed Majed ))    disj-simp from { 41 }
33. ( Believes-Traitor Majed Essid )    modus-ponens2 from { 16 , 30 }
45. ~( Believes-Traitor Majed Majed )    modus-ponens1 from { 44 , 33 }
5. (all X)(~( Lower-Rank X John ) -> ( Believes-Traitor Majed X))    Given
18. ~( Lower-Rank x8 John ) -> ( Believes-Traitor Majed x8 )    UI from { 5 }
46. ( Lower-Rank Majed John )    modus-tollens2 from { 18 , 45 }
86. (( Believes-Traitor Majed John ) -> ( Lower-Rank Majed John ))    Conditionalization from { 46 }
87. ~( Believes-Traitor Majed John ) v ( Lower-Rank Majed John )    disj-cond from { 86 }
88. ~( Believes-Traitor Majed John ) & ~( Lower-Rank Majed John )    i-DM from { 87 }
3. (all X)(( Believes-Traitor John X ) -> ~( Believes-Traitor Essid X))    Given

Argument

Conclusion and select a  
 conclusion, and then  
 validate the argument

# Prior R&D

## PROVERB



Omega Publication

**Proof Verbalization as an  
Application of NLG**

Xiaorong Huang and Armin Fiedler

Published as: Proceedings of the Fifteenth International Joint Conference  
on Artificial Intelligence

## But...

Dormant?

Taps into “unprincipled” NLG

Reasoning that is input  
lacks power of Athena

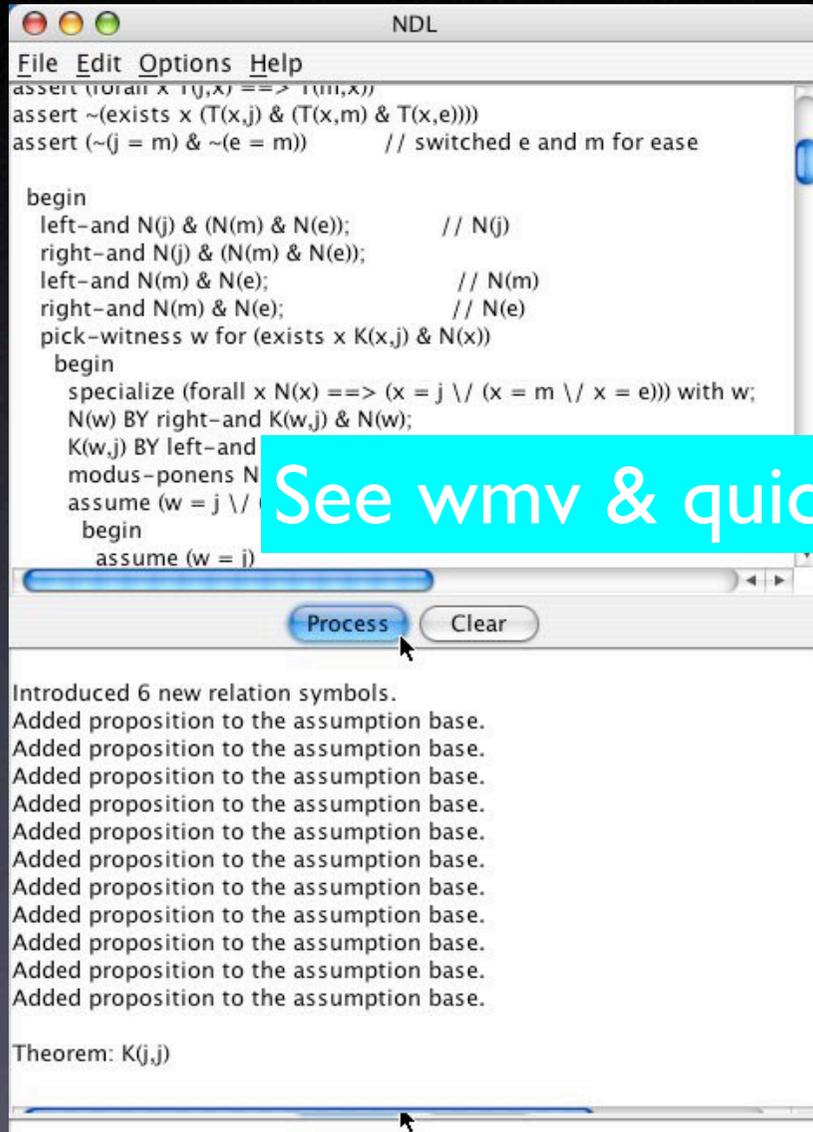
No natural language  
corresponding to  
diagrammatic knowledge

Can't handle resolution-  
based reasoning

Can't handle methods, only  
proofs (not dynamic proofs)

# NDL Proofs to English

*Type<sub>α</sub>DPL*



```
File Edit Options Help
assert (forall x T(j,x) ==> T(m,x))
assert ~(exists x (T(x,j) & (T(x,m) & T(x,e))))
assert (~(j = m) & ~(e = m)) // switched e and m for ease

begin
left-and N(j) & (N(m) & N(e)); // N(j)
right-and N(j) & (N(m) & N(e));
left-and N(m) & N(e); // N(m)
right-and N(m) & N(e); // N(e)
pick-witness w for (exists x K(x,j) & N(x))
begin
specialize (forall x N(x) ==> (x = j \/ (x = m \/ x = e))) with w;
N(w) BY right-and K(w,j) & N(w);
K(w,j) BY left-and
modus-ponens N
assume (w = j \/
begin
assume (w = j)

```

Introduced 6 new relation symbols.  
Added proposition to the assumption base.  
Theorem: K(j,j)

REPORT ON NEW ORDER KILLING

To: David Lessing, ---  
From: <firstname> <lastname>  
Date: 6.16.05

I have now concluded my analysis. The answer is that John committed suicide. I trust you will find this new fact useful in our agency's ongoing attempt to defeat Al-Qaeda. My argument for this conclusion runs as follows.

See wmv & quicktime movies for demos

... n killed  
... d killed John,  
... and we know that neither Majed nor Essed killed John, we can infer that John committed suicide. This means that we have three sub-goals to aim for. The first one is that the culprit was either John, Majed, or Essed. But this goal is easy to substantiate: It can be derived from the given fact that someone in New Order performed the killing, combined with the fact that there were only three members of New Order at the time of the execution. We turn our attention now to the other two sub-goals. If we can explain how to reach them, the case is closed.

...

A good tool for IAs is  
*interoperable* with other  
tools and databases...

# Tracking a Dirty Bomb

## More and more, smugglers are trafficking in radioactive materials

By Joly Warrick  
Washington Post Staff Writer



Containers used to transport radioactive instruments have become targets of thieves.

**W**HILE IN GEORGIA, police caught up with him on May 31, Tolo Makheria was headed toward Tbilisi's main rail station, his briefcase hidden in boxes lined with lead so thick his feet sagged from the weight. The suspicious policeman who halted the cab had barely opened the trunk when he noticed the boxes and the distinctive bluish that warned, "Danger: Radiation."

More police arrived within minutes, and a Geiger counter was produced. As Makheria smoked nervously in the back seat, the officers flipped the instruments "on" and watched the needle leap off the screen. "It first was just shocked," said Lt. Lev Ostalava, the ranking officer at the scene, recalled later. "Then we all started heading away slowly."

Inside Makheria's boxes were two capsules of highly radioactive isotopes—strontium and cesium—of a type that terrorism experts say can be used in a dirty bomb, a device that spews radiation but does not trigger a nuclear explosion. A third container held a vial of brown liquid that Georgian police identified as the substance used in mustard gas, one of the earliest chemical weapons. Only later did police identify Makheria's role in the affair: He was a courier for criminals trading in components and materials for weapons of mass destruction.

In a scheme still not fully understood, the boxes were delivered to Makheria by another Georgian, a man with a history of drug offenses. Makheria's job was to carry the boxes by train from Tbilisi to Adzharia province's troubled enclave on Georgia's southwestern frontier. From there, police believe, they were to be transported by other couriers across the border into Turkey or perhaps even Iran, for delivery to an expert customer. The buyer's identity remains unknown. What is certain is that the Georgians who sought to profit from selling components of a dirty bomb far from their own shores have been dozens of cases of trafficking in radioactive materials over the past three years, along with what some weapons experts describe as a disturbing new trend. While most sellers of such materials have traditionally been amateur—opportunists and lone actors in search of easy profits—authorities are now seeing a surge of interest among criminal groups in what are currently in private hands or have simply been discarded. In Georgia and other unstable corners of the world, radioactive materials are turning up on black markets alongside more traditional contraband, such as drugs or Kalashnikov rifles.

They are a curiously of the global gray zone, a dangerous mixture of failed states, porous borders and weak law enforcement, where the tools of terrorism are being sold and used.

The involvement of professional smugglers and criminals only increases the odds that some of the radioactive materials will end up in the hands of terrorists, U.S. experts say. Already, the sheer volume of such materials in circulation has prompted scientists

well within the grasp of international terrorist group nuclear experts say.

Documents seized from training camps in Afghanistan two years ago by U.S. forces showed that al Qaeda leaders planned to build a dirty bomb and may have been gathering materials for one. Iraq, which struggled in vain for a decade to master the complexities of a nuclear weapon, built and tested a dirty bomb in the 1980s before abandoning the program on the grounds that it was ineffective against military targets, according to U.N. weapons inspectors.

Such a bomb would likely unleash panic and trigger economic and social upheavals. From a moderately sized dirty bomb exploded in a modern city could contaminate billions of red state with radiation, rendering some areas uninhabitable for months or years.

Last year, the Federation of American Scientists conducted a computer simulation to determine the impact exploding less than two ounces of cesium-137, about 3.5¢ curies, in the heart of Manhattan. (A curie is a unit used to measure radioactivity.) Experts say that a device of only a few dozen curies could make an effective bomb. In the simulation, fine cesium particles spread across an area covering 40 square blocks. Cleanup and relocation followed the blast would take years to complete and cost tens of billions of dollars, the study found.

**WHETHER THE RADIATION FROM SUCH A BLAST** would cause deaths or injuries is a subject of intense debate. A view long held by radiation experts was that it would be those closest to the blast who would die. But new scientific work is suggesting that a significant health threat in the clouds of radioactive dust thrown up



These are just some of the attempts made over the past year to steal materials that could be used to make 'dirty bombs' capable of dispersing radiation over large areas.

- In Brazil, a number of well loggers have been stolen.
- A person with possible links to al Qaeda may have these well loggers.
- An analyst's task is to determine whether or not it is possible this person has obtained material sufficient to construct a radiological dispersion device.

# Where Are They Now?

## Missing dirty bombs are traced to a tiny former Soviet enclave, raising concern

By Joly Warrick  
Washington Post Staff Writer

**I**n the ethnic conflicts that surrounded the collapse of the Soviet Union, fighters in several countries seized upon an unlikely new weapon: a small, thin rocket known as the Atan. Originally built for weather experiments, the Alban rockets were packed with explosives and lobbed into cities. Military records show that at least 30 Alban warheads were modified to carry radioactive material, effectively creating the world's first surface-to-surface dirty bomb.

The radioactive warheads are not known to have been used, but now, according to experts and officials, have disappeared.

The last known repository was here, in a tiny separatist enclave known as Transnistria, which broke away from Moldova 12 years ago. The Transnistrian Moldovan Republic is a sliver of land no bigger than Rhode Island located along Moldova's eastern border with Ukraine. Its government is recognized by no other nation. But its weapons stockpile—some used and modified—has drawn the attention of black-market arms dealers worldwide. And there it lay, according to U.S. and Moldovan officials and weapons experts.

When the Soviet army withdrew from this corner of Eastern Europe, the weapons were deposited into an arsenal of shipping containers. In striped banners are stored 50,000 tons of aging artillery shells, mines and rockets, enough to fill 1200 buses.



Moldovan officials say this Transnistrian manufacturer could arm for sale abroad, and outfit groups.

**Gray Zones**  
The self-proclaimed Transnistrian Moldovan Republic is one of several quasi-states that are hotbeds for trafficking in weapons and other contraband. They exist in war-torn areas that are largely outside the norms of international law.



The enormous Soviet-style banners stretched across intersections in downtown Tiraspol bid visitors welcome to 'The People's Pride: The Transnistrian Moldovan Republic.' The city is locked in a Bezarcevska war. Nearly every corner bears a reminder of the region's stubborn resistance of old-school Soviet communism: a statue of Lenin, a hammer-and-sickle banner, a street named for Karl Marx.

**FOR TERRORISTS, THIS IS THE BEST MARKET YOU** could imagine: cheap, efficient and forgotten by the whole world," says Vladimir Orlov, founding director of the Center for Policy Studies in Moscow, a group that studies proliferation issues.

Why the Alban warheads were made is unknown. The urgent question—where are they now?—is a matter of grave concern to terrorism and nonproliferation experts who know the damage such devices could do. A dirty bomb is not a nuclear device but a weapon that uses conventional explosives to disperse radioactive materials, which could cause widespread disruption and expose people to dangerous radiation. Unlike other kinds of dirty bombs, this one would come with its own delivery system, and in a single usage. A number of terrorist groups, including al Qaeda, have sought to build or buy one.

While it has no nuclear bombs of its own, Transnistria is regarded by experts as a prime shopping ground for out-

side the main rail line into the town. Steals blasts from a complex of gray buildings housing the city's Elektronovskaya, a leading factory that manufactures electrical equipment. According to Moldovan and Western intelligence officials, the factory's product line includes small-size and machine pistols, a centerpiece of Transnistria's most profitable industrial weapons.

Once the industrial heartland of the Moldavian Soviet Socialist Republic, Transnistria has a long history as a production center for arms and weapons, including machine guns and rockets. Today, the tradition continues in at least six

the enormous Soviet-style banners stretched across intersections in downtown Tiraspol bid visitors welcome to 'The People's Pride: The Transnistrian Moldovan Republic.' The city is locked in a Bezarcevska war. Nearly every corner bears a reminder of the region's stubborn resistance of old-school Soviet communism: a statue of Lenin, a hammer-and-sickle banner, a street named for Karl Marx.

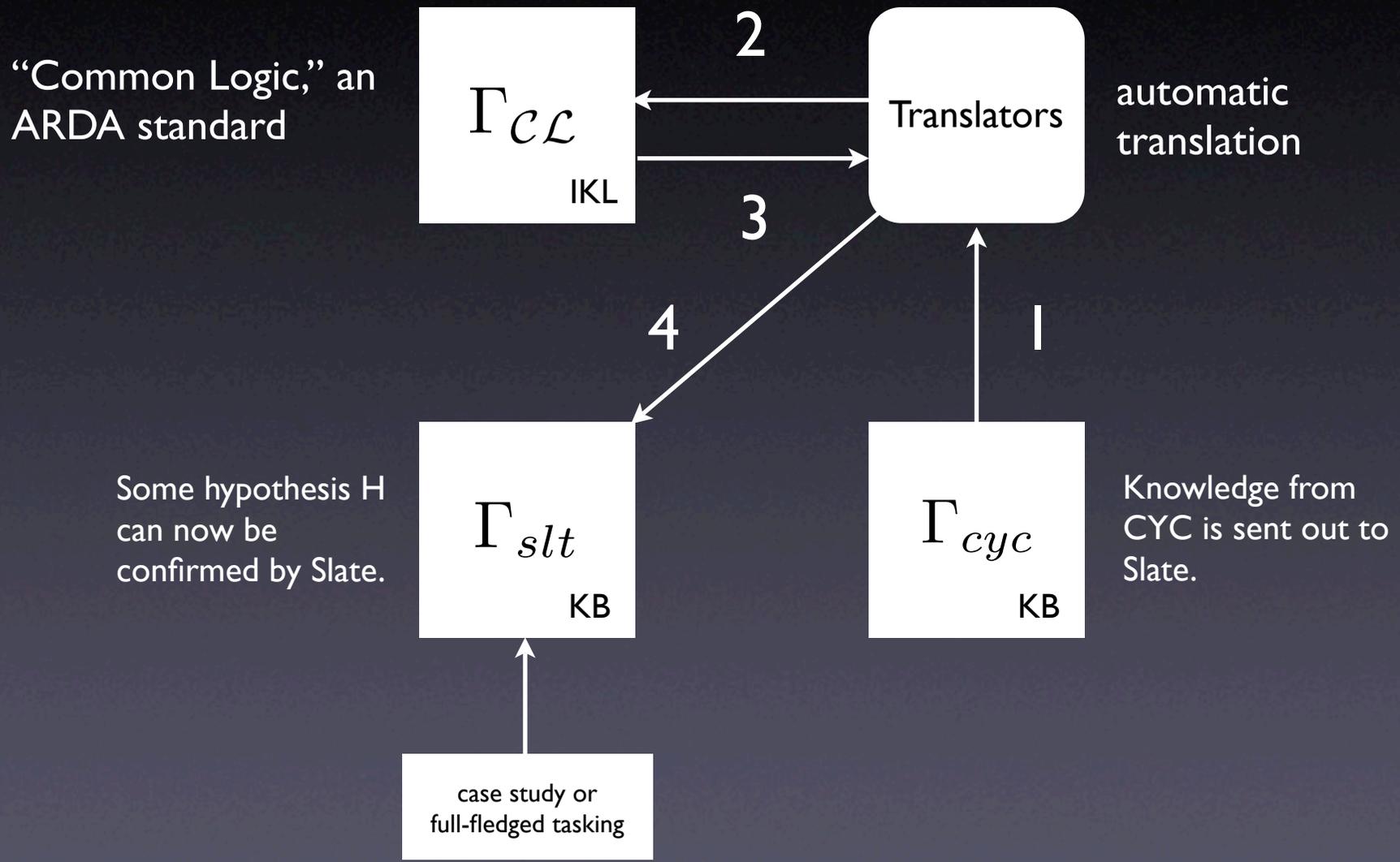
**A LARGE PORTION OF THE POPULATION IS** made up of Russian-speaking prisoners, many of them Soviet military retirees who served in the area and chose to stay because of the relatively mild climate. Like the elderly elsewhere in the former Soviet Union, the retirees are nostalgic for a simpler, more predictable time when the socialist state took care of all their needs.

North of Tiraspol, an industrial center straddles the main rail line into the town. Steals blasts from a complex of gray buildings housing the city's Elektronovskaya, a leading factory that manufactures electrical equipment. According to Moldovan and Western intelligence officials, the factory's product line includes small-size and machine pistols, a centerpiece of Transnistria's most profitable industrial weapons.

Once the industrial heartland of the Moldavian Soviet Socialist Republic, Transnistria has a long history as a production center for arms and weapons, including machine guns and rockets. Today, the tradition continues in at least six

- With the promising interoperability enabled by IKRIS, this task can be handled collaboratively in striking ways.
- The basic idea in a super-short demo...

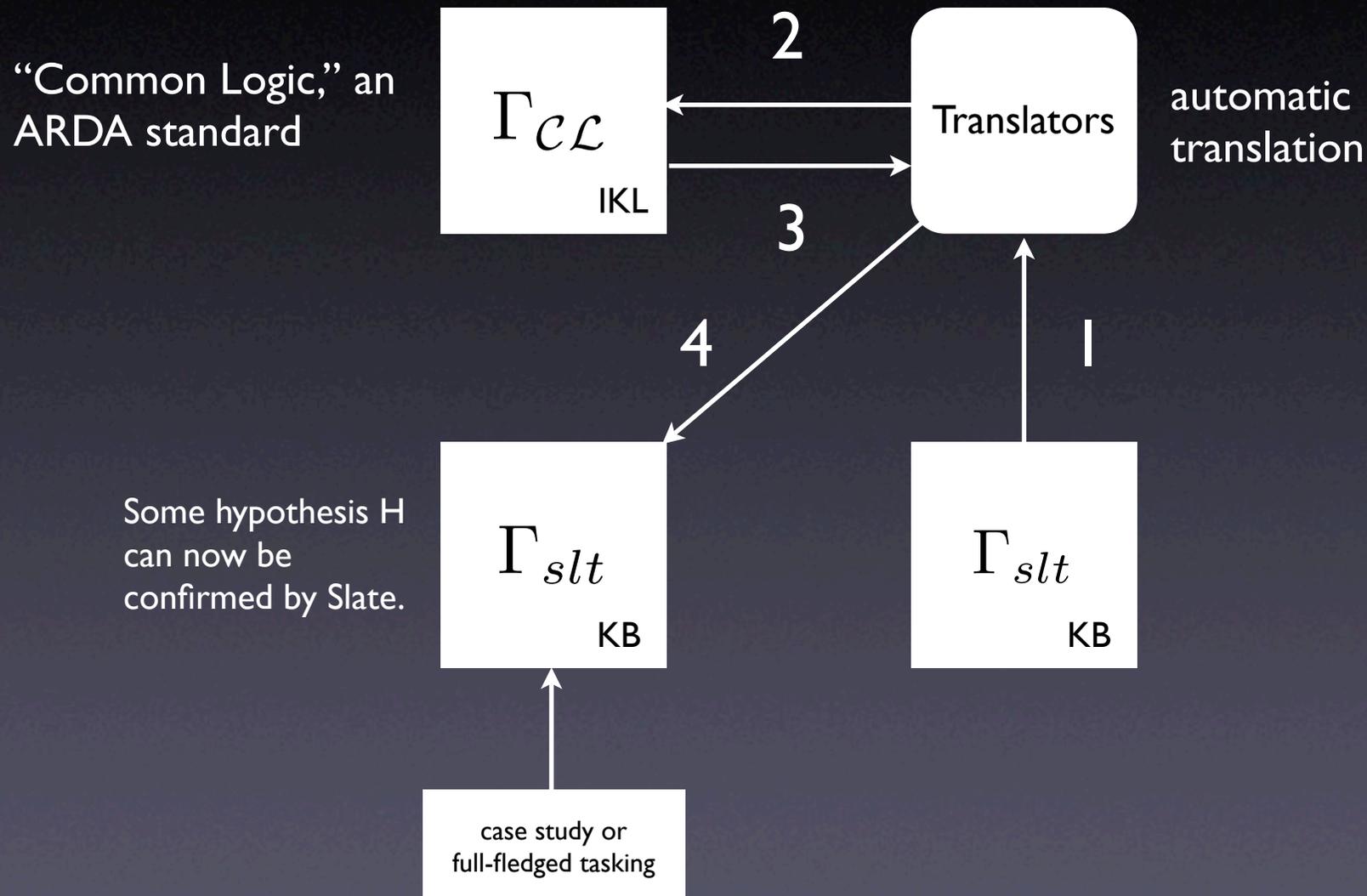
# Interoperability Challenge



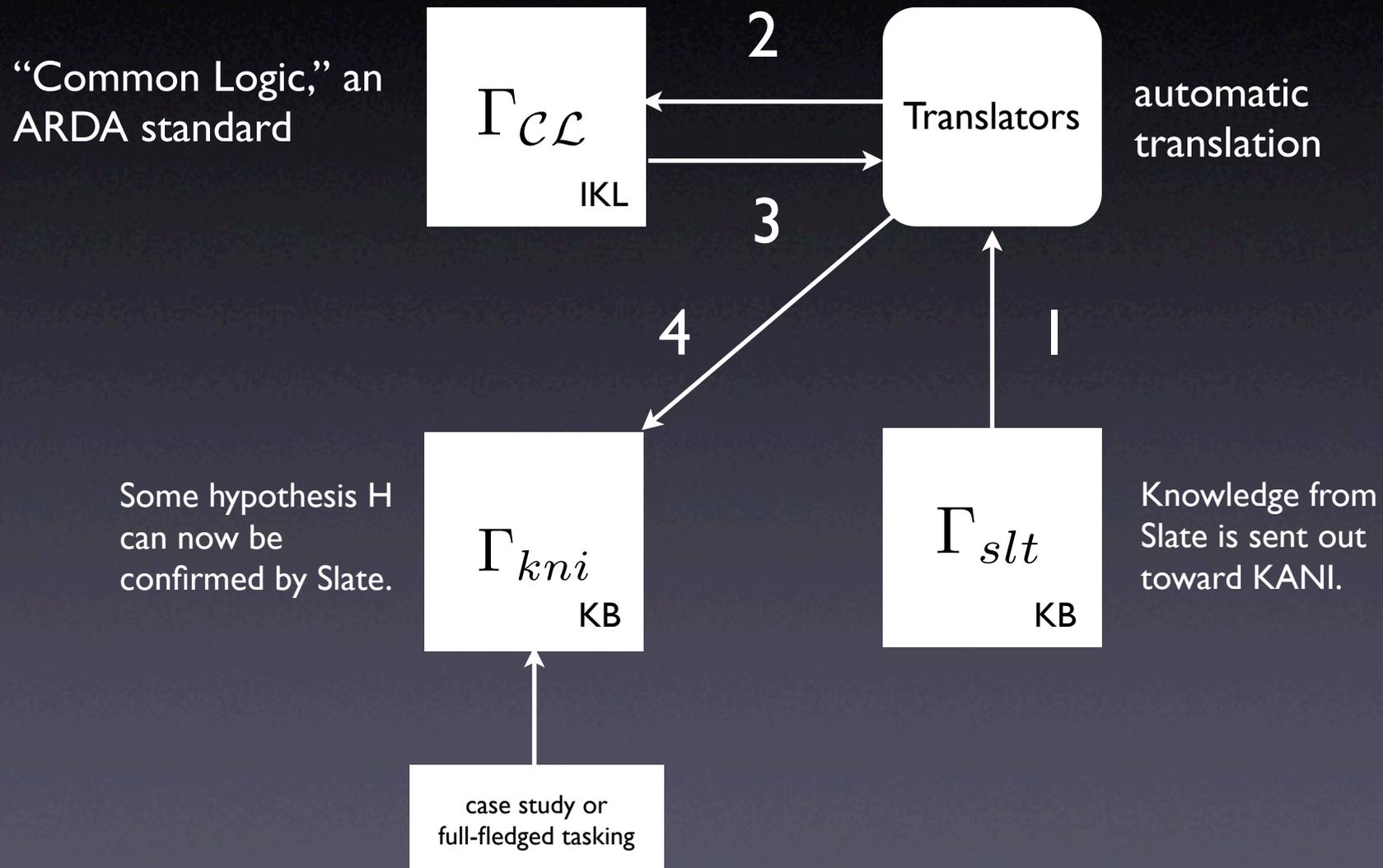


# Interoperability Challenge

We're close!



# Interoperability Challenge



# Part II (brief)

Depth vs Breadth of Reasoning...

“In the intelligence field, the amount of data we have to deal with is ungodly. An intelligence analyst has to deal on a regular basis, for example, with petabytes of data. It seems to me, therefore, that an approach in which a machine assistant is to reason over the data faced by IAs is doomed: there’s just too much data.”

a petabytes is 1,125,899,906,842,624 bytes, or 1,024 terabytes

But our initial experiments indicate that the *real* challenge may be *deep* reasoning over *few* propositions; reasoning over large numbers of propositions, all things being equal, is easier than one might think.

Have run a series of tests on 12 queries with 1,000,000 formulae in the KB. For each query, Otter starts with only 1 of the 1,000,000 propositions assumed, and at each failure, we double the number of propositions used. This doubling continues until Otter finds a proof, or the number of added propositions exceeds 1,000,000. The execution of all 12 queries takes less than 10 seconds.

$$KB \vdash \exists x P_{12}(C_9) \wedge \exists x P_{14}(C_{13})$$

```
#####  
Searching for proof of - (exists x P12(C9)) & (exists x P14(C13)).  
#####
```

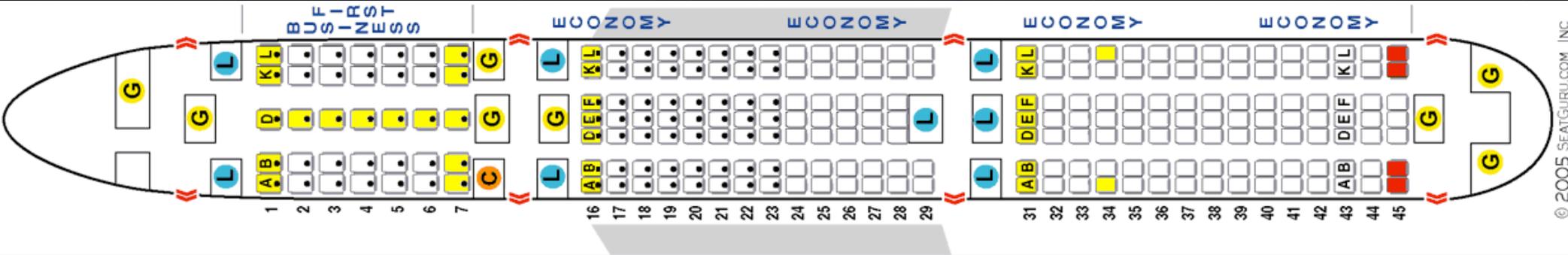
```
Searching for proof using 1 of the 999999 lines.  
Searching for proof using 2 of the 999999 lines.  
Searching for proof using 4 of the 999999 lines.  
Searching for proof using 8 of the 999999 lines.  
Searching for proof using 16 of the 999999 lines.  
Searching for proof using 32 of the 999999 lines.  
Searching for proof using 64 of the 999999 lines.  
Searching for proof using 128 of the 999999 lines.  
Searching for proof using 256 of the 999999 lines.  
Searching for proof using 512 of the 999999 lines.  
Searching for proof using 1024 of the 999999 lines.  
Searching for proof using 2048 of the 999999 lines.
```

PROOF FOUND!

$$\mathcal{P}(\emptyset) = \{\emptyset\}$$

Since motive, means, intent remain (along with some notion of *singular attractiveness*), formalize planes and ask Slate to hypothesize as to how terrorists can once again use them as missiles.

767-400



Last NIMD PI meeting, Nov 28-Dec 2 2005!

Penetrating reasoning w/o  
invading personal privacy...

### **Flight Training Fails; Mihdhar Bails Out**

Hazmi and Mihdhar came to the United States to learn English, take flying lessons, and become pilots as quickly as possible. They turned out, however, to have no aptitude for English. Even with help and tutoring from Mohdar Abdul=lah and other bilingual friends, Hazmi and Mihdhar's efforts to learn proved futile. This lack of language skills in turn became an insurmountable barrier to learning how to fly.<sup>36</sup>

A pilot they consulted at one school, the Sorbi Flying Club in San Diego, spoke Arabic. He explained to them that their flight instruction would begin with small planes. Hazmi and Mihdhar emphasized their interest in learning to fly jets, Boeing aircraft in particular, and asked where they might enroll to train

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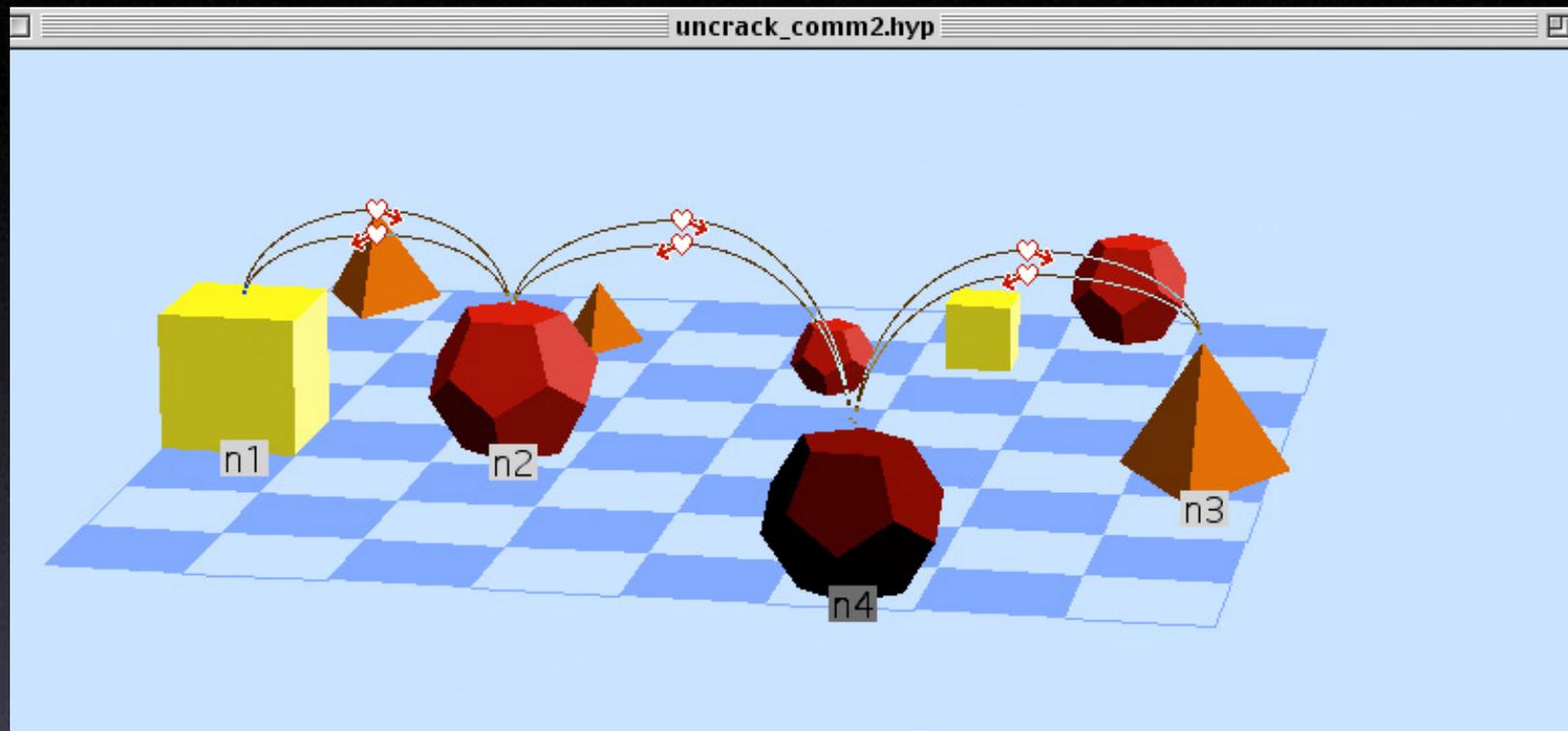
THE 9/11 COMMISSION REPORT

on jets right away. Convinced that the two were either joking or dreaming, the pilot responded that no such school existed. Other instructors who worked with Hazmi and Mihdhar remember them as poor students who focused on learning to control the aircraft in flight but took no interest in takeoffs or land=ings. By the end of May 2000, Hazmi and Mihdhar had given up on learning how to fly.<sup>37</sup>

You didn't have to be Sherlock Holmes...

Uncrackable Communication  
Relative to Automated  
Eavesdropper  $E...$

# We Need Automated *Visual* Reasoning



•  $\forall x \forall y \forall z ((\text{Likes}(x,y) \wedge \text{Likes}(y,z)) \rightarrow \text{Likes}(x,z))$

✓ Given

•  $\text{Cube}(n_1) \wedge \text{Dodec}(n_2) \wedge \text{Dodec}(n_4) \wedge \text{Tet}(n_3)$

✓ Given

•  $\text{Likes}(n_1, n_2) \wedge \text{Likes}(n_2, n_1) \wedge \text{Likes}(n_2, n_4) \wedge \text{Likes}(n_4, n_2) \wedge$   
 $\text{Likes}(n_4, n_3) \wedge \text{Likes}(n_3, n_4)$

✓ Observe

✓ Observe

▶ •  $\exists x \exists y \exists z \exists u ((\text{Cube}(x) \vee \text{Dodec}(x) \vee \text{Tet}(x)) \wedge (\text{Cube}(y) \vee$   
 $\text{Dodec}(y) \vee \text{Tet}(y)) \wedge (\text{Cube}(z) \vee \text{Dodec}(z) \vee \text{Tet}(z)) \wedge (\text{Cube}(u) \vee$   
 $\text{Dodec}(u) \vee \text{Tet}(u)) \wedge \text{Likes}(x,y) \dots \}$

Log Con

# DNDL by Arkoudas & Bringsjord

## A general framework for sentential and diagrammatic natural deduction

DRAFT

This research was supported by DARPA IPTO

Konstantine Arkoudas and Selmer Bringsjord

July 18, 2005

$$\begin{array}{c}
 \frac{(\beta \cup \{F_1, \dots, F_n\}; (\sigma; \rho)) \vdash (\sigma'; \rho') \text{ by thinning with } F_1, \dots, F_n \rightsquigarrow (\sigma'; \rho')}{\text{provided } (\sigma; \rho) \models_{\{F_1, \dots, F_n\}} (\sigma'; \rho')} \quad [\text{Thinning}] \\
 \\
 \frac{(\beta \cup \{F_1, \dots, F_n\}; (\sigma; \rho)) \vdash (\sigma'; \rho') \text{ by widening } \rightsquigarrow (\sigma'; \rho')}{\text{provided } (\sigma; \rho) \sqsubseteq (\sigma'; \rho')} \quad [\text{Widening}] \\
 \\
 \frac{(\beta \cup \{\text{false}\}; (\sigma; \rho)) \vdash (\sigma'; \rho') \text{ by absurdity } \rightsquigarrow (\sigma'; \rho')}{\text{provided } (\sigma; \rho) \sqsubseteq (\sigma'; \rho')} \quad [\text{Absurdity}] \\
 \\
 \frac{}{(\beta; (\sigma; \rho)) \vdash \text{claim } (\sigma; \rho) \rightsquigarrow (\sigma; \rho)} \quad [\text{Diagram-Reiteration}] \\
 \\
 \frac{(\beta \cup \{F_1, \dots, F_k\}; (\sigma_1; \rho_1)) \vdash \Delta_1 \rightsquigarrow (\sigma'; \rho')}{\vdots} \\
 \frac{(\beta \cup \{F_1, \dots, F_k\}; (\sigma_n; \rho_n)) \vdash \Delta_n \rightsquigarrow (\sigma'; \rho')}{(\beta \cup \{F_1, \dots, F_k\}; (\sigma; \rho)) \vdash \text{cases from } F_1, \dots, F_k: (\sigma_1; \rho_1) \rightarrow \Delta_1 \mid \dots \mid (\sigma_n; \rho_n) \rightarrow \Delta_n \rightsquigarrow (\sigma'; \rho')} \quad [\text{C}] \\
 \text{provided } (\sigma; \rho) \models_{\{F_1, \dots, F_k\}} \{(\sigma_1; \rho_1), \dots, (\sigma_n; \rho_n)\} \\
 \\
 \frac{(\beta \cup \{F_1\}; (\sigma; \rho)) \vdash \Delta_1 \rightsquigarrow (\sigma'; \rho') \quad (\beta \cup \{F_2\}; (\sigma; \rho)) \vdash \Delta_2 \rightsquigarrow (\sigma'; \rho')}{(\beta; (\sigma; \rho)) \vdash \text{cases } F_1 \vee F_2: F_1 \rightarrow \Delta_1 \mid F_2 \rightarrow \Delta_2 \rightsquigarrow (\sigma'; \rho')} \quad [\text{C}\#] \\
 \\
 \frac{(\beta; (\sigma; \rho)) \vdash D \rightsquigarrow F \quad (\beta \cup \{F\}; (\sigma; \rho)) \vdash \Delta \rightsquigarrow (\sigma'; \rho')}{(\beta; (\sigma; \rho)) \vdash D; \Delta \rightsquigarrow (\sigma'; \rho')} \quad [\text{SD}] \\
 \\
 \frac{(\beta; (\sigma; \rho)) \vdash \Delta \rightsquigarrow (\sigma'; \rho') \quad (\beta; (\sigma'; \rho')) \vdash D \rightsquigarrow F}{(\beta; (\sigma; \rho)) \vdash \Delta; D \rightsquigarrow F} \quad [\text{DS}] \\
 \\
 \frac{(\beta; (\sigma; \rho)) \vdash \Delta_1 \rightsquigarrow (\sigma_1; \rho_1) \quad (\beta; (\sigma_1; \rho_1)) \vdash \Delta_2 \rightsquigarrow (\sigma_2; \rho_2)}{(\beta; (\sigma; \rho)) \vdash \Delta_1; \Delta_2 \rightsquigarrow (\sigma_2; \rho_2)} \quad [\text{DD}] \\
 \\
 \frac{(\beta; (\sigma; \rho)) \vdash D_1 \rightsquigarrow F_1 \quad (\beta \cup \{F_1\}; (\sigma; \rho)) \vdash D_2 \rightsquigarrow F_2}{(\beta; (\sigma; \rho)) \vdash D_1; D_2 \rightsquigarrow F_2} \quad [\text{SS}] \\
 \\
 \frac{(\beta \cup \{F[x \mapsto z]\}; (\sigma; \rho)) \vdash \Delta \rightsquigarrow (\sigma'; \rho')}{(\beta; (\sigma; \rho)) \vdash \text{pick-witness } w \text{ for } \exists x. F: \Delta \rightsquigarrow (\sigma'; \rho') \text{ provided } z \text{ is fresh}} \quad [\text{Exist}]
 \end{array}$$

Figure 1.3: Formal semantics of diagrammatic deductions

End