Advanced Topics

A bluffer's guide to Cyc-style KBs

Dumping sketch knowledge to files

Extending the knowledge base

Making queries interactively

A KQML API for connecting CogSketch to other software

OpenCyc Knowledge Base

- Cyc = World's largest and most complete general knowledge base
  - Hundreds of thousands of terms
  - Millions of assertions
  - English strings corresponding to many concept terms

- OpenCyc = open-source subset of Cyc
  - Entire ontology
  - Structural facts
- Two ways to explore
  - Download OpenCyc from SourceForge
    - Will not have the QRG extensions to OpenCyc
  - Use the browsing capabilities built into CogSketch

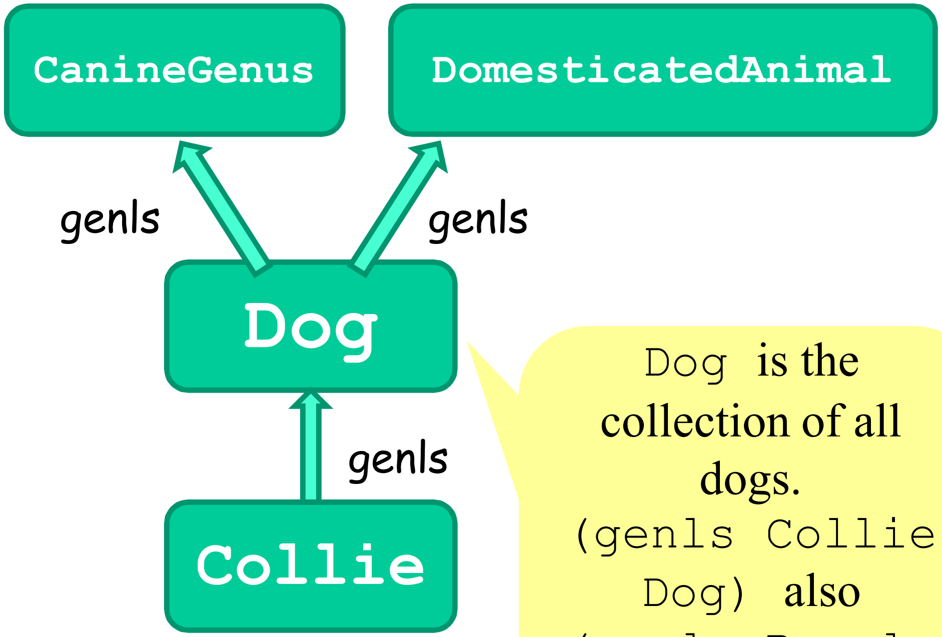
QRG

OpenCyc.org

NORTHWESTERN UNIVERSITY · QUAECUMQUE SUNT VERA · 1851

Collections and Genls

- Concepts and categories in OpenCyc are modeled as *collections*.
- Collections are related to each other through the *genls hierarchy*.
- You can have instances of collections
- Collection names begin with capital letters



`Dog` is the collection of all dogs. `(genls Collie Dog)` also `(genls Beagle Dog)`

Everything that is an instance of `Collie` *is also an instance of* `Dog` *but not vice versa*

`Collie` is the collection of all dogs of the breed Collie

Individuals

- An *individual* is a single thing, not a collection
- Individuals do not have instances
- Use `isa` to relate an individual to a collection

`(isa Lassie1 Dog)`

`Lassie1` is an *instance* of the *collection* `Dog`.

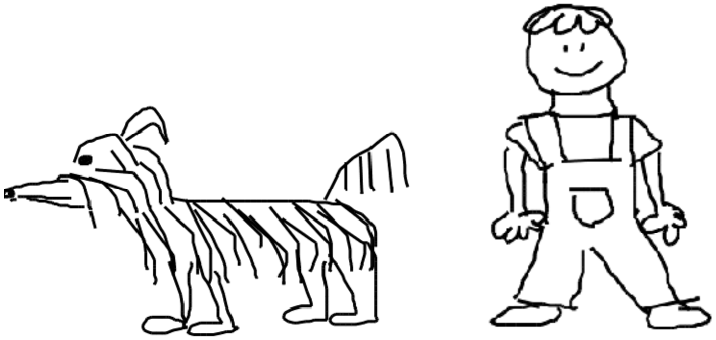
`Lassie1` is also an *individual.*

`(isa Timmy1 MaleChild)`

Predicates and genlPreds

- *Predicates* are used to build *sentences*
- A sentence built with a predicate is either true or false
- Predicate names begin with lower-case letters
- *genlPreds* indicates a hierarchical relationship between predicates

```
(genlPreds mother
           biologicalRelative)
```



```
(owns Timmy1 Lassie1)
```

True

False

```
(biologicalRelatives Timmy1
        Lassie1)
```

Predicates can also relate Collections

```
(animalTypeMakesSoundType
          Dog
          BarkingSound)

(disjointWith Cat Dog)
```

Arity and Argument Types

- Every predicate has two central features:
  - *Arity*: How many arguments does it require?
  - *Argument types:* What types of arguments does it require?
    - arg*N*isa
    - arg*N*Genl
- Every sentence must be both *semantically* and *syntactically* well-formed

Predicate: owns
arity: 2
arg1Isa: SocialBeing
arg2Isa: SomethingExisting

```
(owns Timmy1 Lassie1)
```

OK!

```
(owns Timmy1 Lassie1 Rover2)
```

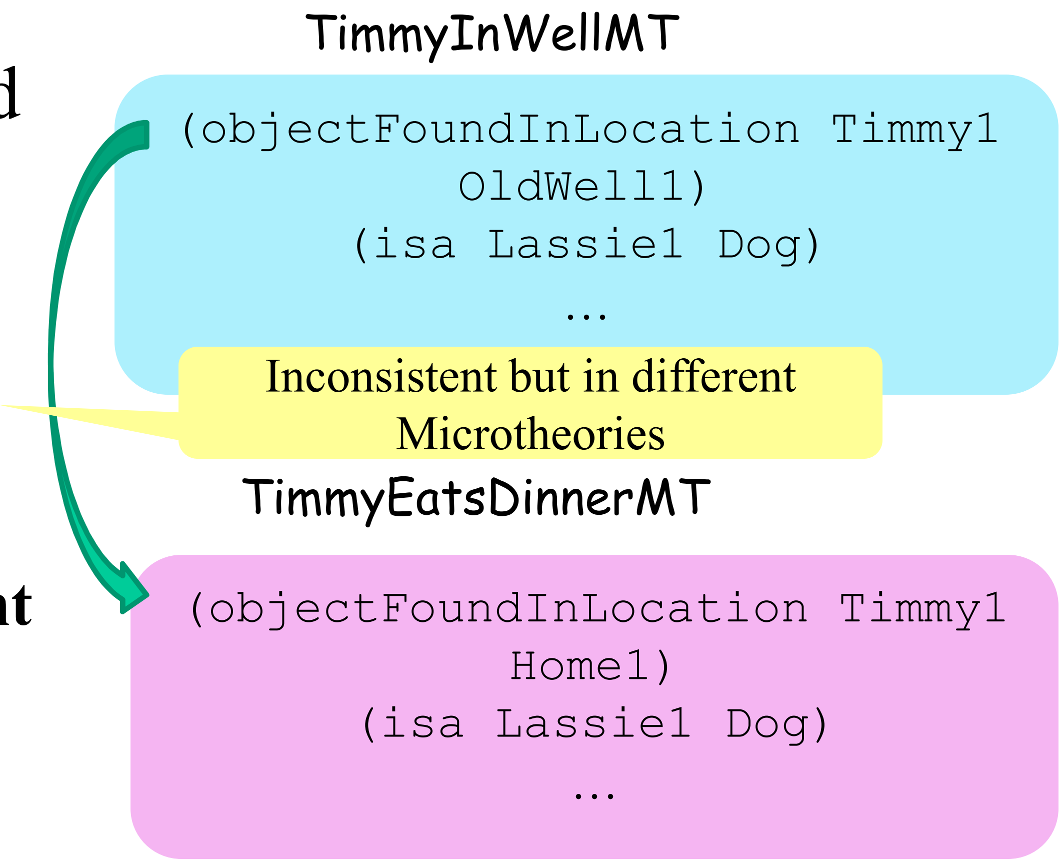
Syntactically poorly-formed

```
(owns Timmy1 Dog)
```

Semantically poorly-formed

Microtheories

- The knowledge in OpenCyc is organized into *Microtheories*
  - Assertions **within** a microtheory must be must be mutually consistent
  - Assertions in **different** microtheories may be inconsistent



TimmyInWellMT

```
(objectFoundInLocation Timmy1
        OldWell1)
    (isa Lassie1 Dog)
           ...
```

Inconsistent but in different Microtheories

TimmyEatsDinnerMT

```
(objectFoundInLocation Timmy1
         Home1)
    (isa Lassie1 Dog)
           ...
```

Can separate statements based on:
Time, source, granularity, …

Using Microtheories

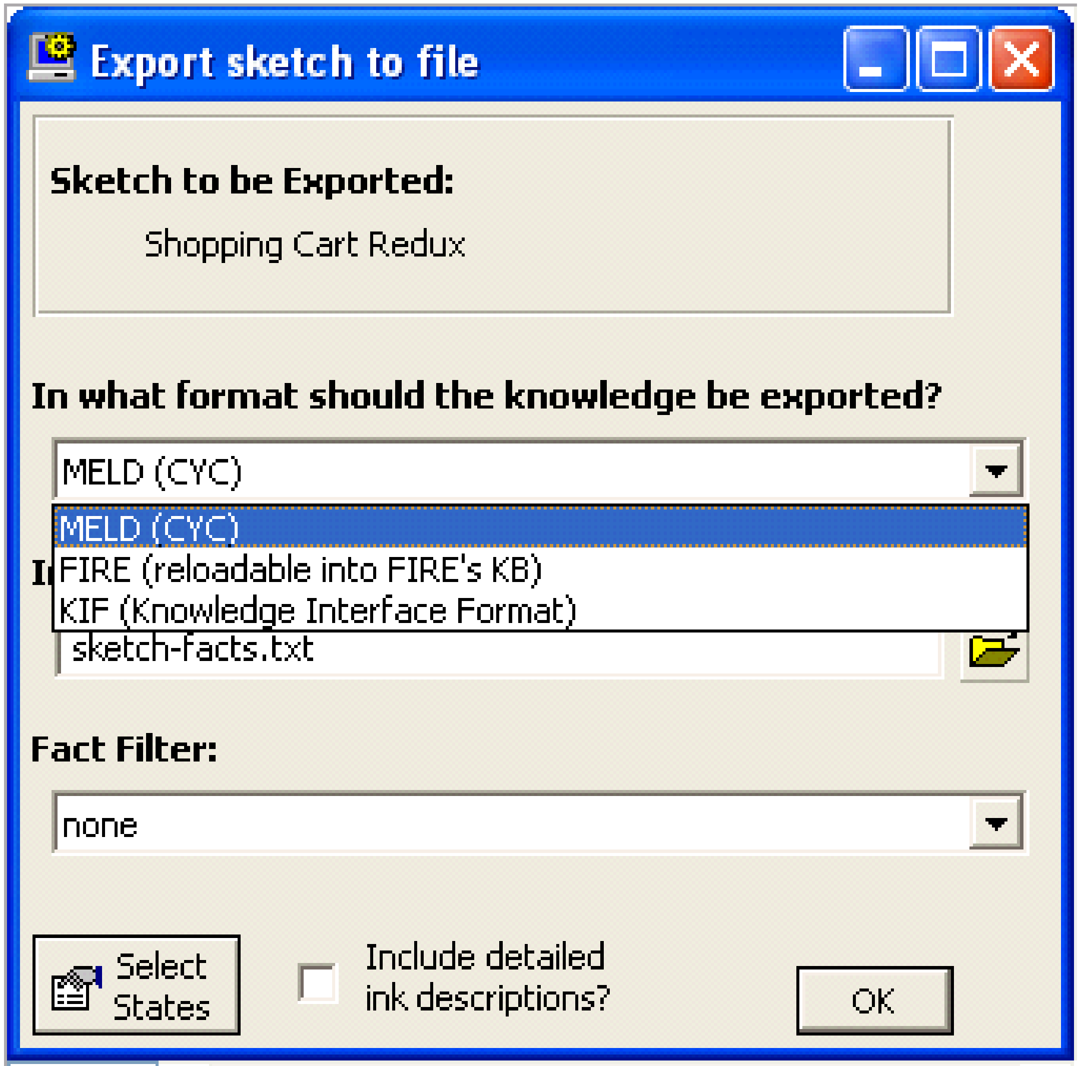
- To make a new microtheory
  - (isa TimmyInWellMT Microtheory)
- To relate one microtheory to another
  - (*genlMt* TimmyInWellMT LassieMT)

Every assertion that is true in `LassieMT` is also true in `TimmyInWellMT`

- To make a statement om a microtheory
  - (*ist-Information* LassieMT
    (isa Lassie1 Dog))

The assertion `(isa Lassie Dog)` **is true** in the microtheory `LassieMT`

Exporting knowledge to files



Export sketch to file

Sketch to be Exported:

Shopping Cart Redux

In what format should the knowledge be exported?

MELD (CYC)

- MELD (CYC)
- FIRE (reloadable into FIRE's KB)
- KIF (Knowledge Interface Format)

I

sketch-facts.txt

Fact Filter:

none

□ Include detailed ink descriptions?

MELD format files

- Similar to Cyc KE format

```
;; constant: Case-3429195339.
;; in Mt: BaseKB.
(isa Case-3429195339 Microtheory)
(isa Case-3429195339 COASpecificationMicrotheory)
(genlMt Case-3429195339 BaseKB)

;; constant: BCase-3429195452.
;; in Mt: BaseKB.
(isa BCase-3429195452 Microtheory)
(isa BCase-3429195452 COASpecificationMicrotheory)
(genlMt BCase-3429195452 Case-3429195339)


;; Default Mt: Case-3429195339.
```

FIRE format

- Pure Lisp syntax
- Microtheory toggled by directives in file
  - cf. KB extension example

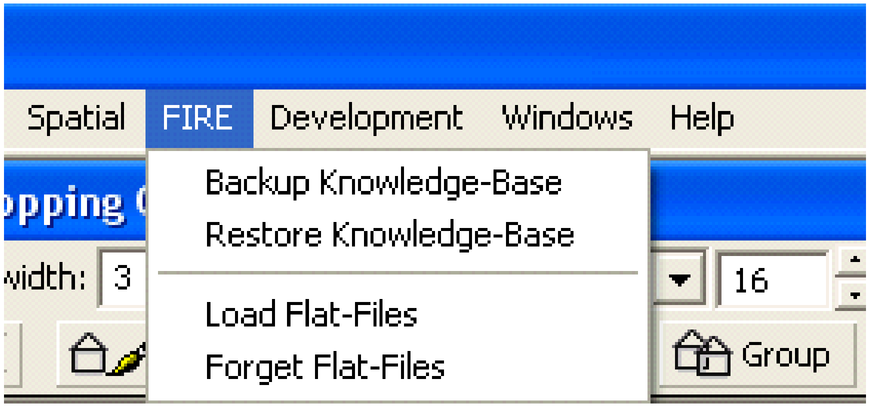
```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;; Shopping Cart Redux

(genlMt BCase-3429195452 Case-3429195339)
(genlMt Case-3429195339 SKEAReasoningCollectorMt)


(ist-Information Case-3429195339
 (askConceptualForBinaryVisualRelation Case-3429195339 BCase-3429195452
  Object-145 Object-147 rcc8-EC PhysicalView-SubSketch
  LookingFromSide-SubSketch))
(ist-Information Case-3429195339
 (askConceptualForBinaryVisualRelation Case-3429195339 BCase-3429195452
  Object-145 Object-148 rcc8-EC PhysicalView-SubSketch
  LookingFromSide-SubSketch))
```

Extending the Knowledge Base

- OpenCyc has a lot of knowledge … but it might not have everything you need
- You add knowledge using a .meld file
- Create using your favorite text editor.



Hint: Use an editor that matches parentheses, such as emacs!

Example: A Simple Flat-File

```
(in-microtheory TimmyInWellMT) ;; Tells file
;; loader what microtheory to use.  All forms after
;; this command are facts for that microtheory.
(isa Lassie1 Dog)
(isa Timmy1 MaleChild)
(isa OldWell1 Well)
(owns Timmy1 Lassie1)
(objectInLocation Timmy1 OldWell1)
(isa LassieGetHelp RescuingSomeone)
(performedBy LassieGetHelp Lassie1)
(beneficiary LassieGetHelp Timmy1)
```

Adding a Collection

To add a collection you need at least three things:

1. A statement that it is a Collection
2. A genls statement
3. A comment describing the collection

```
(isa Firefly Collection)
(genls Firefly Insect)
(comment Firefly
 “the collection of all
insects that having
glowing   posteriors”)
```

Adding a Relation

To add a relation you need at least four things:

1. A statement that it isa Relation
2. An arity statement
3. ArgIsa statements
4. A comment describing the relation

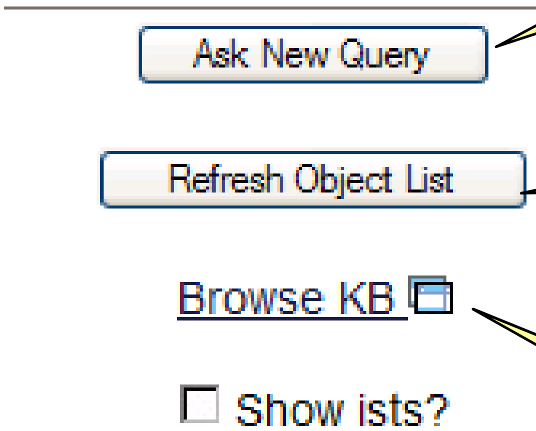
```
(isa aboveGrazingLine
     Relation)
(arity aboveGrazingLine 2)
(arg1Isa aboveGrazingLine
         NuSketchGlyph)
(arg2Isa aboveGrazingLine
         NuSketchGlyph)
(comment aboveGrazingLine
  “the figure object
represented by the glyph in
arg1 is above the grazing
line created by the ground
object represented by the
glyph in arg2”)
```

Using Your New KB entries in CogSketch

- Your new collections
  - Can be used in conceptual labeling
  - Can be used to constrain arguments to relations
- Your new relations
  - Can show up as hypothesized visual/conceptual relationship questions, if you weave them into the `genlPreds` hierarchy correctly.
  - Can be used for your own reasoning, if you add Horn clause axioms involving them also
    - Via browser query window, or API calls
    - Documentation on doing this is in progress

Querying the KB

Bottom left of
Knowledge Inspector
page



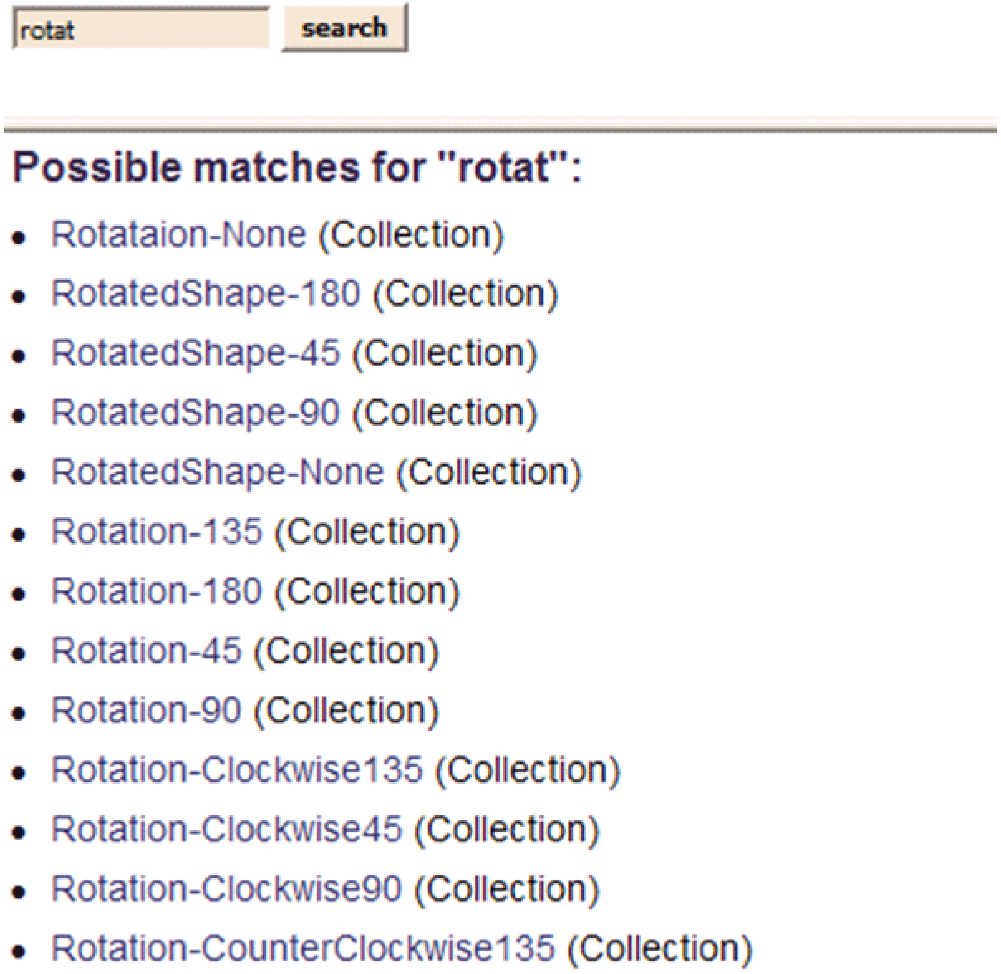
Can type in queries to the reasoner of a sketch

If you've edited the sketch, click this.

Invokes a KB browser

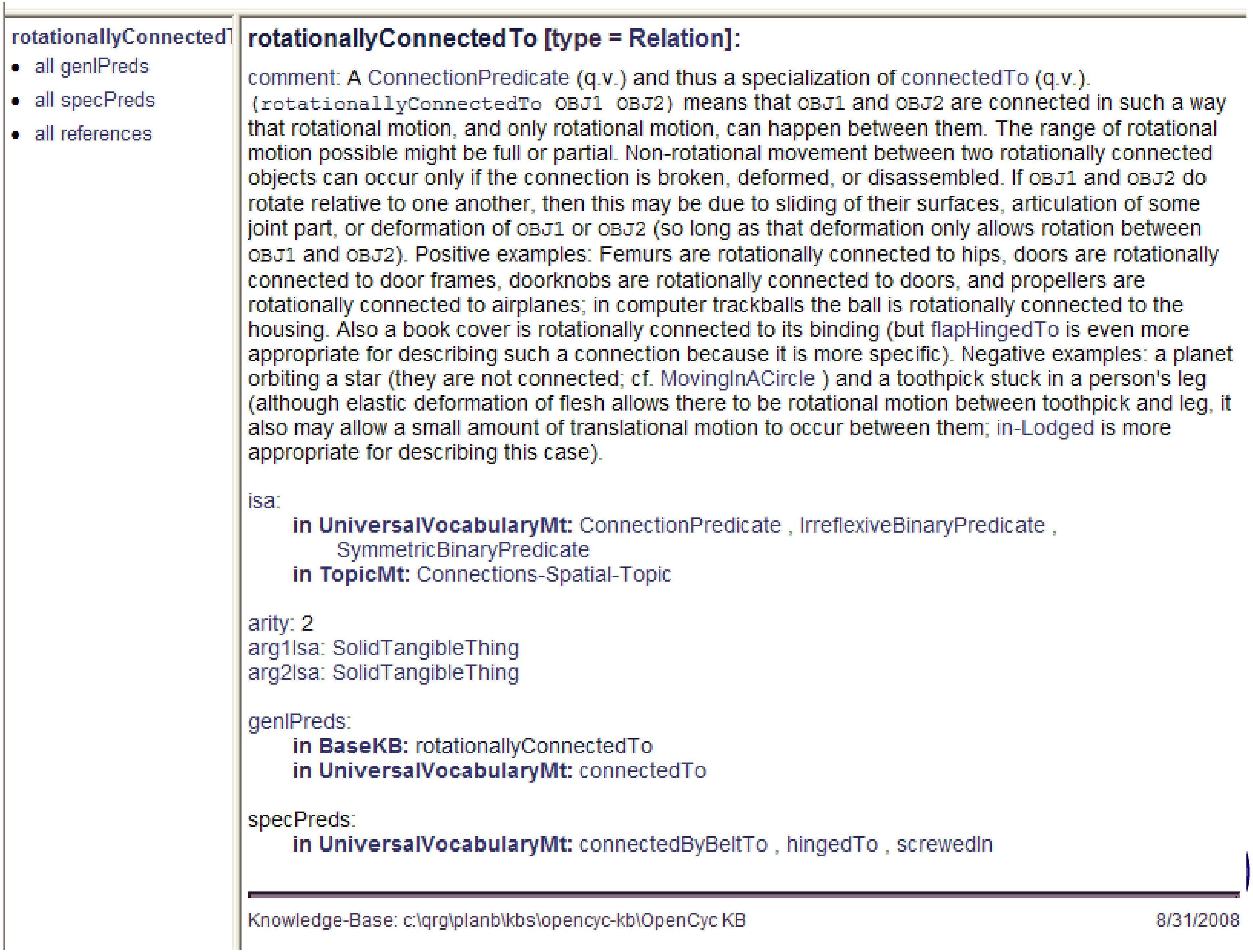
Example: Browsing

- Let’s look for other relationships involving rotation with the KB browser



Possible matches for "rotat":

- Rotataion-None (Collection)
- RotatedShape-180 (Collection)
- RotatedShape-45 (Collection)
- RotatedShape-90 (Collection)
- RotatedShape-None (Collection)
- Rotation-135 (Collection)
- Rotation-180 (Collection)
- Rotation-45 (Collection)
- Rotation-90 (Collection)
- Rotation-Clockwise135 (Collection)
- Rotation-Clockwise45 (Collection)
- Rotation-Clockwise90 (Collection)
- Rotation-CounterClockwise135 (Collection)



rotationallyConnectedT

- all genlPreds
- all specPreds
- all references

rotationallyConnectedTo [type = Relation]:

comment: A ConnectionPredicate (q.v.) and thus a specialization of connectedTo (q.v.). `(rotationallyConnectedTo OBJ1 OBJ2)` means that `OBJ1` and `OBJ2` are connected in such a way that rotational motion, and only rotational motion, can happen between them. The range of rotational motion possible might be full or partial. Non-rotational movement between two rotationally connected objects can occur only if the connection is broken, deformed, or disassembled. If `OBJ1` and `OBJ2` do rotate relative to one another, then this may be due to sliding of their surfaces, articulation of some joint part, or deformation of `OBJ1` or `OBJ2` (so long as that deformation only allows rotation between `OBJ1` and `OBJ2`). Positive examples: Femurs are rotationally connected to hips, doors are rotationally connected to door frames, doorknobs are rotationally connected to doors, and propellers are rotationally connected to airplanes; in computer trackballs the ball is rotationally connected to the housing. Also a book cover is rotationally connected to its binding (but flapHingedTo is even more appropriate for describing such a connection because it is more specific). Negative examples: a planet orbiting a star (they are not connected; cf. MovingInACircle) and a toothpick stuck in a person's leg (although elastic deformation of flesh allows there to be rotational motion between toothpick and leg, it also may allow a small amount of translational motion to occur between them; in-Lodged is more appropriate for describing this case).

isa:
in UniversalVocabularyMt: ConnectionPredicate , IrreflexiveBinaryPredicate , SymmetricBinaryPredicate
in TopicMt: Connections-Spatial-Topic

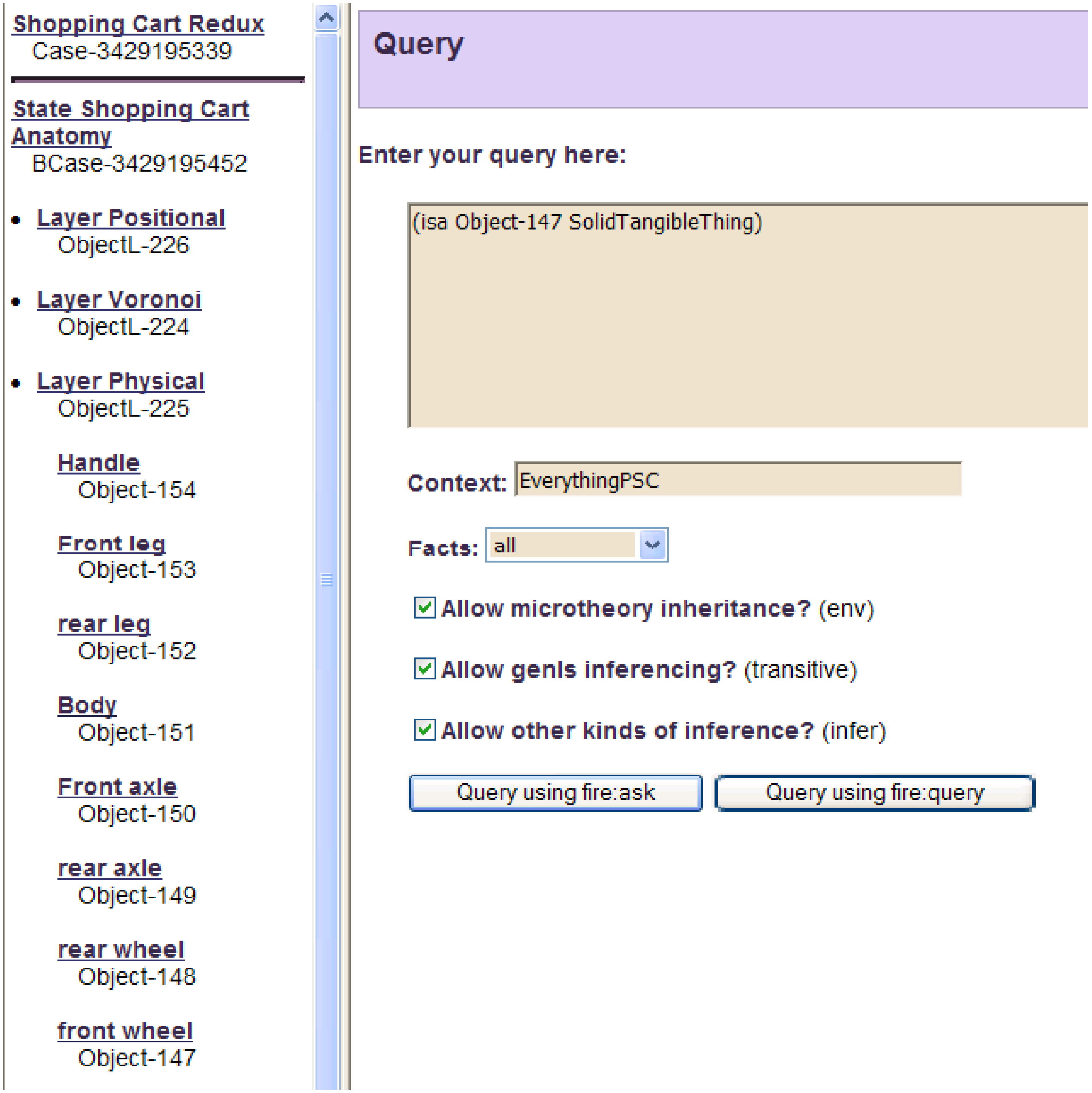
arity: 2
arg1Isa: SolidTangibleThing
arg2Isa: SolidTangibleThing

genlPreds:
in BaseKB: rotationallyConnectedTo
in UniversalVocabularyMt: connectedTo

specPreds:
in UniversalVocabularyMt: connectedByBeltTo , hingedTo , screwedIn

Knowledge-Base: c:\qrg\planb\kbs\opencyc-kb\OpenCyc KB 8/31/2008

Making Queries



Shopping Cart Redux
Case-3429195339

State Shopping Cart Anatomy
BCase-3429195452

- Layer Positional
  ObjectL-226
- Layer Voronoi
  ObjectL-224
- Layer Physical
  ObjectL-225

Handle
Object-154

Front leg
Object-153

rear leg
Object-152

Body
Object-151

Front axle
Object-150

rear axle
Object-149

rear wheel
Object-148

front wheel
Object-147

Query

Enter your query here:

```
(isa Object-147 SolidTangibleThing)
```

Context: EverythingPSC

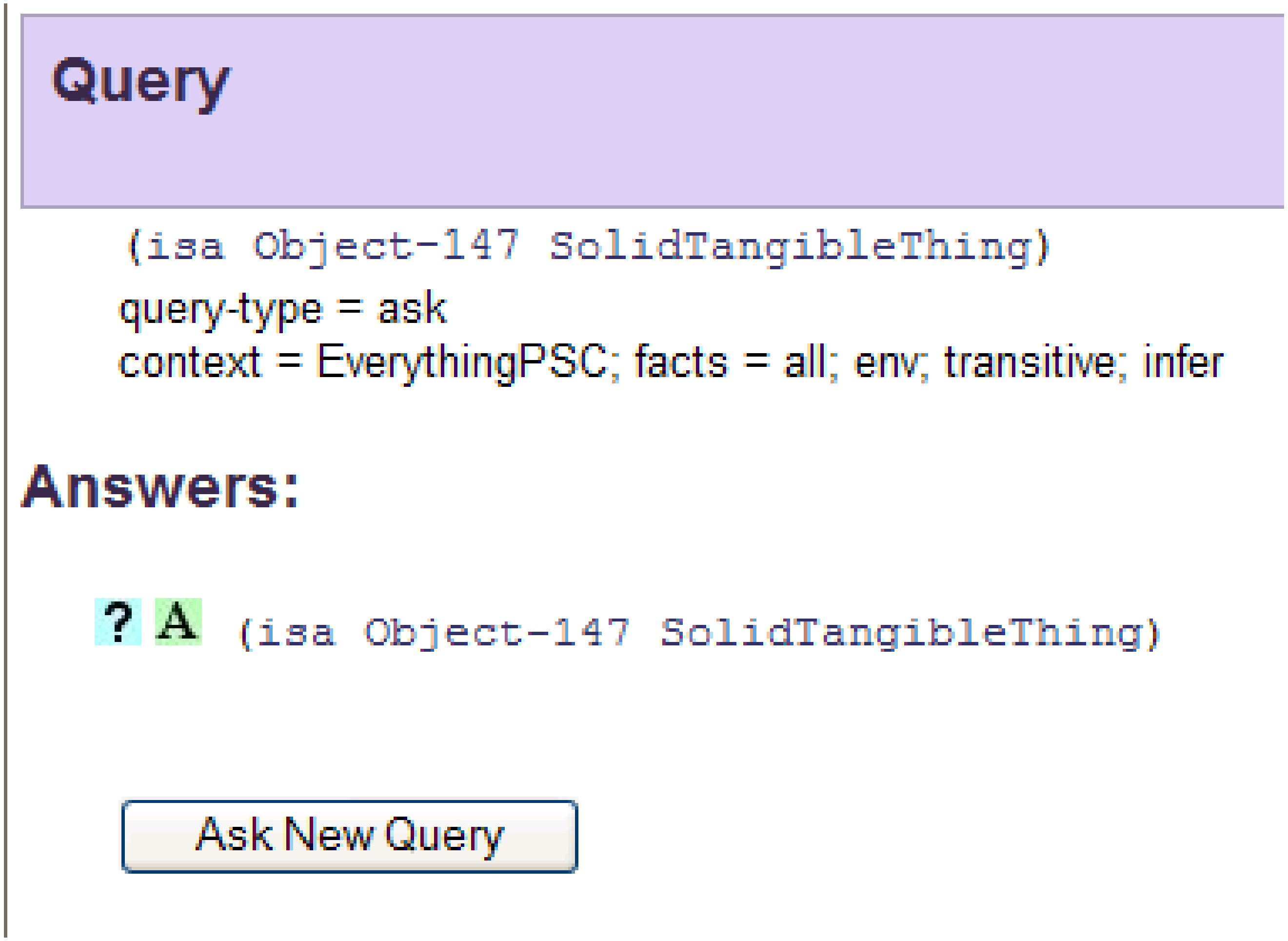
Facts: all

☑ Allow microtheory inheritance? (env)

☑ Allow genls inferencing? (transitive)

☑ Allow other kinds of inference? (infer)

Can get Answers



Query

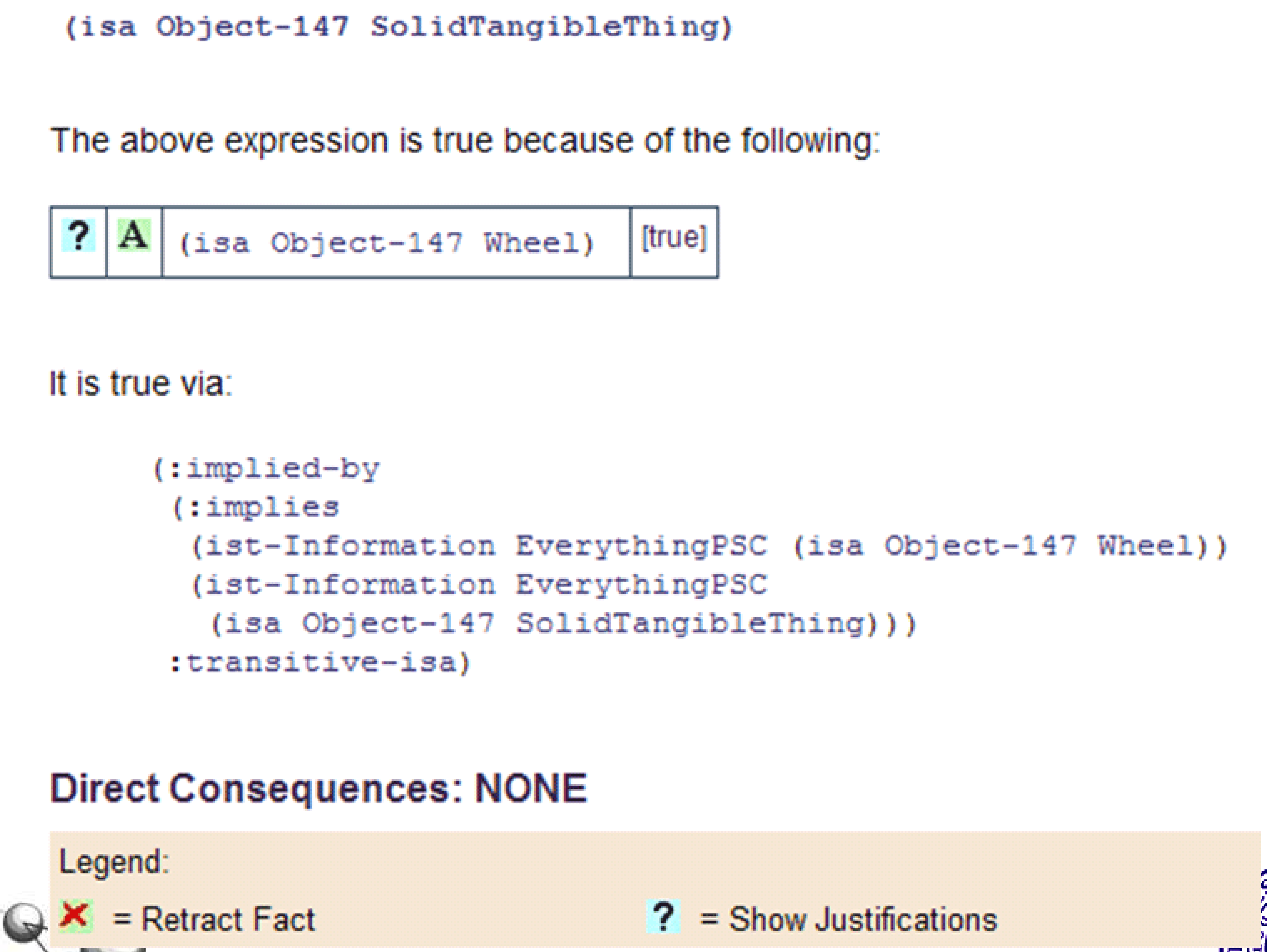
```
(isa Object-147 SolidTangibleThing)
```

query-type = ask
context = EverythingPSC; facts = all; env; transitive; infer

Answers:

```
? A (isa Object-147 SolidTangibleThing)
```

Can Drill Down for Reasons



```
(isa Object-147 SolidTangibleThing)
```

The above expression is true because of the following:

?	A	`(isa Object-147 Wheel)`	[true]

It is true via:

```
(:implied-by
 (:implies
  (ist-Information EverythingPSC (isa Object-147 Wheel))
  (ist-Information EverythingPSC
   (isa Object-147 SolidTangibleThing)))
 :transitive-isa)
```

Direct Consequences: NONE

Legend:

✗ = Retract Fact

? = Show Justifications

What is an API? Why do I want one?

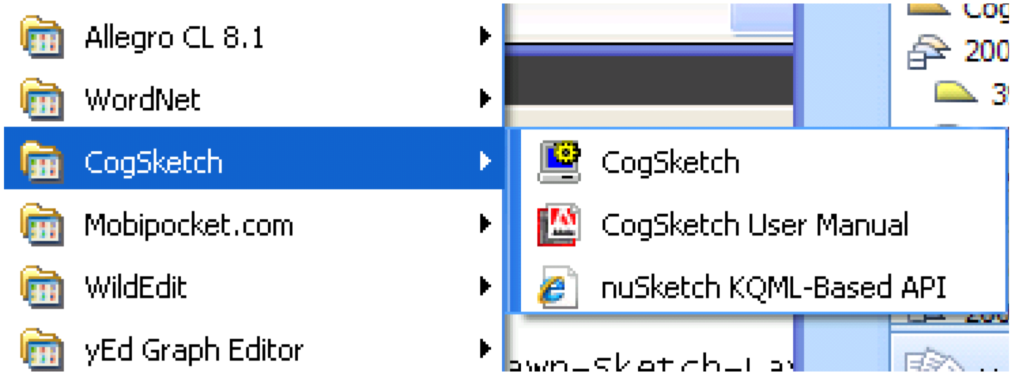
- **A**pplication **P**rogramming **I**nterface
- Allows you to access CogSketch from code
- Socket-based, using KQML messages
- Documentation and sample client provided with CogSketch executable

What Can I do with the API?

- Manipulate Sketches
- **(list-open-sketches)**
- **(get-active-sketch)**
- **(set-active-sketch :sketch-id <sketch id>)**
- **(save-sketch-to-file :sketch-id <sketch id>)**
- **(close-sketch :sketch-id <sketch id>)**
- **(open-sketch-from-file :filepath <full path to file (string)>)**
- **(create-new-sketch)**
- **(name-of-sketch :sketch-id <sketch id>)**
- **(user-namestring-of-sketch :sketch-id <sketch id>)**

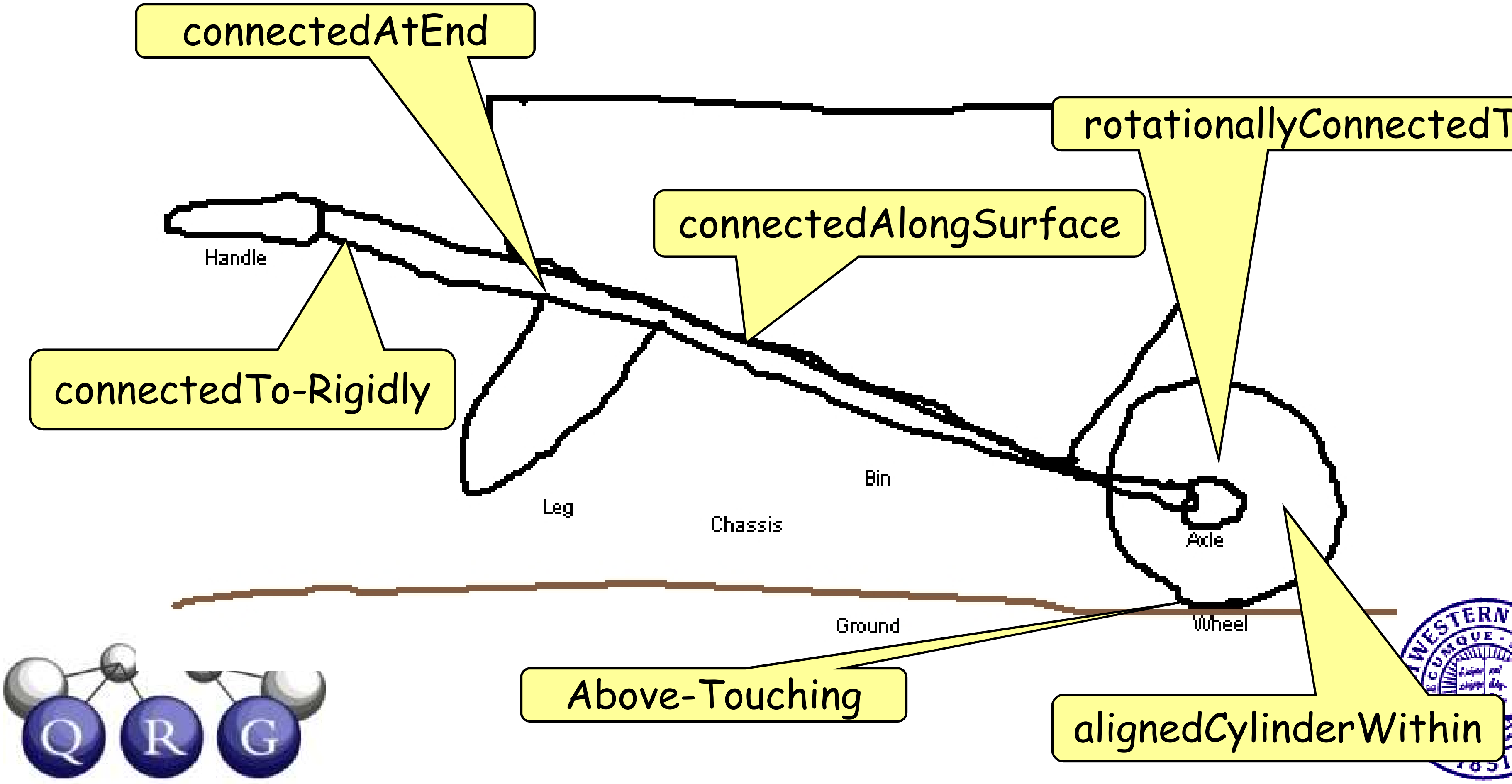
What Can I do with the API?

- You can also manipulate subsketches, Layers and Glyphs
- **(list-bundles :sketch-id <sketch id>)**
- **(list-layers :sketch-id <sketch id> :bundle-id <bundle id>)**
- **(name-of-layer :sketch-id <sketch id> :layer-id <layer id>)**
- **(kind-of-layer :sketch-id <sketch id> :layer-id <layer id>)**
- **(list-glyphs :sketch-id <sketch id> :layer-id <layer id>)**
- **(delete-glyph :sketch-id <sketch id> :glyph-id <glyph id>)**
- These are just examples of some of the available commands



Visual/Conceptual Relationships

- People use conventions for depicting physical relationships in sketches
- You can tell CogSketch about your assumptions



connectedAtEnd

rotationallyConnectedTo

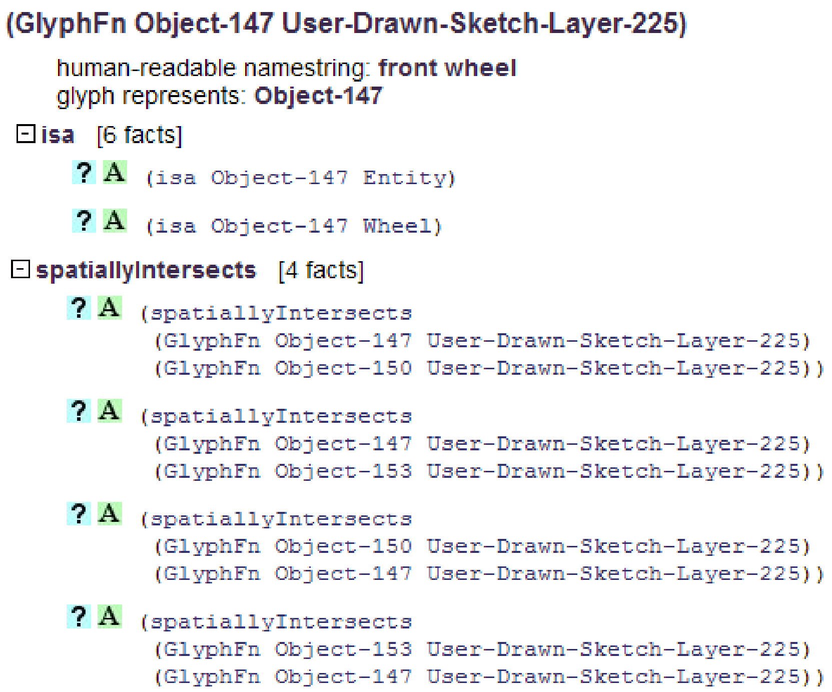
connectedAlongSurface

connectedTo-Rigidly

Above-Touching

alignedCylinderWithin

Example: Shopping Cart



(GlyphFn Object-147 User-Drawn-Sketch-Layer-225)

human-readable namestring: **front wheel**
glyph represents: **Object-147**

⊟ **isa** [6 facts]

```
? A (isa Object-147 Entity)

? A (isa Object-147 Wheel)
```

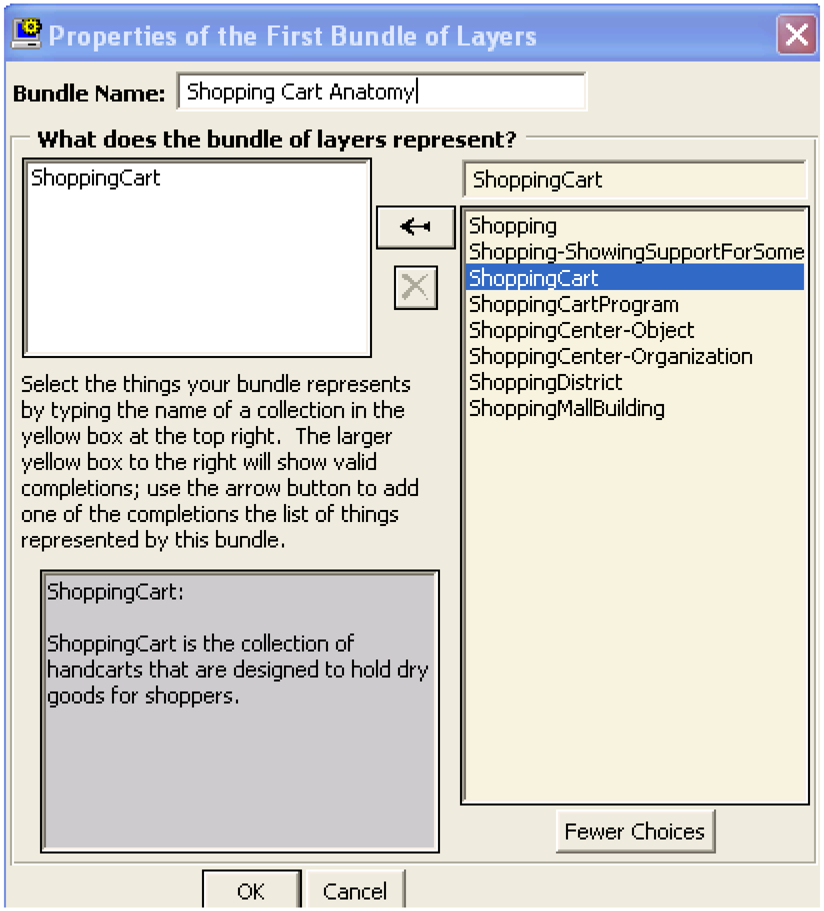
⊟ **spatiallyIntersects** [4 facts]

```
? A (spatiallyIntersects
     (GlyphFn Object-147 User-Drawn-Sketch-Layer-225)
     (GlyphFn Object-150 User-Drawn-Sketch-Layer-225))

? A (spatiallyIntersects
     (GlyphFn Object-147 User-Drawn-Sketch-Layer-225)
     (GlyphFn Object-153 User-Drawn-Sketch-Layer-225))

? A (spatiallyIntersects
     (GlyphFn Object-150 User-Drawn-Sketch-Layer-225)
     (GlyphFn Object-147 User-Drawn-Sketch-Layer-225))

? A (spatiallyIntersects
     (GlyphFn Object-153 User-Drawn-Sketch-Layer-225)
     (GlyphFn Object-147 User-Drawn-Sketch-Layer-225))
```



Properties of the First Bundle of Layers

Bundle Name: Shopping Cart Anatomy

What does the bundle of layers represent?

ShoppingCart

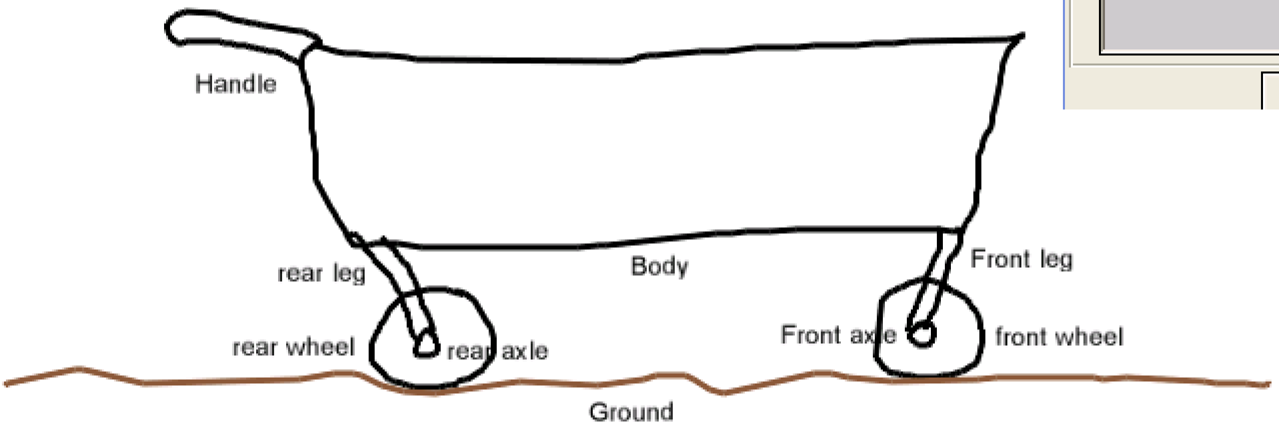
ShoppingCart

Shopping
Shopping-ShowingSupportForSome
ShoppingCart
ShoppingCartProgram
ShoppingCenter-Object
ShoppingCenter-Organization
ShoppingDistrict
ShoppingMallBuilding

Select the things your bundle represents by typing the name of a collection in the yellow box at the top right. The larger yellow box to the right will show valid completions; use the arrow button to add one of the completions the list of things represented by this bundle.

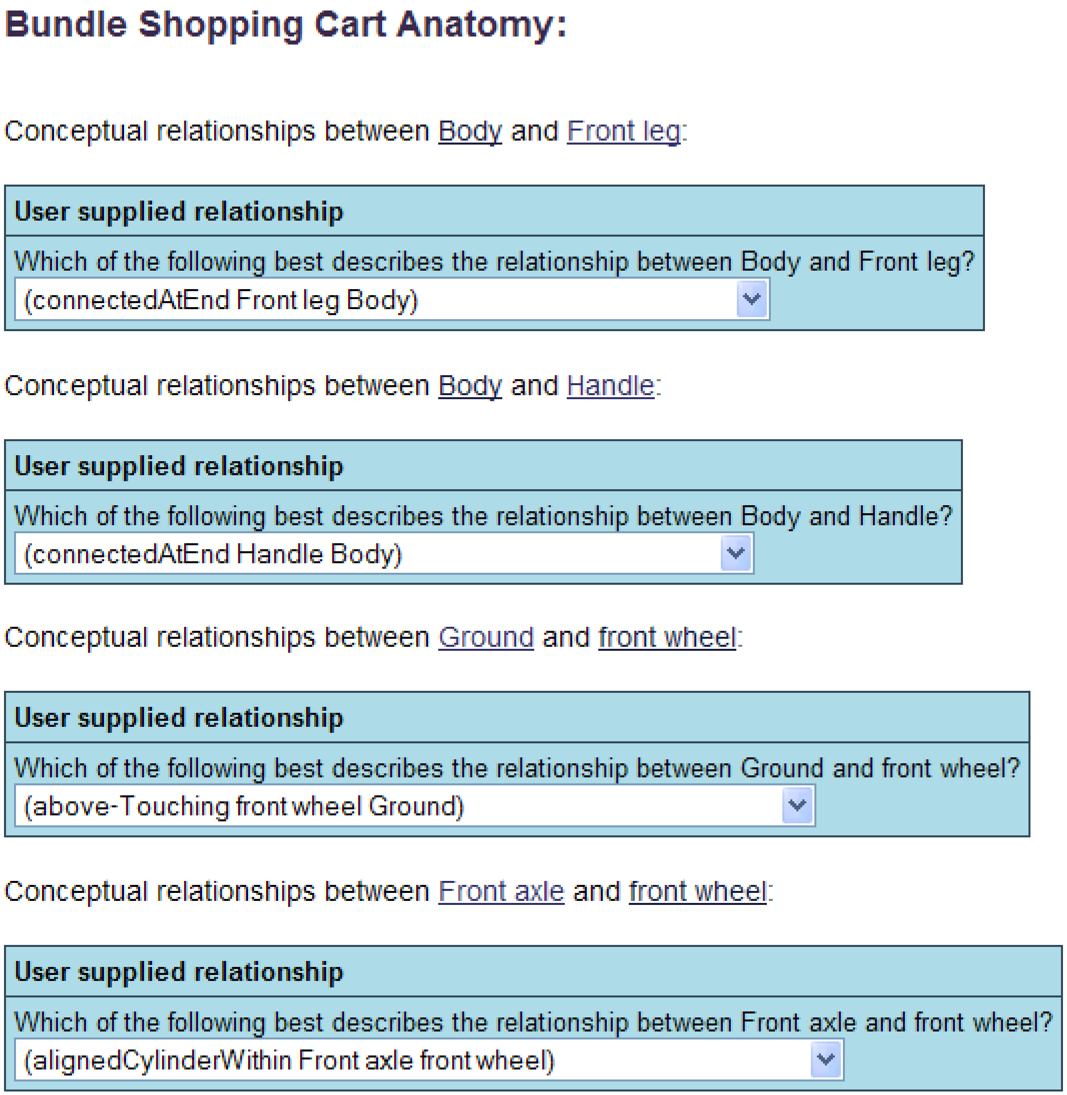
ShoppingCart:

ShoppingCart is the collection of handcarts that are designed to hold dry goods for shoppers.



Providing Visual/Conceptual Relations

Use this button to bring up web interface on selected bundle



Bundle Shopping Cart Anatomy:

Conceptual relationships between Body and Front leg:

User supplied relationship

Which of the following best describes the relationship between Body and Front leg?

(connectedAtEnd Front leg Body)

Conceptual relationships between Body and Handle:

User supplied relationship

Which of the following best describes the relationship between Body and Handle?

(connectedAtEnd Handle Body)

Conceptual relationships between Ground and front wheel:

User supplied relationship

Which of the following best describes the relationship between Ground and front wheel?

(above-Touching front wheel Ground)

Conceptual relationships between Front axle and front wheel:

User supplied relationship

Which of the following best describes the relationship between Front axle and front wheel?

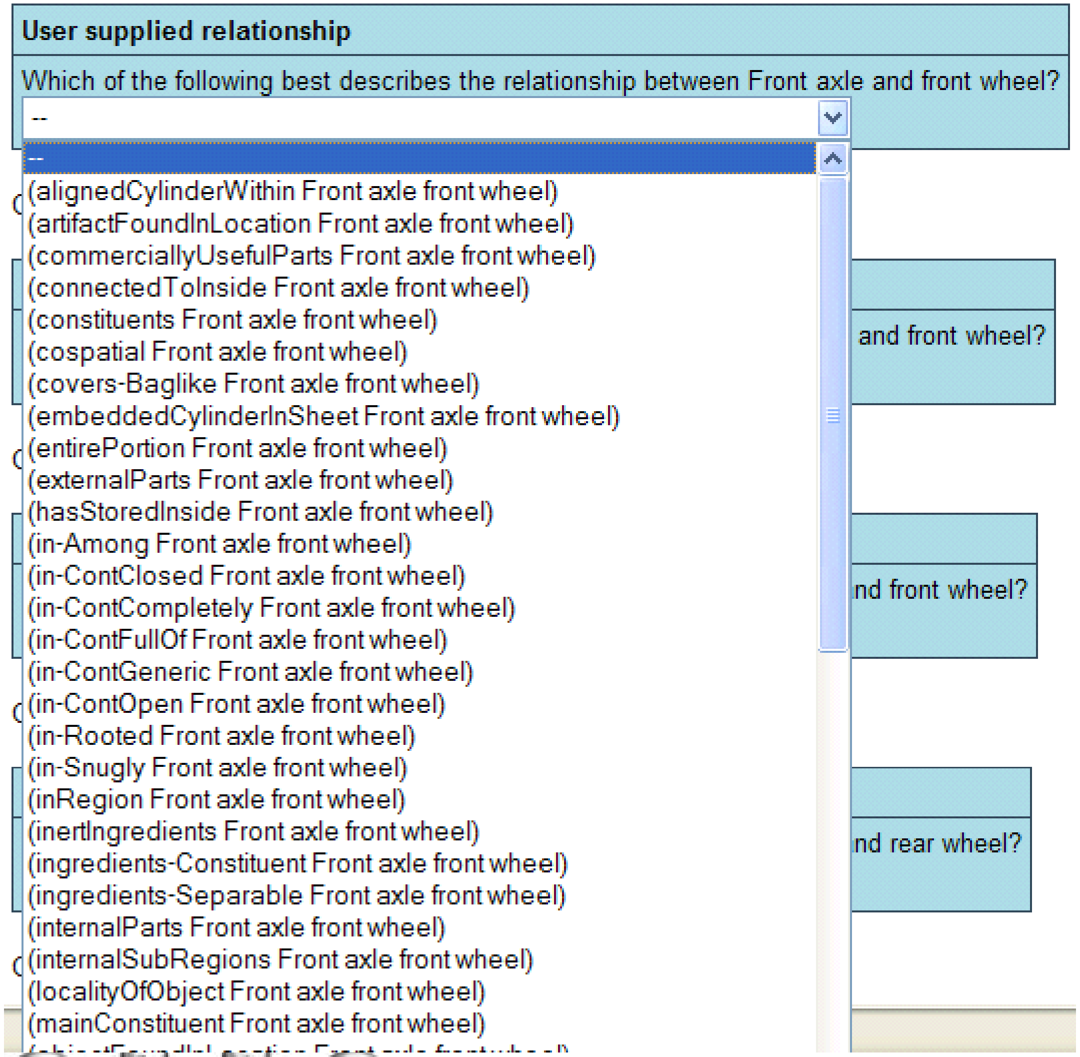
(alignedCylinderWithin Front axle front wheel)

How visual/conceptual relations are hypothesized

- Qualitative topology used to suggest initial candidates
  - `(insideInSketch o1 o2)` if `(glyph o1)` is inside `(glyph o2)`
  - `(atOrOverlapsInSketch o1 o2)` if `(glyph o1)` touches or overlaps `(glyph o2)`
- Possible specializations filtered by argument type relationships
- You can choose more specialized relationship if desired.
- Not an easy problem
  - Worst case: 150 possibilities for **`insideInSketch`**, 204 for **`atOrOverlapsInSketch`**, with ResearchCyc KB
  - For one corpus of 34 sketches:
    - Mean # questions/sketch = 4
    - Mean # candidates to consider per question = 122

Example: Front Wheel/Axle

Conceptual relationships between Front axle and front wheel:



User supplied relationship

Which of the following best describes the relationship between Front axle and front wheel?

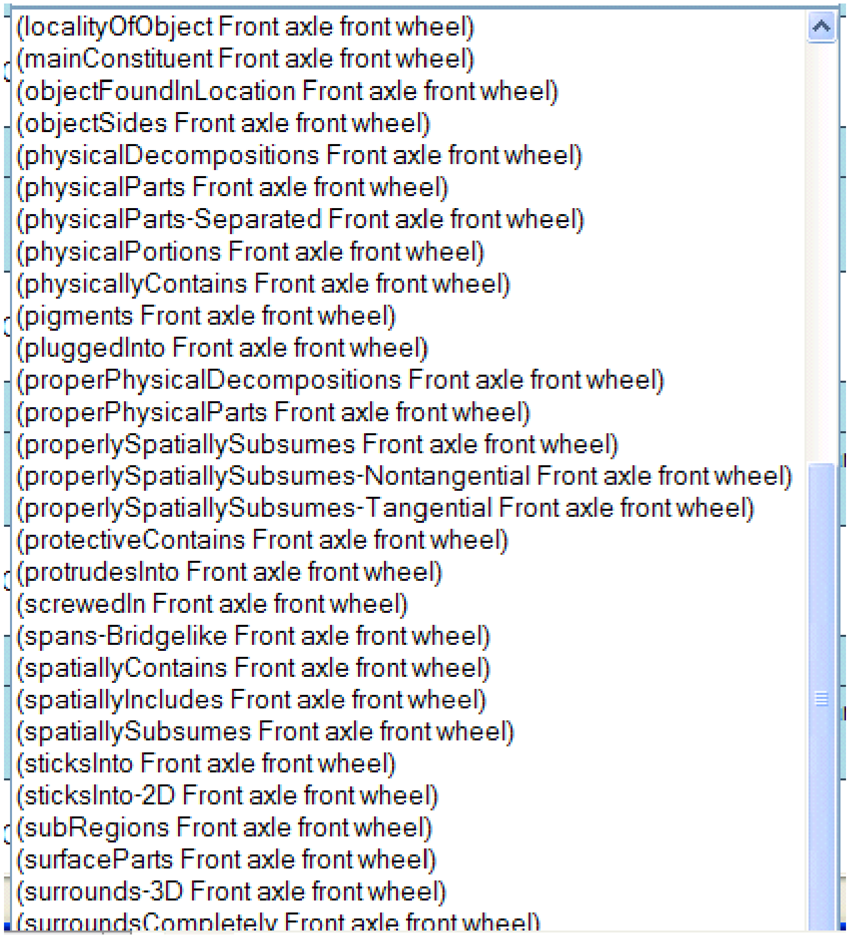
--

--
(alignedCylinderWithin Front axle front wheel)
(artifactFoundInLocation Front axle front wheel)
(commerciallyUsefulParts Front axle front wheel)
(connectedToInside Front axle front wheel)
(constituents Front axle front wheel)
(cospatial Front axle front wheel)
(covers-Baglike Front axle front wheel)
(embeddedCylinderInSheet Front axle front wheel)
(entirePortion Front axle front wheel)
(externalParts Front axle front wheel)
(hasStoredInside Front axle front wheel)
(in-Among Front axle front wheel)
(in-ContClosed Front axle front wheel)
(in-ContCompletely Front axle front wheel)
(in-ContFullOf Front axle front wheel)
(in-ContGeneric Front axle front wheel)
(in-ContOpen Front axle front wheel)
(in-Rooted Front axle front wheel)
(in-Snugly Front axle front wheel)
(inRegion Front axle front wheel)
(inertIngredients Front axle front wheel)
(ingredients-Constituent Front axle front wheel)
(ingredients-Separable Front axle front wheel)
(internalParts Front axle front wheel)
(internalSubRegions Front axle front wheel)
(localityOfObject Front axle front wheel)
(mainConstituent Front axle front wheel)

and front wheel?

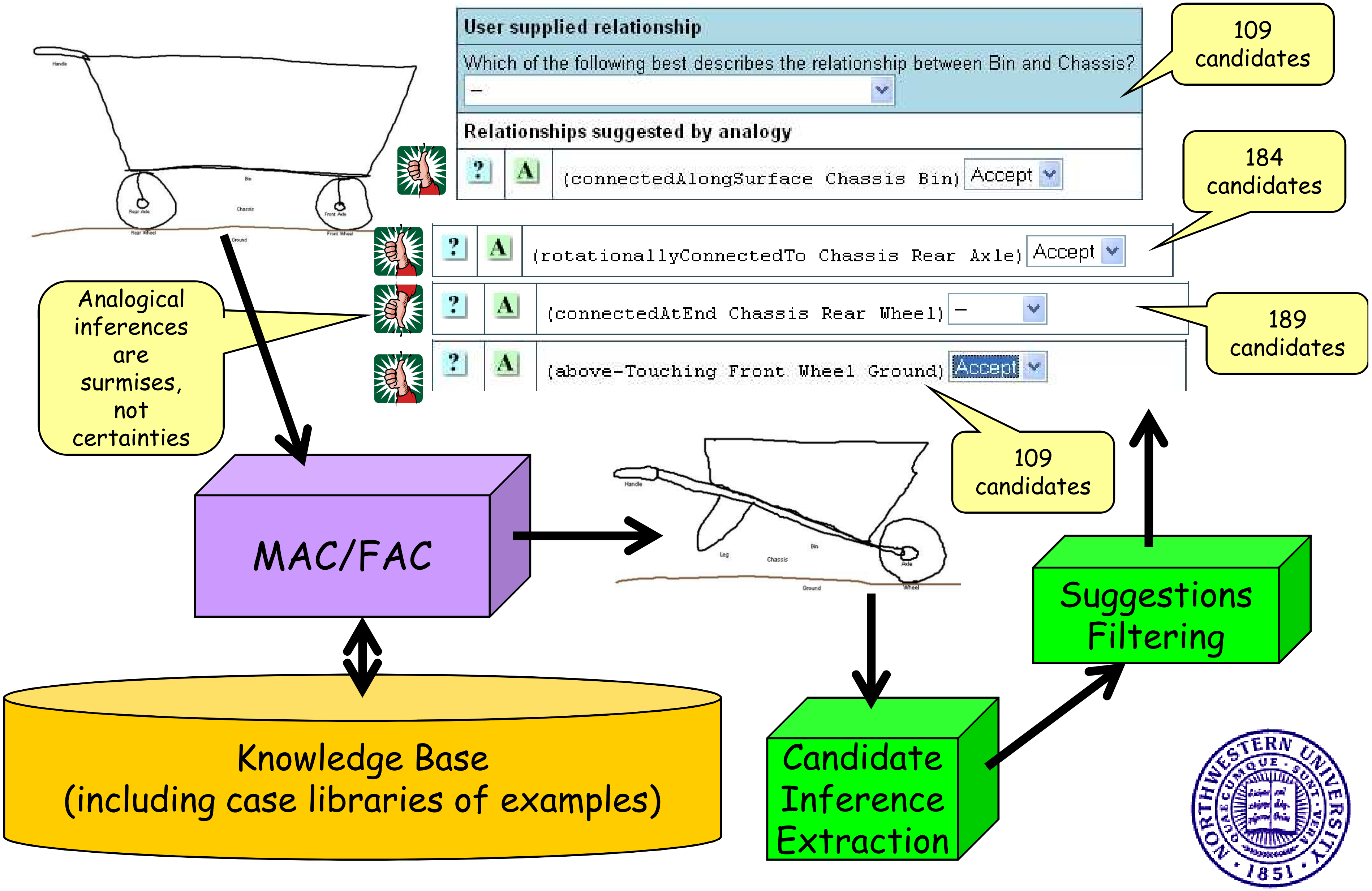
nd front wheel?

nd rear wheel?



(localityOfObject Front axle front wheel)
(mainConstituent Front axle front wheel)
(objectFoundInLocation Front axle front wheel)
(objectSides Front axle front wheel)
(physicalDecompositions Front axle front wheel)
(physicalParts Front axle front wheel)
(physicalParts-Separated Front axle front wheel)
(physicalPortions Front axle front wheel)
(physicallyContains Front axle front wheel)
(pigments Front axle front wheel)
(pluggedInto Front axle front wheel)
(properPhysicalDecompositions Front axle front wheel)
(properPhysicalParts Front axle front wheel)
(properlySpatiallySubsumes Front axle front wheel)
(properlySpatiallySubsumes-Nontangential Front axle front wheel)
(properlySpatiallySubsumes-Tangential Front axle front wheel)
(protectiveContains Front axle front wheel)
(protrudesInto Front axle front wheel)
(screwedIn Front axle front wheel)
(spans-Bridgelike Front axle front wheel)
(spatiallyContains Front axle front wheel)
(spatiallyIncludes Front axle front wheel)
(spatiallySubsumes Front axle front wheel)
(sticksInto Front axle front wheel)
(sticksInto-2D Front axle front wheel)
(subRegions Front axle front wheel)
(surfaceParts Front axle front wheel)
(surrounds-3D Front axle front wheel)
(surroundsCompletely Front axle front wheel)

Suggesting visual/conceptual relations by analogy



User supplied relationship

Which of the following best describes the relationship between Bin and Chassis?

–

Relationships suggested by analogy

```
(connectedAlongSurface Chassis Bin)        Accept
(rotationallyConnectedTo Chassis Rear Axle) Accept
(connectedAtEnd Chassis Rear Wheel)        –
(above-Touching Front Wheel Ground)        Accept
```

109 candidates

184 candidates

189 candidates

109 candidates

Analogical inferences are surmises, not certainties

Knowledge Base (including case libraries of examples)

Candidate Inference Extraction

Suggestions Filtering