# Flexible Tools for the Semantic Web

**Michael Wessel**
**(instead of Jans Aasman from Franz Inc.)**

**Software Systems Group (STS)**
**Hamburg University of Technology (TUHH)**
**Hamburg-Harburg, Germany**

**(and Racer Systems GmbH & Co. KG)**

STS

TUHH
Technische Universität Hamburg-Harburg

# Flexible Tools for the Semantic Web

- Portfolio of tools offered by Franz Inc. & Racer Systems
  - RacerPro, RacerPorter
  - AllegroGraph, Gruff
- These tools
  - are mature
  - are open for users (extensible)
  - are compatible with W3C standards and OpenSource frameworks
  - offer flexible and pragmatic solutions for which there are no standards yet (e.g., spatial queries via SPARQL extensions in AllegroGraph)
  - can be combined

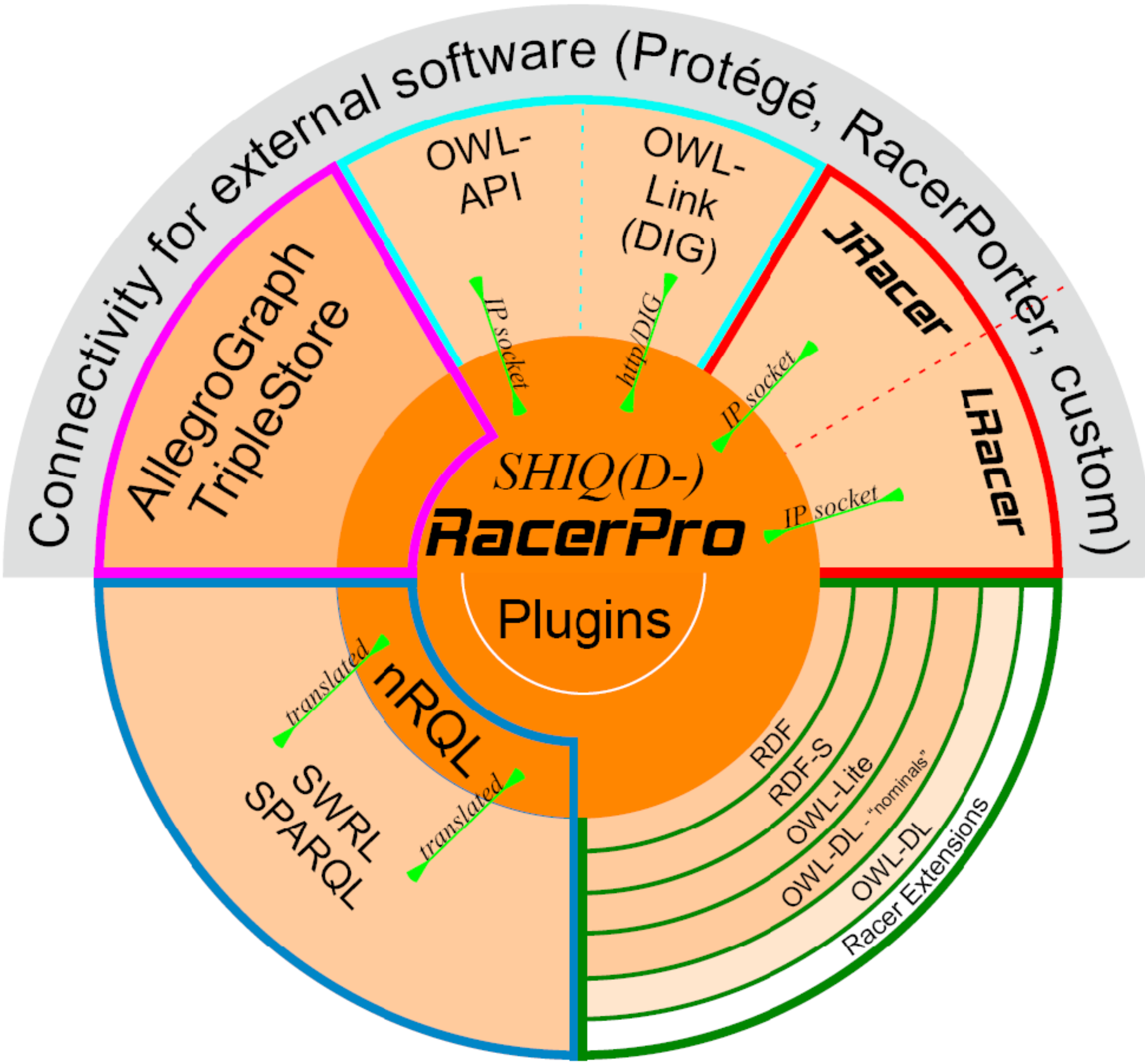
# STS, Racer Systems, Franz Inc.

- Racer Systems GmbH & Co. KG
  - Private, founded 2004
    - Prof. V. Haarslev (Concordia)
    - Prof. R. Möller (STS)
    - Kay Hidde
    - Michael Wessel (STS)
  - Commercial home of RacerPro
  - RacerPro, RacerPorter
  - Consulting

Offer expertise in semantics-based applications and mature and scalable tools

- Franz Inc.
  - Private, founded 1984 - U.C. Berkeley
  - CEO Dr. Jans Aasman
  - Lisp Vendor, AllegroGraph
  - Consulting
- STS
  - Databases, Software Systems, Semantic Web
  - The second „academic home“ of RacerPro

# RacerPro - Architecture & History

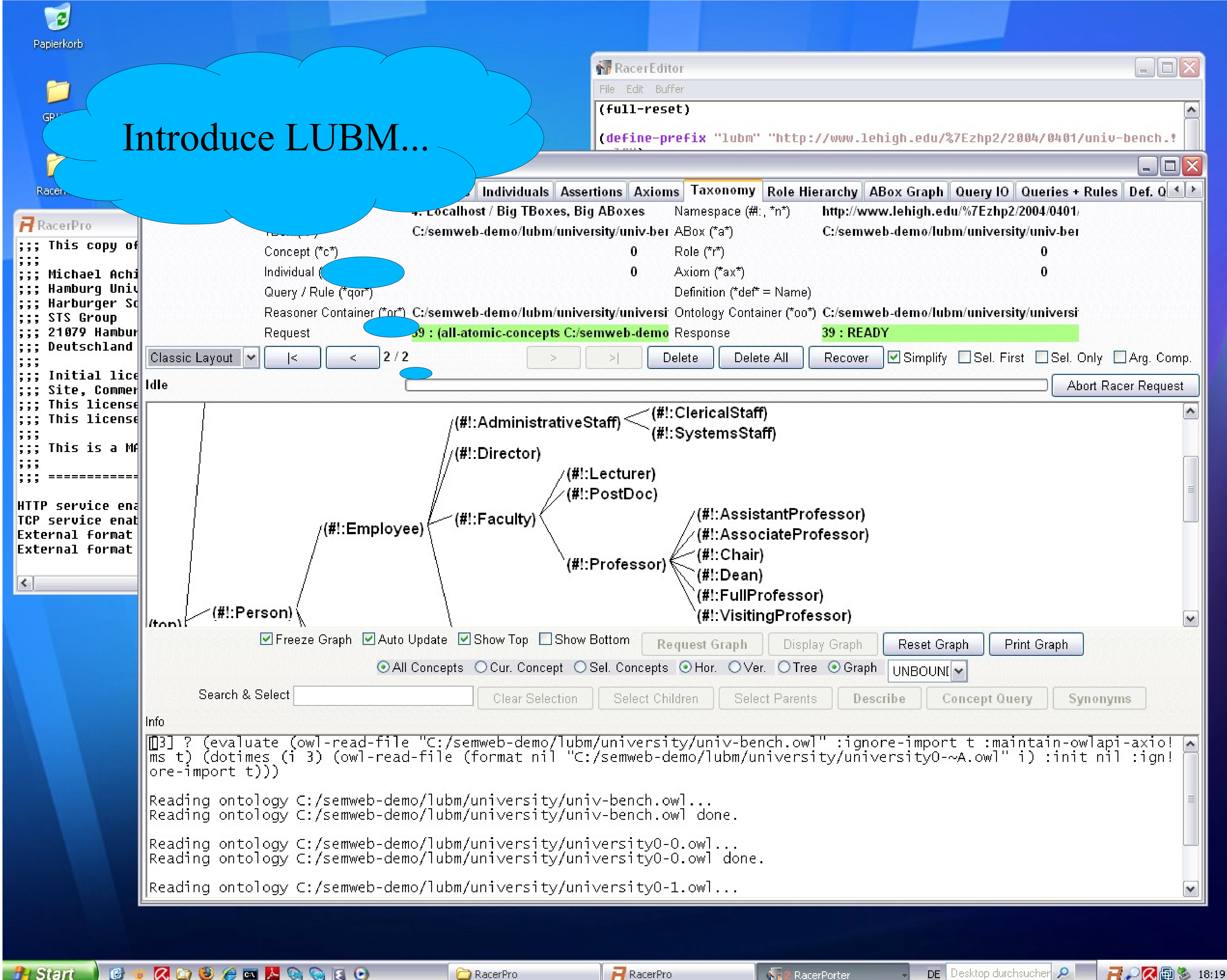


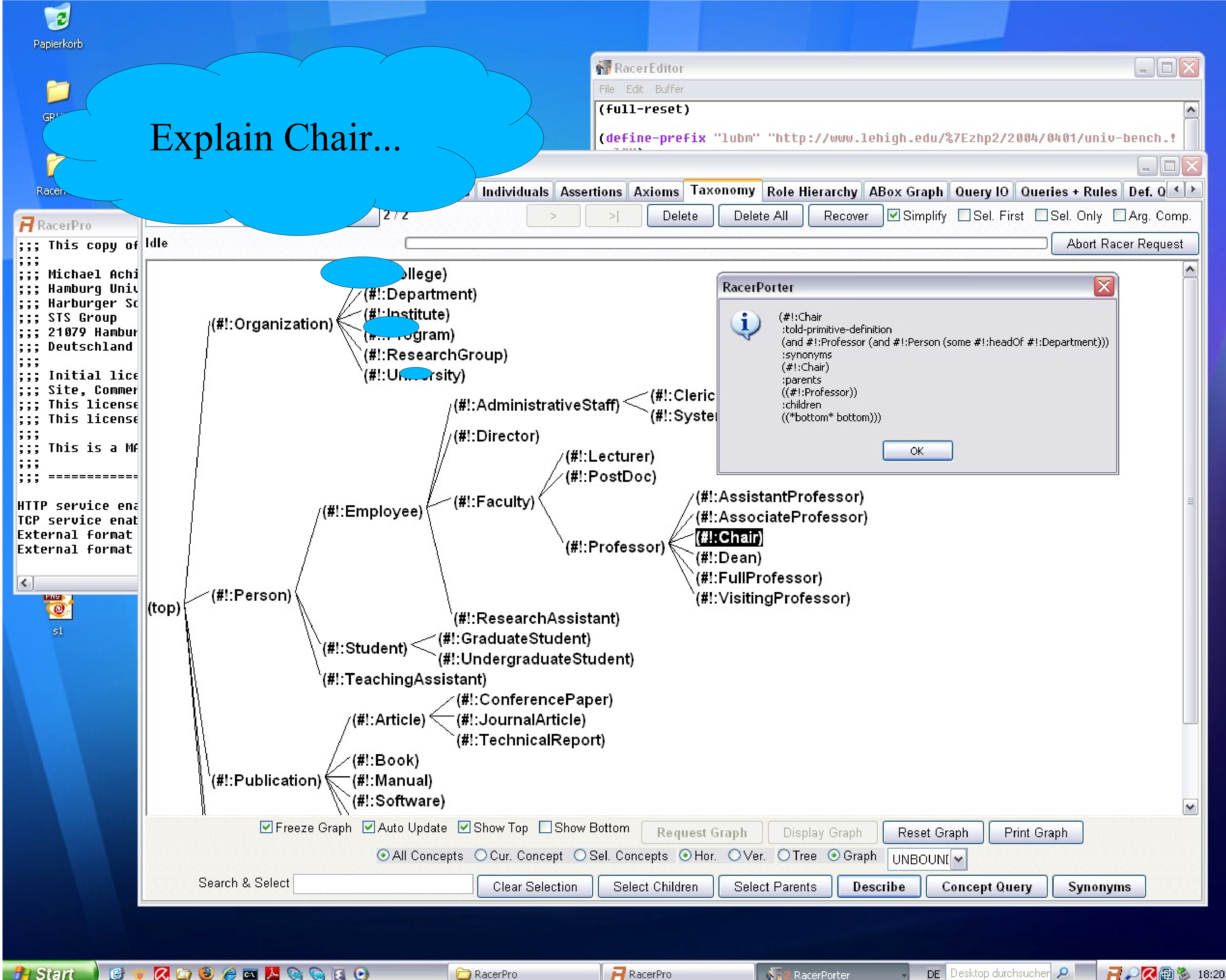

- Started as Racer at the University of Hamburg in 1998
- Working on large Aboxes since 1998 as a DL Abox reasoner
- One of the first OWL DL (-) system (2002), DL $\mathcal{SHIQ}(D)$
- Commercial offspring RacerPro by Racer Systems (2004 - today)
- Expressive Abox query lang. nRQL
- First DL system that passed the „LUBM“ (2004)
- First DL system with DL-aware SWRL (-) & SPARQL
- Interfaces: native, DIG (Protege 3), OWLAPI, OWLLink
- Main memory based, but interface to AllegroGraph
- Some special-purpose representations and reasoning
- **Free for education & research**

# Demo of Tools ...

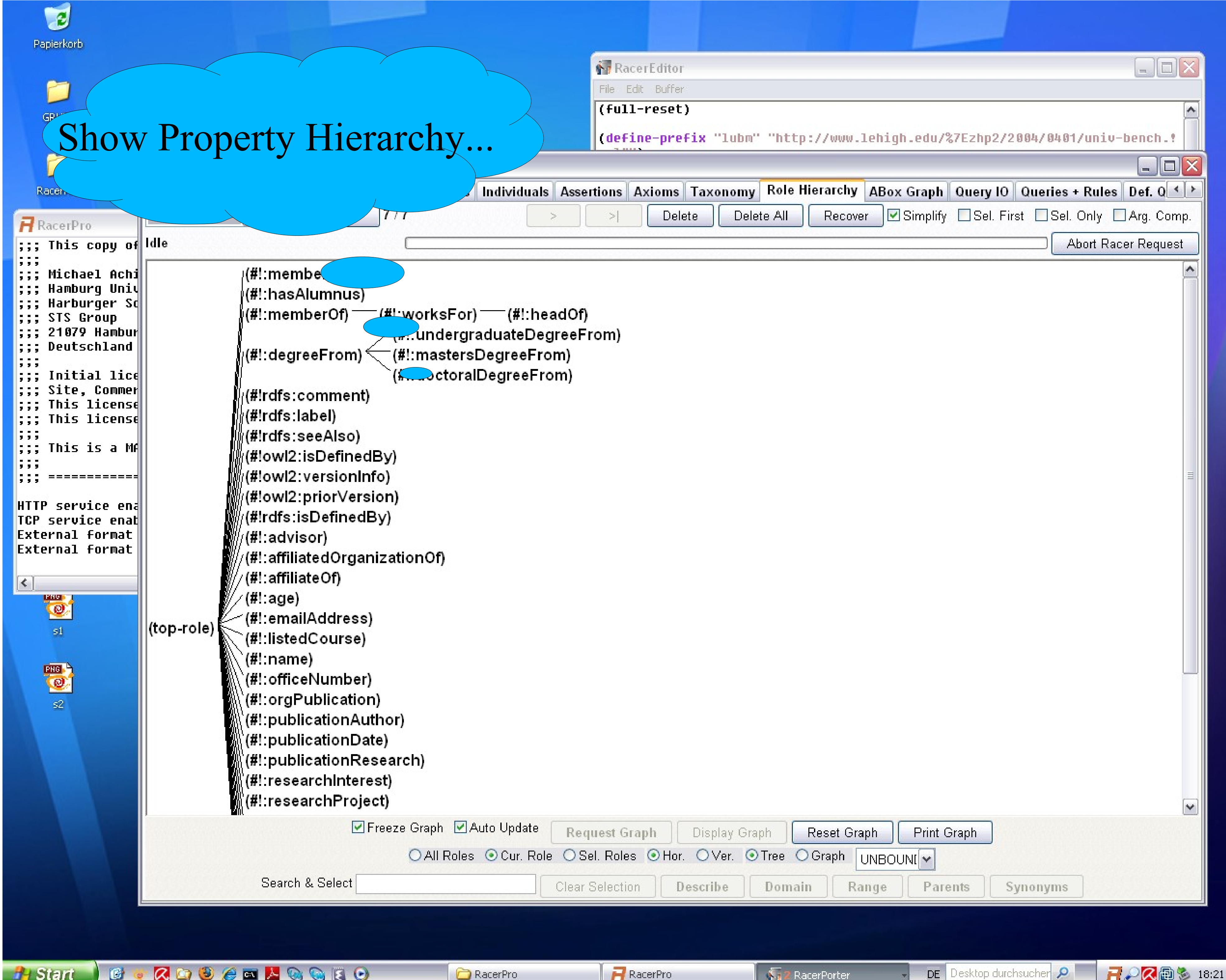
… using a well-known „standard“ OWL ontology

- Lehigh University Benchmark (LUBM)
- Standard inferences via RacerPro & RacerPorter
  - Taxonomy computation
  - Classification
  - Consistency checks
- Query answering
  - LUBM queries (chair example)
  - Queries with aggregation operators
  - Pragmatic stuff: HTML report generation via MiniLisp

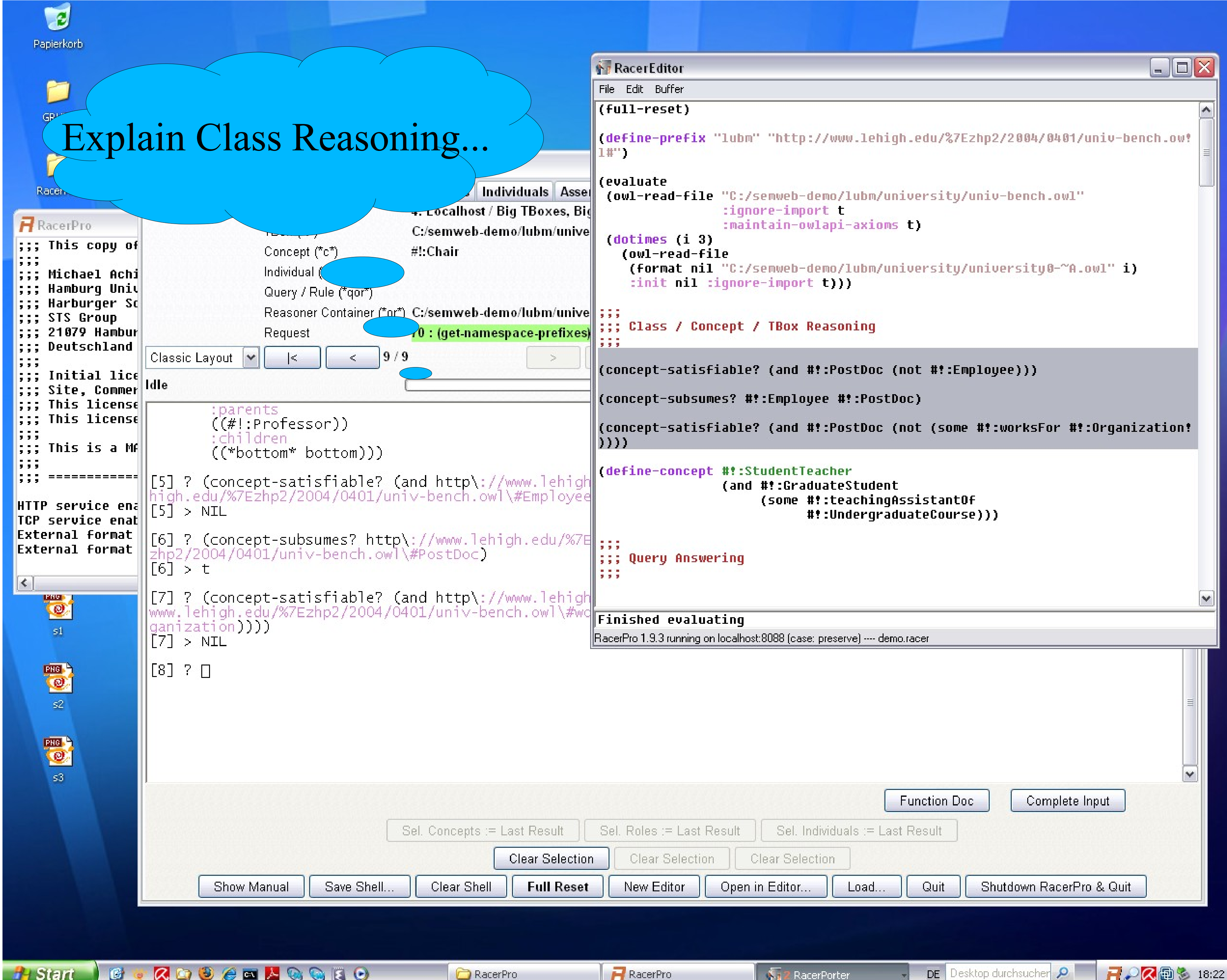

Introduce LUBM...
RacerEditor
(full-reset)
(define-prefix "lubm" "http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.
Individuals
Assertions
Axioms
Taxonomy
Role Hierarchy
ABox Graph
Query IO
Queries + Rules
Namespace (#:, *n*)
http://www.lehigh.edu/%7Ezhp2/2004/0401/
ABox (*a*)
C:/semweb-demo/lubm/university/univ-ber
Concept (*c*)
Role (*r*)
Individual
Axiom (*ax*)
Query / Rule (*qor*)
Definition (*def* = Name)
Reasoner Container (*or*)
Ontology Container (*oo*)
Request
Response
39 : READY
Classic Layout
Delete
Delete All
Recover
Simplify
Sel. First
Sel. Only
Arg. Comp.
Idle
Abort Racer Request
(#!:AdministrativeStaff)
(#!:ClericalStaff)
(#!:SystemsStaff)
(#!:Director)
(#!:Lecturer)
(#!:PostDoc)
(#!:Employee)
(#!:Faculty)
(#!:AssistantProfessor)
(#!:AssociateProfessor)
(#!:Chair)
(#!:Dean)
(#!:Professor)
(#!:FullProfessor)
(#!:VisitingProfessor)
(#!:Person)
Freeze Graph
Auto Update
Show Top
Show Bottom
Request Graph
Display Graph
Reset Graph
Print Graph
All Concepts
Cur. Concept
Sel. Concepts
Hor.
Ver.
Tree
Graph
Search & Select
Clear Selection
Select Children
Select Parents
Describe
Concept Query
Synonyms
Info
Reading ontology C:/semweb-demo/lubm/university/univ-bench.owl...
Reading ontology C:/semweb-demo/lubm/university/univ-bench.owl done.
Reading ontology C:/semweb-demo/lubm/university/university0-0.owl...
Reading ontology C:/semweb-demo/lubm/university/university0-0.owl done.
Reading ontology C:/semweb-demo/lubm/university/university0-1.owl...


Explain Chair...
RacerPorter
(#!:Chair
:told-primitive-definition
(and #!:Professor (and #!:Person (some #!:headOf #!:Department)))
:synonyms
(#!:Chair)
:parents
((#!:Professor))
:children
((*bottom* bottom)))
OK
Individuals
Assertions
Axioms
Taxonomy
Role Hierarchy
ABox Graph
Query IO
Queries + Rules
(top)
(#!:Organization)
(#!:Department)
(#!:ResearchGroup)
(#!:Person)
(#!:Employee)
(#!:AdministrativeStaff)
(#!:Director)
(#!:Faculty)
(#!:Lecturer)
(#!:PostDoc)
(#!:Professor)
(#!:AssistantProfessor)
(#!:AssociateProfessor)
(#!:Chair)
(#!:Dean)
(#!:FullProfessor)
(#!:VisitingProfessor)
(#!:ResearchAssistant)
(#!:Student)
(#!:GraduateStudent)
(#!:UndergraduateStudent)
(#!:TeachingAssistant)
(#!:Publication)
(#!:Article)
(#!:ConferencePaper)
(#!:JournalArticle)
(#!:TechnicalReport)
(#!:Book)
(#!:Manual)
(#!:Software)
Describe
Concept Query
Synonyms

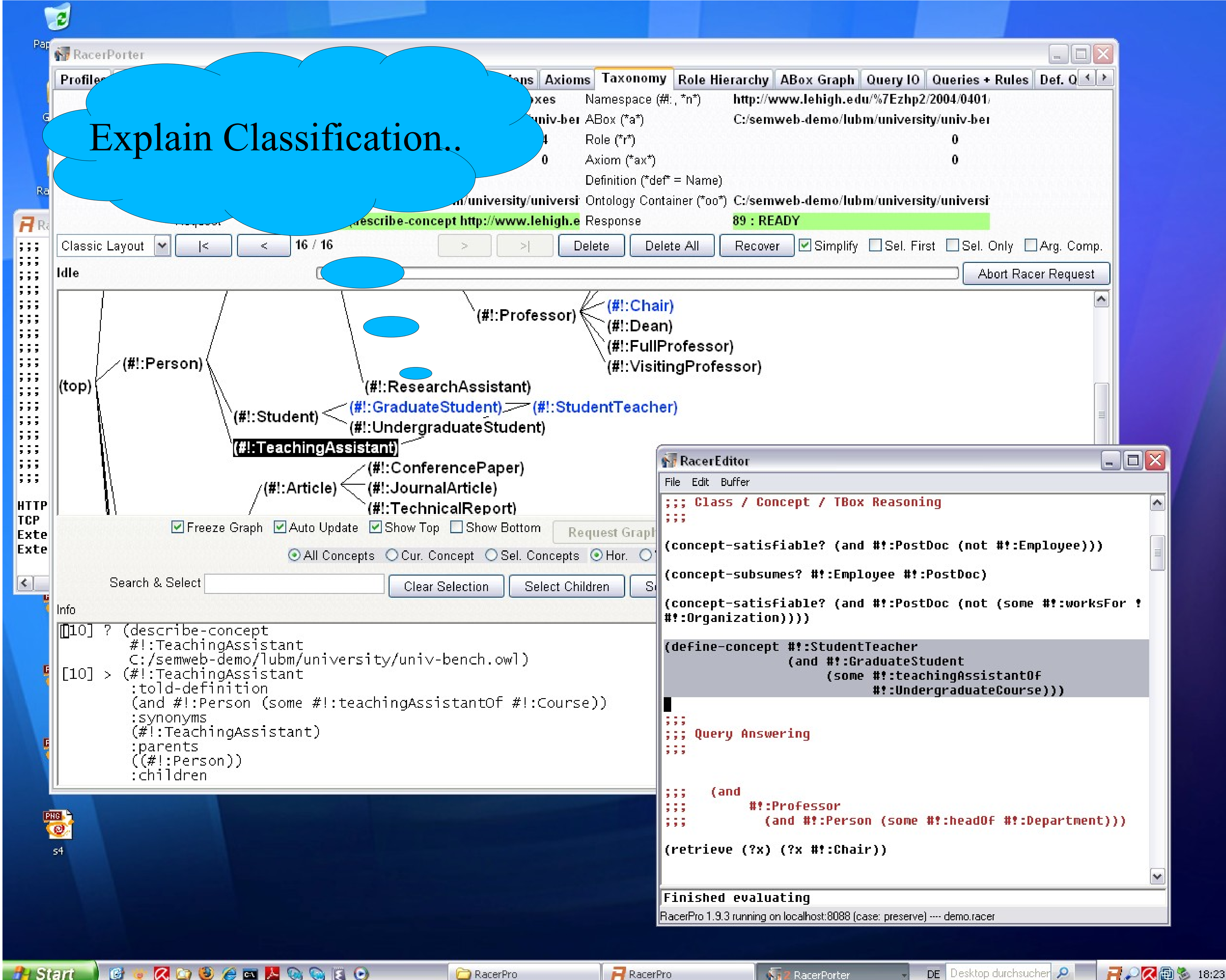
# Show Property Hierarchy...

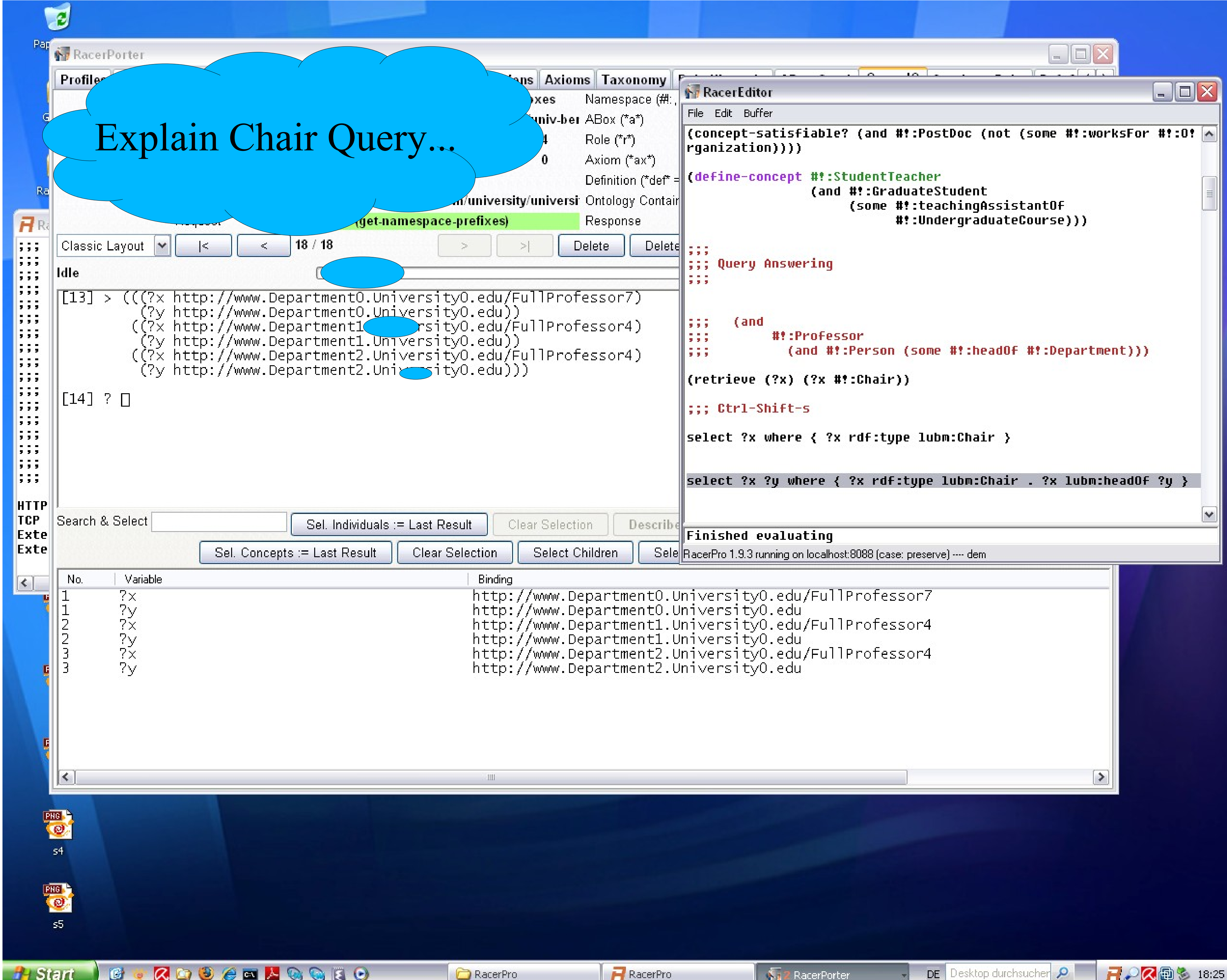


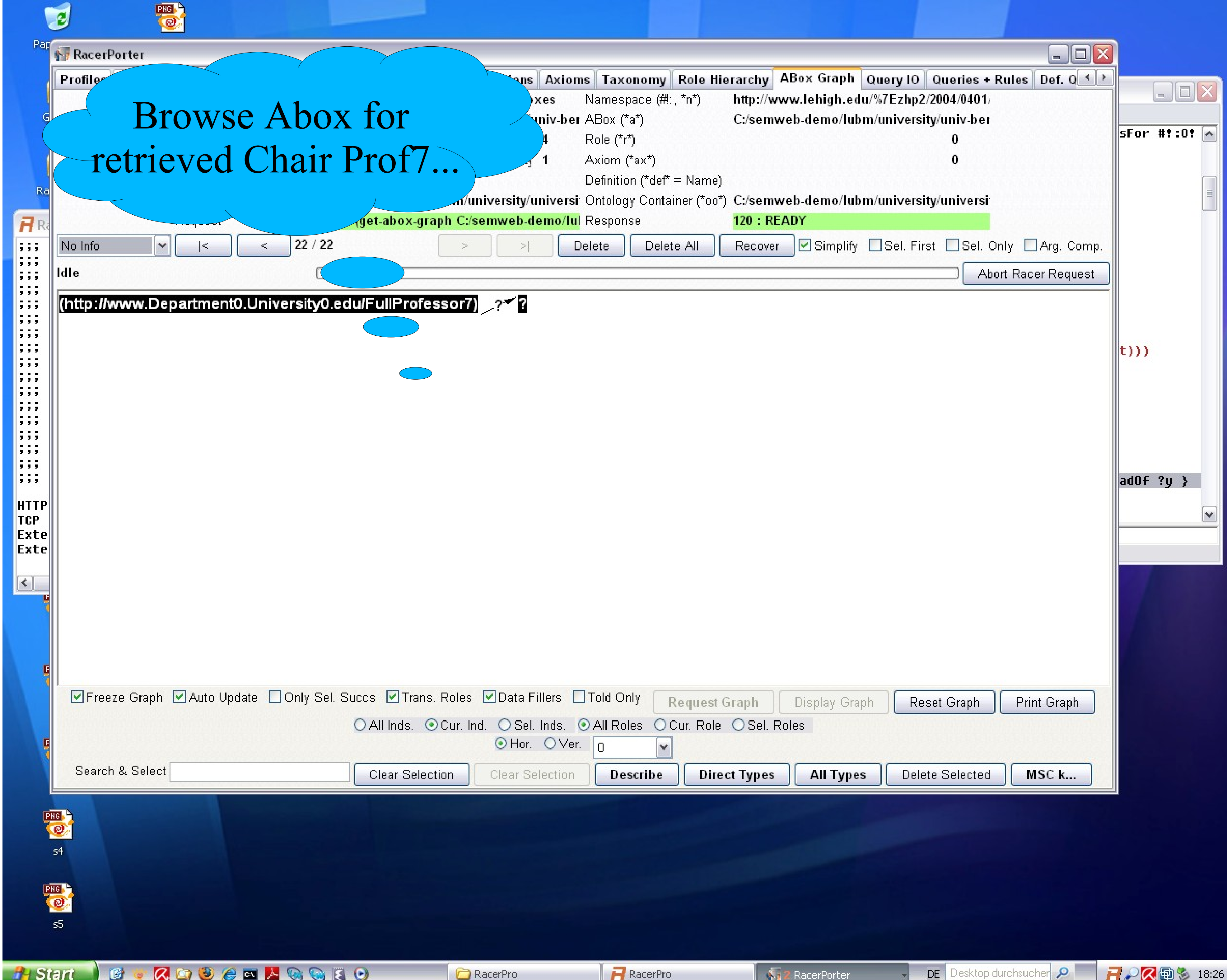
# Explain Class Reasoning...

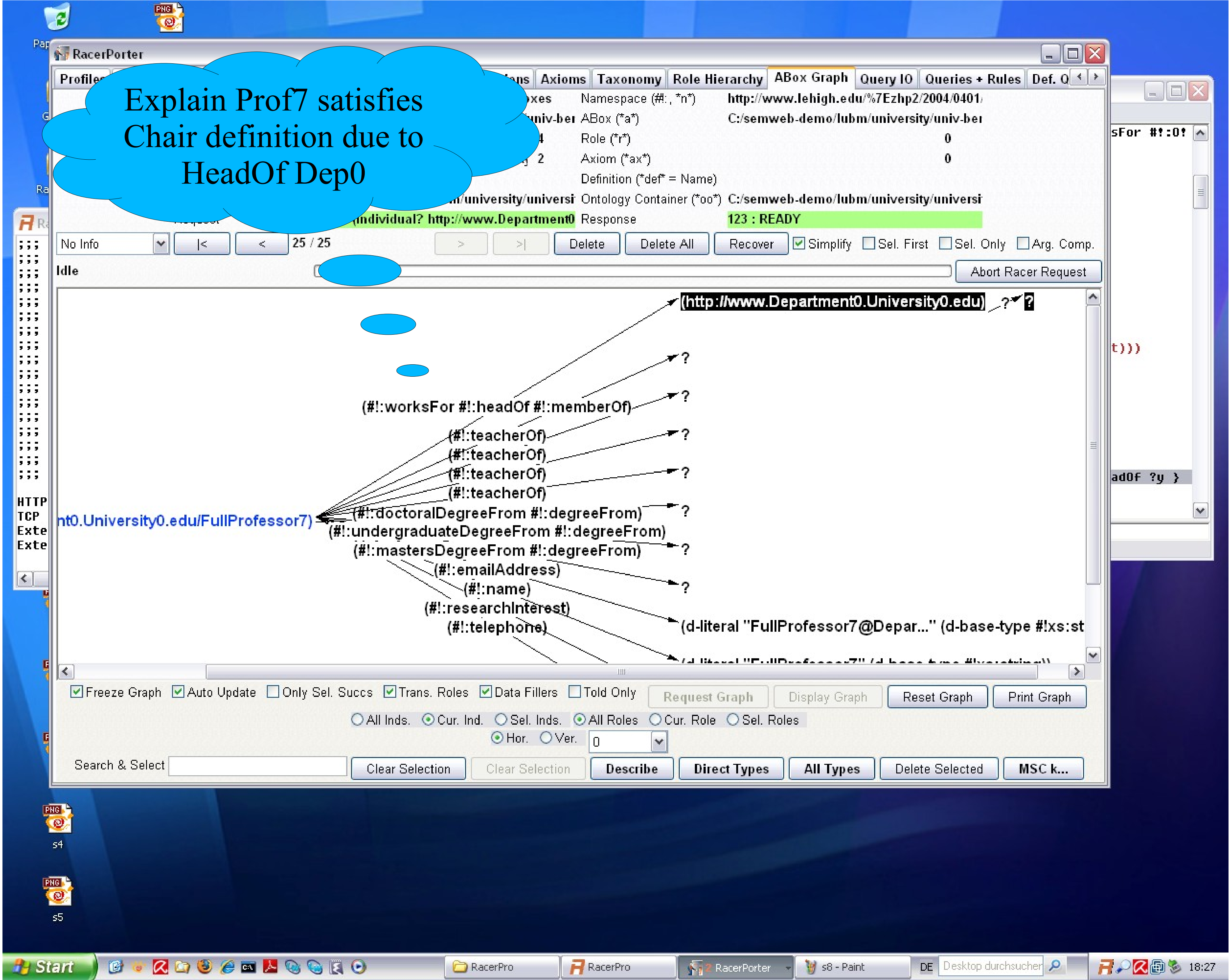


# Explain Classification..



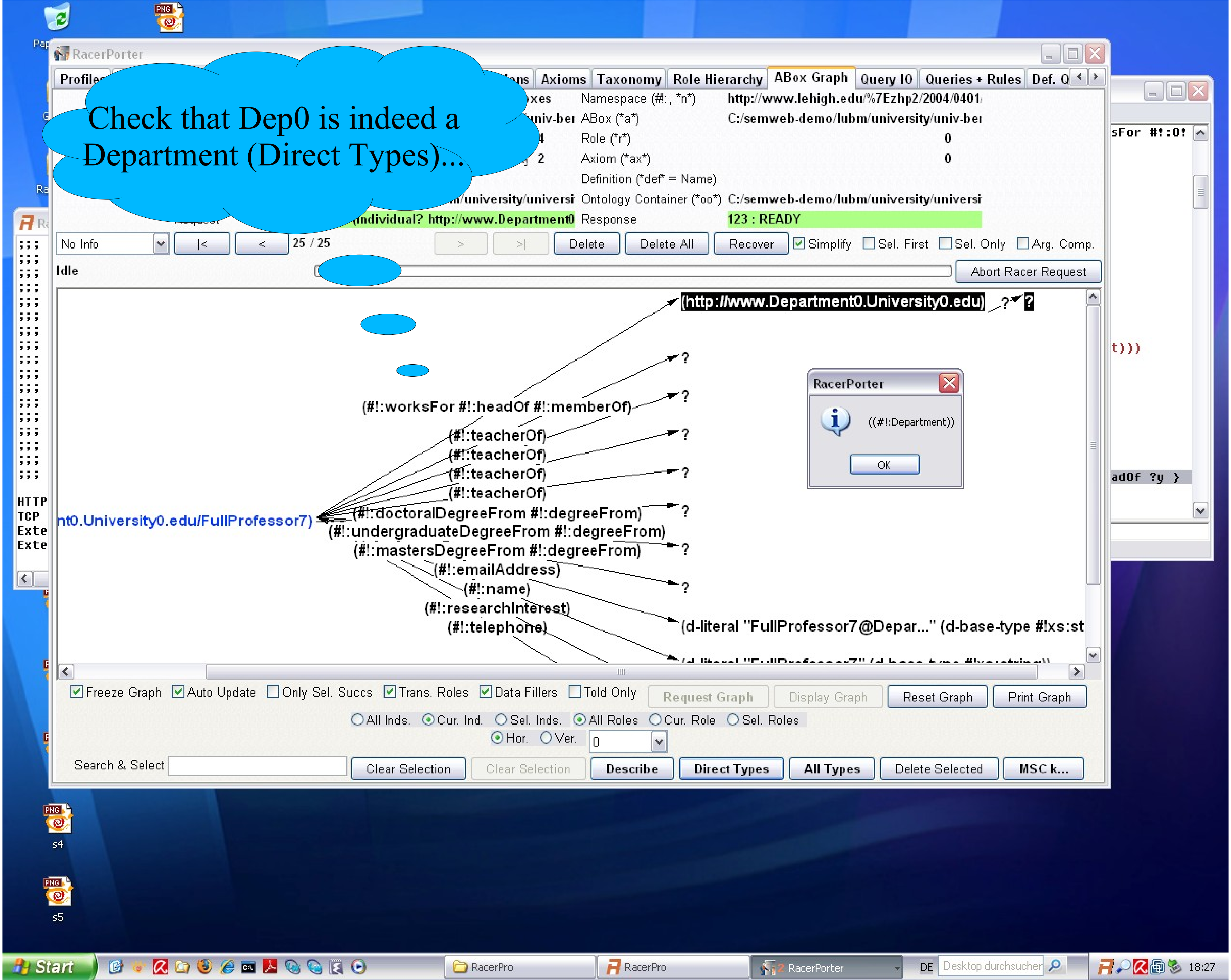

Explain Chair Query...
RacerPorter
Profiles
Axioms
Taxonomy
Namespace (#!:
ABox (*a*)
Role (*r*)
Axiom (*ax*)
Definition (*def* =
Ontology Contain
(get-namespace-prefixes)
Response
Classic Layout
18 / 18
Delete
Idle
[13] > (((?x http://www.Department0.University0.edu/FullProfessor7)
(?y http://www.Department0.University0.edu))
((?x http://www.Department1.University0.edu/FullProfessor4)
(?y http://www.Department1.University0.edu))
((?x http://www.Department2.University0.edu/FullProfessor4)
(?y http://www.Department2.University0.edu)))
[14] ?
Search & Select
Sel. Individuals := Last Result
Clear Selection
Sel. Concepts := Last Result
Clear Selection
Select Children
No.
Variable
Binding
1 ?x http://www.Department0.University0.edu/FullProfessor7
1 ?y http://www.Department0.University0.edu
2 ?x http://www.Department1.University0.edu/FullProfessor4
2 ?y http://www.Department1.University0.edu
3 ?x http://www.Department2.University0.edu/FullProfessor4
3 ?y http://www.Department2.University0.edu
RacerEditor
File Edit Buffer
(concept-satisfiable? (and #!:PostDoc (not (some #!:worksFor #!:Organization))))
(define-concept #!:StudentTeacher
(and #!:GraduateStudent
(some #!:teachingAssistantOf
#!:UndergraduateCourse)))
;;;
;;; Query Answering
;;;
;;; (and
;;; #!:Professor
;;; (and #!:Person (some #!:headOf #!:Department)))
(retrieve (?x) (?x #!:Chair))
;;; Ctrl-Shift-s
select ?x where { ?x rdf:type lubm:Chair }
select ?x ?y where { ?x rdf:type lubm:Chair . ?x lubm:headOf ?y }
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) ---- dem
s4
s5
Start
RacerPro
RacerPro
RacerPorter
DE
Desktop durchsuchen
18:25

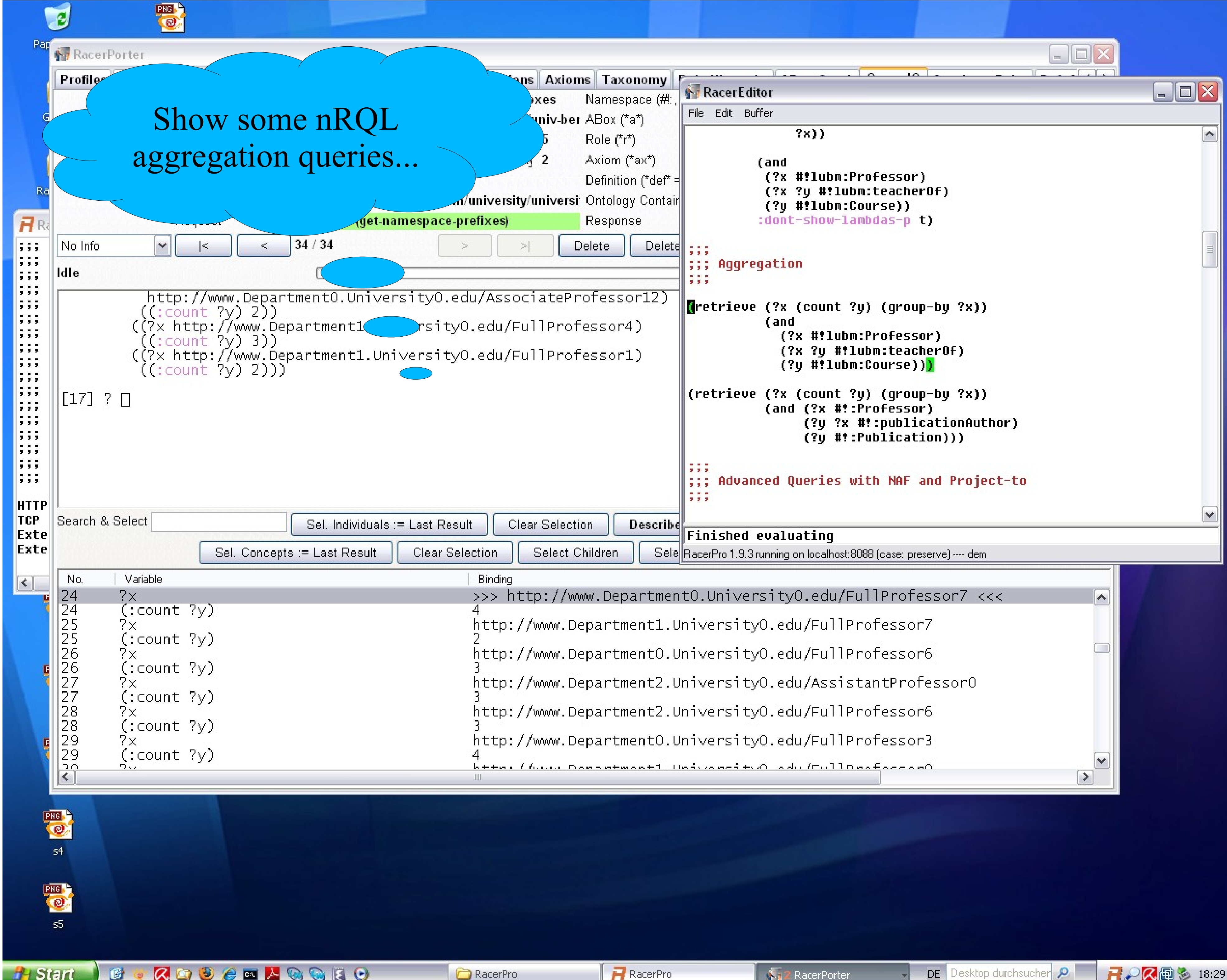

Browse Abox for retrieved Chair Prof7...
RacerPorter
Profiles
Axioms
Taxonomy
Role Hierarchy
ABox Graph
Query IO
Queries + Rules
Namespace (#!:, *n*) http://www.lehigh.edu/%7Ezhp2/2004/0401/
ABox (*a*) C:/semweb-demo/lubm/university/univ-ber
Role (*r*) 0
Axiom (*ax*) 0
Definition (*def* = Name)
Ontology Container (*oo*) C:/semweb-demo/lubm/university/universi
(get-abox-graph C:/semweb-demo/lu
Response 120 : READY
No Info
22 / 22
Delete
Delete All
Recover
Simplify
Sel. First
Sel. Only
Arg. Comp.
Idle
Abort Racer Request
(http://www.Department0.University0.edu/FullProfessor7)
Freeze Graph
Auto Update
Only Sel. Succs
Trans. Roles
Data Fillers
Told Only
Request Graph
Display Graph
Reset Graph
Print Graph
All Inds.
Cur. Ind.
Sel. Inds.
All Roles
Cur. Role
Sel. Roles
Hor.
Ver.
Search & Select
Clear Selection
Describe
Direct Types
All Types
Delete Selected
MSC k...
Start
RacerPro
RacerPro
RacerPorter
DE
Desktop durchsuchen
18:26



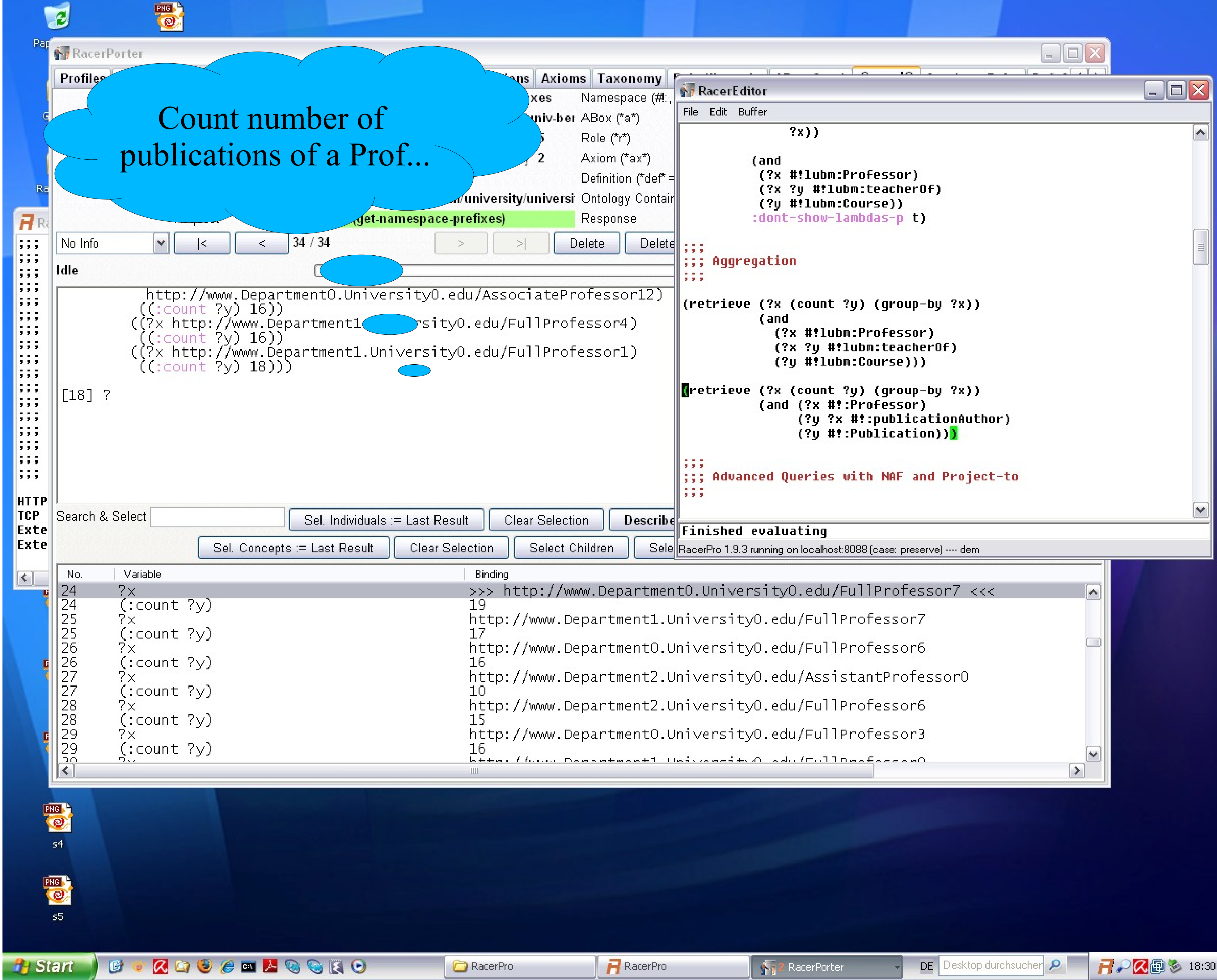
Explain Prof7 satisfies Chair definition due to HeadOf Dep0
RacerPorter
ABox Graph
(http://www.Department0.University0.edu)
(#!:worksFor #!:headOf #!:memberOf)
(#!:teacherOf)
(#!:doctoralDegreeFrom #!:degreeFrom)
(#!:undergraduateDegreeFrom #!:degreeFrom)
(#!:mastersDegreeFrom #!:degreeFrom)
(#!:emailAddress)
(#!:name)
(#!:researchInterest)
(#!:telephone)
nt0.University0.edu/FullProfessor7)
(d-literal "FullProfessor7@Depar..." (d-base-type #!xs:st
123 : READY

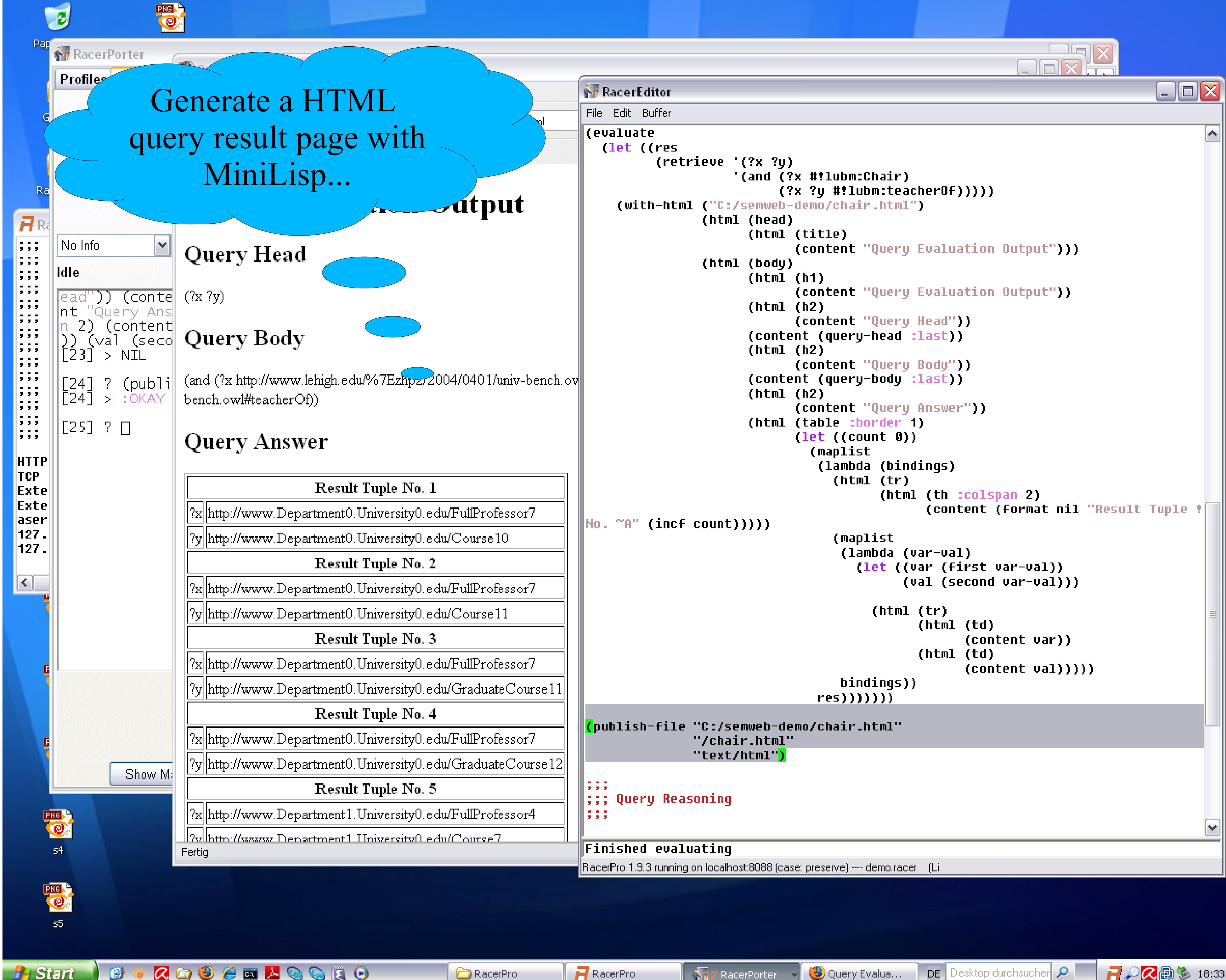
Check that Dep0 is indeed a Department (Direct Types)...





Show some nRQL aggregation queries...
RacerPorter
RacerEditor
;;;
;;; Aggregation
;;;
(retrieve (?x (count ?y) (group-by ?x))
(and
(?x #!lubm:Professor)
(?x ?y #!lubm:teacherOf)
(?y #!lubm:Course)))
(retrieve (?x (count ?y) (group-by ?x))
(and (?x #!:Professor)
(?y ?x #!:publicationAuthor)
(?y #!:Publication)))
;;;
;;; Advanced Queries with NAF and Project-to
;;;
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) ---- dem
http://www.Department0.University0.edu/AssociateProfessor12)
((:count ?y) 2))
((?x http://www.Department1.University0.edu/FullProfessor1)
((:count ?y) 2)))
[17] ?
No. Variable Binding
24 ?x >>> http://www.Department0.University0.edu/FullProfessor7 <<<
24 (:count ?y) 4
25 ?x http://www.Department1.University0.edu/FullProfessor7
25 (:count ?y) 2
26 ?x http://www.Department0.University0.edu/FullProfessor6
26 (:count ?y) 3
27 ?x http://www.Department2.University0.edu/AssistantProfessor0
27 (:count ?y) 3
28 ?x http://www.Department2.University0.edu/FullProfessor6
28 (:count ?y) 3
29 ?x http://www.Department0.University0.edu/FullProfessor3
29 (:count ?y) 4

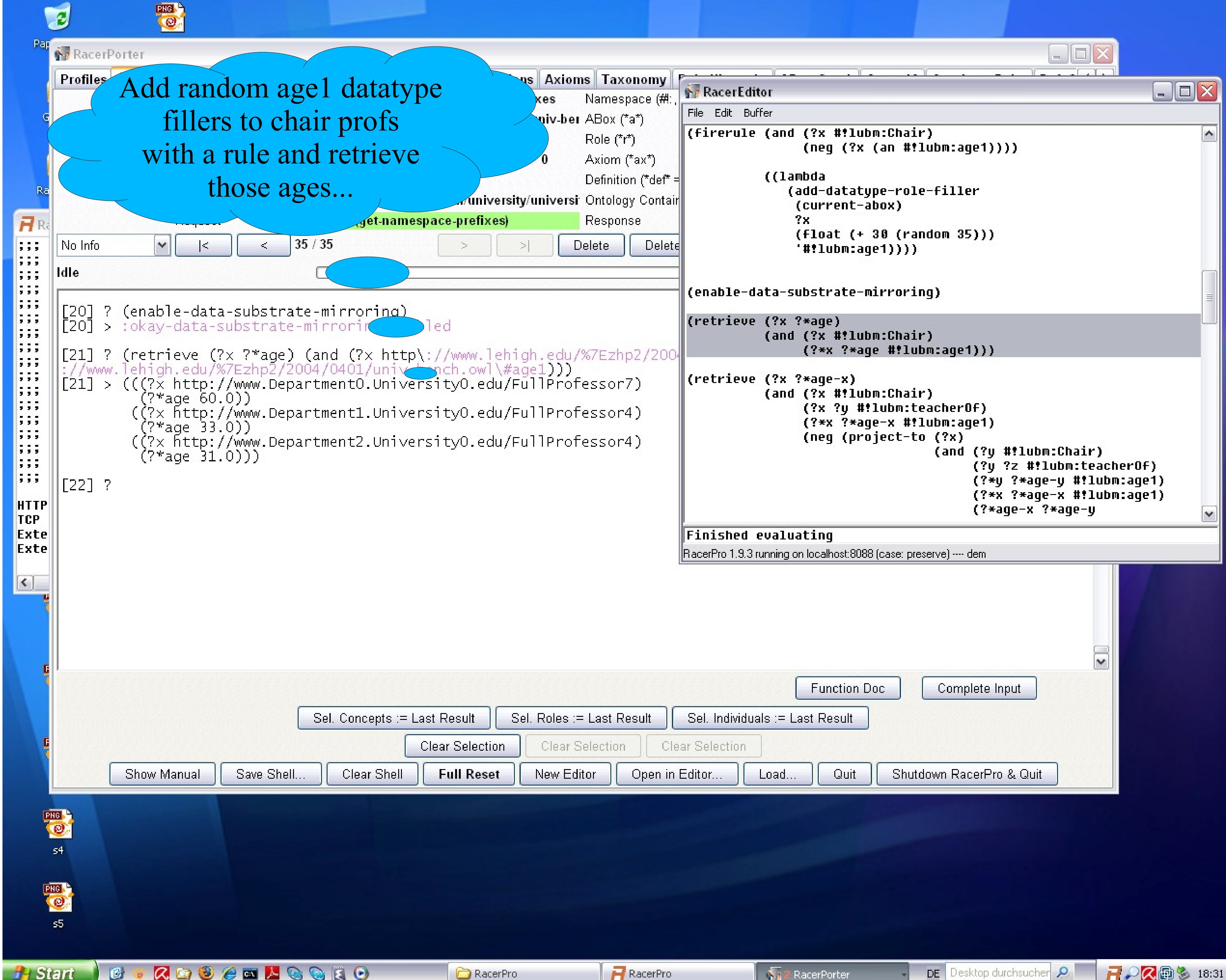

Count number of publications of a Prof...
RacerPorter
RacerEditor
File Edit Buffer
;;; Aggregation
(retrieve (?x (count ?y) (group-by ?x))
(and
(?x #!lubm:Professor)
(?x ?y #!lubm:teacherOf)
(?y #!lubm:Course)))
(retrieve (?x (count ?y) (group-by ?x))
(and (?x #!:Professor)
(?y ?x #!:publicationAuthor)
(?y #!:Publication)))
;;; Advanced Queries with NAF and Project-to
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) ---- dem
((?x http://www.Department1.University0.edu/FullProfessor1)
((:count ?y) 18)))
[18] ?
No. Variable Binding
24 ?x >>> http://www.Department0.University0.edu/FullProfessor7 <<<
24 (:count ?y) 19
25 ?x http://www.Department1.University0.edu/FullProfessor7
25 (:count ?y) 17
26 ?x http://www.Department0.University0.edu/FullProfessor6
26 (:count ?y) 16
27 ?x http://www.Department2.University0.edu/AssistantProfessor0
27 (:count ?y) 10
28 ?x http://www.Department2.University0.edu/FullProfessor6
28 (:count ?y) 15
29 ?x http://www.Department0.University0.edu/FullProfessor3
29 (:count ?y) 16


Generate a HTML query result page with MiniLisp...
RacerPorter
RacerEditor
File Edit Buffer
Query Head
(?x ?y)
Query Body
Query Answer
Result Tuple No. 1
?x http://www.Department0.University0.edu/FullProfessor7
?y http://www.Department0.University0.edu/Course10
Result Tuple No. 2
?x http://www.Department0.University0.edu/FullProfessor7
?y http://www.Department0.University0.edu/Course11
Result Tuple No. 3
?x http://www.Department0.University0.edu/FullProfessor7
?y http://www.Department0.University0.edu/GraduateCourse11
Result Tuple No. 4
?x http://www.Department0.University0.edu/FullProfessor7
?y http://www.Department0.University0.edu/GraduateCourse12
Result Tuple No. 5
?x http://www.Department1.University0.edu/FullProfessor4
(evaluate
(let ((res
(retrieve '(?x ?y)
'(and (?x #!lubm:Chair)
(?x ?y #!lubm:teacherOf)))))
(with-html ("C:/semweb-demo/chair.html")
(html (head)
(html (title)
(content "Query Evaluation Output")))
(html (body)
(html (h1)
(content "Query Evaluation Output"))
(html (h2)
(content "Query Head"))
(content (query-head :last))
(html (h2)
(content "Query Body"))
(content (query-body :last))
(html (h2)
(content "Query Answer"))
(html (table :border 1)
(let ((count 0))
(maplist
(lambda (bindings)
(html (tr)
(html (th :colspan 2)
(content (format nil "Result Tuple No. ~A" (incf count)))))
(maplist
(lambda (var-val)
(let ((var (first var-val))
(val (second var-val)))
(html (tr)
(html (td)
(content var))
(html (td)
(content val)))))
bindings))
res)))))))
(publish-file "C:/semweb-demo/chair.html"
"/chair.html"
"text/html")
;;; Query Reasoning
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) ---- demo.racer
Fertig

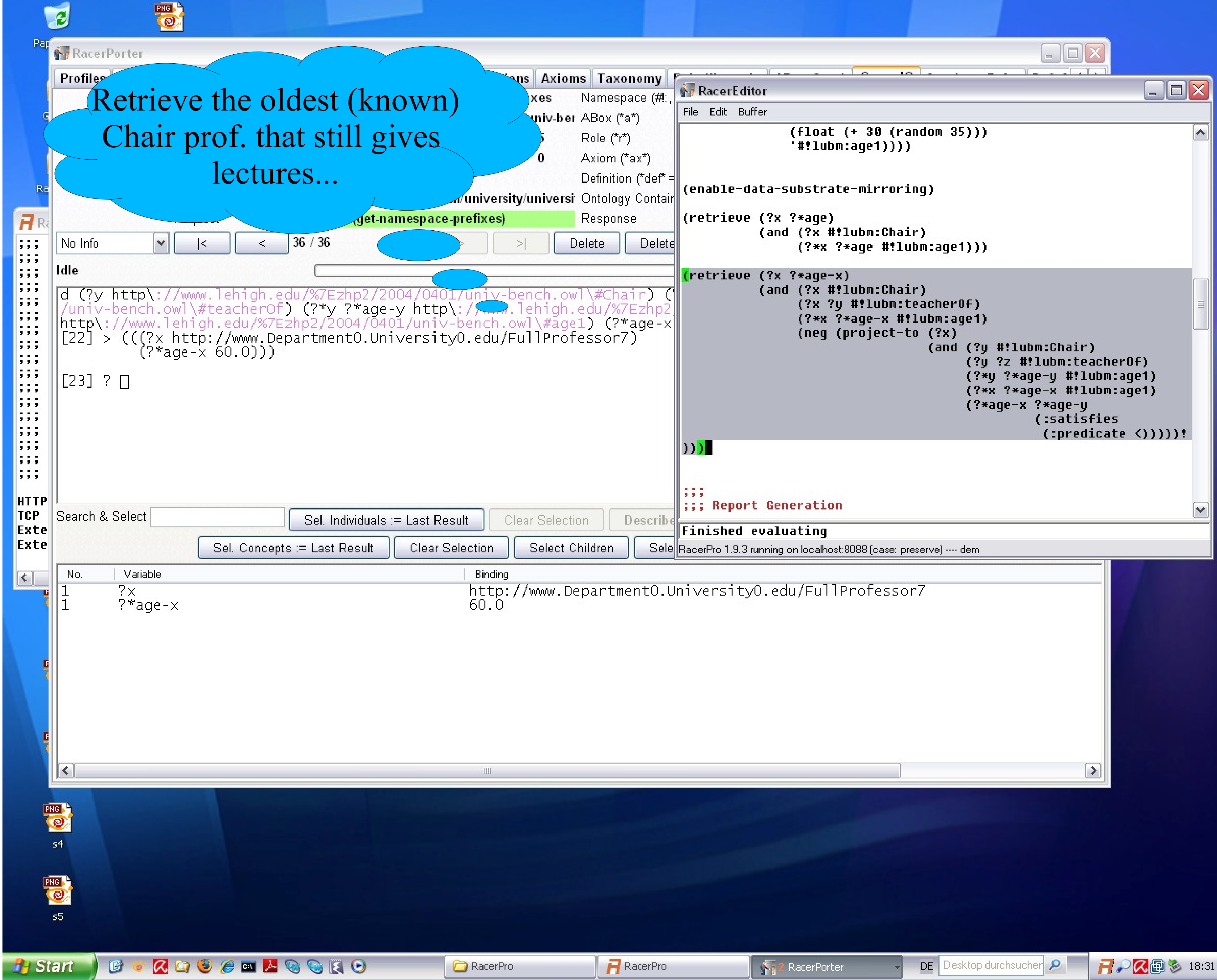
# First-Order Features of nRQL

- NAF and projection
  - e.g., for closed-domain universal quantification
  - „find the oldest **known** professor that still gives lectures“ (**all** other known lecture giving professors are younger)
  - makes sense, even with Open World Assumption
  - Non-DL-safe non-monotonic rules that `construct` new individuals and auto-disable (termination)

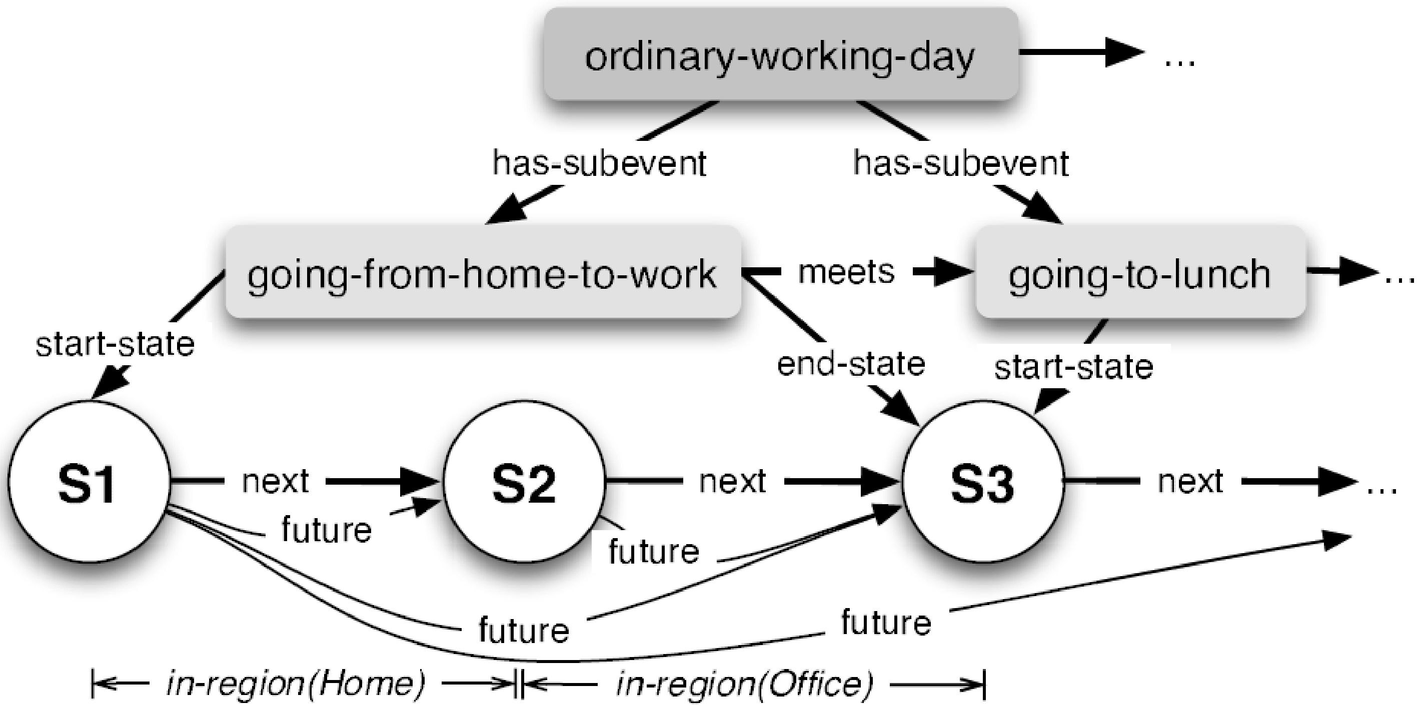
- In principle, this is also possible with SPARQL
  - equivalent to relational Algebra (Angles, ISWC '08)
  - … but not handy (no explicit NAF and projection, have to use `bound`)


Add random age1 datatype fillers to chair profs with a rule and retrieve those ages...
RacerPorter
Profiles
Axioms
Taxonomy
Namespace
ABox (*a*)
Role (*r*)
Axiom (*ax*)
Definition (*def*
Ontology Contain
Response
get-namespace-prefixes)
No Info
35 / 35
Delete
Idle
[20] ? (enable-data-substrate-mirroring)
[21] ? (retrieve (?x ?*age) (and (?x http\://www.lehigh.edu/%7Ezhp2/200
[21] > (((?x http://www.Department0.University0.edu/FullProfessor7)
(?*age 60.0))
((?x http://www.Department1.University0.edu/FullProfessor4)
(?*age 33.0))
((?x http://www.Department2.University0.edu/FullProfessor4)
(?*age 31.0)))
[22] ?
RacerEditor
File Edit Buffer
(firerule (and (?x #!lubm:Chair)
(neg (?x (an #!lubm:age1))))
((lambda
(add-datatype-role-filler
(current-abox)
?x
(float (+ 30 (random 35)))
'#!lubm:age1))))
(enable-data-substrate-mirroring)
(retrieve (?x ?*age)
(and (?x #!lubm:Chair)
(?*x ?*age #!lubm:age1)))
(retrieve (?x ?*age-x)
(and (?x #!lubm:Chair)
(?x ?y #!lubm:teacherOf)
(?*x ?*age-x #!lubm:age1)
(neg (project-to (?x)
(and (?y #!lubm:Chair)
(?y ?z #!lubm:teacherOf)
(?*y ?*age-y #!lubm:age1)
(?*x ?*age-x #!lubm:age1)
(?*age-x ?*age-y
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) --- dem
Function Doc
Complete Input
Sel. Concepts := Last Result
Sel. Roles := Last Result
Sel. Individuals := Last Result
Clear Selection
Show Manual
Save Shell...
Clear Shell
Full Reset
New Editor
Open in Editor...
Load...
Quit
Shutdown RacerPro & Quit
Start
RacerPro
RacerPorter
18:31

Retrieve the oldest (known) Chair prof. that still gives lectures...



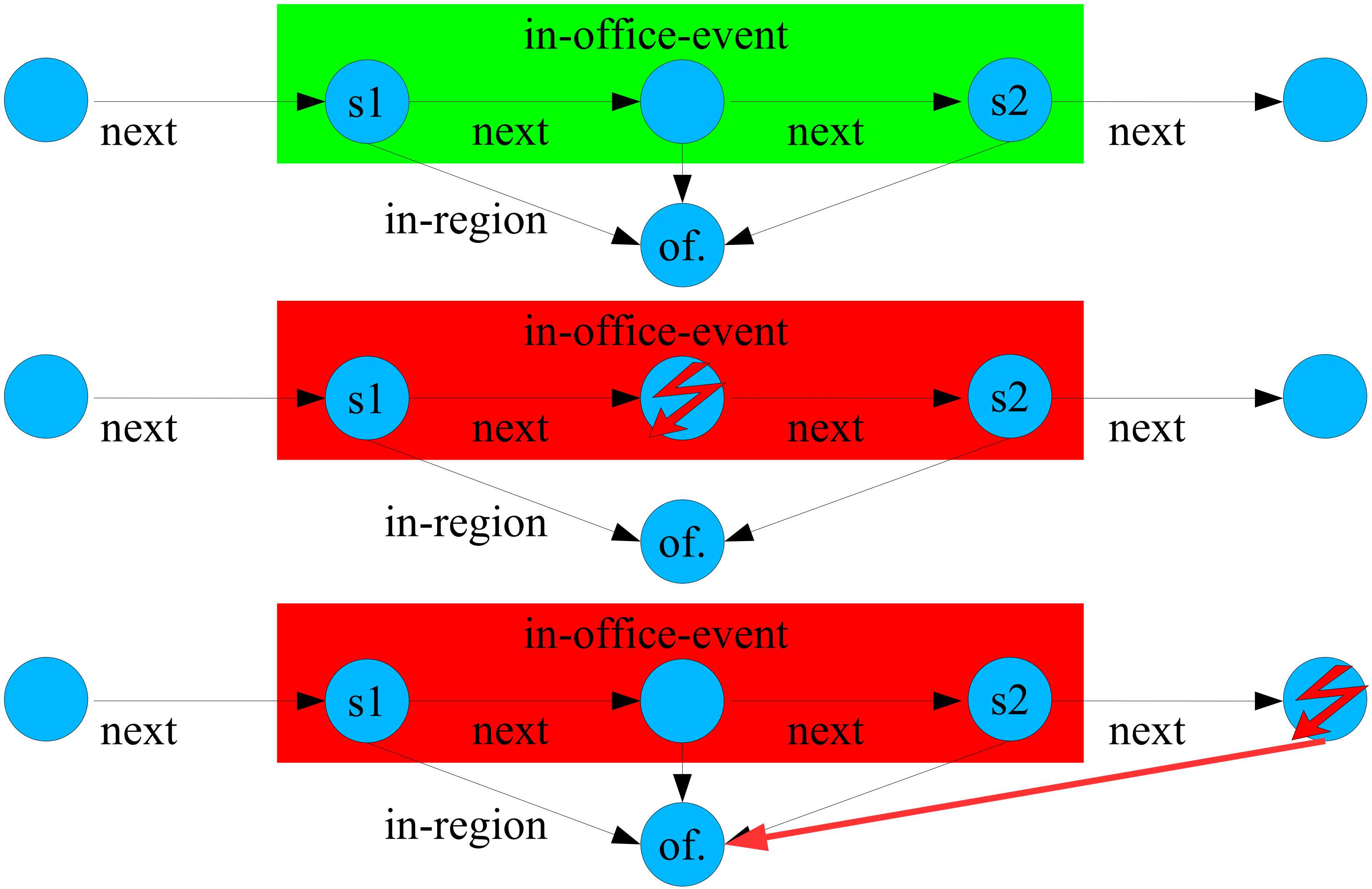
# Application – Linear Time Event Recognition




- States = situations → simple events → complex events
  - Linear time model (**next** role, transitive superrole **future**)
  - Allen temporal relation via concrete domain reasoning
  - Event constructions (aggregates!) via forward chaining rules

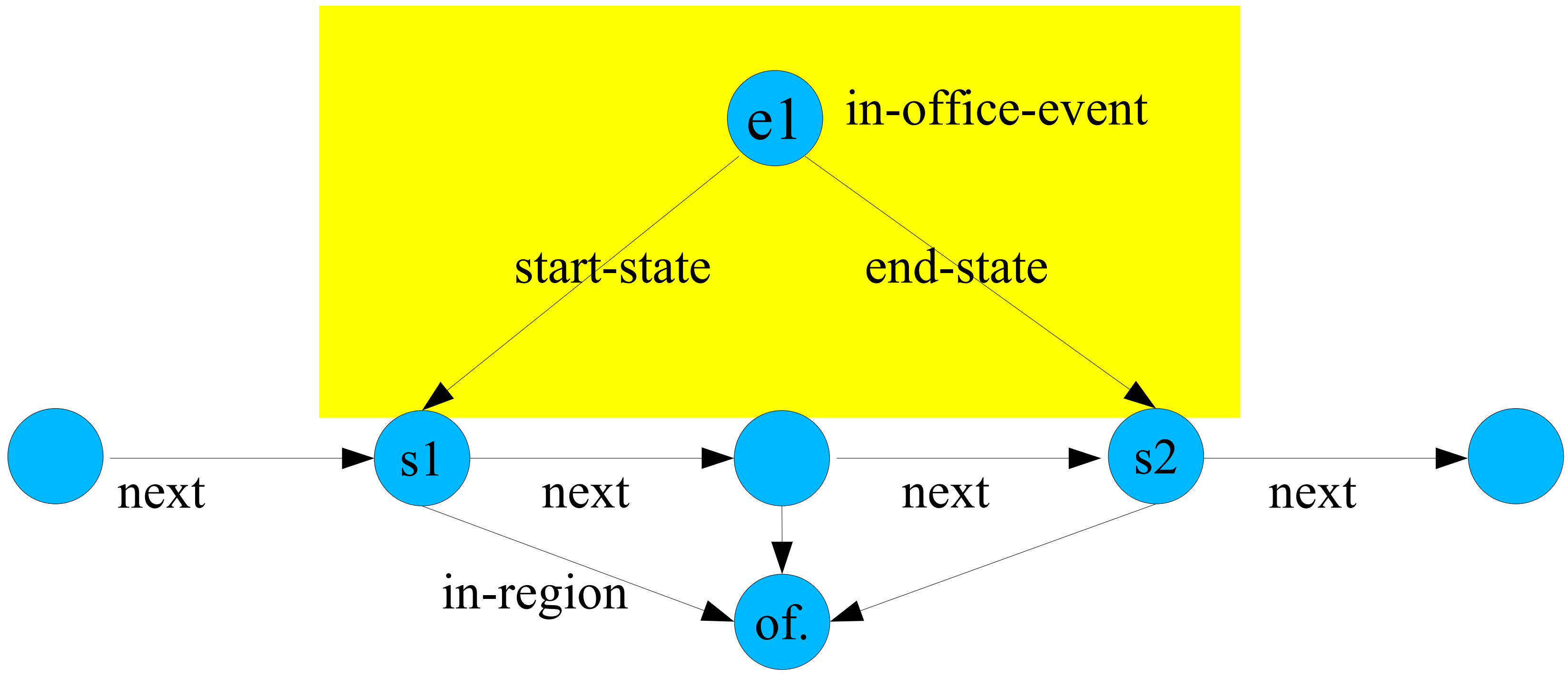
# Ensure Maximum Duration & Homogeneity

… e.g., for the „staying in office event“



# Ensure Maximum Duration & Homogeneity

… and construct a new aggregating event,
similar to SPARQL `construct`



# nRQL Event Rule Example

```
(prepare-abox-rule
      (and (?s1 state) (?s2 state) (?s1 ?s2 future)
           (?s1 ?r in-region) (?s2 ?r in-region) (?r office)
           (neg (project-to (?s2 ?r)
                  (and (?s2 ?s next) (?s ?r in-region))))
           (neg (project-to (?s1 ?r)
                  (and (?s ?s1 next) (?s ?r in-region))))
           (neg (project-to (?s1 ?s2 ?r)
                  (and (?s1 ?s future) (?s ?s2 future)
                       (neg (?s ?r in-region))))))
           (neg (project-to (?s1 ?s2)
                  (and (?e in-office-event)
                       (?e ?s1 start-state)
                       (?e ?s2 end-state)))))

  ((instance (new-ind new-simple-event ?s1 ?s2) in-office-event)
   (related  (new-ind new-simple-event ?s1 ?s2) ?s1 start-state)
   (related  (new-ind new-simple-event ?s1 ?s2) ?s2 end-state)))
```

right maximal

left minimal

homogeneous

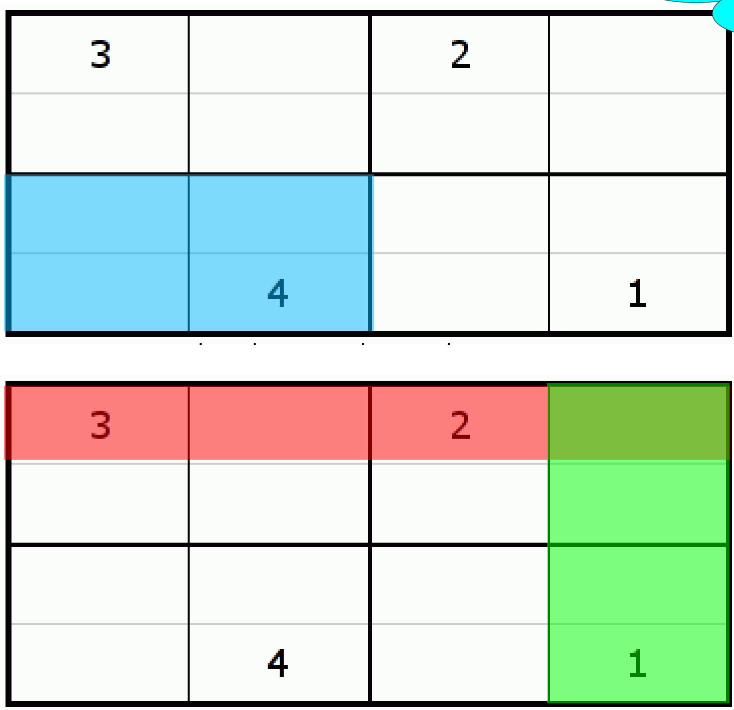
fire only once

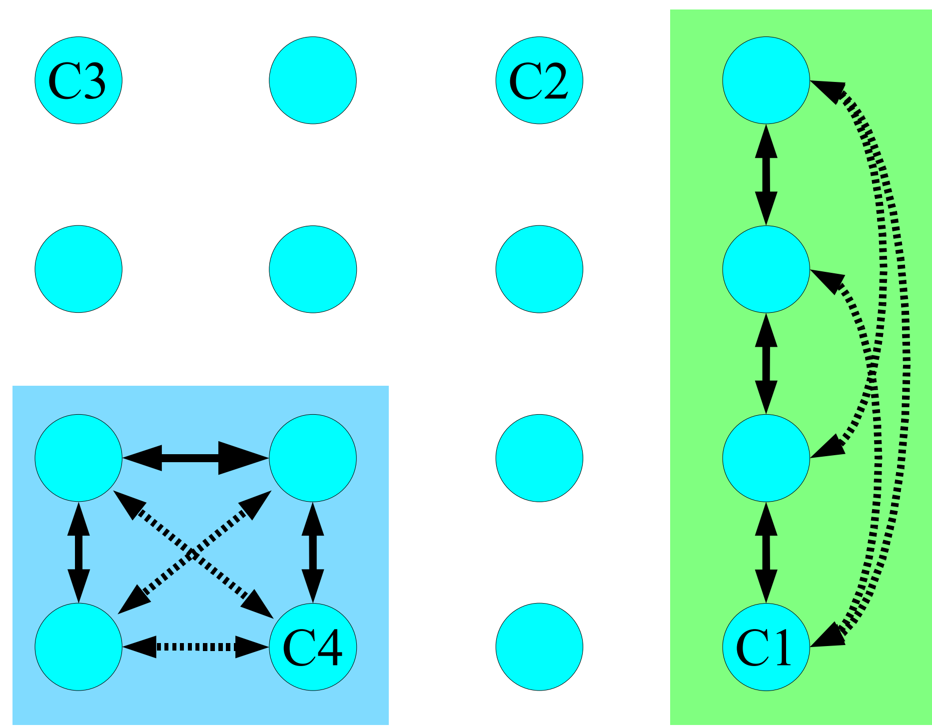
# Solving Constraint Satisfaction Problems by Reasoning - Sudoku

Create a KB whose
logical models represent
all possible Sudoku solutions. If a Sudoku
has only ONE solution, then the solution
can be obtained with a query
(solution = entailed atoms)

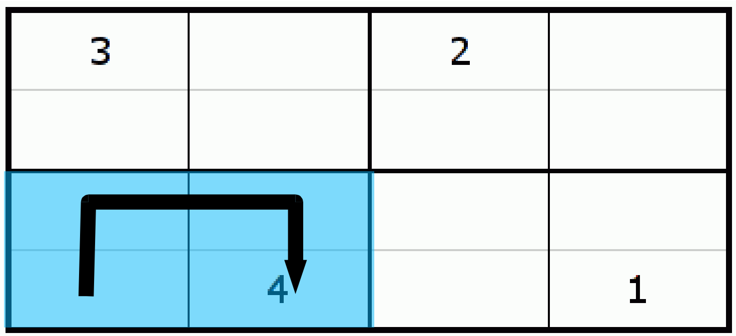
$$\mathsf{pairwise\_disjoint}(C_1, C_2, C_3, C_4)$$

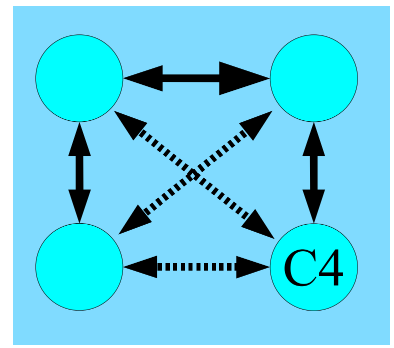
$$\begin{aligned}\top \dot{\sqsubseteq}\ & (C_1 \sqcup C_2 \sqcup C_3 \sqcup C_4) \sqcap \\ & (C_1 \rightarrow \forall R.\neg C_1) \sqcap (C_2 \rightarrow \forall R.\neg C_2) \sqcap \\ & (C_3 \rightarrow \forall R.\neg C_3) \sqcap (C_4 \rightarrow \forall R.\neg C_4) \sqcap \\ & \ldots\end{aligned}$$

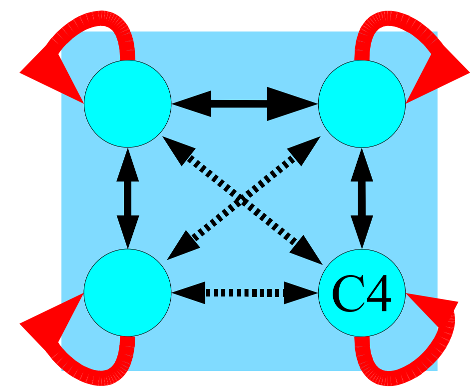


# Sudoku – Abox Construction

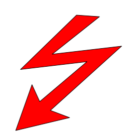


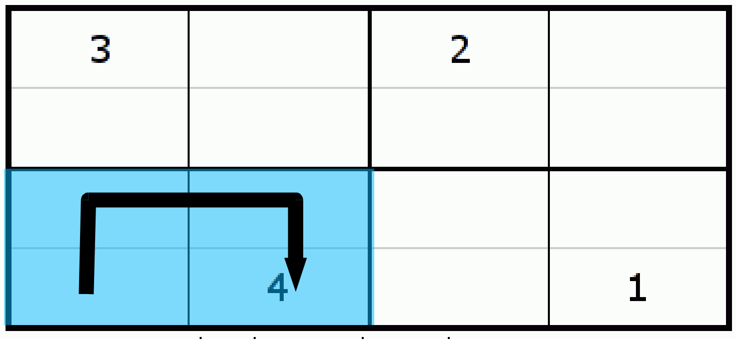




$C_4 \rightarrow \forall R.\neg C_4$

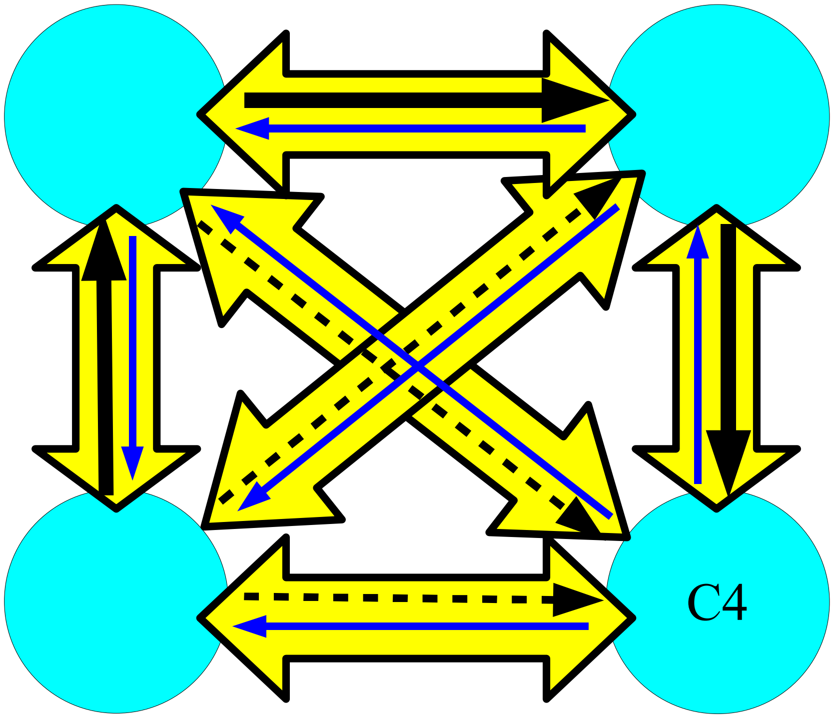
ABox construction

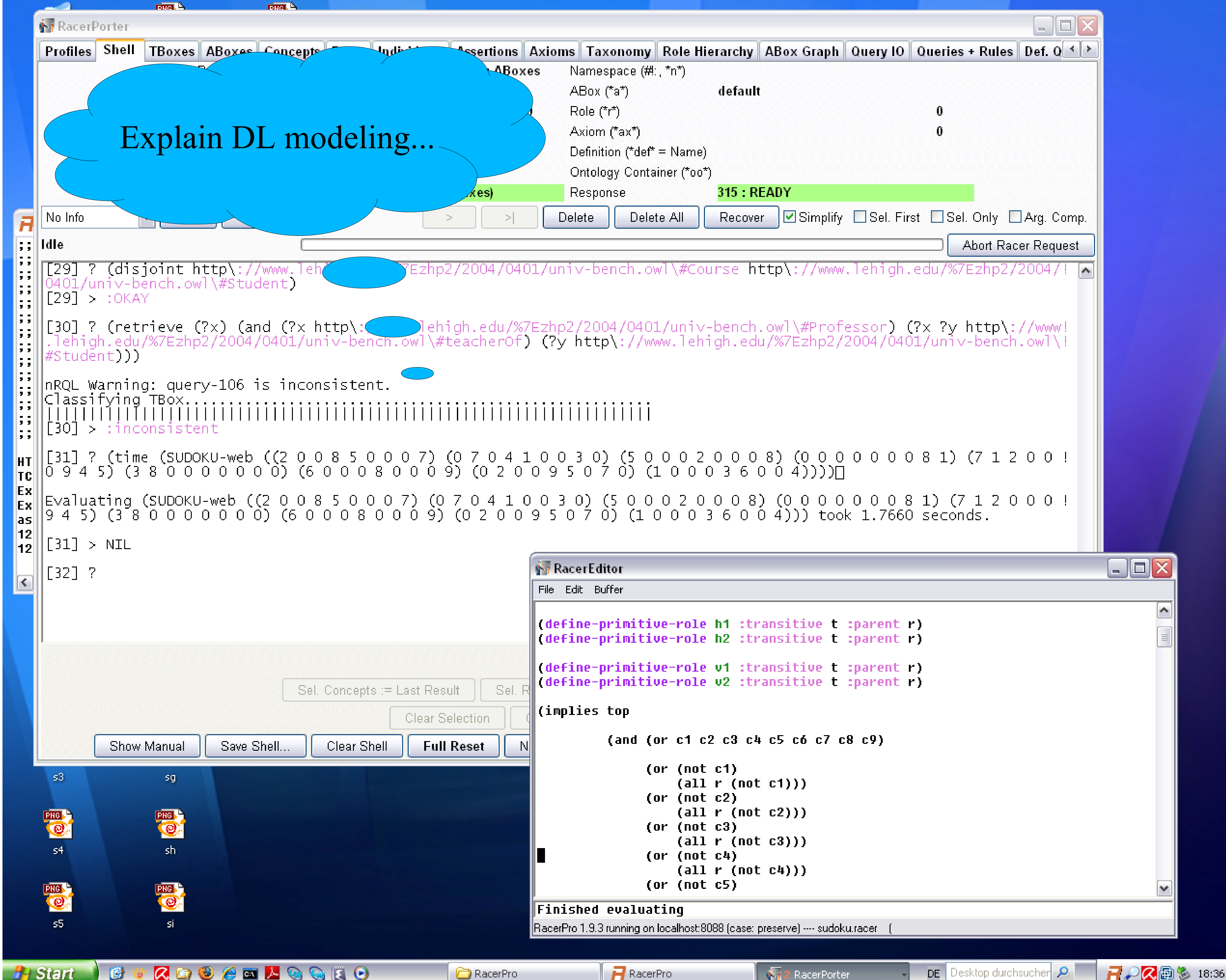
- by hand? OK for 4x4, but for 9x9?
  $\rightarrow$ create the structure programmatically (MiniLisp or OWLAPI)
- or via rules from asserted part
- transitive & symmetric property $\rightarrow$ 
  - use different backward property instead of a symmetric property
  - qualification over common parent property

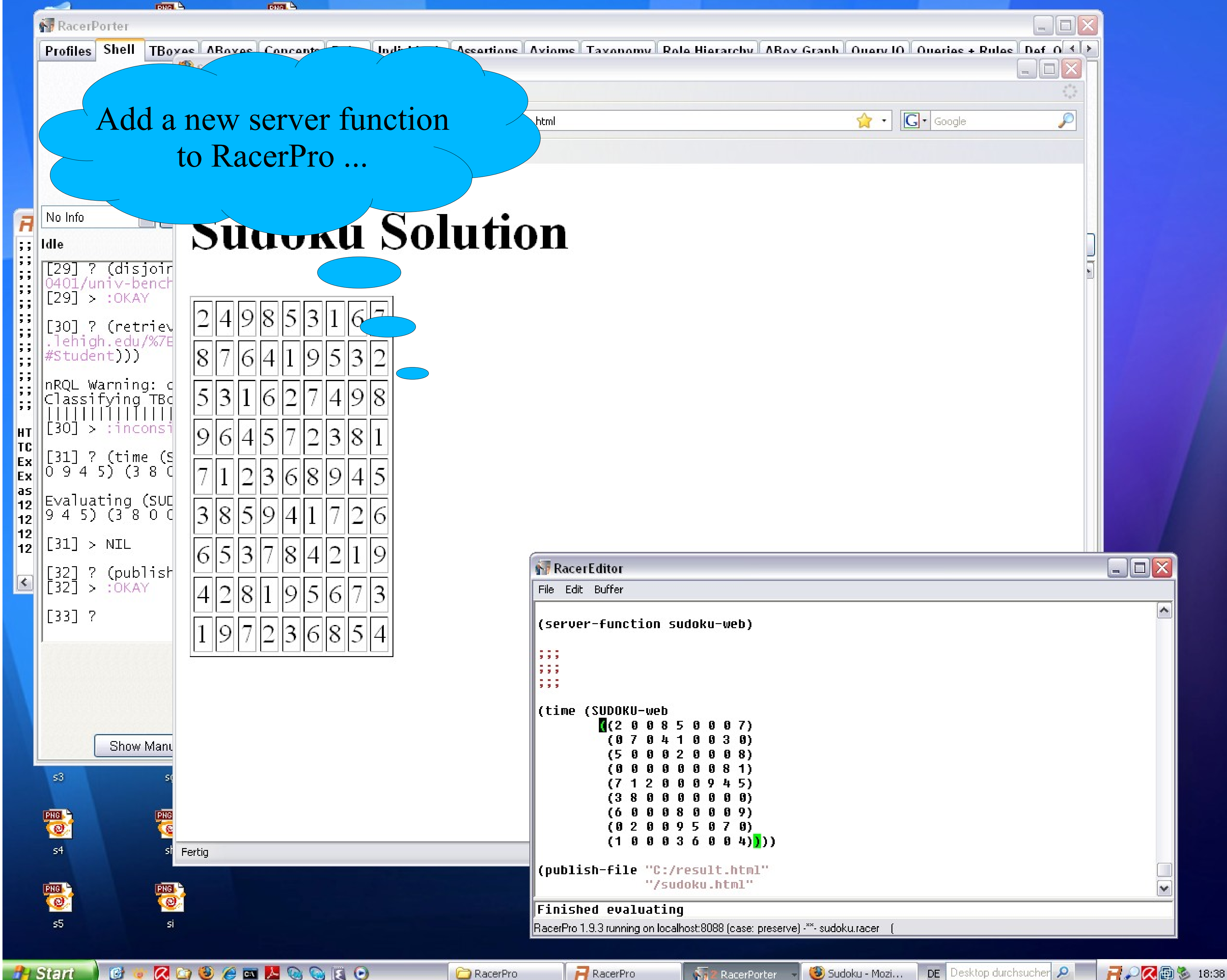
# Sudoku (3)




$$Q_1 \dot{\sqsubseteq} R$$
$$Q_2 \dot{\sqsubseteq} R$$
$$\mathsf{transitive}(Q_1)$$
$$\mathsf{transitive}(Q_2)$$
$$Q_1(x, y) \leftrightarrow Q_2(y, x)$$

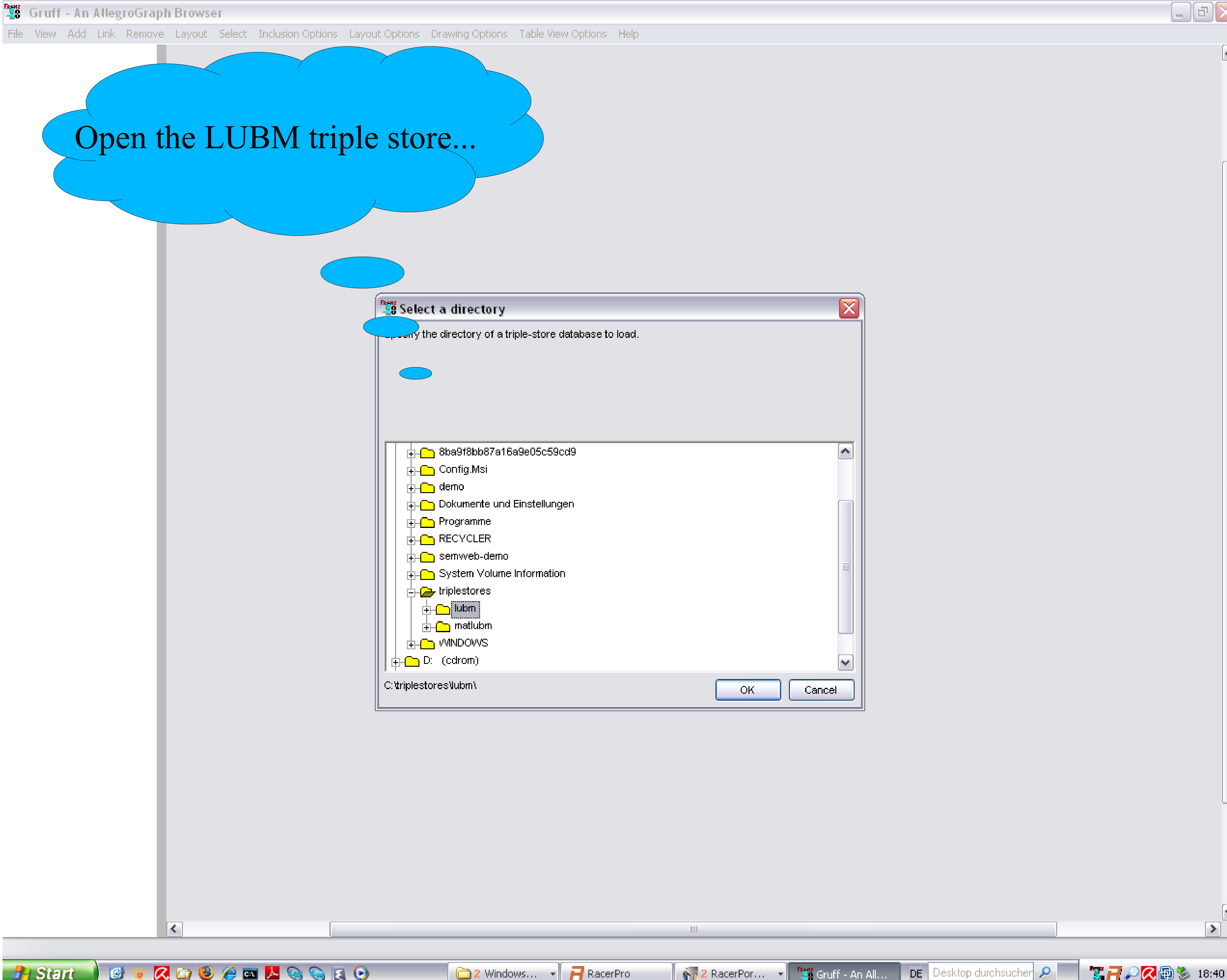


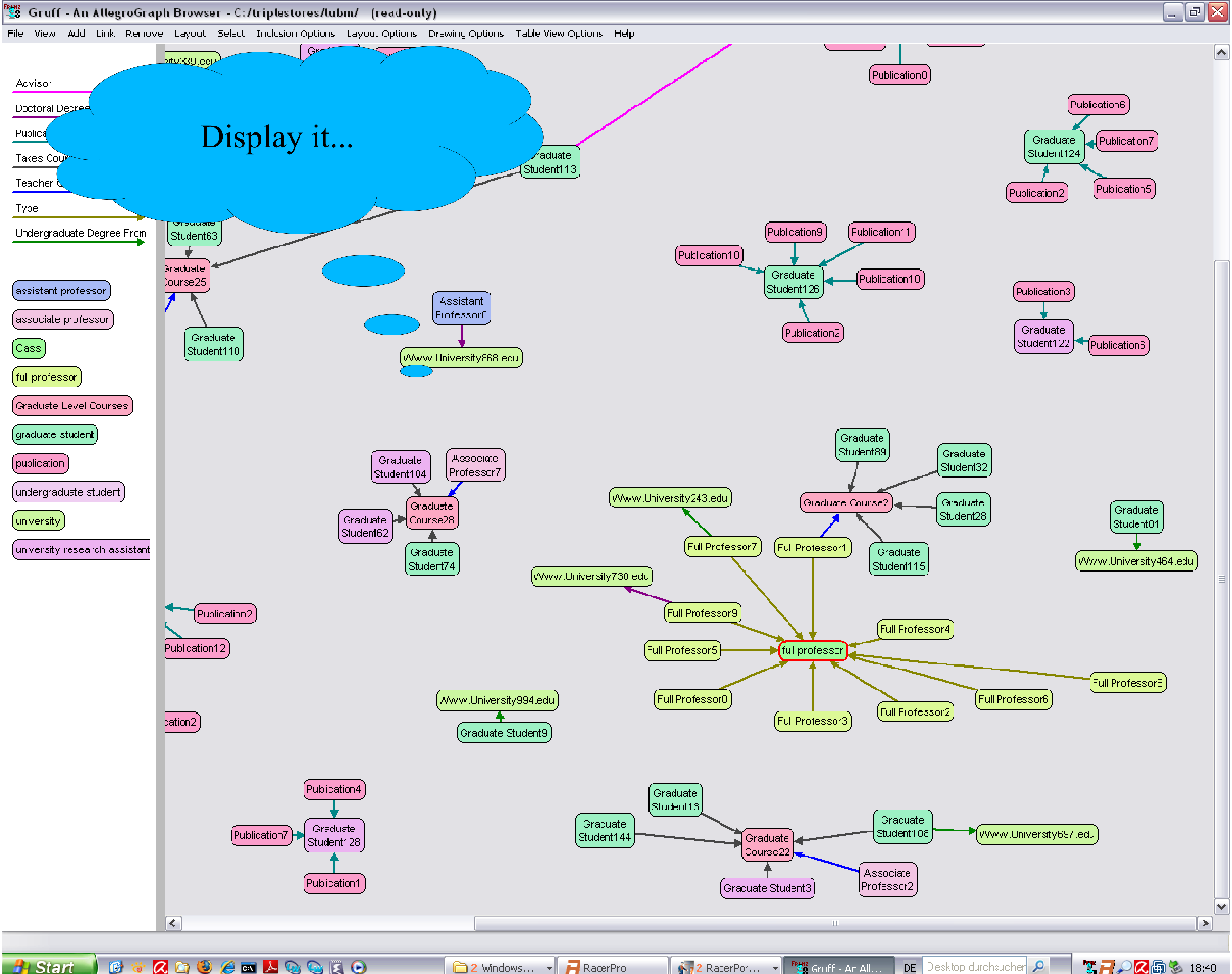

Explain DL modeling...
RacerPorter
Profiles
Shell
TBoxes
ABoxes
Taxonomy
Role Hierarchy
ABox Graph
Query IO
Queries + Rules
Namespace (#!:, *n*)
ABox (*a*) default
Role (*r*) 0
Axiom (*ax*) 0
Definition (*def* = Name)
Ontology Container (*oo*)
Response 315 : READY
No Info
Delete
Delete All
Recover
Simplify
Sel. First
Sel. Only
Arg. Comp.
Idle
Abort Racer Request
[29] > :OKAY
nRQL Warning: query-106 is inconsistent.
Classifying TBox.
[30] > :inconsistent
[31] ? (time (SUDOKU-web ((2 0 0 8 5 0 0 0 7) (0 7 0 4 1 0 0 3 0) (5 0 0 0 2 0 0 0 8) (0 0 0 0 0 0 0 8 1) (7 1 2 0 0 0 9 4 5) (3 8 0 0 0 0 0 0 0) (6 0 0 0 8 0 0 0 9) (0 2 0 0 9 5 0 7 0) (1 0 0 0 3 6 0 0 4))))
Evaluating (SUDOKU-web ((2 0 0 8 5 0 0 0 7) (0 7 0 4 1 0 0 3 0) (5 0 0 0 2 0 0 0 8) (0 0 0 0 0 0 0 8 1) (7 1 2 0 0 0 9 4 5) (3 8 0 0 0 0 0 0 0) (6 0 0 0 8 0 0 0 9) (0 2 0 0 9 5 0 7 0) (1 0 0 0 3 6 0 0 4))) took 1.7660 seconds.
[31] > NIL
[32] ?
Sel. Concepts := Last Result
Clear Selection
Show Manual
Save Shell...
Clear Shell
Full Reset
RacerEditor
File Edit Buffer
(define-primitive-role h1 :transitive t :parent r)
(define-primitive-role h2 :transitive t :parent r)
(define-primitive-role v1 :transitive t :parent r)
(define-primitive-role v2 :transitive t :parent r)
(implies top
(and (or c1 c2 c3 c4 c5 c6 c7 c8 c9)
(or (not c1)
(all r (not c1)))
(or (not c2)
(all r (not c2)))
(or (not c3)
(all r (not c3)))
(or (not c4)
(all r (not c4)))
(or (not c5)
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) ---- sudoku.racer
Start
RacerPro
RacerPorter
18:36

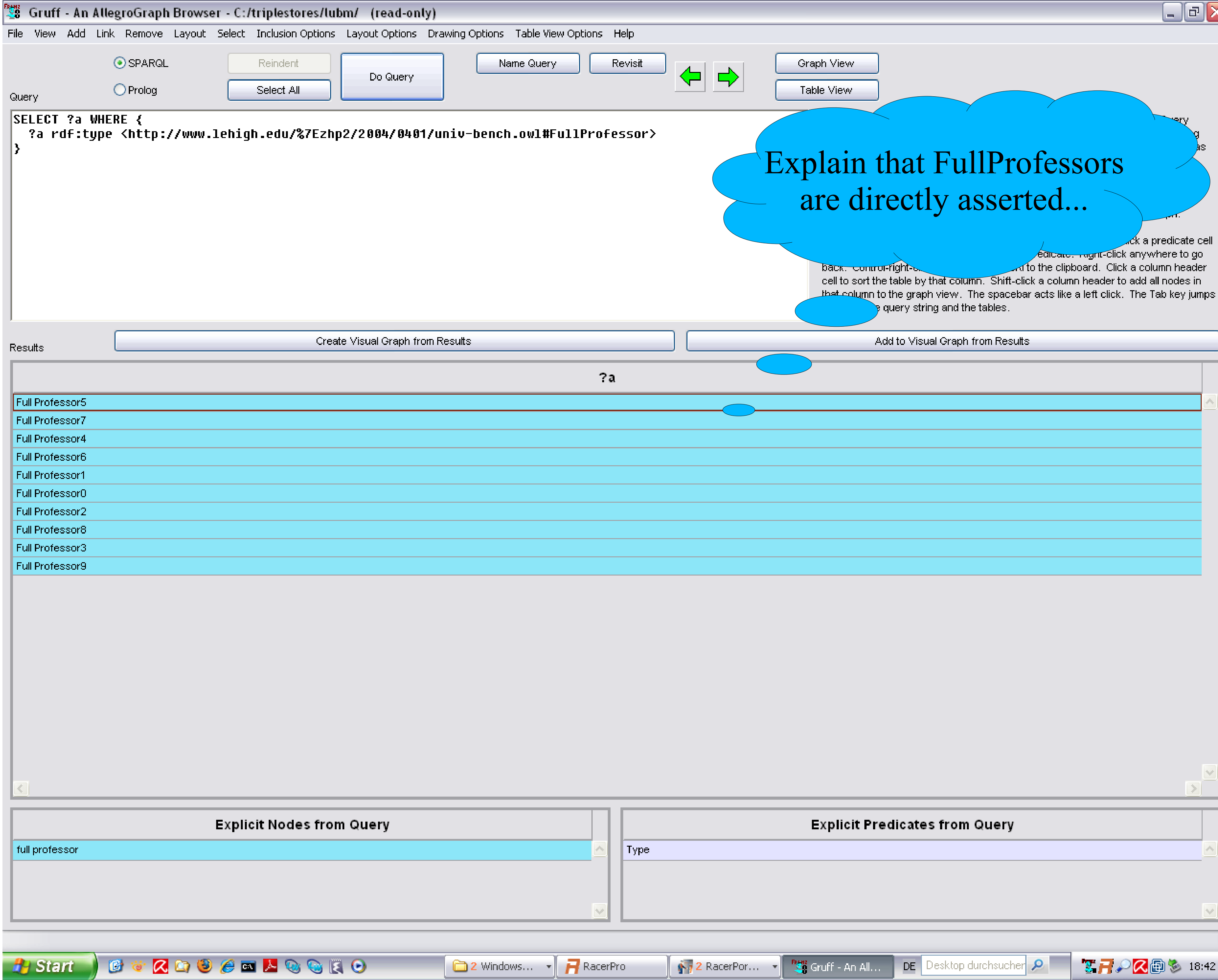

Add a new server function
to RacerPro ...
RacerPorter
Profiles
Shell
Sudoku Solution
2 4 9 8 5 3 1 6 7
8 7 6 4 1 9 5 3 2
5 3 1 6 2 7 4 9 8
9 6 4 5 7 2 3 8 1
7 1 2 3 6 8 9 4 5
3 8 5 9 4 1 7 2 6
6 5 3 7 8 4 2 1 9
4 2 8 1 9 5 6 7 3
1 9 7 2 3 6 8 5 4
RacerEditor
File Edit Buffer
(server-function sudoku-web)
(time (SUDOKU-web
((2 0 0 8 5 0 0 0 7)
(0 7 0 4 1 0 0 3 0)
(5 0 0 0 2 0 0 0 8)
(0 0 0 0 0 0 0 8 1)
(7 1 2 0 0 0 9 4 5)
(3 8 0 0 0 0 0 0 0)
(6 0 0 0 8 0 0 0 9)
(0 2 0 0 9 5 0 7 0)
(1 0 0 0 3 6 0 0 4))))
(publish-file "C:/result.html"
"/sudoku.html"
Finished evaluating
RacerPro 1.9.3 running on localhost:8088 (case: preserve) -**- sudoku.racer
Fertig
Start

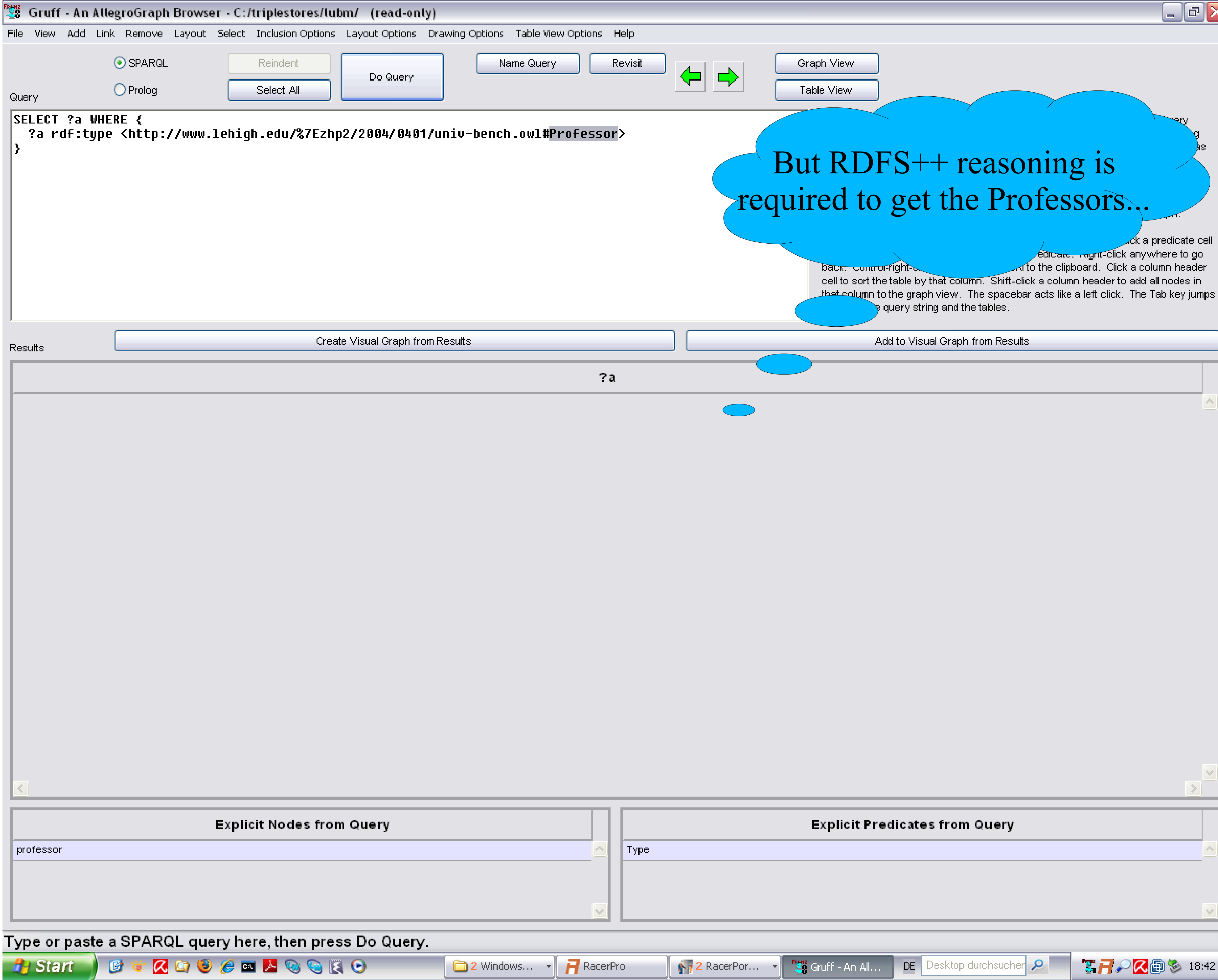
# Franz Inc. - AllegroGraph 3.2 & Gruff

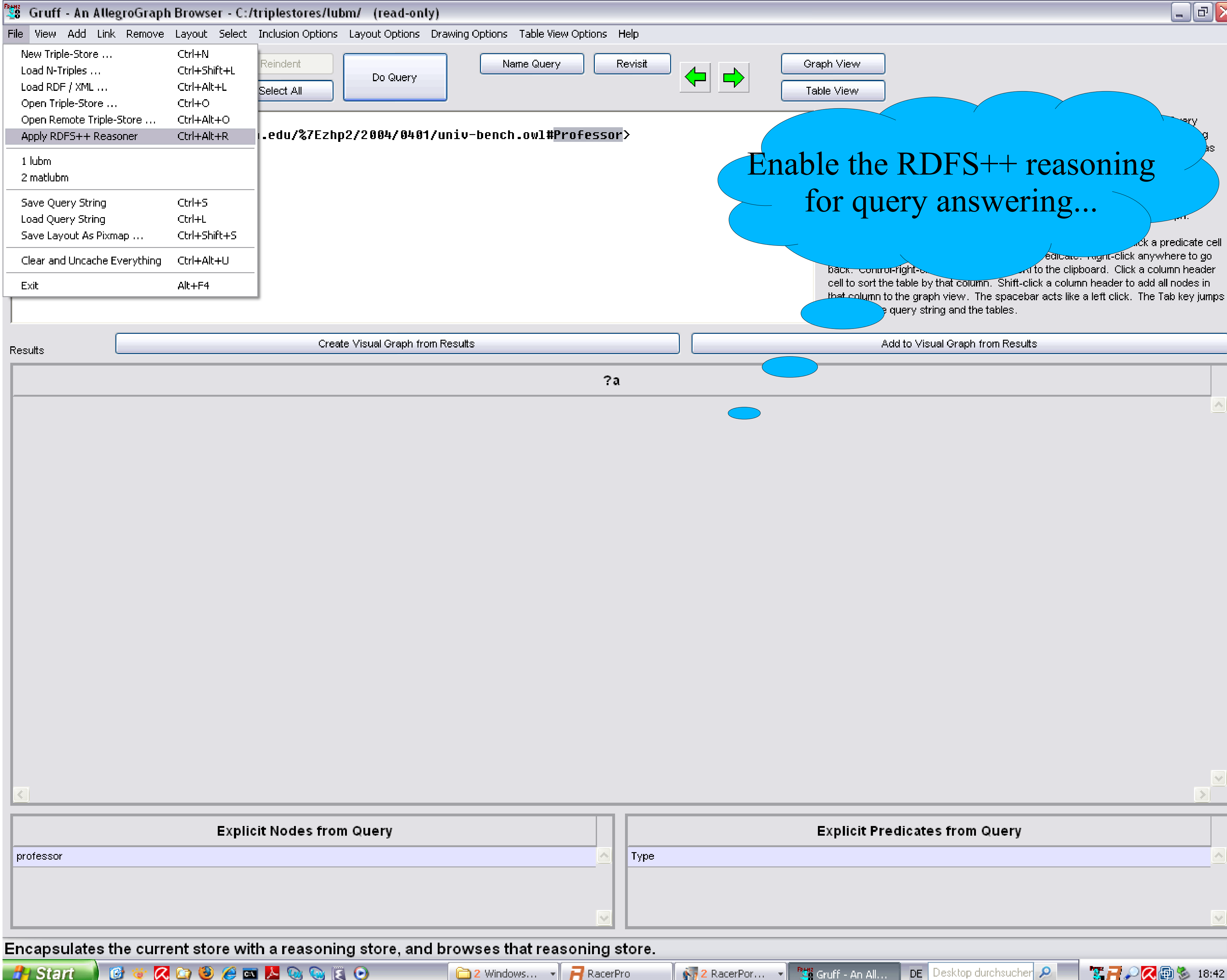
- Scalable and persistent RDF Database (Triple Store)
  - Loads a Billion triples in 8 hours on a 4 processor AMD machine
  - Load 10 Billion triples on EC2 (Amazon) on 10 machines in 10 hours
- Free version: 50.000.000 triples
- RDFS++ SPARQL / Prolog query answering
  - **`rdf:type, rdfs:domain, rdfs:range, rdfs:subClassOf, rdfs:subPropertyOf, owl:inverseOf, owl:sameAs, owl:TransitiveProperty`**
- Federated
  - Create an abstract store that is the union of other triple stores
  - Query answering works transparently against abstract store
- Geo-spatial-temporal and SNA predicates
  - Accessible from Prolog / SPARQL (extension mechanism)

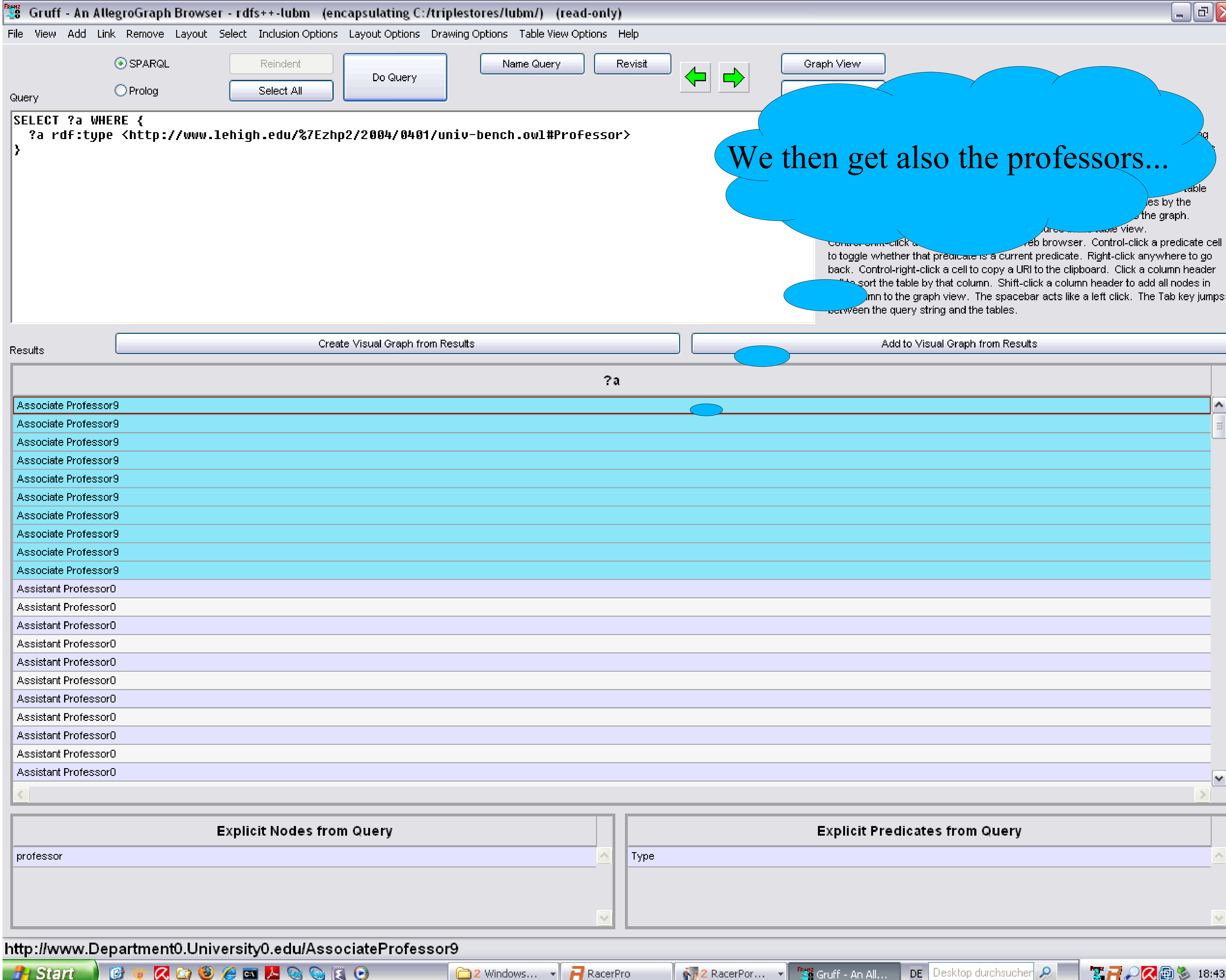

Gruff - An AllegroGraph Browser
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
Open the LUBM triple store...
Select a directory
the directory of a triple-store database to load.
8ba9f8bb87a16a9e05c59cd9
Config.Msi
demo
Dokumente und Einstellungen
Programme
RECYCLER
semweb-demo
System Volume Information
triplestores
lubm
matlubm
WINDOWS
D: (cdrom)
C:\triplestores\lubm\
OK
Cancel
Start
2 Windows...
RacerPro
2 RacerPor...
Gruff - An All...
DE
Desktop durchsuchen
18:40

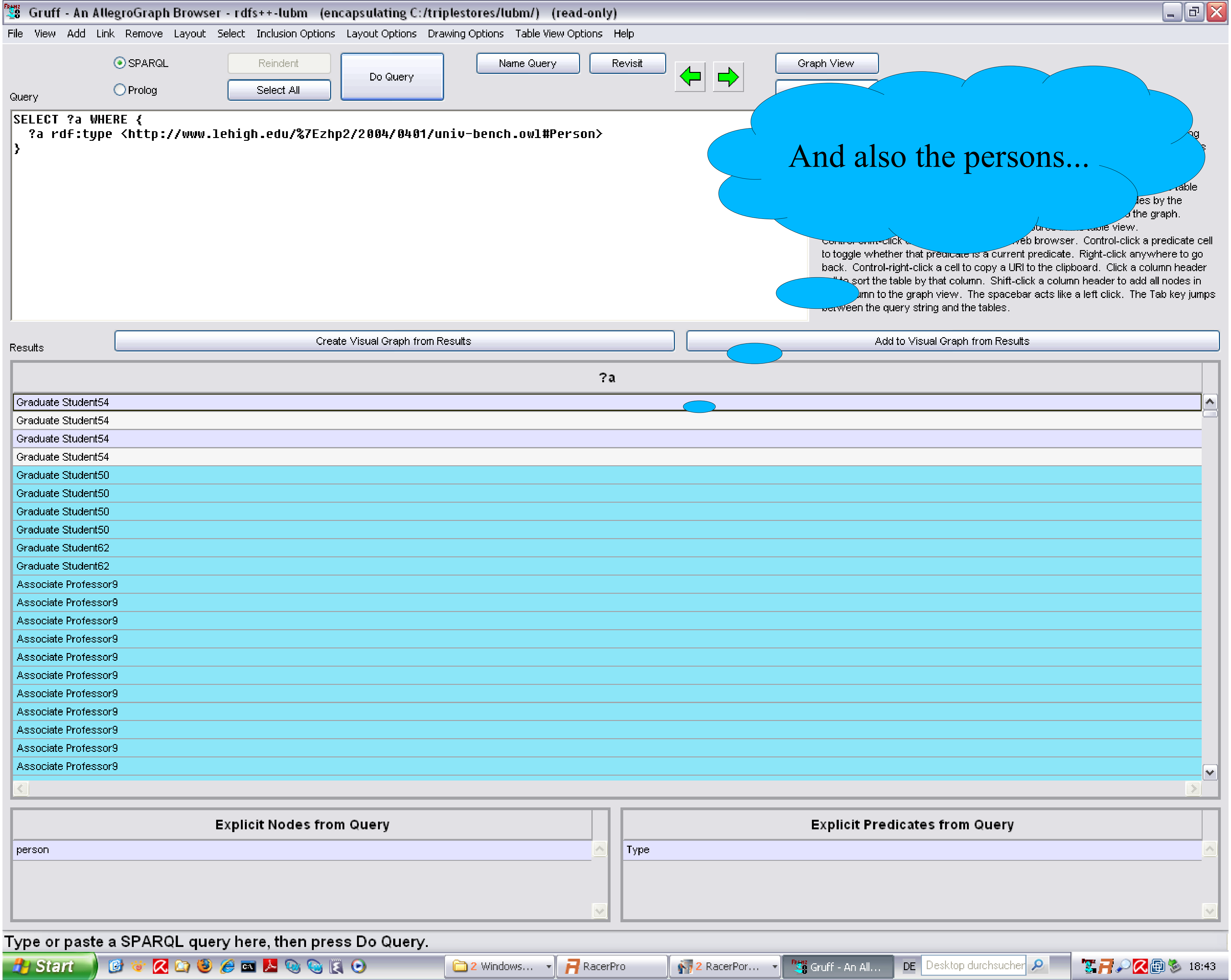

Gruff - An AllegroGraph Browser - C:/triplestores/lubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
Display it...
Advisor
Type
Undergraduate Degree From
assistant professor
associate professor
Class
full professor
Graduate Level Courses
graduate student
publication
undergraduate student
university
university research assistant
Publication0
Publication6
Graduate Student124
Publication7
Publication2
Publication5
Graduate Student113
Publication9
Publication11
Publication10
Graduate Student126
Publication2
Publication3
Graduate Student122
Publication6
Graduate Student63
Graduate Course25
Graduate Student110
Assistant Professor8
Www.University868.edu
Graduate Student89
Graduate Student32
Graduate Student104
Associate Professor7
Www.University243.edu
Graduate Course2
Graduate Student28
Graduate Course28
Graduate Student62
Graduate Student74
Full Professor7
Full Professor1
Graduate Student115
Graduate Student81
Www.University464.edu
Www.University730.edu
Full Professor9
Full Professor4
Publication2
Full Professor5
full professor
Publication12
Full Professor8
Full Professor6
Www.University994.edu
Full Professor0
Full Professor2
Full Professor3
Graduate Student9
Publication4
Graduate Student13
Graduate Student144
Graduate Student108
Publication7
Graduate Student128
Graduate Course22
Www.University697.edu
Publication1
Associate Professor2
Graduate Student3
Start
RacerPro
18:40

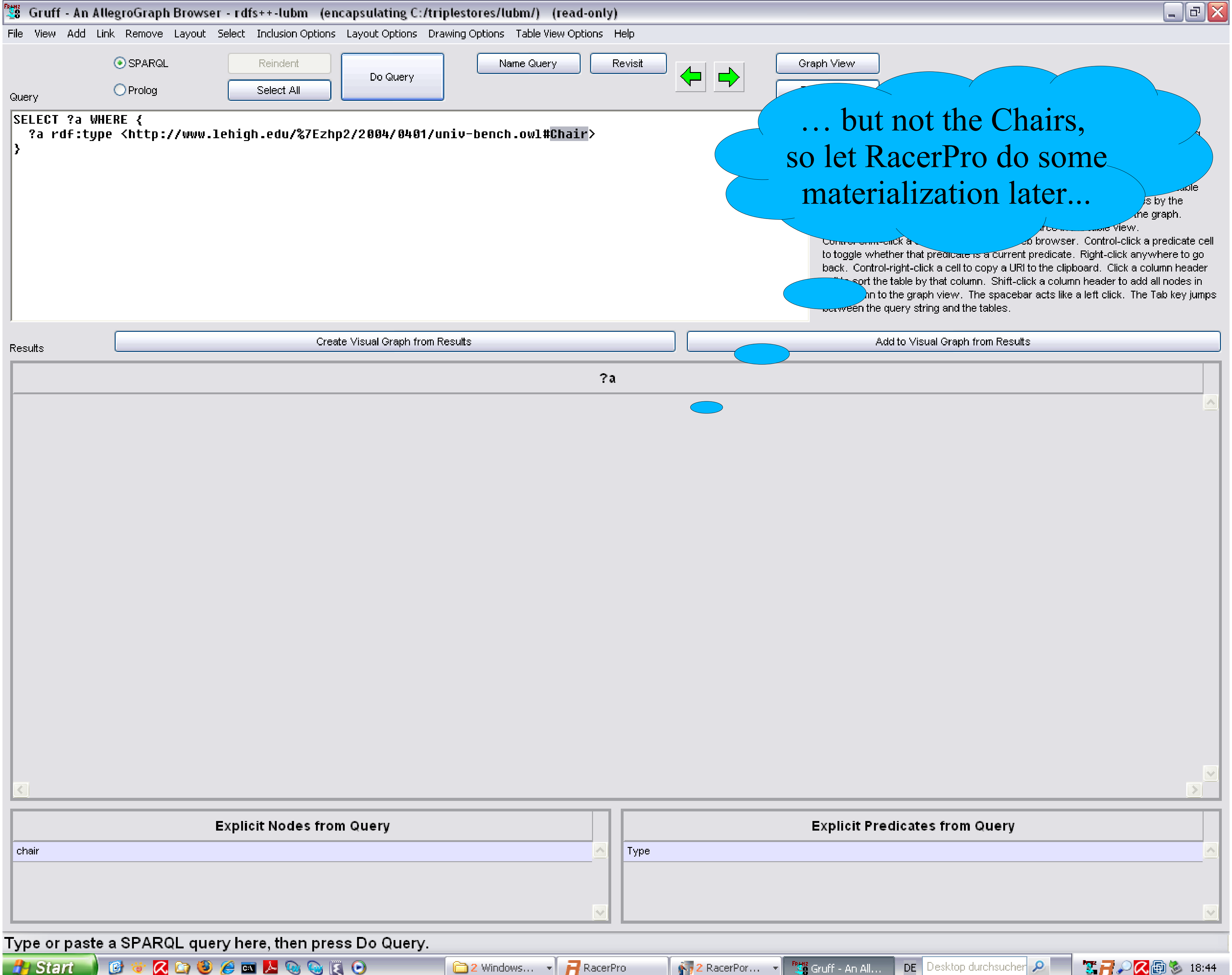

Gruff - An AllegroGraph Browser - C:/triplestores/lubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Query
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Table View
SELECT ?a WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#FullProfessor>
}
Explain that FullProfessors are directly asserted...
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Full Professor5
Full Professor7
Full Professor4
Full Professor6
Full Professor1
Full Professor0
Full Professor2
Full Professor8
Full Professor3
Full Professor9
Explicit Nodes from Query
full professor
Explicit Predicates from Query
Type
Start
RacerPro
Gruff - An All...
DE
Desktop durchsuchen
18:42


Gruff - An AllegroGraph Browser - C:/triplestores/lubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Table View
Query
SELECT ?a WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Professor>
}
But RDFS++ reasoning is required to get the Professors...
cell to sort the table by that column. Shift-click a column header to add all nodes in
query string and the tables.
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Explicit Nodes from Query
professor
Explicit Predicates from Query
Type
Type or paste a SPARQL query here, then press Do Query.
Start
RacerPro
18:42

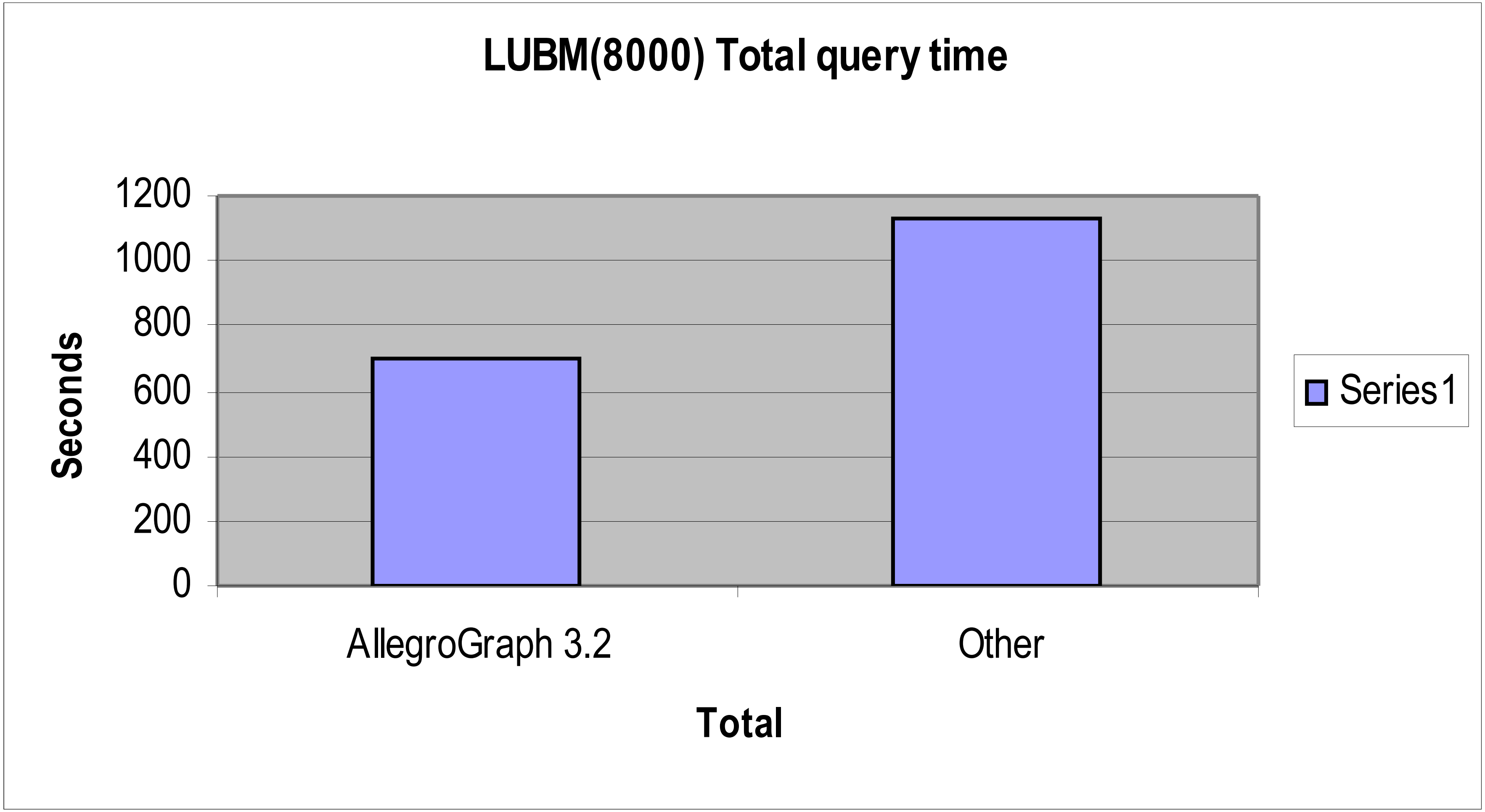

Gruff - An AllegroGraph Browser - C:/triplestores/lubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
New Triple-Store ... Ctrl+N
Load N-Triples ... Ctrl+Shift+L
Load RDF / XML ... Ctrl+Alt+L
Open Triple-Store ... Ctrl+O
Open Remote Triple-Store ... Ctrl+Alt+O
Apply RDFS++ Reasoner Ctrl+Alt+R
1 lubm
2 matlubm
Save Query String Ctrl+S
Load Query String Ctrl+L
Save Layout As Pixmap ... Ctrl+Shift+S
Clear and Uncache Everything Ctrl+Alt+U
Exit Alt+F4
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Table View
.edu/%7Ezhp2/2004/0401/univ-bench.owl#Professor>
Enable the RDFS++ reasoning for query answering...
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Explicit Nodes from Query
professor
Explicit Predicates from Query
Type
Encapsulates the current store with a reasoning store, and browses that reasoning store.
Start
RacerPro
Gruff - An All...
DE
Desktop durchsuchen
18:42


Gruff - An AllegroGraph Browser - rdfs++-lubm (encapsulating C:/triplestores/lubm/) (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Query
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
SELECT ?a WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Professor>
}
We then get also the professors...
to toggle whether that predicate is a current predicate. Right-click anywhere to go back. Control-right-click a cell to copy a URI to the clipboard. Click a column header to sort the table by that column. Shift-click a column header to add all nodes in that column to the graph view. The spacebar acts like a left click. The Tab key jumps between the query string and the tables.
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Assistant Professor0
Explicit Nodes from Query
professor
Explicit Predicates from Query
Type
http://www.Department0.University0.edu/AssociateProfessor9
Start
Windows...
RacerPro
RacerPor...
Gruff - An All...
DE
Desktop durchsuchen
18:43

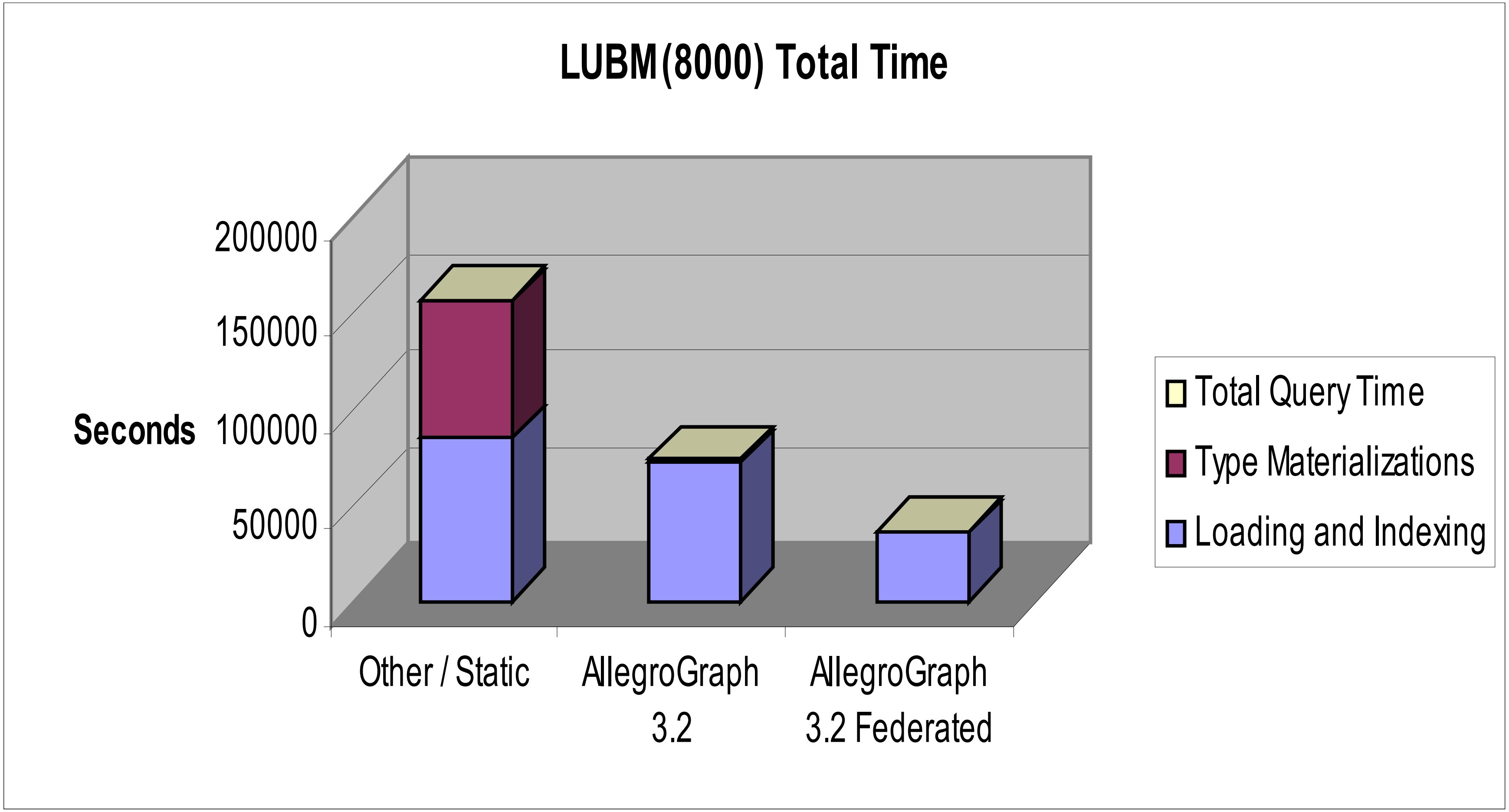

Gruff - An AllegroGraph Browser - rdfs++-lubm (encapsulating C:/triplestores/lubm/) (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Query
SELECT ?a WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Person>
}
And also the persons...
to toggle whether that predicate is a current predicate. Right-click anywhere to go back. Control-right-click a cell to copy a URI to the clipboard. Click a column header to sort the table by that column. Shift-click a column header to add all nodes in that column to the graph view. The spacebar acts like a left click. The Tab key jumps between the query string and the tables.
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Graduate Student54
Graduate Student54
Graduate Student54
Graduate Student54
Graduate Student50
Graduate Student50
Graduate Student50
Graduate Student50
Graduate Student62
Graduate Student62
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Associate Professor9
Explicit Nodes from Query
person
Explicit Predicates from Query
Type
Type or paste a SPARQL query here, then press Do Query.
Start
RacerPro
Gruff - An All...
18:43


… but not the Chairs, so let RacerPro do some materialization later…
Gruff - An AllegroGraph Browser - rdfs++-lubm (encapsulating C:/triplestores/lubm/) (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Query
SELECT ?a WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Chair>
}
to toggle whether that predicate is a current predicate. Right-click anywhere to go back. Control-right-click a cell to copy a URI to the clipboard. Click a column header
the graph view. The spacebar acts like a left click. The Tab key jumps
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
Explicit Nodes from Query
chair
Explicit Predicates from Query
Type
Type or paste a SPARQL query here, then press Do Query.
Start
RacerPro
Gruff - An All...
DE
Desktop durchsuchen
18:44

# LUBM(8000) = 1.105.993.401 Triples



# So what is the big deal?



# Activity Recognition

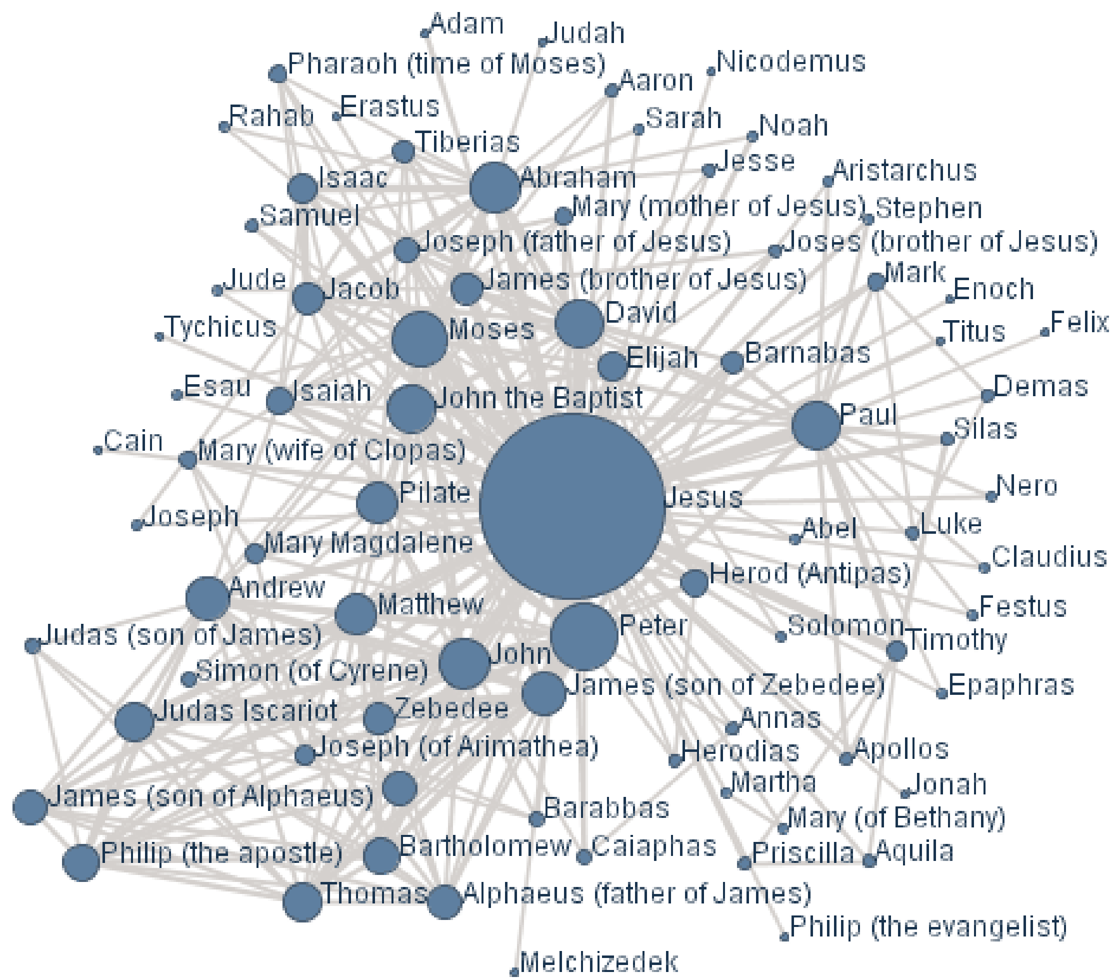
- Our customers use AllegroGraph as an event database with social network analysis and geospatial and temporal reasoning

**Find all meetings that happened in November within 5 miles of Berkeley that was attended by the most important person in Jans' friends and friends of friends.**

```
(select (?x)
   (ego-group person:jans knows ?group 2)                  SNA
   (actor-centrality-members ?group knows ?x ?num)         SNA
   (q ?event fr:actor ?x)                                  DB Lookup
   (qs ?event rdf:type fr:Meeting)                         RDFS
   (interval-during ?event "2008-11-01" "2008-11-06")      Temporal
   (geo-box-around geoname:Berkeley ?event 5 miles)        Spatial
   !)
```

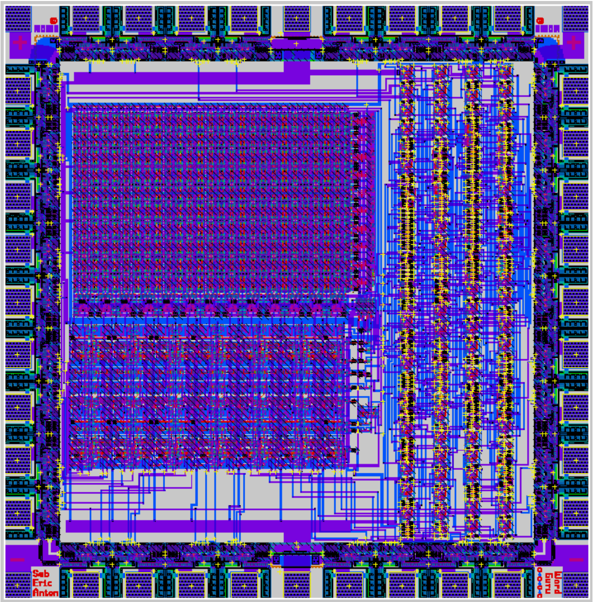
# Social Network Analysis Answers 4 questions

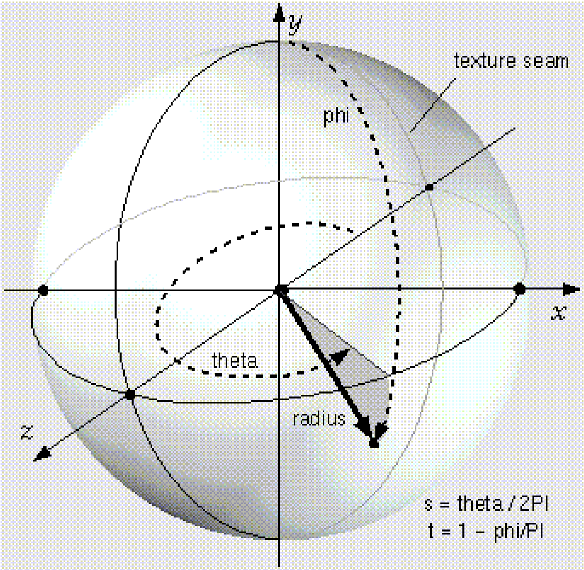
- How far is P1 from P2 (and how strong is the relation?)
- To what groups does this person belong (ego groups, cliques?)
- How important is this person in the group?
- Does this group have a leader, how cohesive are they?



# GeoSpatial

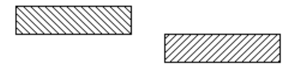
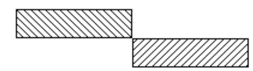
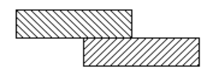
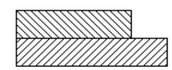
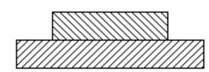
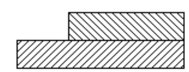
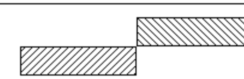
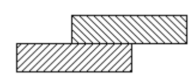
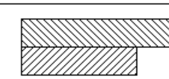
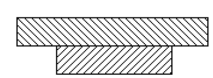
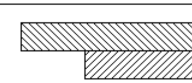
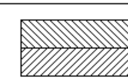
- Make the following super efficient
  - Where did something happen?
  - How far was event1 from event2?
  - Find all the events that occurred in a bounding box or radius of M miles?
  - Do these two shapes overlap?
  - Find all the objects in the intersection of two shapes
- On a very large scale
  - when things don't fit in memory
  - millions of events and polygons





# Temporal Reasoning

- Adhere to our convention to encode StartTimes and EndTimes and enjoy efficient temporal primitives
- Implementation of Allen's interval logic primitives

| | |
|---|---|
|  | (interval-before ?e1 ?e2) |
|  | (interval-meets ?e1 ?e2) |
|  | (interval-overlaps ?e1 ?e2) |
|  | (interval-starts ?e1 ?e2) |
|  | (interval-during ?e1 ?e2) |
|  | (interval-finishes ?e1 ?e2) |
|  | (interval-after ?e1 ?e2) |
|  | (interval-met-by ?e1 ?e2) |
|  | (interval-overlapped-by ?e1 ?e2) |
|  | (interval-started-by ?e1 ?e2) |
|  | (interval-contains ?e1 ?e2) |
|  | (interval-finished-by ?e1 ?e2) |
|  | (interval-cotemporal ?e1 ?e2) |

# A SPARQL query spanning 4 sources

```
prefix go: <http://purl.org/obo/owl/GO#>
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix owl: <http://www.w3.org/2002/07/owl#>
prefix mesh: <http://purl.org/commons/record/mesh/>
prefix sc: <http://purl.org/science/owl/sciencecommons/>
prefix ro: <http://www.obofoundry.org/ro/ro.owl#>

select ?genename ?processname
where
{  graph <http://purl.org/commons/hcls/pubmesh>
    { ?paper ?p mesh:D017966 .
      ?article sc:identified_by_pmid ?paper.
      ?gene sc:describes_gene_or_gene_product_mentioned_by ?article.
    }
   graph <http://purl.org/commons/hcls/goa>
    { ?protein rdfs:subClassOf ?res.
      ?res owl:onProperty ro:has_function.
      ?res owl:someValuesFrom ?res2.
      ?res2 owl:onProperty ro:realized_as.
      ?res2 owl:someValuesFrom ?process.
   graph <http://purl.org/commons/hcls/20070416/classrelations>
    {{?process <http://purl.org/obo/owl/obo#part_of> go:GO_0007166}
      union
     {?process rdfs:subClassOf go:GO_0007166 }}
      ?protein rdfs:subClassOf ?parent.
      ?parent owl:equivalentClass ?res3.
      ?res3 owl:hasValue ?gene.
     }
   graph <http://purl.org/commons/hcls/gene>
    { ?gene rdfs:label ?genename }
   graph <http://purl.org/commons/hcls/20070416>
    { ?process rdfs:label ?processname}
}
```

Mesh: Pyramidal Neurons

↓

Pubmed: Journal Articles

↓

Entrez Gene: Genes

↓

GO: Signal Transduction

*Inference required*

# AllegroGraph and RacerPro

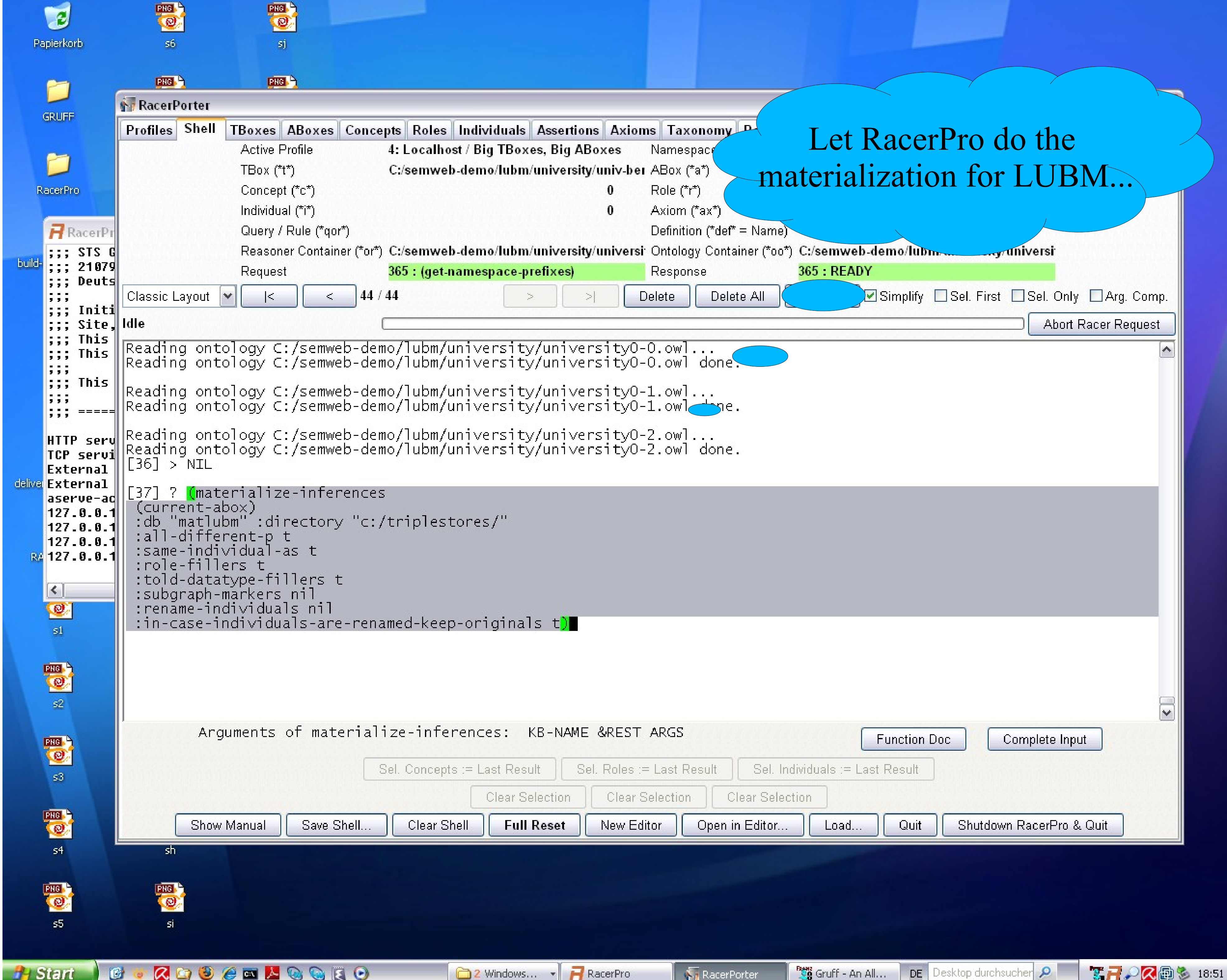
- Racer can do type & property materialization for AllegroGraph
  - Racer can read OWL RDF from triple store, web or file
  - materialize inferences („type & property materialization“)
  - write back

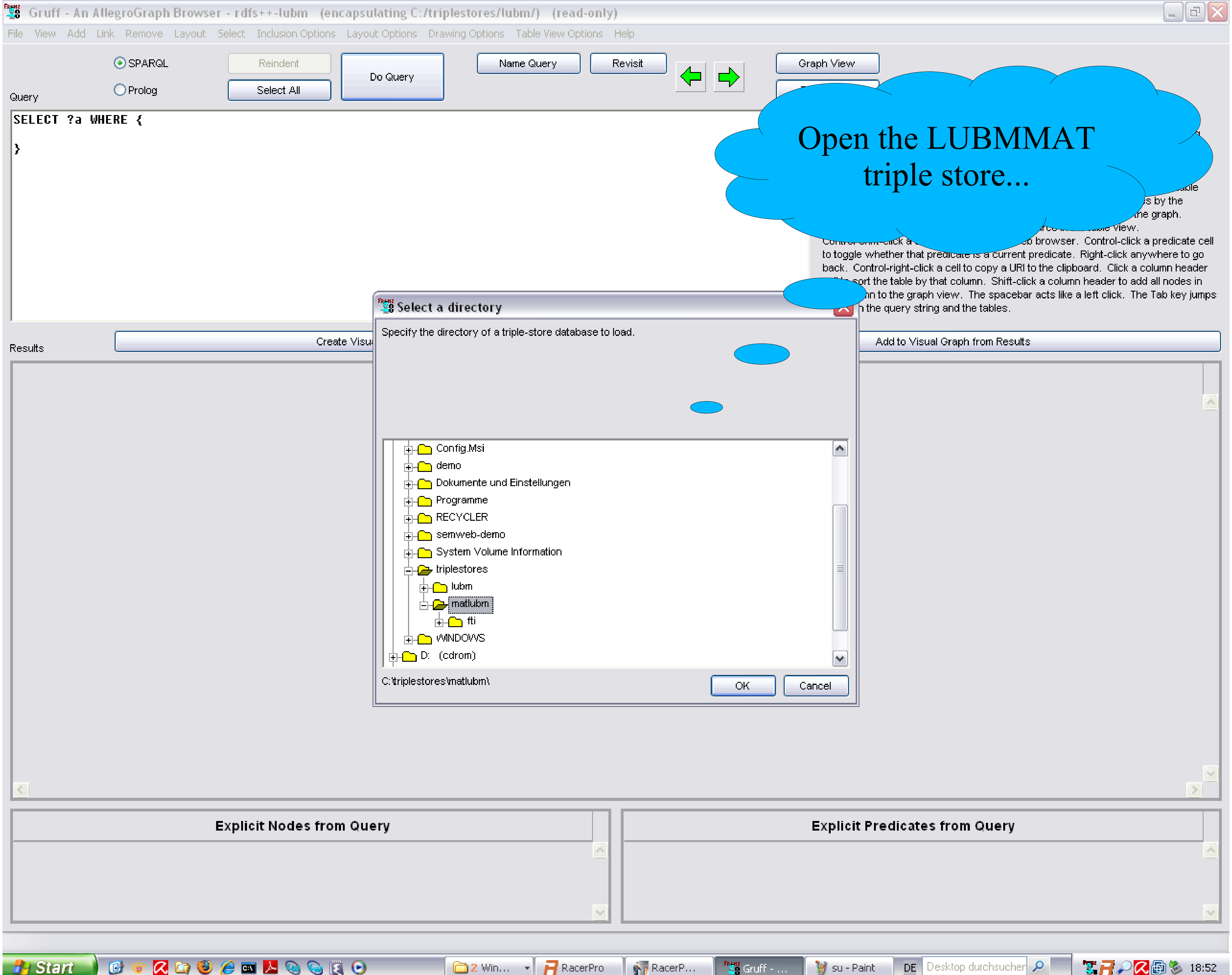
    → e.g., ontology repository of the boemie EU project

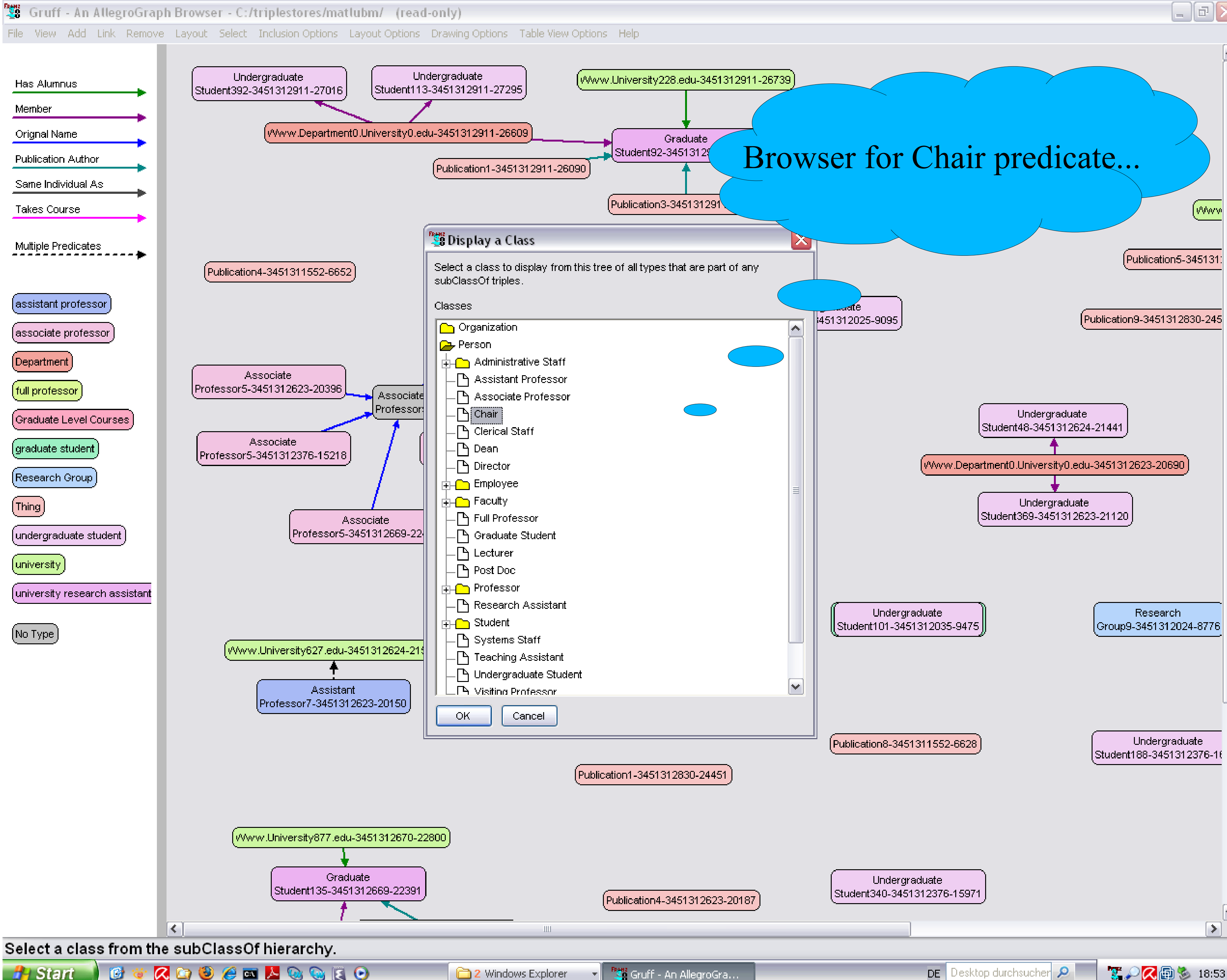
    - Much better than relational DB, same data model
    - Integrated with RacerPro
    - SPARQL queries from AllegroGraph, Gruff, …
- Drawback: type materialization only possible for Aboxes that fit in main memory
  - future work: RacerPro reasoning directly on triple store

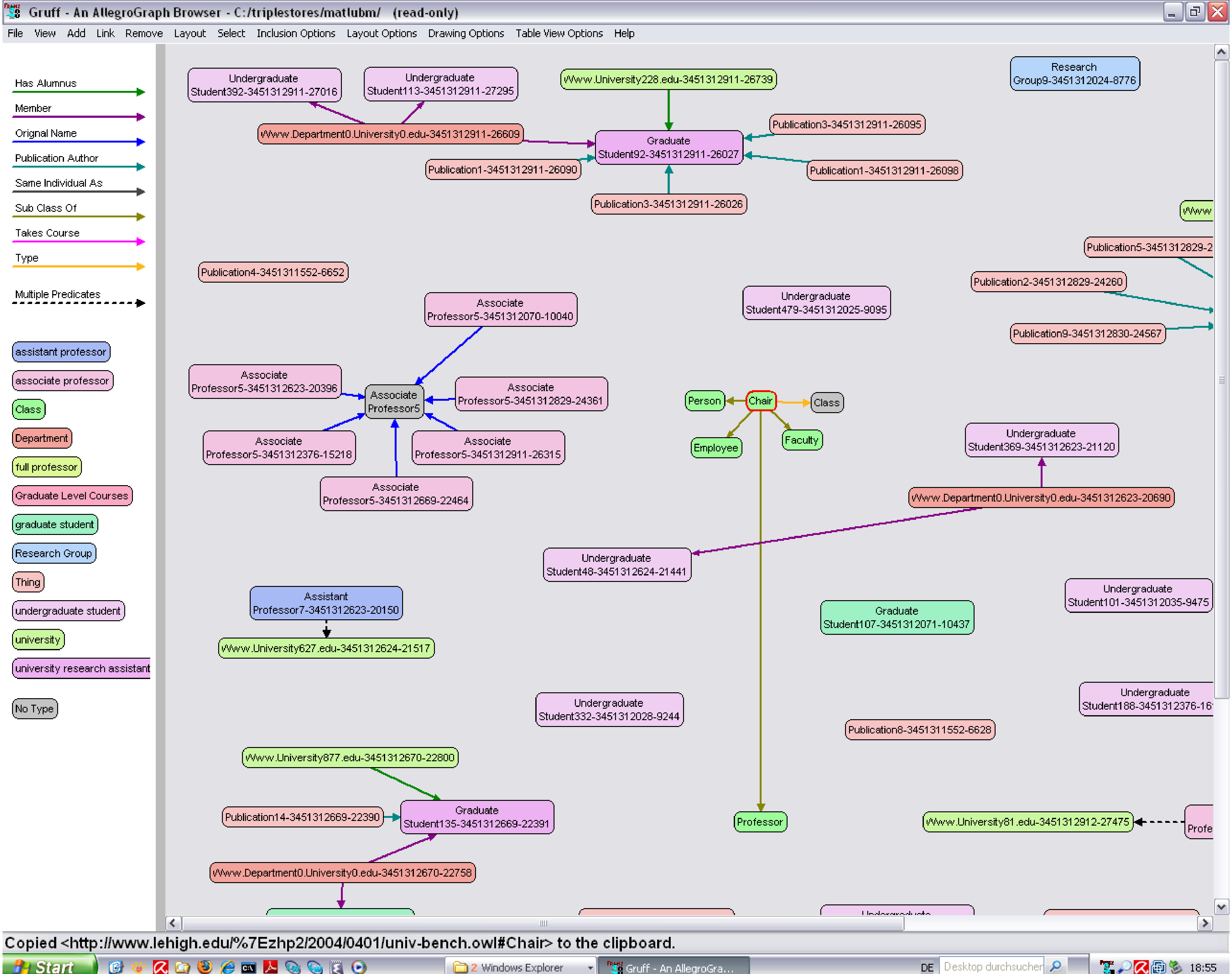
    → not limited w.r.t. main-memory size

Let RacerPro do the materialization for LUBM...

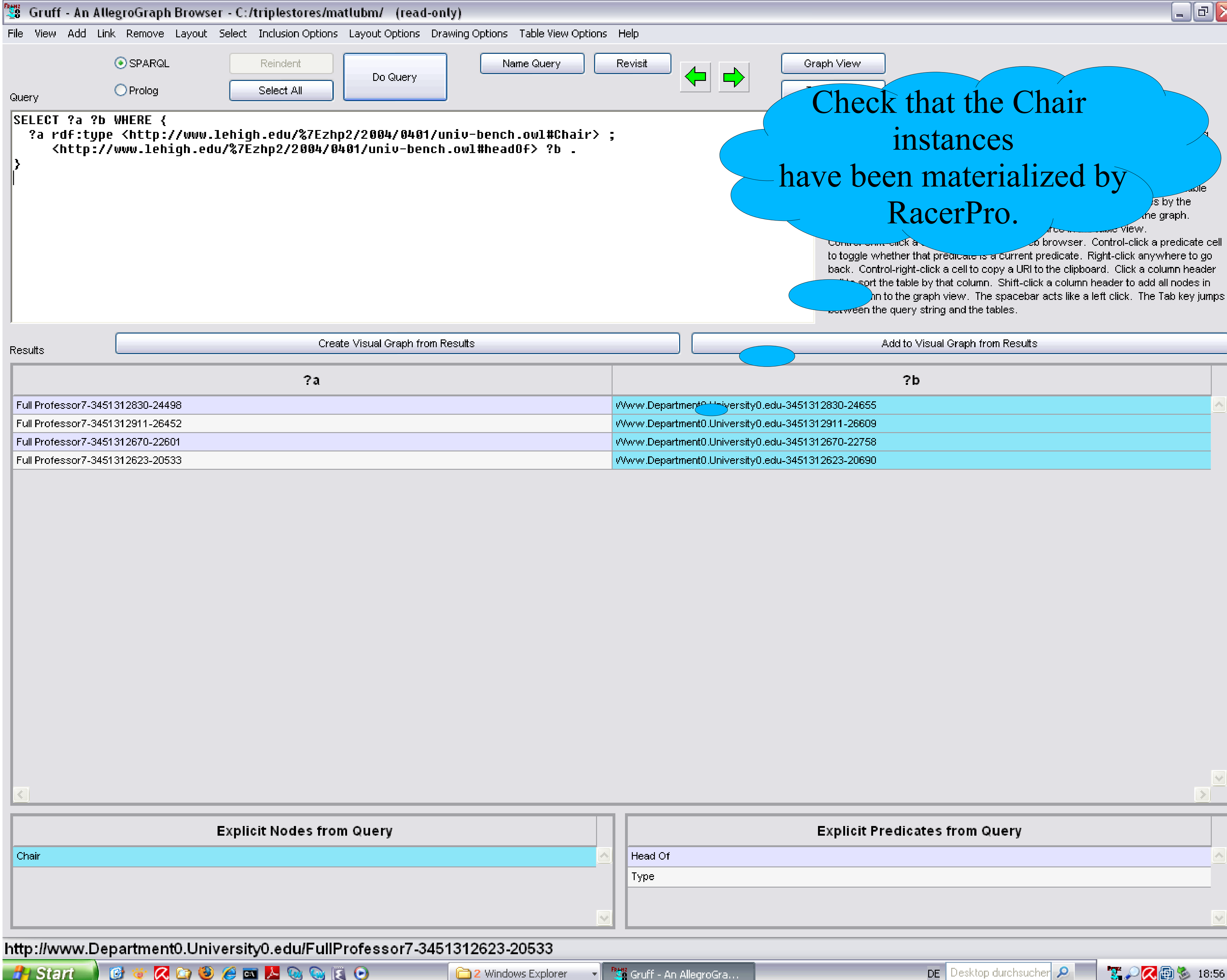



Gruff - An AllegroGraph Browser - rdfs++-lubm (encapsulating C:/triplestores/lubm/) (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Query
SELECT ?a WHERE {
}
Open the LUBMMAT triple store...
Results
Add to Visual Graph from Results
Select a directory
Specify the directory of a triple-store database to load.
Config.Msi
demo
Dokumente und Einstellungen
Programme
RECYCLER
semweb-demo
System Volume Information
triplestores
lubm
matlubm
fti
WINDOWS
D: (cdrom)
C:\triplestores\matlubm\
OK
Cancel
Explicit Nodes from Query
Explicit Predicates from Query
Start
RacerPro
Gruff - ...
su - Paint
Desktop durchsuchen
18:52


Gruff - An AllegroGraph Browser - C:/triplestores/matlubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
Has Alumnus
Member
Orignal Name
Publication Author
Same Individual As
Takes Course
Multiple Predicates
assistant professor
associate professor
Department
full professor
Graduate Level Courses
graduate student
Research Group
Thing
undergraduate student
university
university research assistant
No Type
Browser for Chair predicate...
Display a Class
Select a class to display from this tree of all types that are part of any subClassOf triples.
Classes
Organization
Person
Administrative Staff
Assistant Professor
Associate Professor
Chair
Clerical Staff
Dean
Director
Employee
Faculty
Full Professor
Graduate Student
Lecturer
Post Doc
Professor
Research Assistant
Student
Systems Staff
Teaching Assistant
Undergraduate Student
Visiting Professor
OK
Cancel
Undergraduate Student392-3451312911-27016
Undergraduate Student113-3451312911-27295
Www.University228.edu-3451312911-26739
Www.Department0.University0.edu-3451312911-26609
Publication1-3451312911-26090
Publication4-3451311552-6652
Associate Professor5-3451312623-20396
Associate Professor5-3451312376-15218
Undergraduate Student48-3451312624-21441
Www.Department0.University0.edu-3451312623-20690
Undergraduate Student369-3451312623-21120
Undergraduate Student101-3451312035-9475
Research Group9-3451312024-8776
Assistant Professor7-3451312623-20150
Publication8-3451311552-6628
Publication1-3451312830-24451
Www.University877.edu-3451312670-22800
Graduate Student135-3451312669-22391
Publication4-3451312623-20187
Undergraduate Student340-3451312376-15971
Select a class from the subClassOf hierarchy.
Start
2 Windows Explorer
Gruff - An AllegroGra...
DE
Desktop durchsuchen
18:53



Gruff - An AllegroGraph Browser - C:/triplestores/matlubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
Has Alumnus
Member
Orignal Name
Publication Author
Same Individual As
Sub Class Of
Takes Course
Type
Multiple Predicates
assistant professor
associate professor
Class
Department
full professor
Graduate Level Courses
graduate student
Research Group
Thing
undergraduate student
university
university research assistant
No Type
Undergraduate Student392-3451312911-27016
Undergraduate Student113-3451312911-27295
Www.University228.edu-3451312911-26739
Research Group9-3451312024-8776
Www.Department0.University0.edu-3451312911-26609
Graduate Student92-3451312911-26027
Publication3-3451312911-26095
Publication1-3451312911-26090
Publication1-3451312911-26098
Publication3-3451312911-26026
Publication5-3451312829-2
Publication2-3451312829-24260
Publication9-3451312830-24567
Publication4-3451311552-6652
Associate Professor5-3451312070-10040
Undergraduate Student479-3451312025-9095
Associate Professor5-3451312623-20396
Associate Professor5
Associate Professor5-3451312829-24361
Person
Chair
Class
Employee
Faculty
Associate Professor5-3451312376-15218
Associate Professor5-3451312911-26315
Undergraduate Student369-3451312623-21120
Associate Professor5-3451312669-22464
Www.Department0.University0.edu-3451312623-20690
Undergraduate Student48-3451312624-21441
Undergraduate Student101-3451312035-9475
Assistant Professor7-3451312623-20150
Graduate Student107-3451312071-10437
Www.University627.edu-3451312624-21517
Undergraduate Student332-3451312028-9244
Publication8-3451311552-6628
Www.University877.edu-3451312670-22800
Publication14-3451312669-22390
Graduate Student135-3451312669-22391
Professor
Www.University81.edu-3451312912-27475
Www.Department0.University0.edu-3451312670-22758
Copied <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Chair> to the clipboard.
Start
2 Windows Explorer
Gruff - An AllegroGra...
DE
Desktop durchsuchen
18:55


Gruff - An AllegroGraph Browser - C:/triplestores/matlubm/ (read-only)
File View Add Link Remove Layout Select Inclusion Options Layout Options Drawing Options Table View Options Help
SPARQL
Prolog
Reindent
Select All
Do Query
Name Query
Revisit
Graph View
Query
SELECT ?a ?b WHERE {
?a rdf:type <http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#Chair> ;
<http://www.lehigh.edu/%7Ezhp2/2004/0401/univ-bench.owl#headOf> ?b .
}
Check that the Chair instances have been materialized by RacerPro.
Results
Create Visual Graph from Results
Add to Visual Graph from Results
?a
?b
Full Professor7-3451312830-24498
Full Professor7-3451312911-26452
Full Professor7-3451312670-22601
Full Professor7-3451312623-20533
Www.Department0.University0.edu-3451312911-26609
Www.Department0.University0.edu-3451312670-22758
Www.Department0.University0.edu-3451312623-20690
Explicit Nodes from Query
Chair
Explicit Predicates from Query
Head Of
Type
http://www.Department0.University0.edu/FullProfessor7-3451312623-20533
Start
2 Windows Explorer
Gruff - An AllegroGra...
DE
Desktop durchsuchen
18:56

# boemie – Ontology-Based Information Extraction from Athletics New WebPages

Bootstrapping Ontology Evolution with Multimedia Information Extraction

iaaf.org - Otto and Maresova notch jump victories in Dessau - Mozilla Firefox

http://www.iaaf.org/news/kind=100/newsid=49536.htr

iaaf.org Home of World Athletics

COMPETITIONS | STATISTICS | NEWS CENTRE | VIDEO/AUDIO | FANZONE | ATHLETES | DEVELOPMENT | ABOUT

Latest News | Press Releases | Newsletters | IAAF Magazine | Focus on Athletes

Monday, 02 March 2009

## Otto and Maresova notch jump victories in Dessau

Dessau, Germany - Björn Otto of Germany and Czech Oldriska Maresova took their events at the 8th Jumpers' Meeting in Dessau on Sunday (01) afternoon in front of about 1,500 spectators.

The winning heights were not quite what organisers and fans had hoped for. Otto took the Pole Vault with 5.60m and Maresova cleared 1.89m in the High Jump. But there were some very good attempts at greater heights, though none were ultimately successful. While the winners have not qualified for the upcoming European Indoor Championships they are both targeting the World Championships in Berlin this summer.

Bjorn Otto of Germany in action in the Men's Pole Vault Final (Getty Images)

**Men's Pole Vault -**

5.60m proved to be the decisive height in Dessau's Anhalt Indoor Arena. While there were eight athletes still in contention only two were left when the bar was lifted to 5.70m: Otto, who had cleared the crucial height of 5.60m at his second attempt in convincing style, was in the lead while Russia's Viktor Chistiakov had passed this height after clearing 5.50m with plenty of room above the bar.

Tobias Scherbarth, who had convinced throughout the indoor season with the exception of the vital qualifier at the German indoors last week, was one of those who had promising attempts at 5.60m, but finally had to settle for third with 5.50m. Lars Börgeling also almost cleared 5.60m, but had to settle for fourth with 5.40m. After the dramatic competition at the German indoors in Leipzig eight days earlier it became obvious that the national pole vaulters lacked some tension.

RELATED CONTENT

Not so Otto, who had very good first and third attempts at 5.70m – a height which he had not cleared this winter. Together with his 5.60m jump these three jumps had looked as in his best times two years ago, when Otto had won a silver medal at the European Indoors. This time in Turin he will not be able to compete.

"But my indoor season gives me confidence regarding the summer, when I want to be back in peak form and qualify for the World Championships," Otto said. "It was good to see that it was getting better and better during this indoor season. It was important to get confidence back after my Achilles tendon operation last year."

**Women's High Jump -**

Three women were left in competition when 1.89m had to be cleared: Maresova had cleared all her other heights of 1.75 m, 1.80m and 1.85m at her first attempts. Germany's Aileen Herrmann and Bulgaria's Mirela Demireva had not been that convincing, but managed to jump 1.85m at their final attempts. But for Herrmann and Demireva 1.89m was too high on Sunday. Demireva settled for third and Herrmann took second while Maresova did clear 1.89m at her third attempt.

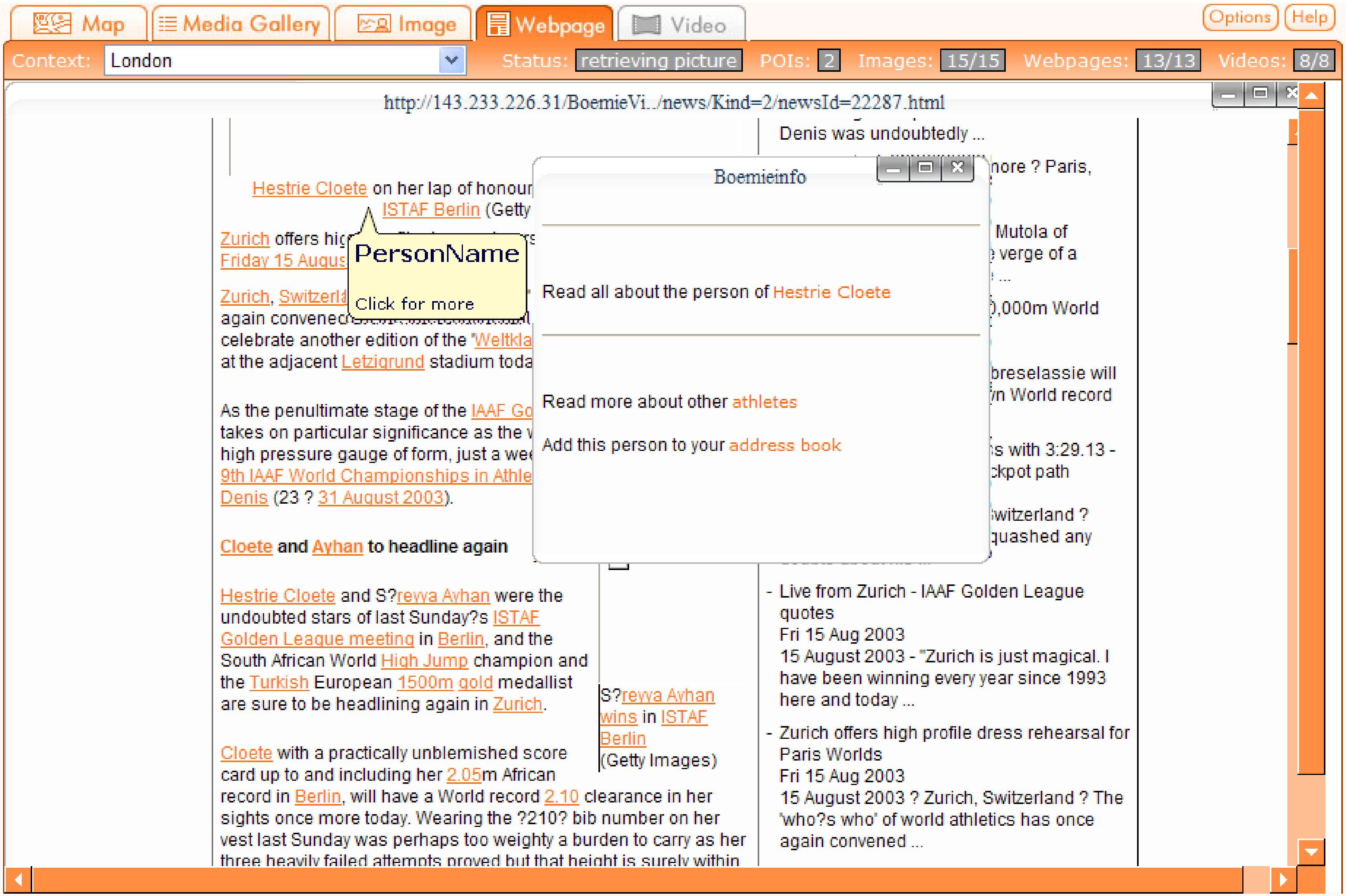
The 22-year-old Czech from Prague then went on for 1.92m, which would have been a personal best. So far she had jumped 1.90m this indoor season in Brno. Particularly her third attempt at 1.92m was a very good one and she was a bit unlucky that the bar came down.

"It was very close today," said Maresova, who will resume her indoor season with two national meetings in mid March. While she has not managed to qualify for Turin Maresova is optimistic concerning Berlin.

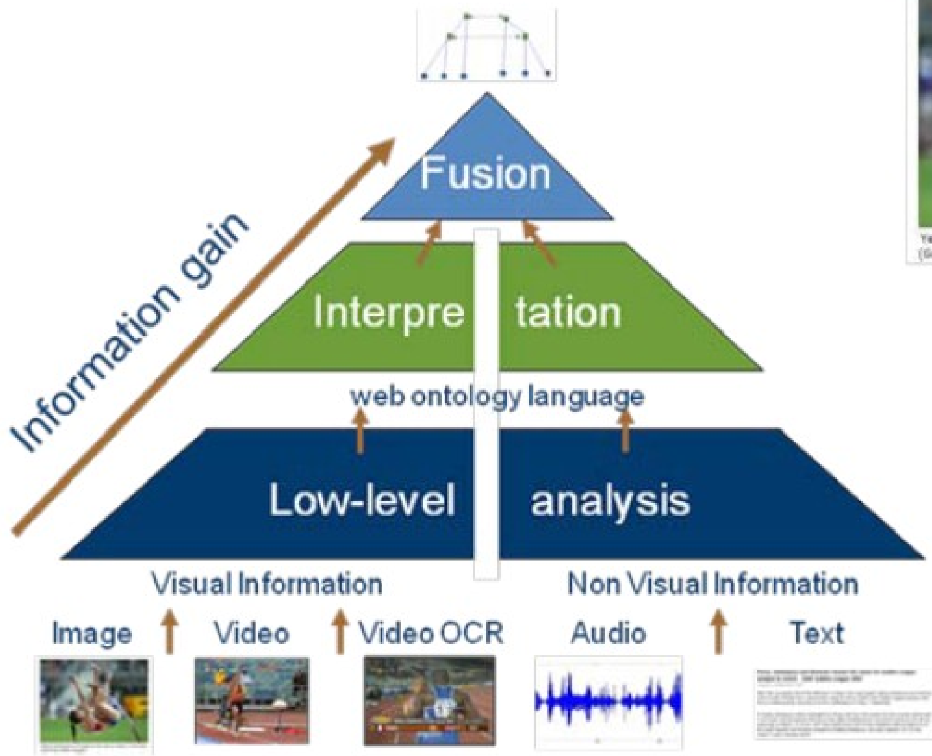
Fertig

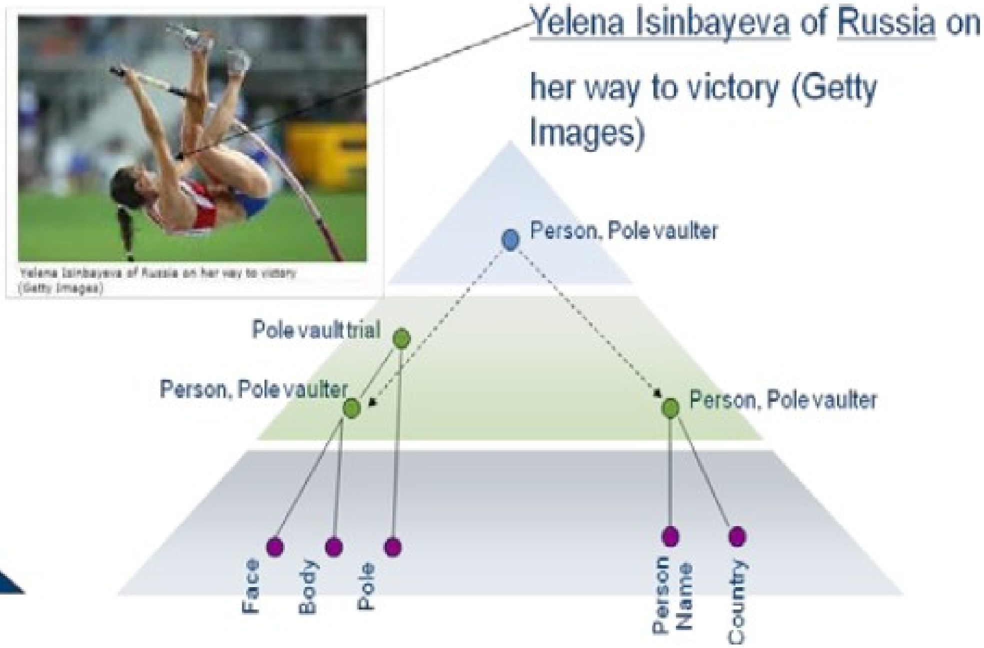
Similar to OpenCalais,
but with deeper and
athletics-domain specific
interpretation capabilities, e.g.
can hypothesize complex
Sports events from parts
By combining „clues“
from different modalities
(→ ontology-based abduction
mechanism!)

# BOEMIE Project – Text Modality



# BOEMIE Project

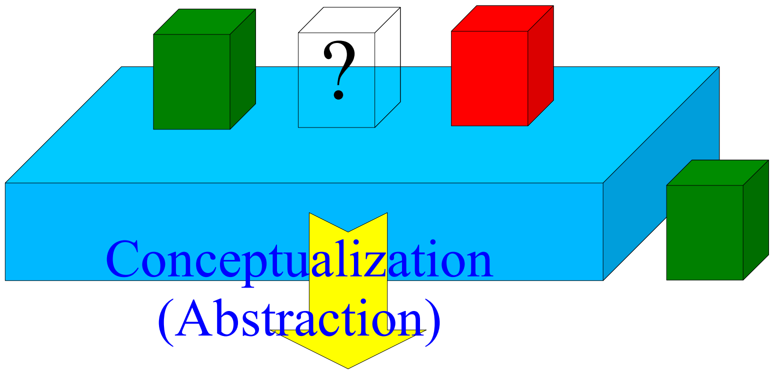


# Conclusion

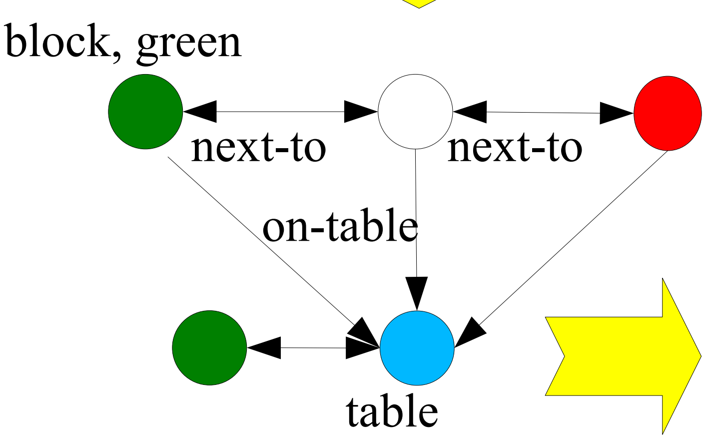
- I have demonstrated
  - RacerPro & RacerPorter
    - Standard reasoning
    - ABox query answering
    - Solving application problems with reasoning
    - Convenient & flexible ad hoc extensibility
  - AllegroGraph & Gruff
    - SPARQL query answering (Prolog also possible)
    - Visualization
    - RDFS++ query answering
    - „Type and inferred property materialization“ via RacerPro
- Thanks

# Abox Query Answering

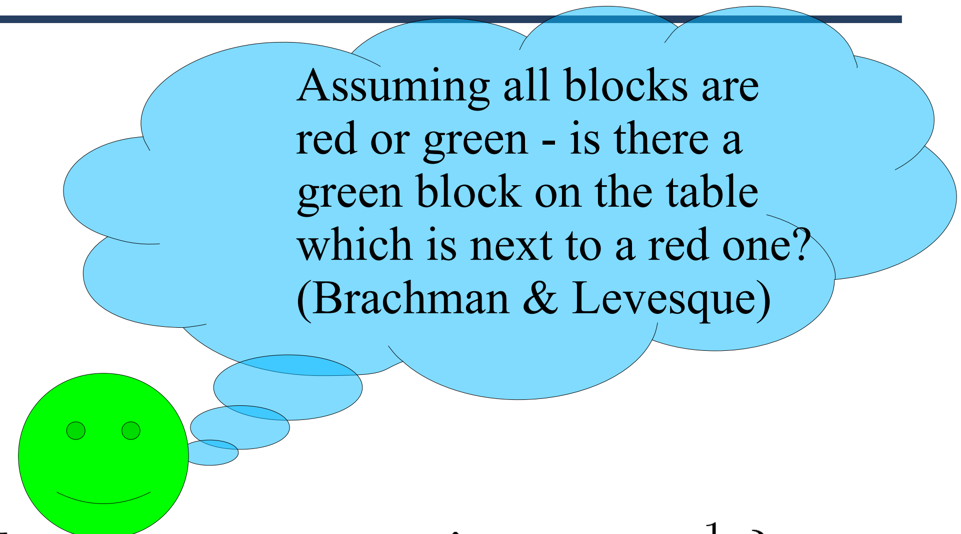



on-table, next-to, block, green, red, ...

Formalization




Problem Solving



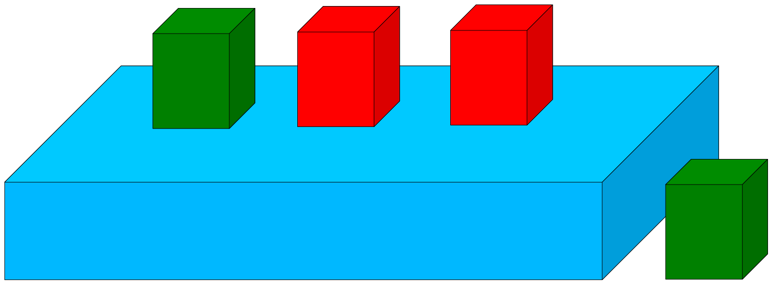

$$\{ \; block \dot{\sqsubseteq} red \sqcup green, next\_to \doteq next\_to^{-1} \; \}$$

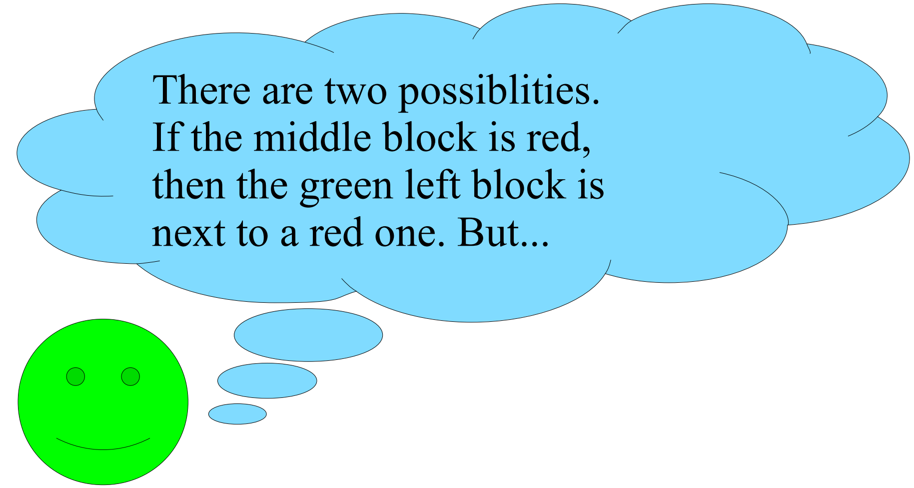
$$\begin{aligned}\{ \;\; & t : table, lb : green \sqcap block, rb : red \sqcap block, \\ & mb : block, ob : green \sqcap block, \\ & (lb, t) : on\_table, (ml, t) : on\_table, (rb, t) : on\_table, \\ & (gb, ob) : next\_to, (ob, rb) : next\_to \; \}\end{aligned}$$

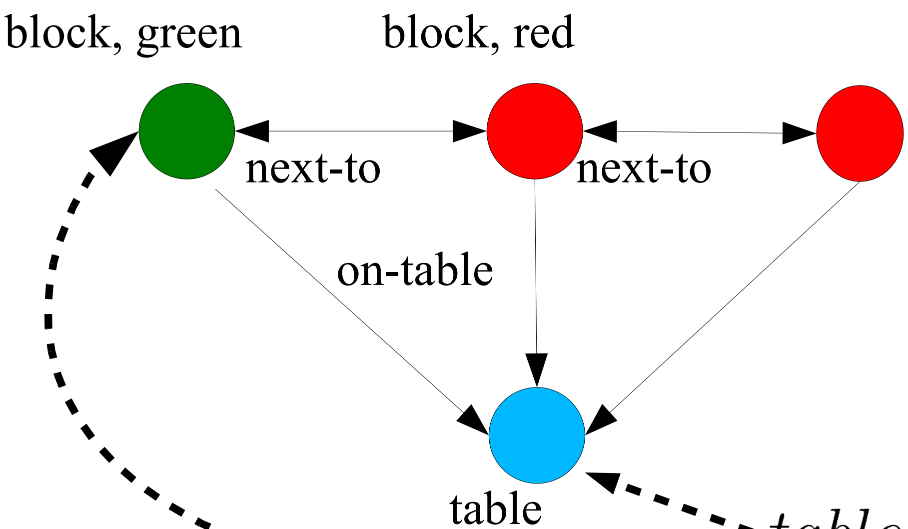
Ask for instances of the concept

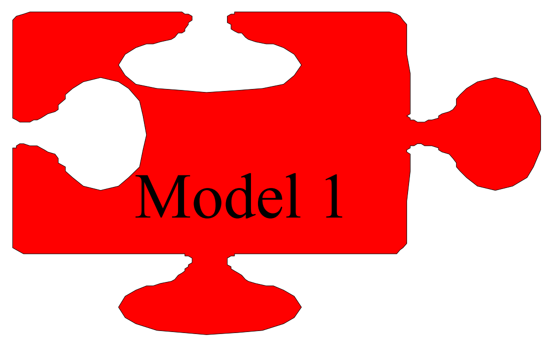
$$\begin{aligned} & table \sqcap \\ & \exists on\_table^{-1}. \; (block \sqcap green \sqcap \\ & \qquad\qquad\qquad \exists next\_to.(red \sqcap block))\end{aligned}$$

# Abox Query Answering (2)



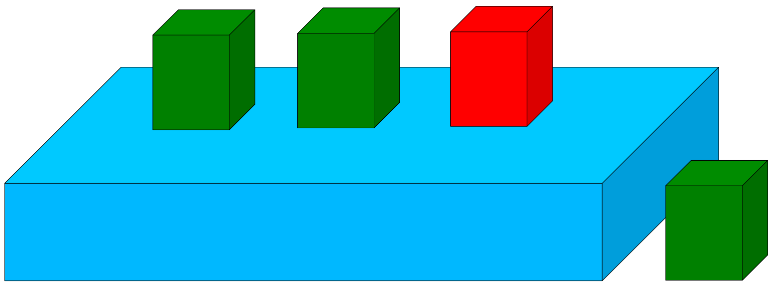


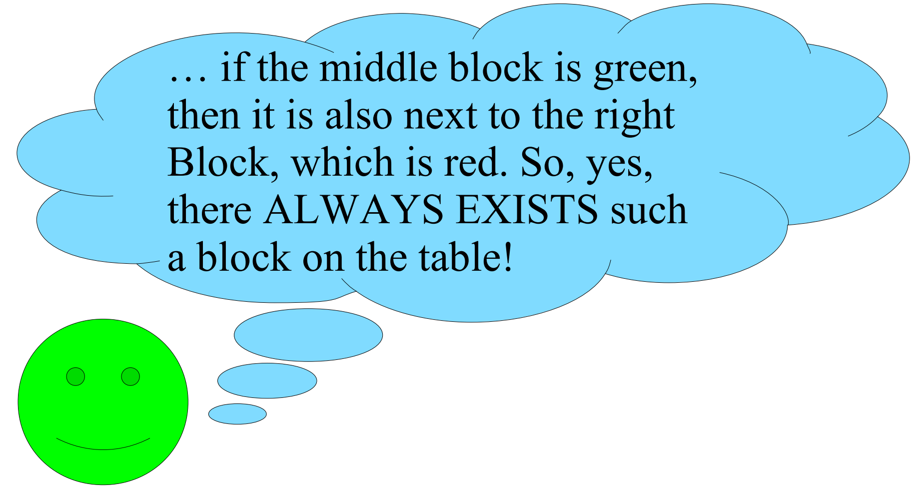



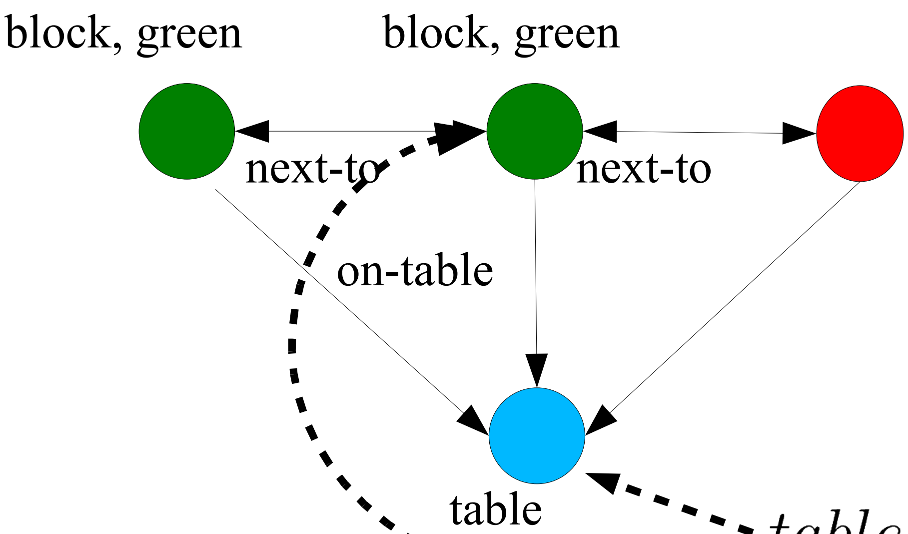



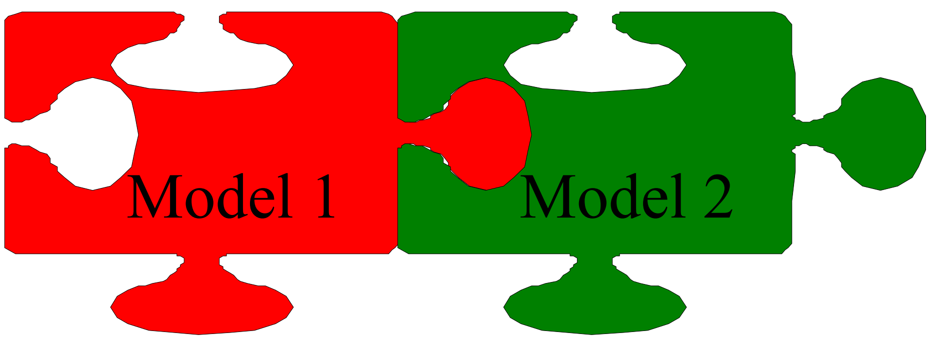

$$table \sqcap \exists on\_table^{-1}.\ (block \sqcap green \sqcap \exists next\_to.(red \sqcap block))$$

# Abox Query Answering (3)



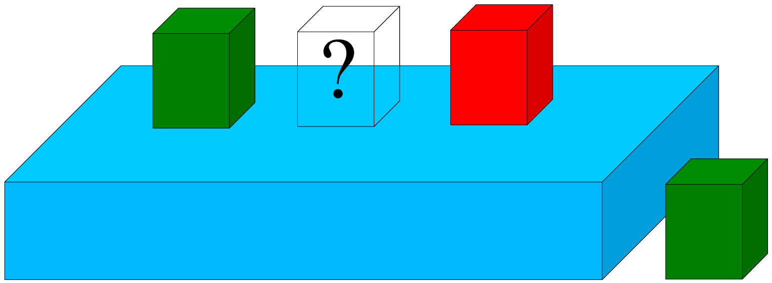



$$table \sqcap \exists on\_table^{-1}.\ (block \sqcap green \sqcap \exists next\_to.(red \sqcap block))$$

# Full Conjunctive Queries

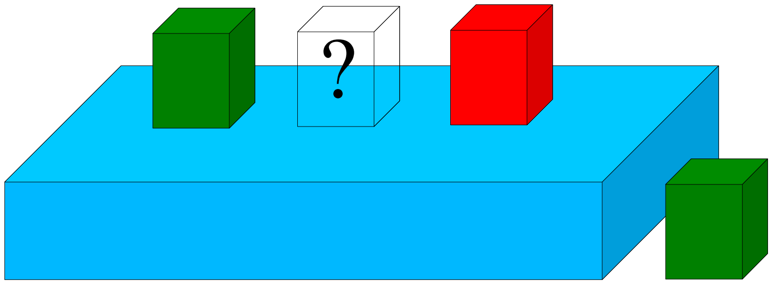



$$\begin{aligned} ans(x) \leftarrow \quad & table(x), on\_table(y,x), \\ & block(y), green(y), \\ & next\_to(y,z), red(z), block(z). \end{aligned}$$

Answer: $x = t$

- However, no answer for head $ans(y) \leftarrow \ldots$
  - distinguished variables in head: binding must hold in ALL models („certain answer“)
  - other variables: treated as existentially quantified

# Grounded Conjunctive Queries

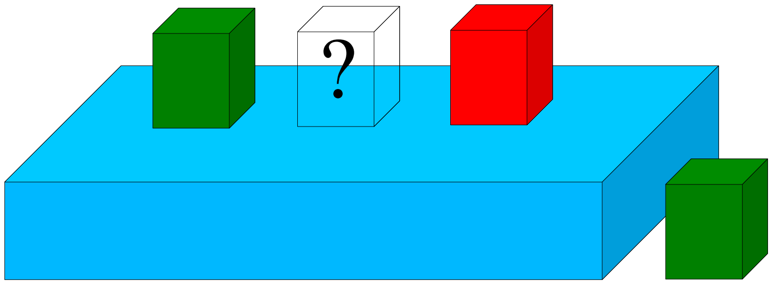



$$\begin{aligned} ans(x) \leftarrow \quad & table(x), on\_table(y,x), \\ & block(y), green(y), \\ & next\_to(y,z), red(z), block(z). \end{aligned}$$

Gives no answer in nRQL!

- In grounded conjunctive queries
  - ALL variables are distinguished; a binding is only established iff it holds in ALL models
  - grounding: subst. variables $\leftrightarrow$ entailed assertions

# Grounded CQs vs. Full CQs




$$ans(x) \leftarrow \quad (table \sqcap \exists on\_table^{-1}.\ldots)(x)$$

In this example, a complex concept can be used. But that's not always the case

- „Rolling up“ technique
  - note that variables may introduce coreferences
  - no automatic rolling up in nRQL
  - newer results for full conjunctive queries and OWL available, but not implemented AFAIK