Querying the Semantic Web with SWRL

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Protégé-OWL

- Widely-used development environment for working with OWL ontologies
- Popular, open source, active mailing list, frequent new releases
- Extensible: many third party plugins developed for it

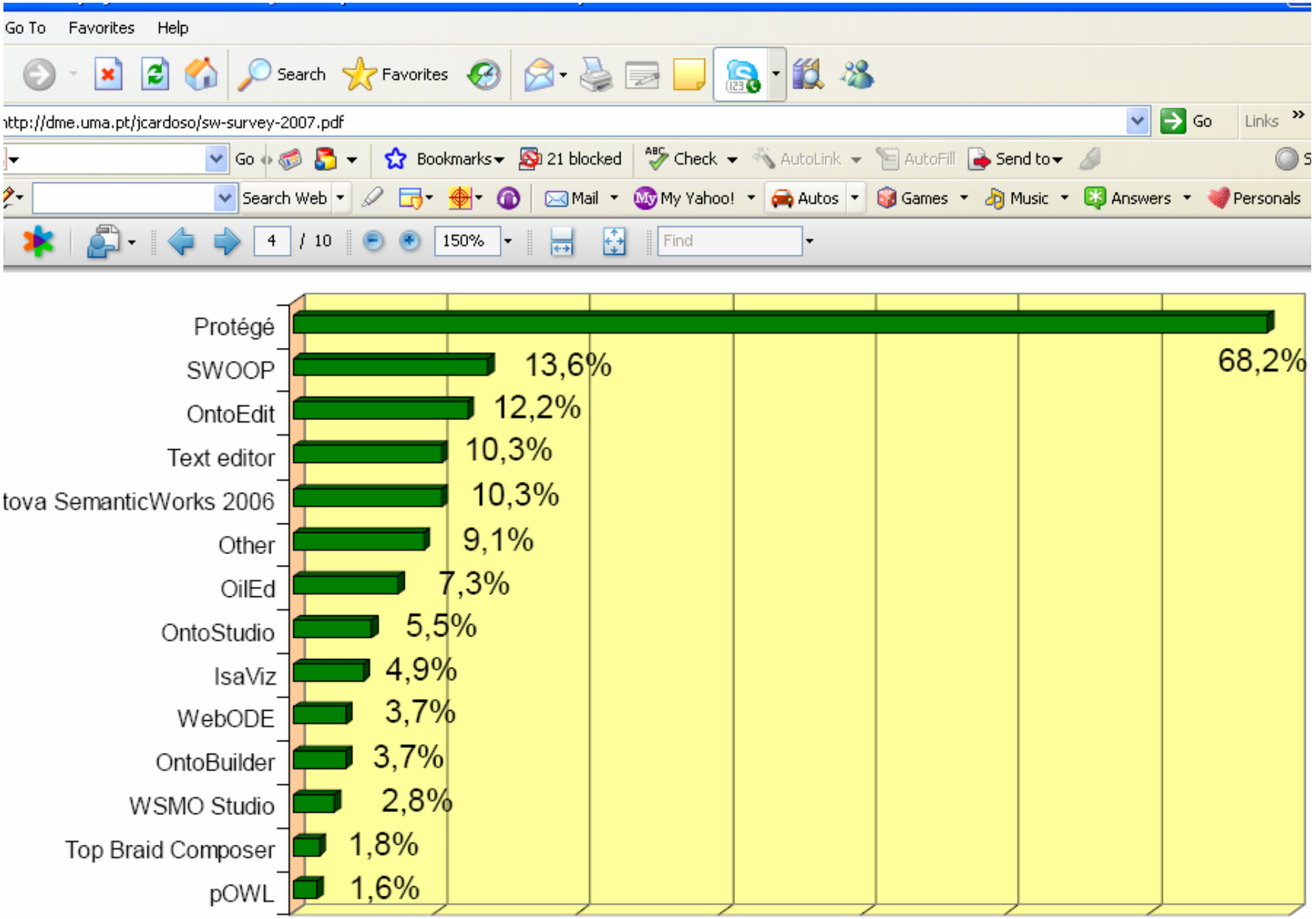
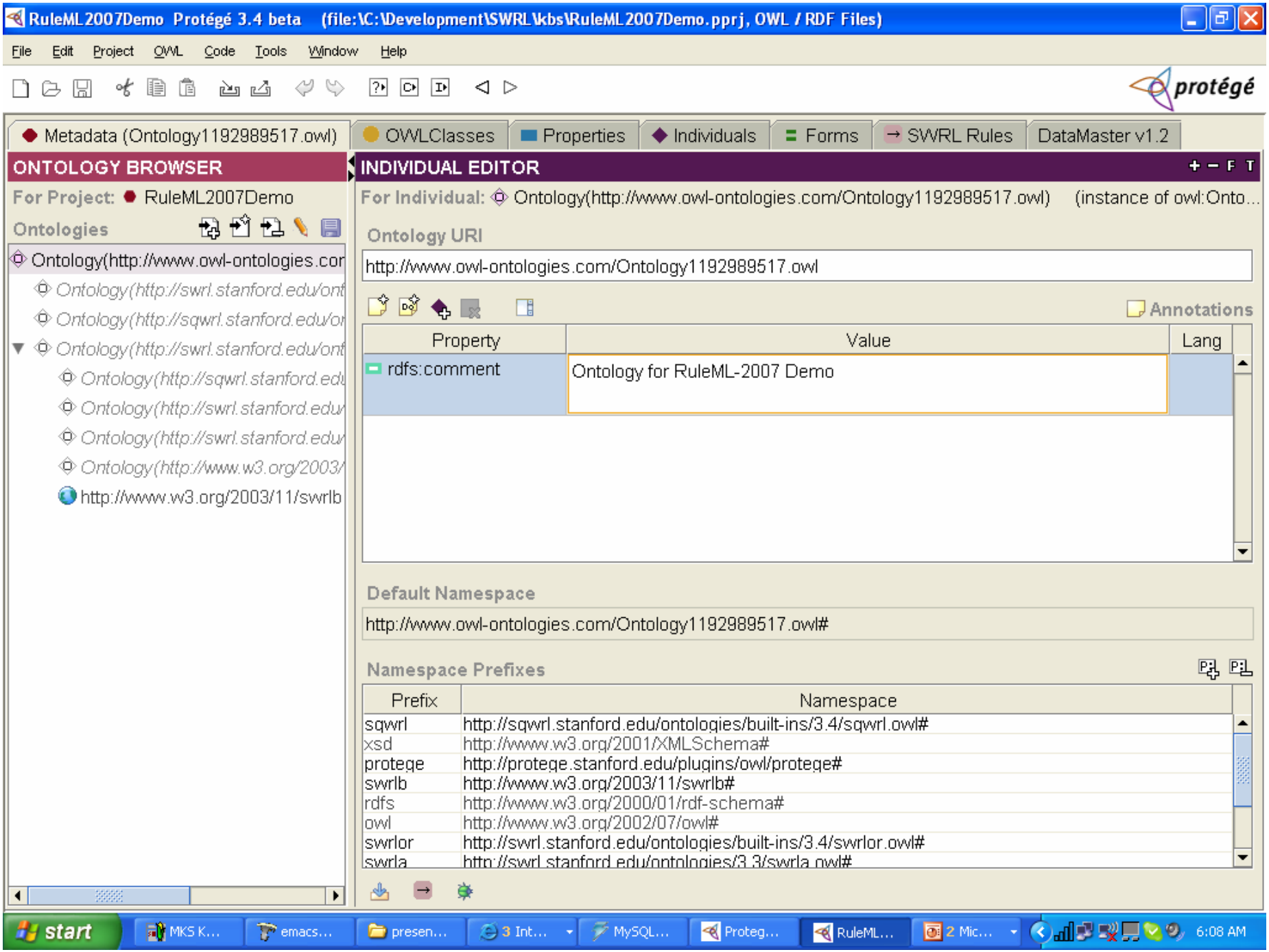


Figure 4. Respondents' use of ontology editors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File Edit Project OWL Code Tools Window Help
protégé
Metadata (Ontology1192989517.owl)
OWLClasses
Properties
Individuals
Forms
SWRL Rules
DataMaster v1.2
ONTOLOGY BROWSER
For Project: RuleML2007Demo
Ontologies
Ontology(http://www.owl-ontologies.com
Ontology(http://swrl.stanford.edu/ont
Ontology(http://sqwrl.stanford.edu/or
Ontology(http://swrl.stanford.edu/ont
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Ontology(http://swrl.stanford.edu/
Ontology(http://swrl.stanford.edu/
Ontology(http://www.w3.org/2003/
http://www.w3.org/2003/11/swrlb
INDIVIDUAL EDITOR
For Individual: Ontology(http://www.owl-ontologies.com/Ontology1192989517.owl) (instance of owl:Onto...
Ontology URI
http://www.owl-ontologies.com/Ontology1192989517.owl
Annotations
Property
Value
Lang
rdfs:comment
Ontology for RuleML-2007 Demo
Default Namespace
http://www.owl-ontologies.com/Ontology1192989517.owl#
Namespace Prefixes
Prefix
Namespace
sqwrl http://sqwrl.stanford.edu/ontologies/built-ins/3.4/sqwrl.owl#
xsd http://www.w3.org/2001/XMLSchema#
protege http://protege.stanford.edu/plugins/owl/protege#
swrlb http://www.w3.org/2003/11/swrlb#
rdfs http://www.w3.org/2000/01/rdf-schema#
owl http://www.w3.org/2002/07/owl#
swrlor http://swrl.stanford.edu/ontologies/built-ins/3.4/swrlor.owl#
swrla http://swrl.stanford.edu/ontologies/3.3/swrla.owl#
start
MKS K...
emacs...
presen...
3 Int...
MySQL...
Proteg...
RuleML...
2 Mic...
6:08 AM

What is SWRL?

- SWRL is an acronym for Semantic Web Rule Language.
- SWRL is intended to be the rule language of the Semantic Web.
- SWRL includes a high-level abstract syntax for Horn-like rules.
- All rules are expressed in terms of OWL concepts (classes, properties, individuals).

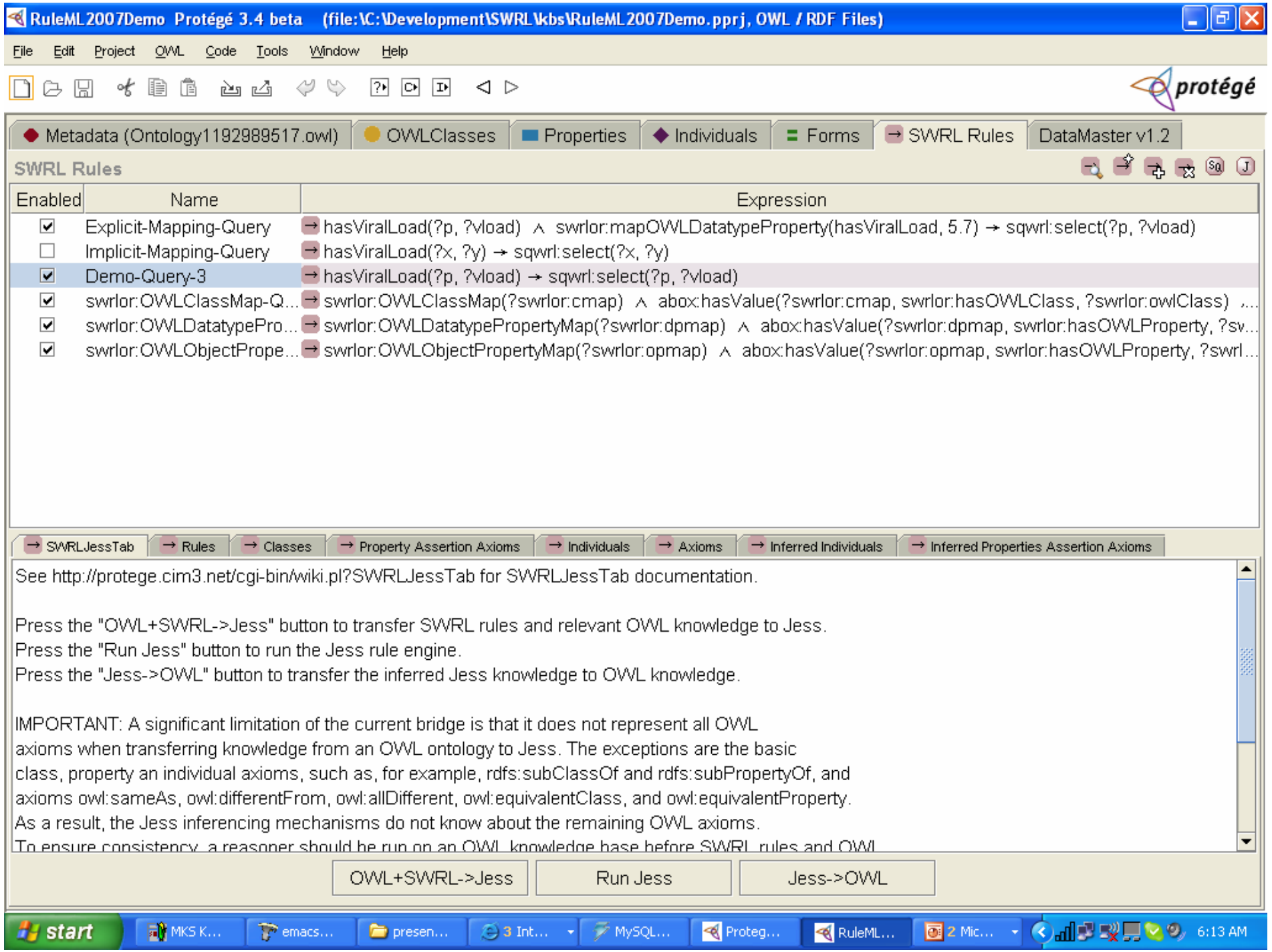
Example SWRL Rule: is adult?

Person(?p) ^ hasAge(?p,?age) ^
swrlb:greaterThan(?age,17)

→ Adult(?p)

SWRLTab

- A Protégé-OWL development environment for working with SWRL rules
- Supports editing and execution of rules
- Extension mechanisms to work with third-party rule engines
- Mechanisms for users to define built-in method libraries
- Supports querying of ontologies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Forms
SWRL Rules
DataMaster v1.2
SWRL Rules
Enabled
Name
Expression
Explicit-Mapping-Query
hasViralLoad(?p, ?vload) ∧ swrlor:mapOWLDatatypeProperty(hasViralLoad, 5.7) → sqwrl:select(?p, ?vload)
Implicit-Mapping-Query
hasViralLoad(?x, ?y) → sqwrl:select(?x, ?y)
Demo-Query-3
hasViralLoad(?p, ?vload) → sqwrl:select(?p, ?vload)
swrlor:OWLClassMap-Q...
swrlor:OWLClassMap(?swrlor:cmap) ∧ abox:hasValue(?swrlor:cmap, swrlor:hasOWLClass, ?swrlor:owlClass) ...
swrlor:OWLDatatypePro...
swrlor:OWLDatatypePropertyMap(?swrlor:dpmap) ∧ abox:hasValue(?swrlor:dpmap, swrlor:hasOWLProperty, ?sv...
swrlor:OWLObjectPrope...
swrlor:OWLObjectPropertyMap(?swrlor:opmap) ∧ abox:hasValue(?swrlor:opmap, swrlor:hasOWLProperty, ?swrl...
SWRLJessTab
Rules
Classes
Property Assertion Axioms
Individuals
Axioms
Inferred Individuals
Inferred Properties Assertion Axioms
See http://protege.cim3.net/cgi-bin/wiki.pl?SWRLJessTab for SWRLJessTab documentation.
Press the "OWL+SWRL->Jess" button to transfer SWRL rules and relevant OWL knowledge to Jess.
Press the "Run Jess" button to run the Jess rule engine.
Press the "Jess->OWL" button to transfer the inferred Jess knowledge to OWL knowledge.
IMPORTANT: A significant limitation of the current bridge is that it does not represent all OWL
axioms when transferring knowledge from an OWL ontology to Jess. The exceptions are the basic
class, property an individual axioms, such as, for example, rdfs:subClassOf and rdfs:subPropertyOf, and
axioms owl:sameAs, owl:differentFrom, owl:allDifferent, owl:equivalentClass, and owl:equivalentProperty.
As a result, the Jess inferencing mechanisms do not know about the remaining OWL axioms.
To ensure consistency, a reasoner should be run on an OWL knowledge base before SWRL rules and OWL
OWL+SWRL->Jess
Run Jess
Jess->OWL
start
MKS K...
emacs...
presen...
3 Int...
MySQL...
Proteg...
RuleML...
2 Mic...
6:13 AM

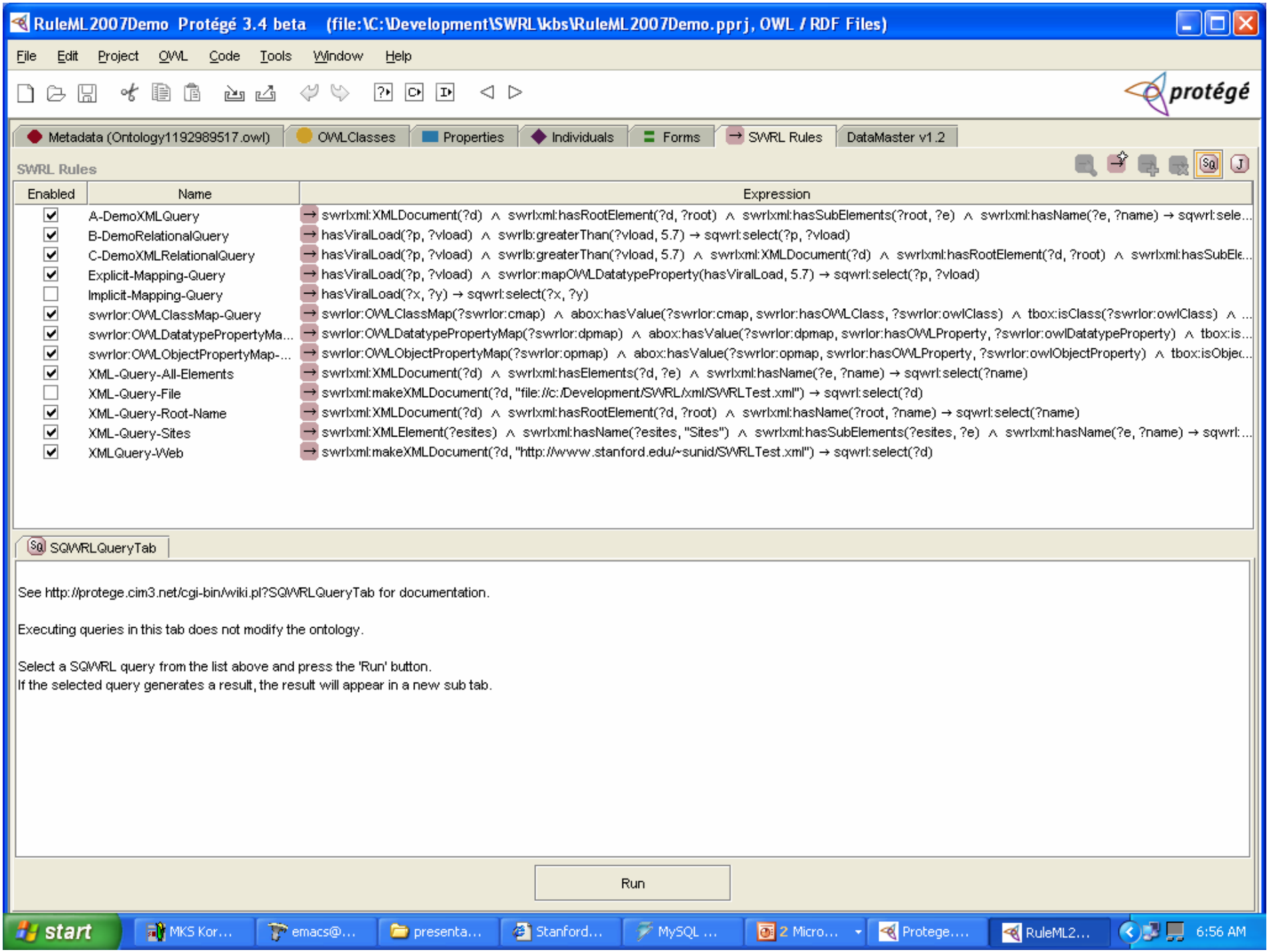
SWRL and Querying: SQWRL

- SWRL is a rule language, not a query language
- However, a rule antecedent can be viewed as a pattern matching specification, i.e., a query
- With built-ins, language compliant query extensions are possible.
- We have developed a SWRL-based query language called SQWRL

A SQWRL Query

Return all adults in an ontology ordered by age:

Person(?p) ^ hasAge(?p, ?age) ^
swrlb:greaterThan(?age, 17) -> sqwrl:select(?p)
^ sqwrl:orderBy(?age)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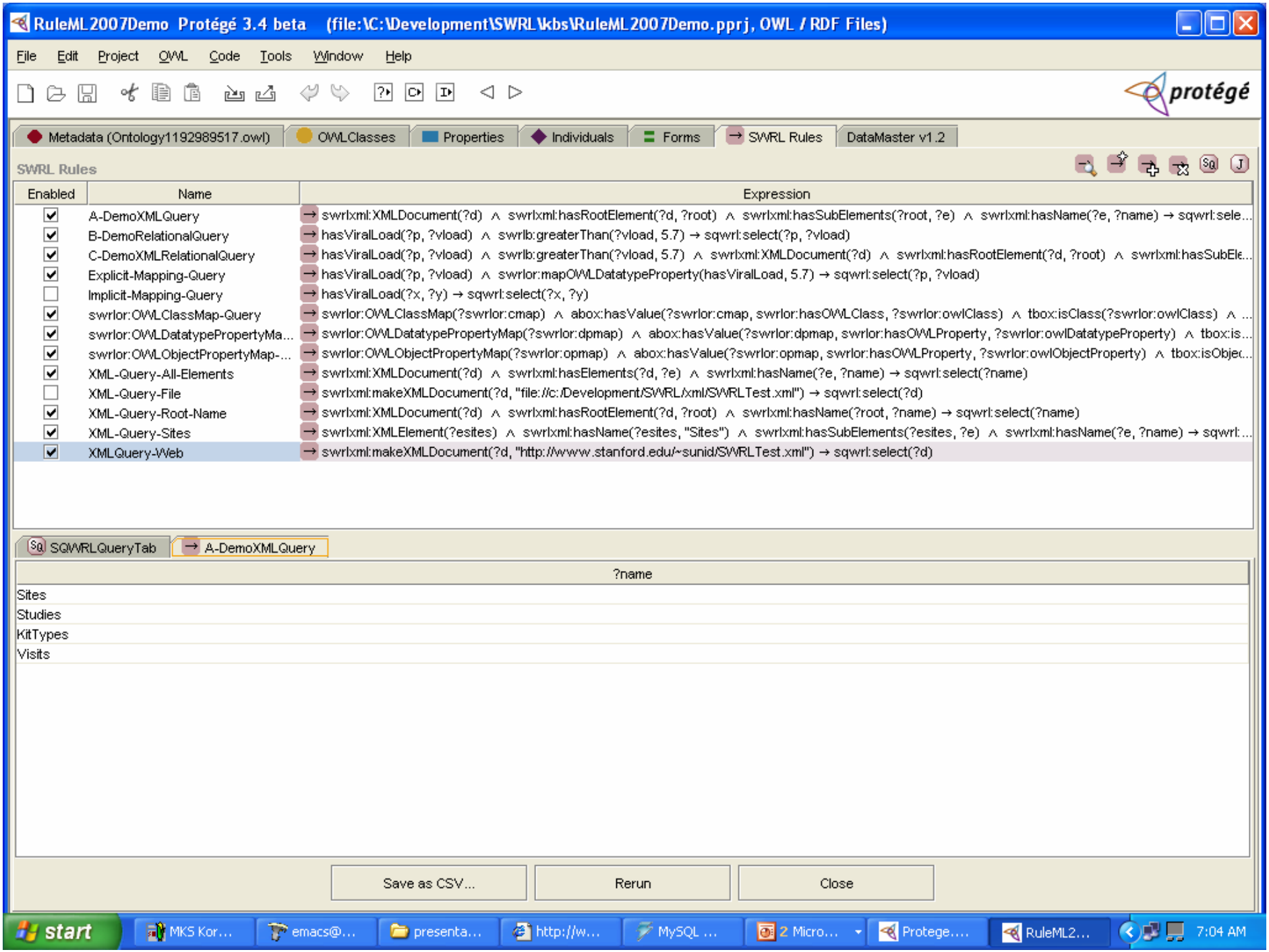
SWRL Rules
Enabled Name Expression
A-DemoXMLQuery swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasSubElements(?root, ?e) ∧ swrlxml:hasName(?e, ?name) → sqwrl:sele...
B-DemoRelationalQuery hasViralLoad(?p, ?vload) ∧ swrlb:greaterThan(?vload, 5.7) → sqwrl:select(?p, ?vload)
C-DemoXMLRelationalQuery hasViralLoad(?p, ?vload) ∧ swrlb:greaterThan(?vload, 5.7) ∧ swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasSubEle...
Explicit-Mapping-Query hasViralLoad(?p, ?vload) ∧ swrlor:mapOWLDatatypeProperty(hasViralLoad, 5.7) → sqwrl:select(?p, ?vload)
Implicit-Mapping-Query hasViralLoad(?x, ?y) → sqwrl:select(?x, ?y)
swrlor:OWLClassMap-Query swrlor:OWLClassMap(?swrlor:cmap) ∧ abox:hasValue(?swrlor:cmap, swrlor:hasOWLClass, ?swrlor:owlClass) ∧ tbox:isClass(?swrlor:owlClass) ∧ ...
swrlor:OWLDatatypePropertyMa... swrlor:OWLDatatypePropertyMap(?swrlor:dpmap) ∧ abox:hasValue(?swrlor:dpmap, swrlor:hasOWLProperty, ?swrlor:owlDatatypeProperty) ∧ tbox:is...
swrlor:OWLObjectPropertyMap-... swrlor:OWLObjectPropertyMap(?swrlor:opmap) ∧ abox:hasValue(?swrlor:opmap, swrlor:hasOWLProperty, ?swrlor:owlObjectProperty) ∧ tbox:isObjec...
XML-Query-All-Elements swrlxml:XMLDocument(?d) ∧ swrlxml:hasElements(?d, ?e) ∧ swrlxml:hasName(?e, ?name) → sqwrl:select(?name)
XML-Query-File swrlxml:makeXMLDocument(?d, "file:/c:/Development/SWRL/xml/SWRLTest.xml") → sqwrl:select(?d)
XML-Query-Root-Name swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasName(?root, ?name) → sqwrl:select(?name)
XML-Query-Sites swrlxml:XMLElement(?esites) ∧ swrlxml:hasName(?esites, "Sites") ∧ swrlxml:hasSubElements(?esites, ?e) ∧ swrlxml:hasName(?e, ?name) → sqwrl:...
XMLQuery-Web swrlxml:makeXMLDocument(?d, "http://www.stanford.edu/~sunid/SWRLTest.xml") → sqwrl:select(?d)
SQWRLQueryTab
See http://protege.cim3.net/cgi-bin/wiki.pl?SQWRLQueryTab for documentation.
Executing queries in this tab does not modify the ontology.
Select a SQWRL query from the list above and press the 'Run' button.
If the selected query generates a result, the result will appear in a new sub tab.
Run
start
MKS Kor...
emacs@...
presenta...
Stanford...
MySQL ...
2 Micro...
Protege....
RuleML2...
6:56 AM

SWRLTab: http://protege.cim3.net/cgi-bin/wiki.pl?SWRLTab

Querying XML

- XML built-in library: http://protege.cim3.net/cgi-bin/wiki.pl?SWRLTabXMLBuiltIns
- Example built-in URL specification:

  swrlxml:makeXMLDocument(?d, "http://www.stanford.edu/~sunid/SWRLTest.xml")
- Can query web and file based XML documents using SQWRL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B-DemoRelationalQuery hasViralLoad(?p, ?vload) ∧ swrlb:greaterThan(?vload, 5.7) → sqwrl:select(?p, ?vload)
C-DemoXMLRelationalQuery hasViralLoad(?p, ?vload) ∧ swrlb:greaterThan(?vload, 5.7) ∧ swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasSubEle...
Explicit-Mapping-Query hasViralLoad(?p, ?vload) ∧ swrlor:mapOWLDatatypeProperty(hasViralLoad, 5.7) → sqwrl:select(?p, ?vload)
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swrlor:OWLClassMap-Query swrlor:OWLClassMap(?swrlor:cmap) ∧ abox:hasValue(?swrlor:cmap, swrlor:hasOWLClass, ?swrlor:owlClass) ∧ tbox:isClass(?swrlor:owlClass) ∧ ...
swrlor:OWLDatatypePropertyMa... swrlor:OWLDatatypePropertyMap(?swrlor:dpmap) ∧ abox:hasValue(?swrlor:dpmap, swrlor:hasOWLProperty, ?swrlor:owlDatatypeProperty) ∧ tbox:is...
swrlor:OWLObjectPropertyMap-... swrlor:OWLObjectPropertyMap(?swrlor:opmap) ∧ abox:hasValue(?swrlor:opmap, swrlor:hasOWLProperty, ?swrlor:owlObjectProperty) ∧ tbox:isObjec...
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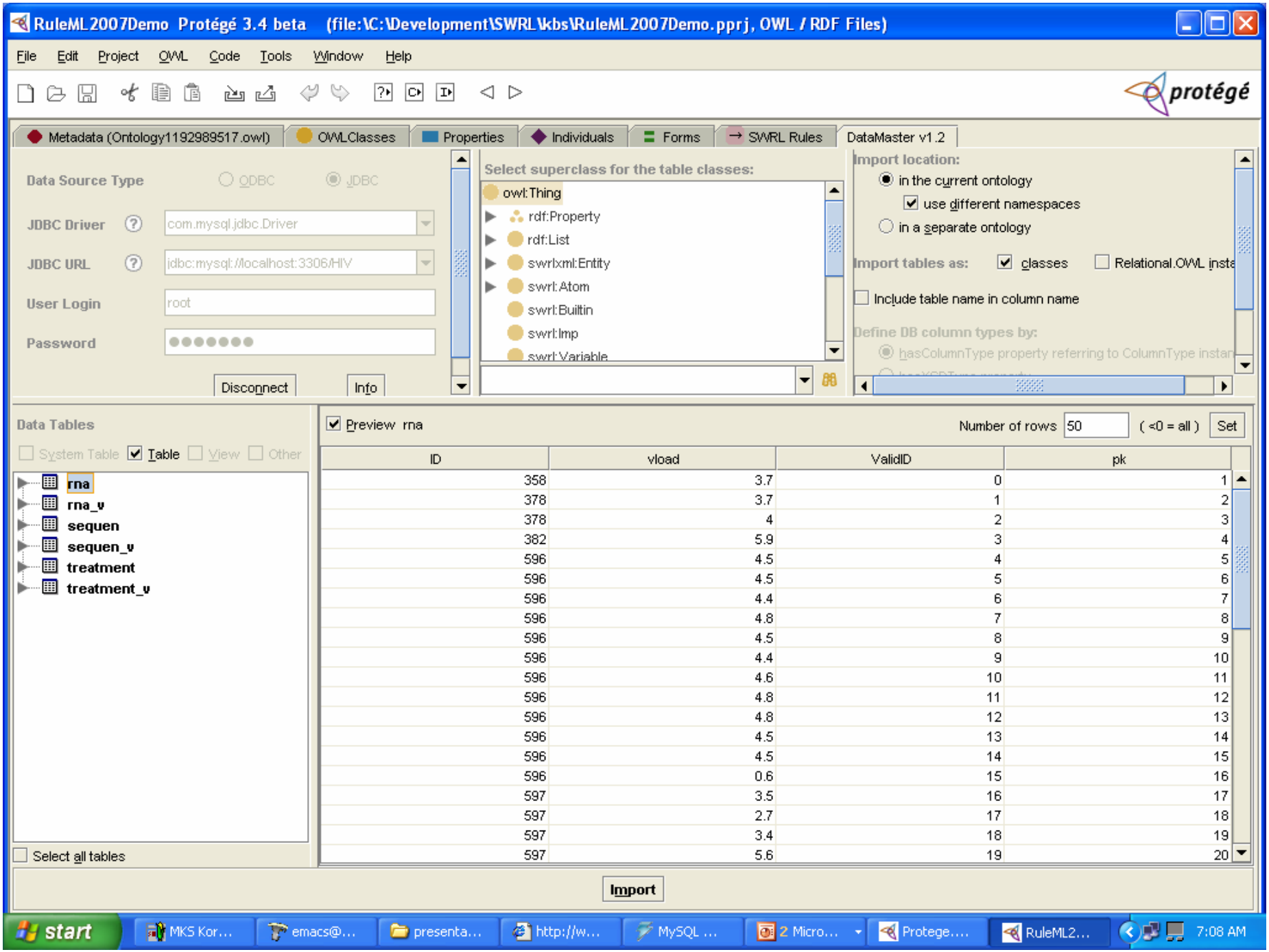
XML-Query-File swrlxml:makeXMLDocument(?d, "file://c:/Development/SWRL/xml/SWRLTest.xml") → sqwrl:select(?d)
XML-Query-Root-Name swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasName(?root, ?name) → sqwrl:select(?name)
XML-Query-Sites swrlxml:XMLElement(?esites) ∧ swrlxml:hasName(?esites, "Sites") ∧ swrlxml:hasSubElements(?esites, ?e) ∧ swrlxml:hasName(?e, ?name) → sqwrl:...
XMLQuery-Web swrlxml:makeXMLDocument(?d, "http://www.stanford.edu/~sunid/SWRLTest.xml") → sqwrl:select(?d)
SQWRLQueryTab A-DemoXMLQuery
?name
Sites
Studies
KitTypes
Visits
Save as CSV... Rerun Close
start MKS Kor... emacs@... presenta... http://w... MySQL ... 2 Micro... Protege.... RuleML2... 7:04 AM

DataMaster

- Imports schema or content of relational databases into Protégé-OWL
- Uses JDBC/ODBC so supports: MySQL, SQL Server, Oracle etc.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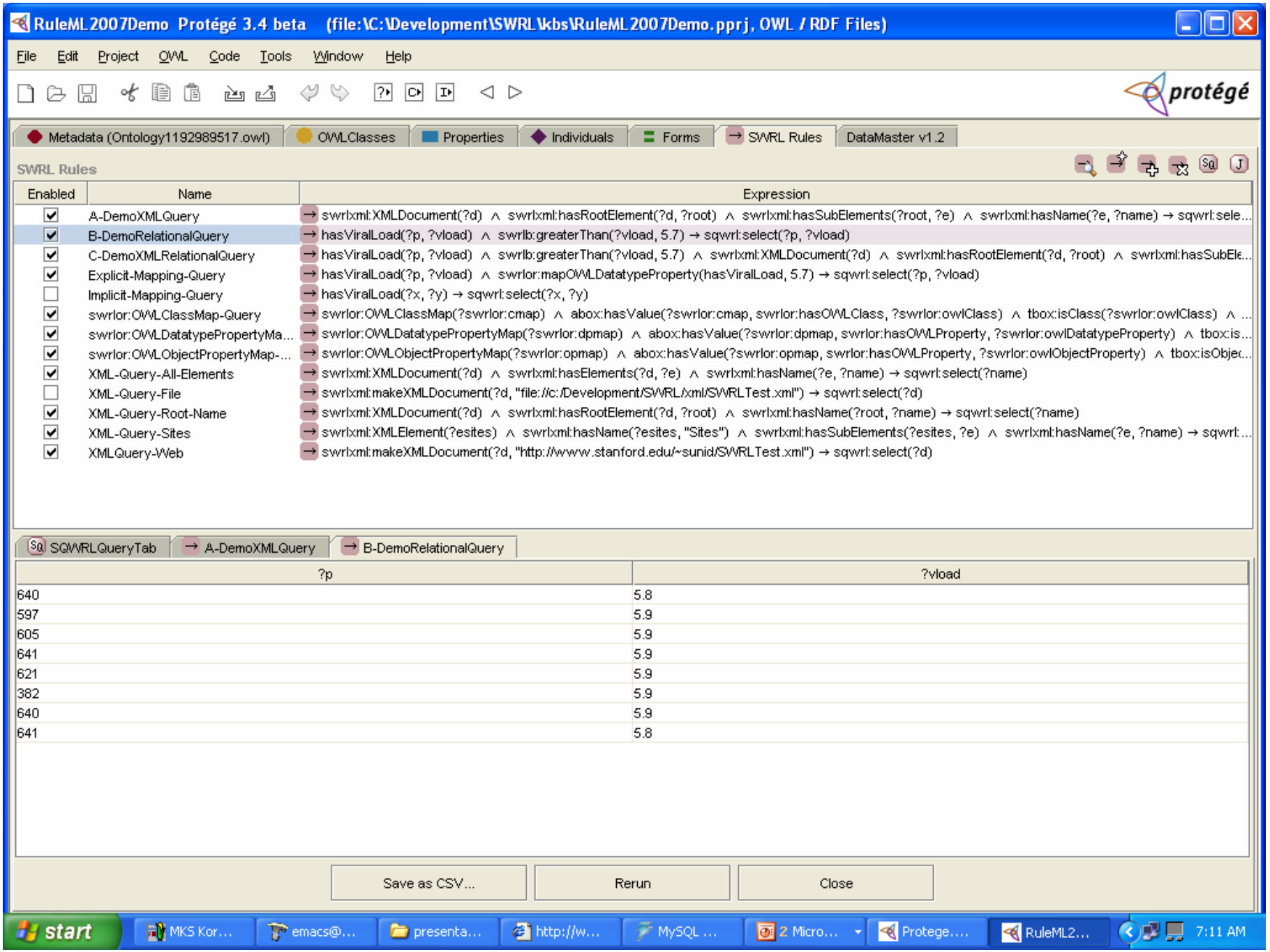
protégé
Metadata (Ontology1192989517.owl) OWLClasses Properties Individuals Forms SWRL Rules DataMaster v1.2
Data Source Type ODBC JDBC
JDBC Driver com.mysql.jdbc.Driver
JDBC URL jdbc:mysql://localhost:3306/HIV
User Login root
Password
Disconnect Info
Select superclass for the table classes:
owl:Thing
rdf:Property
rdf:List
swrlxml:Entity
swrl:Atom
swrl:Builtin
swrl:Imp
swrl:Variable
Import location:
in the current ontology
use different namespaces
in a separate ontology
Import tables as: classes
Include table name in column name
Define DB column types by:
Data Tables
System Table Table View Other
rna
rna_v
sequen
sequen_v
treatment
treatment_v
Select all tables
Preview rna
Number of rows 50 (<0 = all) Set
ID vload ValidID pk
358 3.7 0 1
378 3.7 1 2
378 4 2 3
382 5.9 3 4
596 4.5 4 5
596 4.5 5 6
596 4.4 6 7
596 4.8 7 8
596 4.5 8 9
596 4.4 9 10
596 4.6 10 11
596 4.8 11 12
596 4.8 12 13
596 4.5 13 14
596 4.5 14 15
596 0.6 15 16
597 3.5 16 17
597 2.7 17 18
597 3.4 18 19
597 5.6 19 20
Import
start
MKS Kor...
emacs@...
presenta...
http://w...
MySQL ...
2 Micro...
Protege....
RuleML2...
7:08 AM

SWRLTab and Relational Data

- Can query data imported by DataMaster
- Dynamic querying also supported…
- One-the-fly querying of relational data
- Mapping ontology specifies link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B-DemoRelationalQuery hasViralLoad(?p, ?vload) ∧ swrlb:greaterThan(?vload, 5.7) → sqwrl:select(?p, ?vload)
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swrlor:OWLDatatypePropertyMa... swrlor:OWLDatatypePropertyMap(?swrlor:dpmap) ∧ abox:hasValue(?swrlor:dpmap, swrlor:hasOWLProperty, ?swrlor:owlDatatypeProperty) ∧ tbox:is...
swrlor:OWLObjectPropertyMap-... swrlor:OWLObjectPropertyMap(?swrlor:opmap) ∧ abox:hasValue(?swrlor:opmap, swrlor:hasOWLProperty, ?swrlor:owlObjectProperty) ∧ tbox:isObjec...
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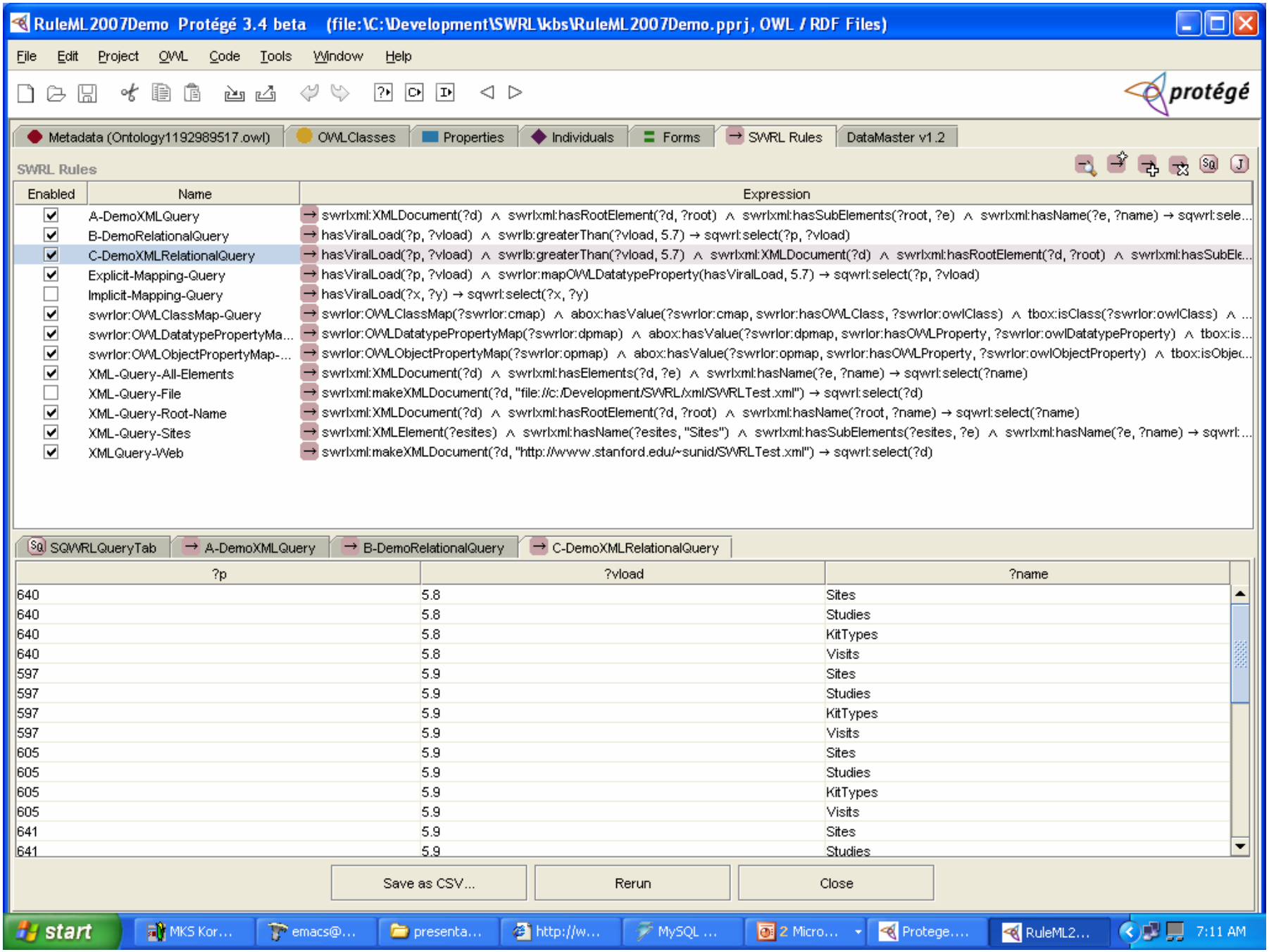
XMLQuery-Web swrlxml:makeXMLDocument(?d, "http://www.stanford.edu/~sunid/SWRLTest.xml") → sqwrl:select(?d)
SQWRLQueryTab A-DemoXMLQuery B-DemoRelationalQuery
?p ?vload
640 5.8
597 5.9
605 5.9
641 5.9
621 5.9
382 5.9
640 5.9
641 5.8
Save as CSV... Rerun Close
start MKS Kor... emacs@... presenta... http://w... MySQL ... 2 Micro... Protege.... RuleML2... 7:11 AM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swrlor:OWLObjectPropertyMap-... swrlor:OWLObjectPropertyMap(?swrlor:opmap) ∧ abox:hasValue(?swrlor:opmap, swrlor:hasOWLProperty, ?swrlor:owlObjectProperty) ∧ tbox:isObjec...
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XML-Query-Root-Name swrlxml:XMLDocument(?d) ∧ swrlxml:hasRootElement(?d, ?root) ∧ swrlxml:hasName(?root, ?name) → sqwrl:select(?name)
XML-Query-Sites swrlxml:XMLElement(?esites) ∧ swrlxml:hasName(?esites, "Sites") ∧ swrlxml:hasSubElements(?esites, ?e) ∧ swrlxml:hasName(?e, ?name) → sqwrl:...
XMLQuery-Web swrlxml:makeXMLDocument(?d, "http://www.stanford.edu/~sunid/SWRLTest.xml") → sqwrl:select(?d)
SQWRLQueryTab A-DemoXMLQuery B-DemoRelationalQuery C-DemoXMLRelationalQuery
?p ?vload ?name
640 5.8 Sites
640 5.8 Studies
640 5.8 KitTypes
640 5.8 Visits
597 5.9 Sites
597 5.9 Studies
597 5.9 KitTypes
597 5.9 Visits
605 5.9 Sites
605 5.9 Studies
605 5.9 KitTypes
605 5.9 Visits
641 5.9 Sites
641 5.9 Studies
Save as CSV... Rerun Close
start MKS Kor... emacs@... presenta... http://w... MySQL ... 2 Micro... Protege.... RuleML2... 7:11 AM

Software Availability

- Free, open source; download at: protégé.stanford.edu
- SWRLTab, Datamaster: v3.31
- SQWRL, XML querying: V3.4 beta
- Dynamic relational querying: 1 month
- Extensive documentation: http://protege.cim3.net/cgi-bin/wiki.pl?SWRLTab