Building Applications with Protégé: An Overview

Protégé Conference

July 23, 2006

Outline

- Protégé and Databases
- Protégé Application Designs
  - API Application Designs
  - Web Application Designs

- Higher-Level Access to Protégé Knowledge Bases
  - Reasoning Systems (Algernon, Jess)
  - Scripting Language Interfaces
  - Problem Solving Methods (PSMs)

What does Protégé do?

Answer: Nothing!

Protégé is a tool.

Allows you to create a model and collect information.

Similar to, and just a useless as, a database.

What you probably want is an application that does something useful…

How is Protégé different from a database?

- Emphasis on *model* vs. *data*
  - Protege: Model is equal or more interest as data
  - Database: Data is important, model is secondary

- Emphasis on *expressiveness* over *performance*
  - Protege: Richer modeling language
    - inheritance relationships
    - constraint “overriding”
    - expressing “webs” of relationships
  - Database: Simpler modeling language, optimized for speed

The misleading question

Q: What can you do with technology X that you cannot do with related technology Y?
A: (Usually) nothing

Q: What can you do with Protégé that is impossible with a database?
A: Nothing

Q: What can you do with a database that is impossible with a file?
A: Nothing

Q: What can you do with Java that is impossible with assembly language?
A: Nothing

Phrasing the question as “possible vs. impossible” leads nowhere.

The real question

When is it *easier*, *clearer*, *more straightforward* to use X instead of Y?

Preferable to have *direct* rather than *simulated* support for desired features.

- Simulation reduces clarity and portability
- Some simulation may be necessary, but the less the better

Protégé might be better than a database when:

- Model consists of *rich* data, with many relationships that are often traversed.
- Requirements and application design are changing and not clearly specified.
  - Protege is a good exploratory and experimentation environment.
  - Quick iterations are possible between model, data, and application changes.

Oversimplified Answer:

- Simple, flat, fixed model, speed paramount -> Database
- Complex, network-like, changing model with concept hierarchies -> Protégé

It doesn’t have to be either/or

- Construct model in Protégé
- Initial implementations with Protégé
- Iterate until requirements/design is firm, initial data is input
- Generate database schema from Protégé model and populate database with Protégé instances

Application designs

- An application design that doesn’t work

- Applications designs that do work
  - API-level application designs
  - Web application designs

An application design that doesn't work

- Idea:
  1. Create Protégé project with database backend
  2. Create the classes and instances
  3. Access the database tables directly with other applications

- Database tables are designed and optimized to work with a particular application in mind.
  - The Protégé database table was designed with the Protégé application in mind
  - The Protégé database table was NOT designed with your application in mind

- Instead access the data though the Protégé API.

Protégé API applications

- Tab as an application
- Standalone application
- Model-based software engineering:
  - Using the *jsave* package
  - Using the automatic code generation command in Protégé-OWL

Protégé tab as an application

- Description
  - Create a custom tab plugin
  - Configure Protégé to just display your tab
- Pros
  - Simple
  - Possible reuse of Protégé's GUI components
  - Great for few users
  - Iteration (change of model, data, app) is very easy
- Cons
  - Protégé must be installed
  - Difficult to permanently disable standard functions
  - Stuck with Protégé menus, toolbar, etc
  - No security on underlying model and data
  - User really should know something about Protégé

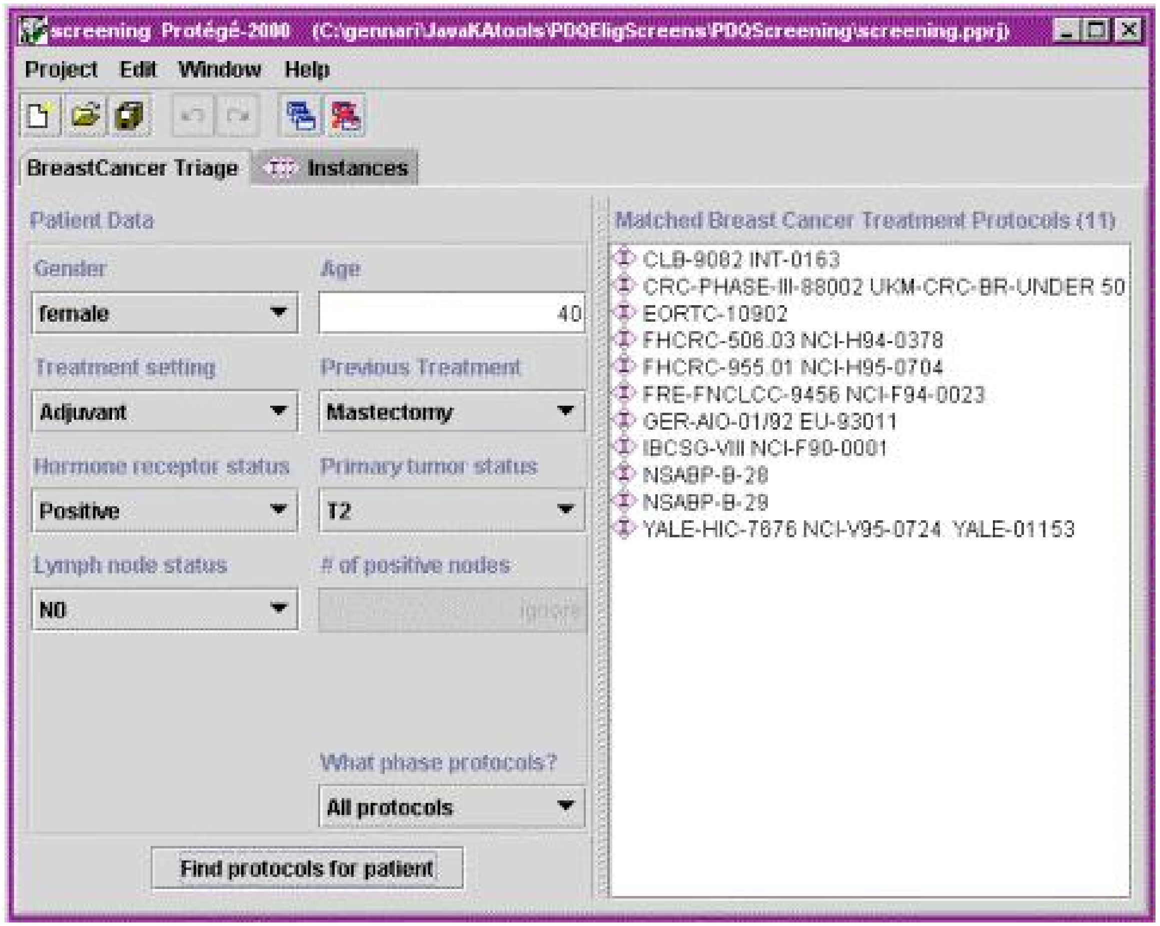
Example: Protocol-eligibility Screening Tab

Goal: Given a simple set of patient data, find potential matching clinical trial protocols.

Knowledge base: Eligibility criteria as listed in NCI's Physician Data Query database.

Method: Criteria are simplified and hand-coded into selection rules.

User interface: tab using Protégé's GUI components.


screening Protégé-2000 (C:\gennari\JavaKAtools\PDQEligScreens\PDQScreening\screening.pprj)

Project Edit Window Help

BreastCancer Triage | Instances

Patient Data

Gender: female	Age: 40
Treatment setting: Adjuvant	Previous Treatment: Mastectomy
Hormone receptor status: Positive	Primary tumor status: T2
Lymph node status: N0	# of positive nodes: ignore
	What phase protocols?: All protocols

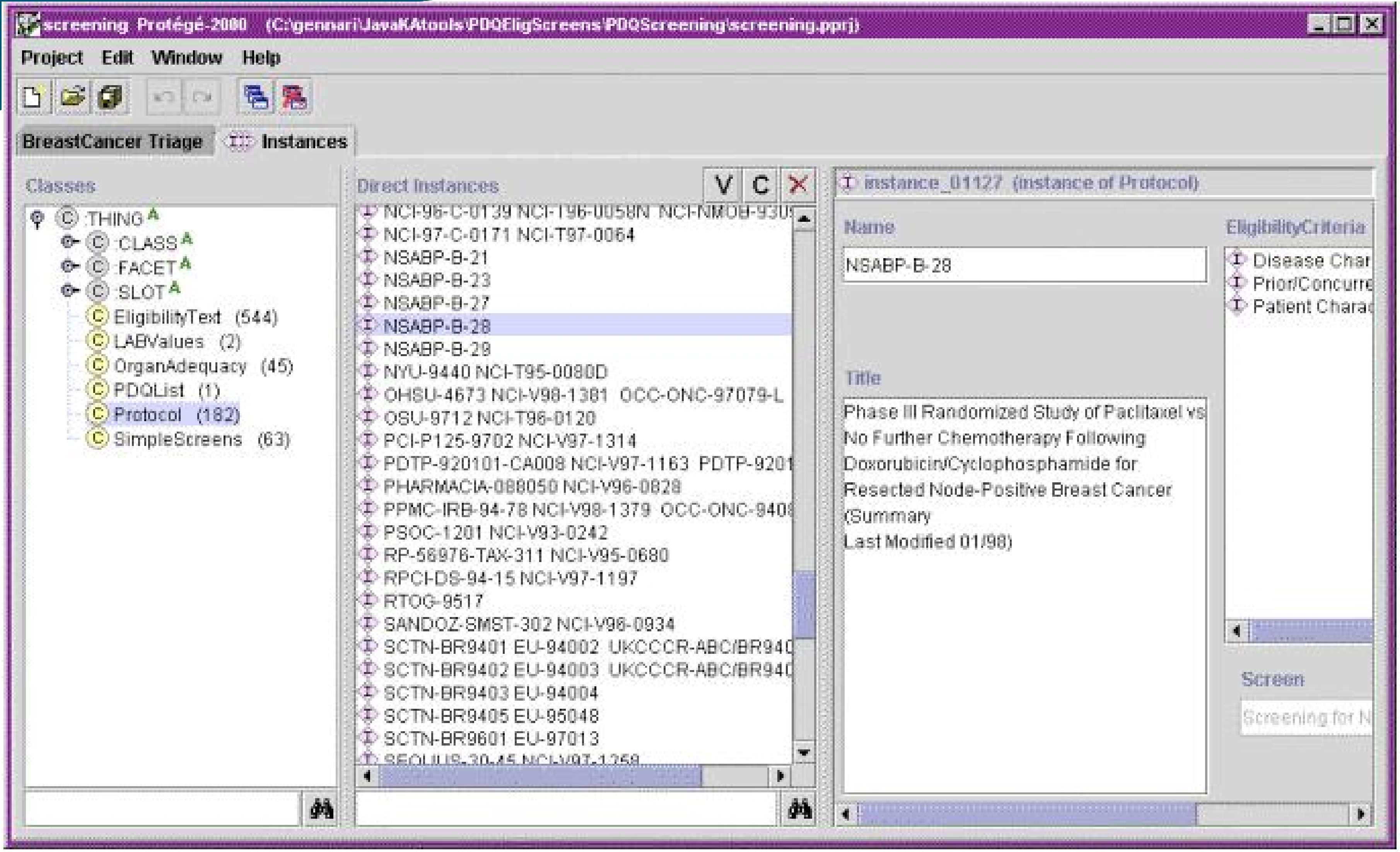
Find protocols for patient

Matched Breast Cancer Treatment Protocols (11)

- CLB-9082 INT-0163
- CRC-PHASE-III-88002 UKM-CRC-BR-UNDER 50
- EORTC-10902
- FHCRC-506.03 NCI-H94-0378
- FHCRC-955.01 NCI-H95-0704
- FRE-FNCLCC-9456 NCI-F94-0023
- GER-AIO-01/92 EU-93011
- IBCSG-VIII NCI-F90-0001
- NSABP-B-28
- NSABP-B-29
- YALE-HIC-7876 NCI-V95-0724 YALE-01153

http://faculty.washington.edu/gennari/Protege-plugins/EligScreeningTab/eligibility_screening_tab.html

Example: Eligibility Tab’s underlying ontology



screening Protégé-2000 (C:\gennari\JavaKAtools\PDQEligScreens\PDQScreening\screening.pprj)

THING
CLASS
FACET
SLOT
EligibilityText (544)
LABValues (2)
OrganAdequacy (45)
PDQList (1)
Protocol (182)
SimpleScreens (63)

NCI-96-C-0139 NCI-T96-0058N NCI-NMOB-930
NCI-97-C-0171 NCI-T97-0064
NSABP-B-21
NSABP-B-23
NSABP-B-27
NSABP-B-28
NSABP-B-29
NYU-9440 NCI-T95-0080D
OHSU-4673 NCI-V98-1381 OCC-ONC-97079-L
OSU-9712 NCI-T96-0120
PCI-P125-9702 NCI-V97-1314
PDTP-920101-CA008 NCI-V97-1163 PDTP-9201
PHARMACIA-088050 NCI-V96-0828
PPMC-IRB-94-78 NCI-V98-1379 OCC-ONC-940
PSOC-1201 NCI-V93-0242
RP-56976-TAX-311 NCI-V95-0680
RPCI-DS-94-15 NCI-V97-1197
RTOG-9517
SANDOZ-SMST-302 NCI-V96-0934
SCTN-BR9401 EU-94002 UKCCCR-ABC/BR940
SCTN-BR9402 EU-94003 UKCCCR-ABC/BR940
SCTN-BR9403 EU-94004
SCTN-BR9405 EU-95048
SCTN-BR9601 EU-97013
SEQUUS-30-45 NCI-V97-1258

instance_01127 (instance of Protocol)

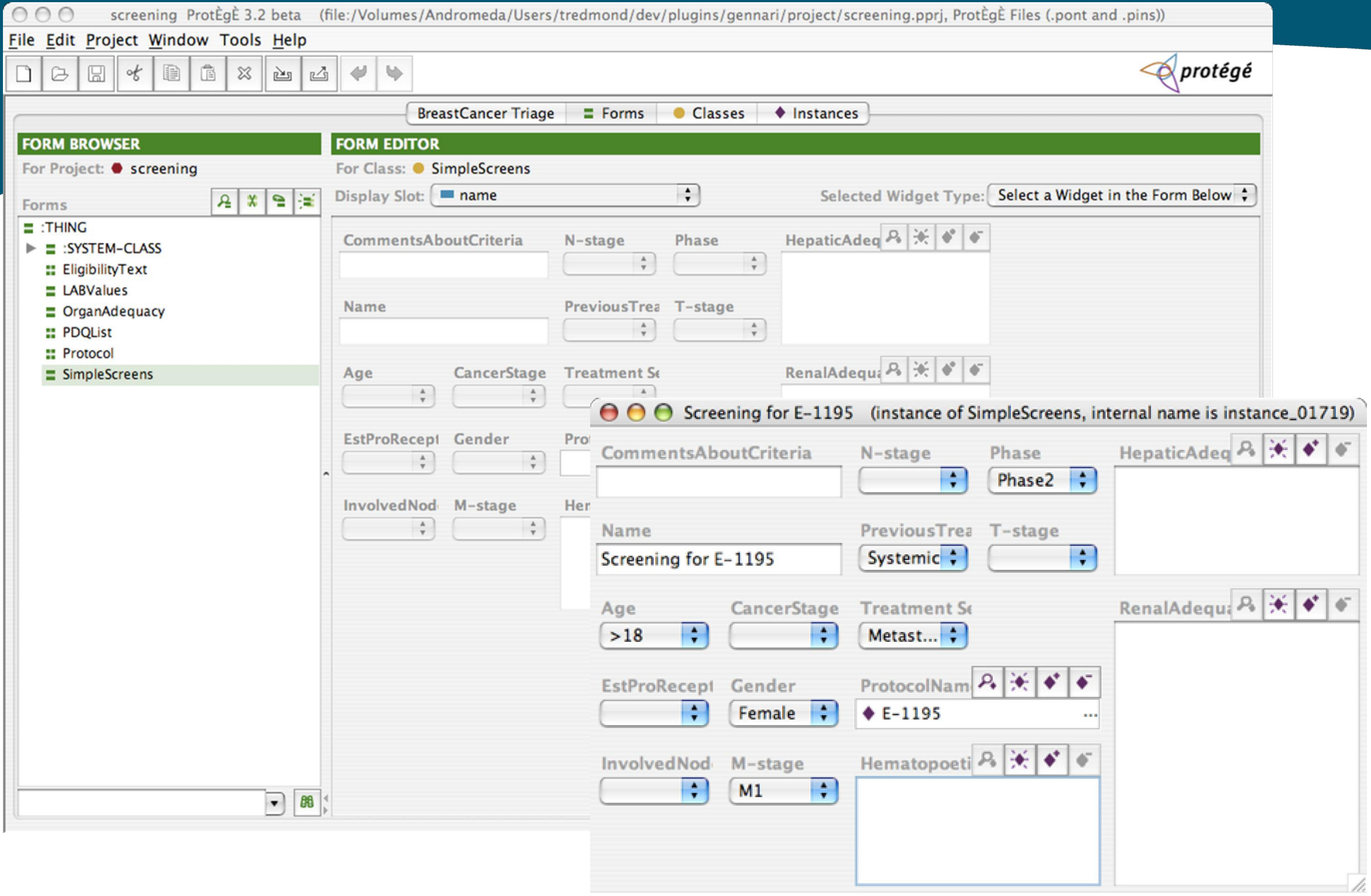
Name: NSABP-B-28

Title: Phase III Randomized Study of Paclitaxel vs No Further Chemotherapy Following Doxorubicin/Cyclophosphamide for Resected Node-Positive Breast Cancer (Summary Last Modified 01/98)

EligibilityCriteria:
Disease Char
Prior/Concurre
Patient Charac

Screen: Screening for N

Example: Eligibility Tab's use of forms



screening ProtÈgÈ 3.2 beta (file:/Volumes/Andromeda/Users/tredmond/dev/plugins/gennari/project/screening.pprj, ProtÈgÈ Files (.pont and .pins))

For Project: screening

For Class: SimpleScreens

Display Slot: name

Selected Widget Type: Select a Widget in the Form Below

Forms:
- :THING
- :SYSTEM-CLASS
- EligibilityText
- LABValues
- OrganAdequacy
- PDQList
- Protocol
- SimpleScreens

Screening for E-1195 (instance of SimpleScreens, internal name is instance_01719)

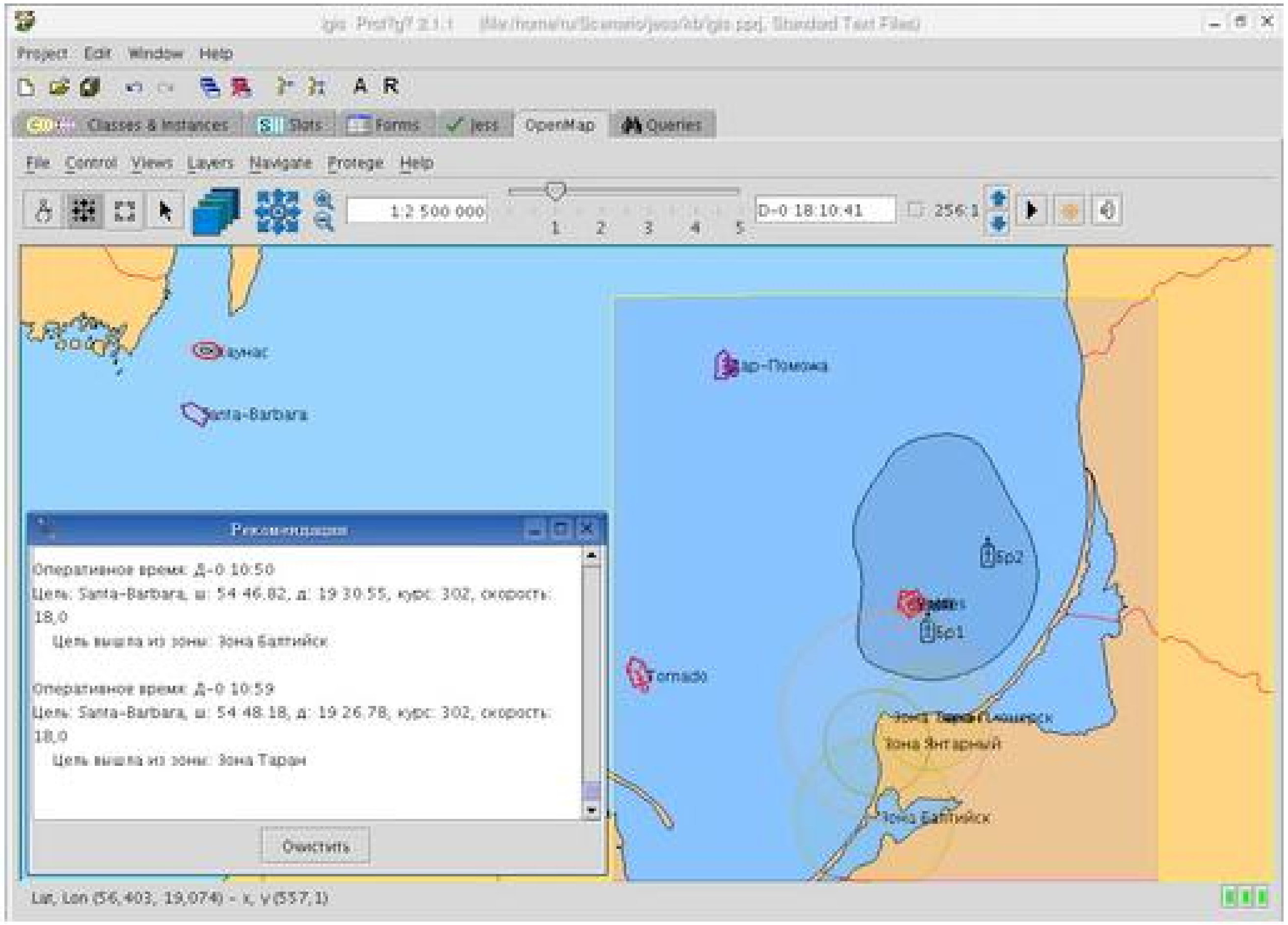
CommentsAboutCriteria:	N-stage:	Phase: Phase2	HepaticAdeq
Name: Screening for E-1195	PreviousTrea: Systemic	T-stage:	
Age: >18	CancerStage:	Treatment Se: Metast...	RenalAdequa
EstProRecept:	Gender: Female	ProtocolNam: E-1195	
InvolvedNod:	M-stage: M1	Hematopoeti	

Example: Intelligent Geographic System (The “OpenMap” tab)

Goal: study complex spatial processes by simulation and modeling.

Method: combination of various inferencing components (e.g. Jess-based)

User interface: entirely custom-tailored tab.



Оперативное время: Д-0 10:50
Цель: Santa-Barbara, ш: 54 46.82, д: 19 30.55, курс: 302, скорость: 18,0
Цель вышла из зоны: Зона Балтийск

Оперативное время: Д-0 10:59
Цель: Santa-Barbara, ш: 54 48.18, д: 19 26.78, курс: 302, скорость: 18,0
Цель вышла из зоны: Зона Таран

Lat, Lon (56,403, 19,074) - x, y (557,1)

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

Standalone application

- Description
  - Write standalone Java Application
  - Call into the Protégé API for knowledge base access
  - Often evolves from a Tab
  - Can be embedded as a Tab

swt1

- Pros
  - No need to install Protégé
  - User doesn’t need to know anything about Protégé
  - Underlying model and data are as secure as you want
  - Can use some or none of the Protégé UI, as desired
    - Forms for classes and instances are available
    - Some tabs will work
- Cons
  - Iteration somewhat more difficult than as Tab

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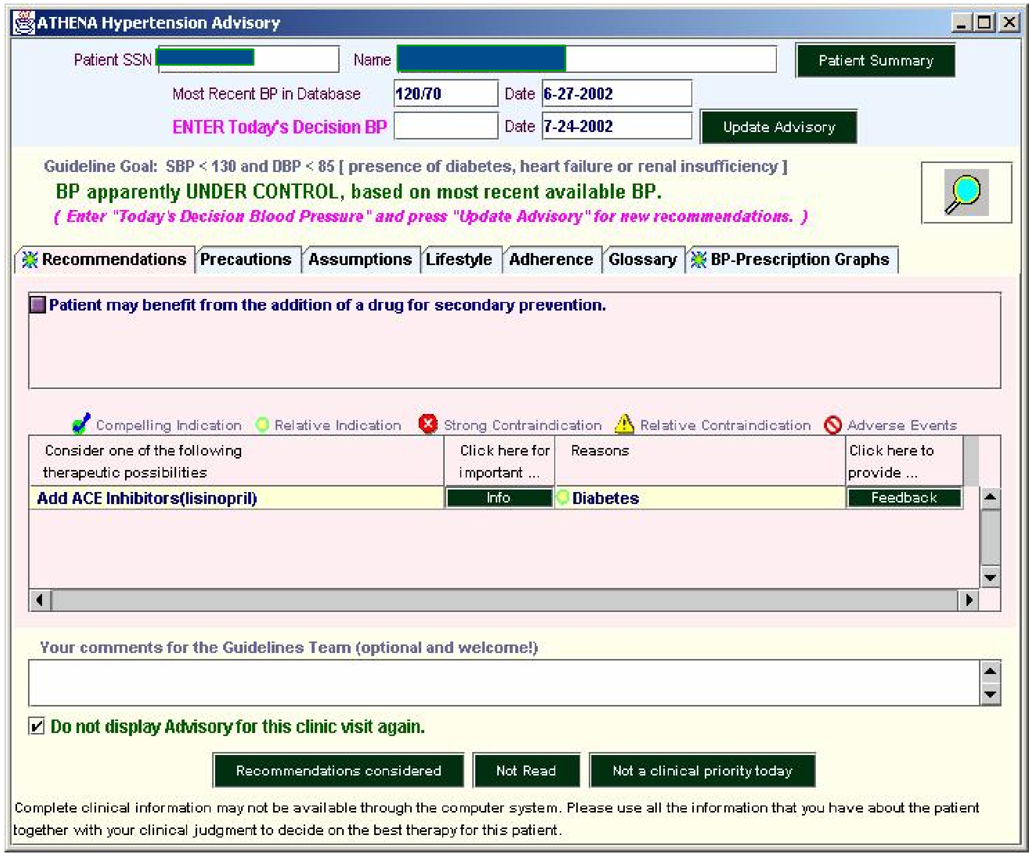
swt1 Standaline application can also be made into a tab. In ATHENA, we started with a standalone interface and then created a tab for demo and testing. The tab is tremendously useful as a testing environment. You can change the knowledge base and test it right away.

Samson Tu, 3/25/2006

Example: The EON and ATHENA projects

swt2

- Goal: provide decision support systems for guideline-based care
- Knowledge base: model of clinical practice guidelines and protocols, instantiated for hypertension and other medical problems.
- Methods: software components that assist clinicians (therapy advisory; database mediator for time-oriented queries; explanation and visualization facilities).
- User interface: Custom, standalone application, within larger VA clinical information system (also embedded as Protégé tab for testing purpose)



ATHENA Hypertension Advisory

Patient SSN [redacted] Name [redacted] Patient Summary

Most Recent BP in Database 120/70 Date 6-27-2002

ENTER Today's Decision BP Date 7-24-2002 Update Advisory

Guideline Goal: SBP < 130 and DBP < 85 [presence of diabetes, heart failure or renal insufficiency]

BP apparently UNDER CONTROL, based on most recent available BP.

(Enter "Today's Decision Blood Pressure" and press "Update Advisory" for new recommendations.)

Recommendations | Precautions | Assumptions | Lifestyle | Adherence | Glossary | BP-Prescription Graphs

Patient may benefit from the addition of a drug for secondary prevention.

✓ Compelling Indication ● Relative Indication ✗ Strong Contraindication ⚠ Relative Contraindication ⊘ Adverse Events

Consider one of the following therapeutic possibilities	Click here for important ...	Reasons	Click here to provide ...
Add ACE Inhibitors(lisinopril)	Info	● Diabetes	Feedback

Your comments for the Guidelines Team (optional and welcome!)

☑ Do not display Advisory for this clinic visit again.

Recommendations considered | Not Read | Not a clinical priority today

Complete clinical information may not be available through the computer system. Please use all the information that you have about the patient together with your clinical judgment to decide on the best therapy for this patient.

http://www.chce.research.med.va.gov/athena/

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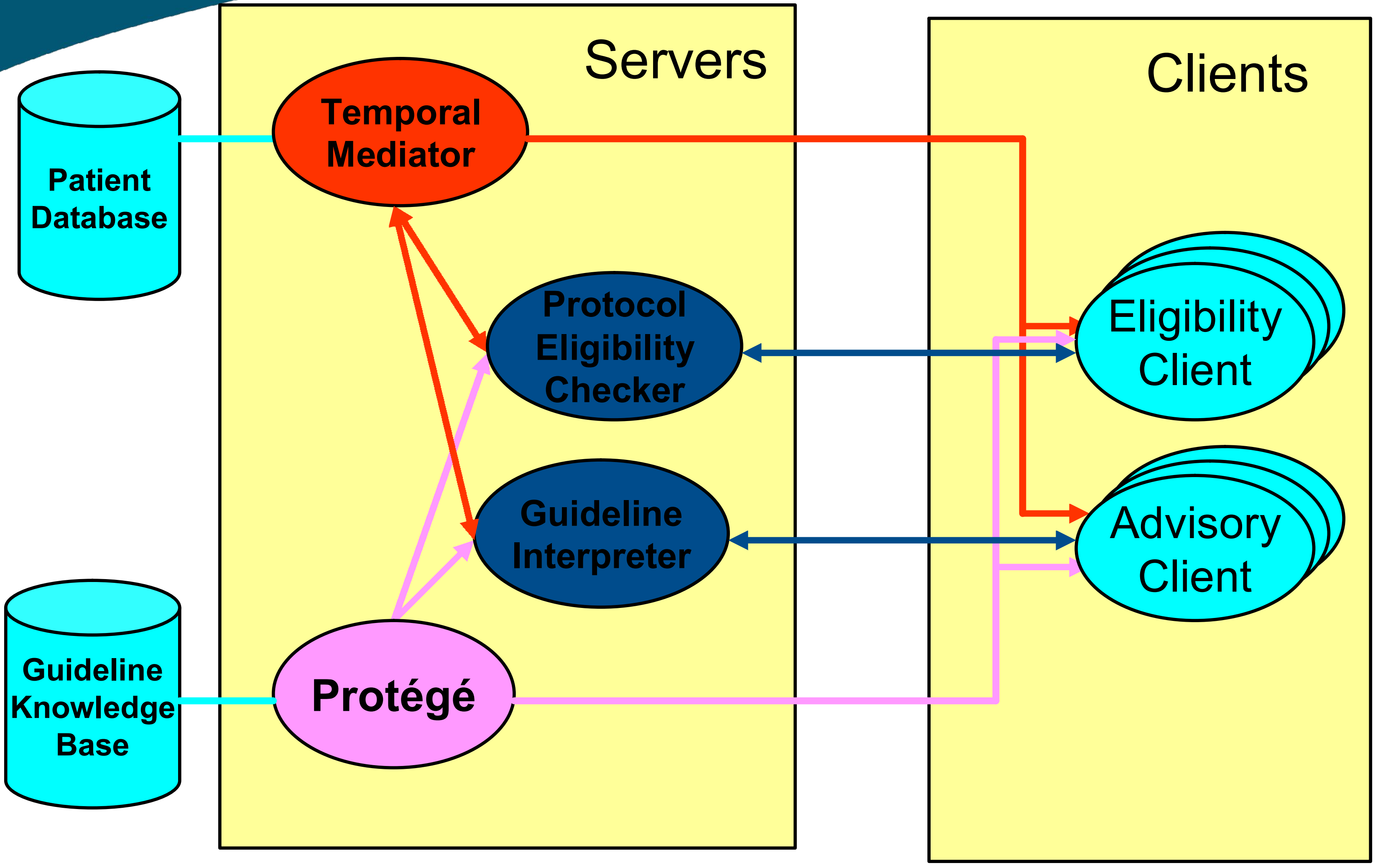
swt2 I know it makes exposition more difficult, butI can't resist separating the two projects. EON develops the underlying software components and guideline model. ATHENA applies them to specific medical problems in VA.

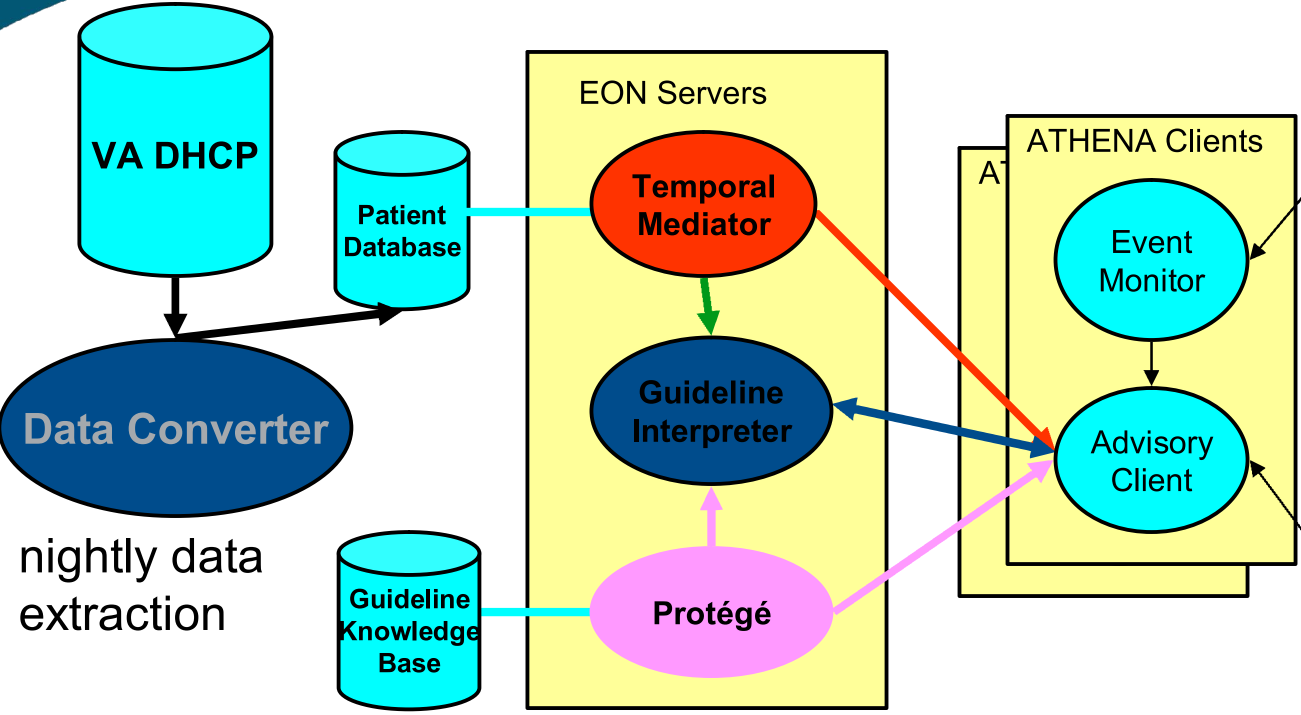
(BTW, ATHENA is no longer limited to hypertension. ATHENA Opioid Therapy is being developed. ATHENA Chronic Kidney Disease is in proposal stage.)

Samson Tu, 3/25/2006

EON: An Architecture for Guideline-Based Decision Support

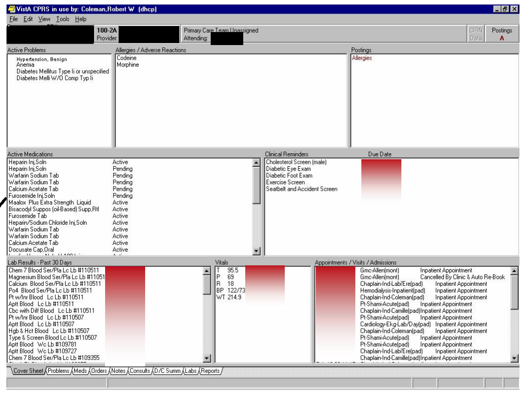


Building ATHENA System From EON Components



nightly data extraction

VA CPRS


VistA CPRS in use by: Coleman,Robert W (dhcp)

File Edit View Tools Help

[redacted] 100-2A Provider: [redacted] Primary Care Team Unassigned Attending: [redacted] CIRN Data Postings A

Active Problems
Hypertension, Benign
Anemia
Diabetes Mellitus Type Ii or unspecified
Diabetes Melli W/O Comp Typ Ii

Allergies / Adverse Reactions
Codeine
Morphine

Postings
Allergies

Active Medications	
Heparin Inj,Soln	Active
Heparin Inj,Soln	Pending
Warfarin Sodium Tab	Pending
Warfarin Sodium Tab	Pending
Calcium Acetate Tab	Pending
Furosemide Inj,Soln	Pending
Maalox Plus Extra Strength Liquid	Active
Bisacodyl Suppos (oil-Based) Supp,Rtl	Active
Furosemide Tab	Active
Heparin/Sodium Chloride Inj,Soln	Active
Warfarin Sodium Tab	Active
Warfarin Sodium Tab	Active
Calcium Acetate Tab	Active
Docusate Cap,Oral	Active

Clinical Reminders	Due Date
Cholesterol Screen (male)	
Diabetic Eye Exam	
Diabetic Foot Exam	
Exercise Screen	
Seatbelt and Accident Screen	

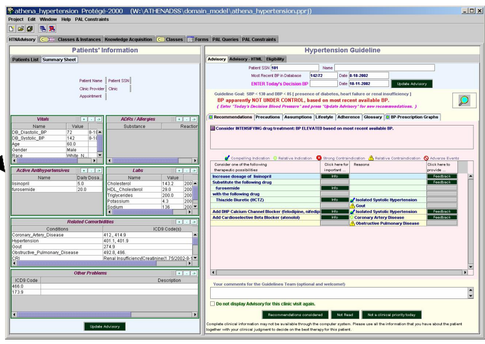
Lab Results - Past 30 Days
Chem 7 Blood Ser/Pla Lc Lb #110511
Magnesium Blood Ser/Pla Lc Lb #11051
Calcium Blood Ser/Pla Lc Lb #110511
Po4 Blood Ser/Pla Lc Lb #110511
Pt w/Inr Blood Lc Lb #110511
Aptt Blood Lc Lb #110511
Cbc with Diff Blood Lc Lb #110511
Pt w/Inr Blood Lc Lb #110507
Aptt Blood Lc Lb #110507
Hgb & Hct Blood Lc Lb #110507
Type & Screen Blood Lc Lb #110507
Aptt Blood Wc Lb #109781
Aptt Blood Wc Lb #109727
Chem 7 Blood Ser/Pla Lc Lb #109355

Vitals
T 95.5
P 69
R 18
BP 122/73
WT 214.9

Appointments / Visits / Admissions	
Gmc-Allen(mont)	Inpatient Appointment
Gmc-Allen(mont)	Cancelled By Clinic & Auto Re-Book
Chaplain-Ind-Labi'Ere(pad)	Inpatient Appointment
Hemodialysis-Inpatient(pad)	Inpatient Appointment
Chaplain-Ind-Coleman(pad)	Inpatient Appointment
Pt-Shami-Acute(pad)	Inpatient Appointment
Chaplain-Ind-Camille(pad)	Inpatient Appointment
Pt-Shami-Acute(pad)	Inpatient Appointment
Cardiology-Ekg-Lab/Day(pad)	Inpatient Appointment
Chaplain-Ind-Coleman(pad)	Inpatient Appointment
Pt-Shami-Acute(pad)	Inpatient Appointment
Pt-Shami-Acute(pad)	Inpatient Appointment
Chaplain-Ind-Labi'Ere(pad)	Inpatient Appointment
Chaplain-Ind-Camille(pad)	Inpatient Appointment

Cover Sheet / Problems / Meds / Orders / Notes / Consults / D/C Summ / Labs / Reports

ATHENA GUI


athena_hypertension Protégé-2000 (W:\ATHENADSS\domain_model\athena_hypertension.pprj)

Project Edit Window Help PAL Constraints

HTNAdvisory | Classes & Instances | Knowledge Acquisition | Classes | Forms | PAL Queries | PAL Constraints

Patients' Information

Patients List | Summary Sheet

Patient Name: Patient SSN
Clinic Provider: Clinic
Appointment:

Vitals

Name	Value	
DB_Diastolic_BP	72	8-18
DB_Systolic_BP	142	8-18
Age	60.0	
Gender	Male	
Race	White_N...	

ADRs / Allergies

Substance	Reaction

Active Antihypertensives

Name	Daily Dosa...
lisinopril	5.0
furosemide	20.0

Labs

Name	Value	
Cholesterol	143.2	200
HDL_Cholesterol	29.0	200
Triglycerides	200.0	200
Potassium	4.3	200
Sodium	136	200

Related Comorbidities

Conditions	ICD9 Code(s)
Coronary_Artery_Disease	412., 414.9
Hypertension	401.1, 401.9
Gout	274.9
Obstructive_Pulmonary_Disease	492.8, 496.
CRI	Renal Insufficiency[Creatinine(1.75/2002-8-1

Other Problems

ICD9 Code	Description
466.0	
173.9	

Update Advisory

Hypertension Guideline

Advisory | Advisory - HTML | Eligibility

Patient SSN 101 Name
Most Recent BP in Database 142/72 Date 8-18-2002
ENTER Today's Decision BP Date 10-11-2002 Update Advisory

Guideline Goal: SBP < 130 and DBP < 85 [presence of diabetes, heart failure or renal insufficiency]
BP apparently NOT UNDER CONTROL, based on most recent available BP.
(Enter "Today's Decision Blood Pressure" and press "Update Advisory" for new recommendations.)

Recommendations | Precautions | Assumptions | Lifestyle | Adherence | Glossary | BP-Prescription Graphs

Consider INTENSIFYING drug treatment: BP ELEVATED based on most recent available BP.

Compelling Indication / Relative Indication / Strong Contraindication / Relative Contraindication / Adverse Events

Consider one of the following therapeutic possibilities	Click here for important ...	Reasons	Click here to provide ...
Increase dosage of lisinopril	Info		Feedback
Substitute the following drug			Feedback
furosemide	Info		
with the following drug			
Thiazide Diuretic (HCTZ)	Info	Isolated Systolic Hypertension	
		Gout	
Add DHP Calcium Channel Blocker (felodipine, nifedipi	Info	Isolated Systolic Hypertension	Feedback
Add Cardioselective Beta Blocker (atenolol)	Info	Coronary Artery Disease	Feedback
		Obstructive Pulmonary Disease	

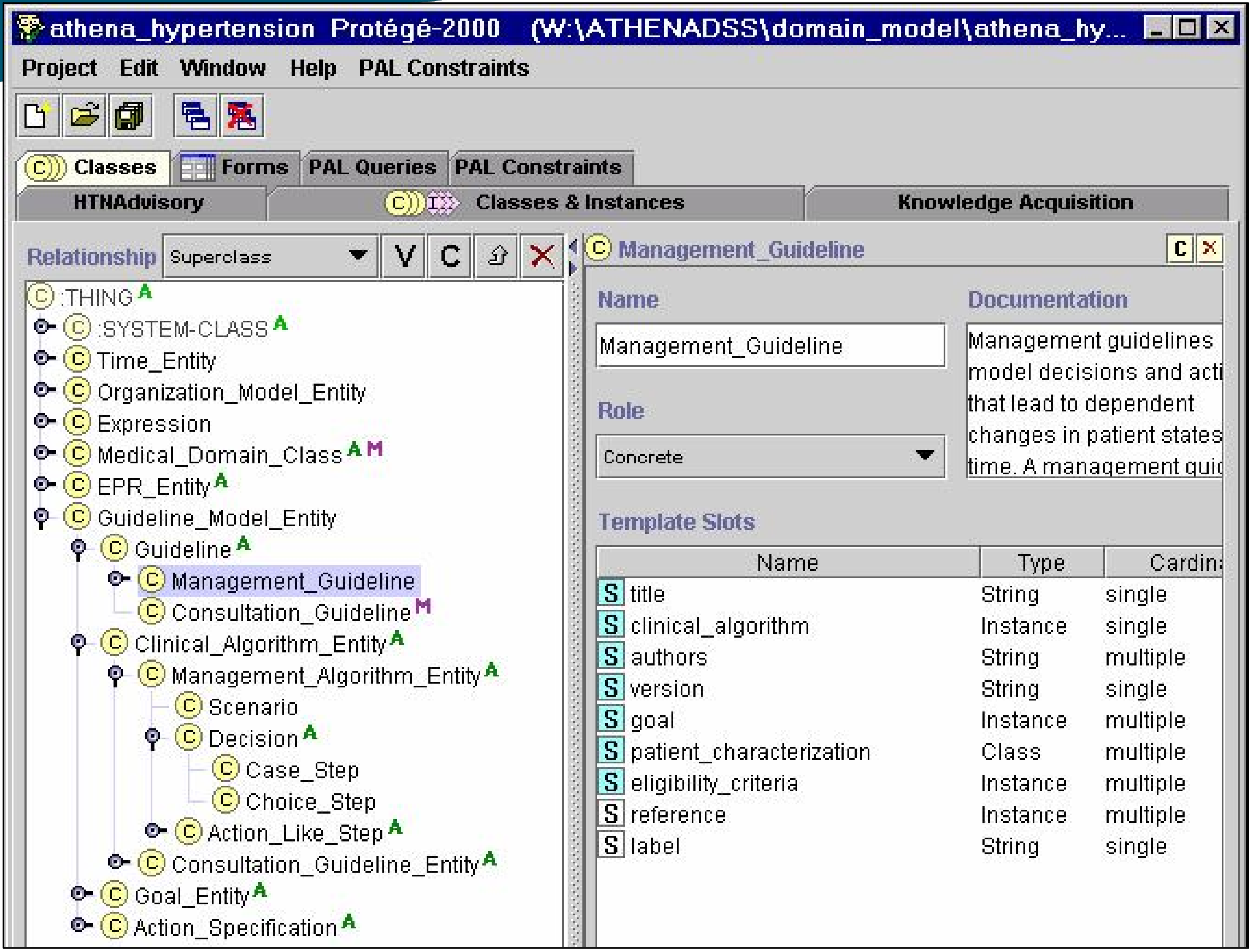
Your comments for the Guidelines Team (optional and welcome!)

☐ Do not display Advisory for this clinic visit again.

Recommendations considered | Not Read | Not a clinical priority today

Complete clinical information may not be available through the computer system. Please use all the information that you have about the patient together with your clinical judgment to decide on the best therapy for this patient.

Example: Underlying ontology of guidelines



athena_hypertension Protégé-2000 (W:\ATHENADSS\domain_model\athena_hy...
Project Edit Window Help PAL Constraints
Classes Forms PAL Queries PAL Constraints
HTNAdvisory Classes & Instances Knowledge Acquisition
Relationship Superclass

:THING
- :SYSTEM-CLASS
- Time_Entity
- Organization_Model_Entity
- Expression
- Medical_Domain_Class
- EPR_Entity
- Guideline_Model_Entity
  - Guideline
    - Management_Guideline
    - Consultation_Guideline
  - Clinical_Algorithm_Entity
    - Management_Algorithm_Entity
      - Scenario
      - Decision
        - Case_Step
        - Choice_Step
      - Action_Like_Step
    - Consultation_Guideline_Entity
  - Goal_Entity
  - Action_Specification

Management_Guideline

Name: Management_Guideline

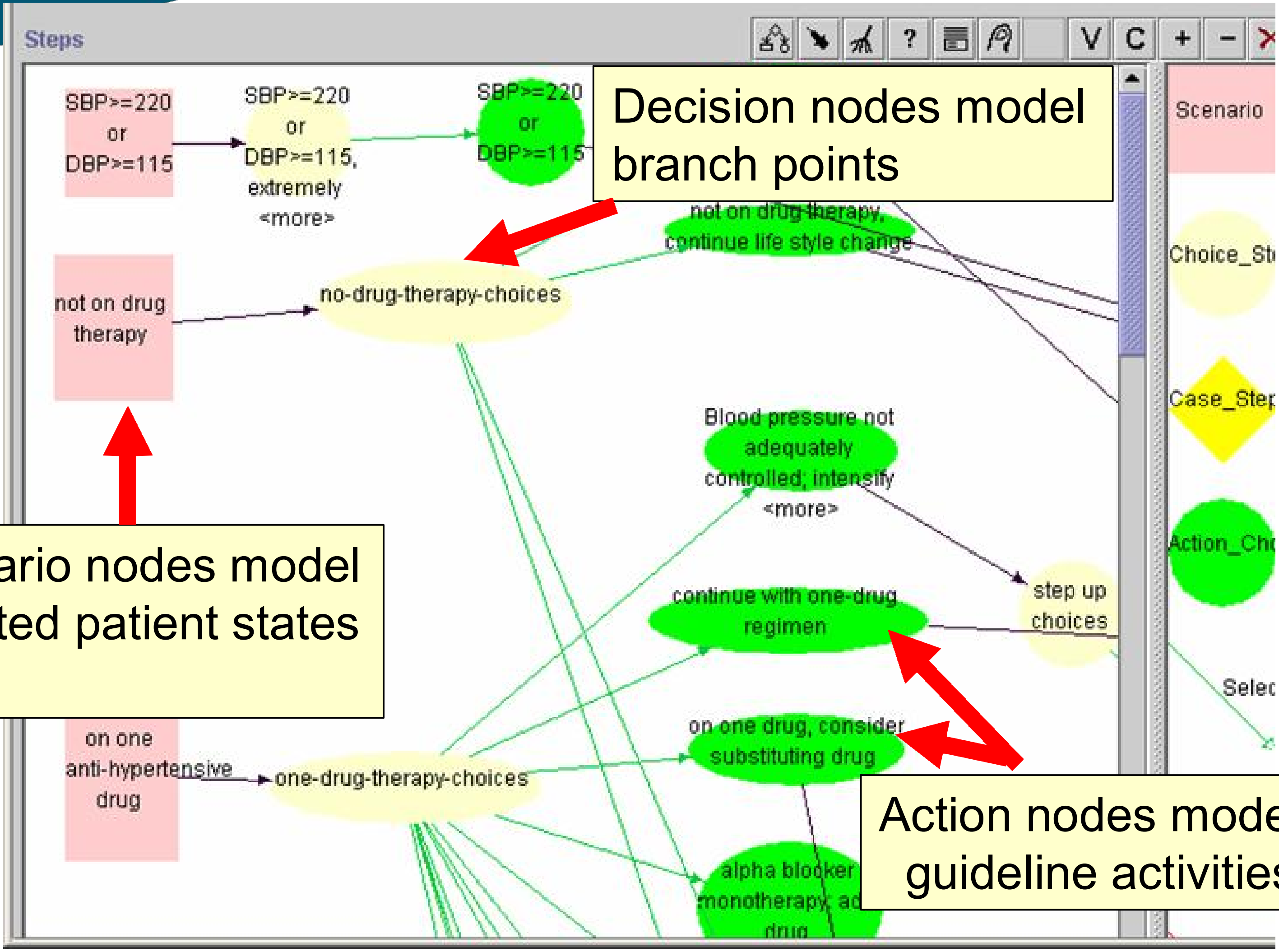
Role: Concrete

Documentation: Management guidelines model decisions and acti that lead to dependent changes in patient states time. A management guic

Template Slots

Name	Type	Cardin
title	String	single
clinical_algorithm	Instance	single
authors	String	multiple
version	String	single
goal	Instance	multiple
patient_characterization	Class	multiple
eligibility_criteria	Instance	multiple
reference	Instance	multiple
label	String	single

Example: ATHENA's underlying model of process knowledge using Protégé graph widget

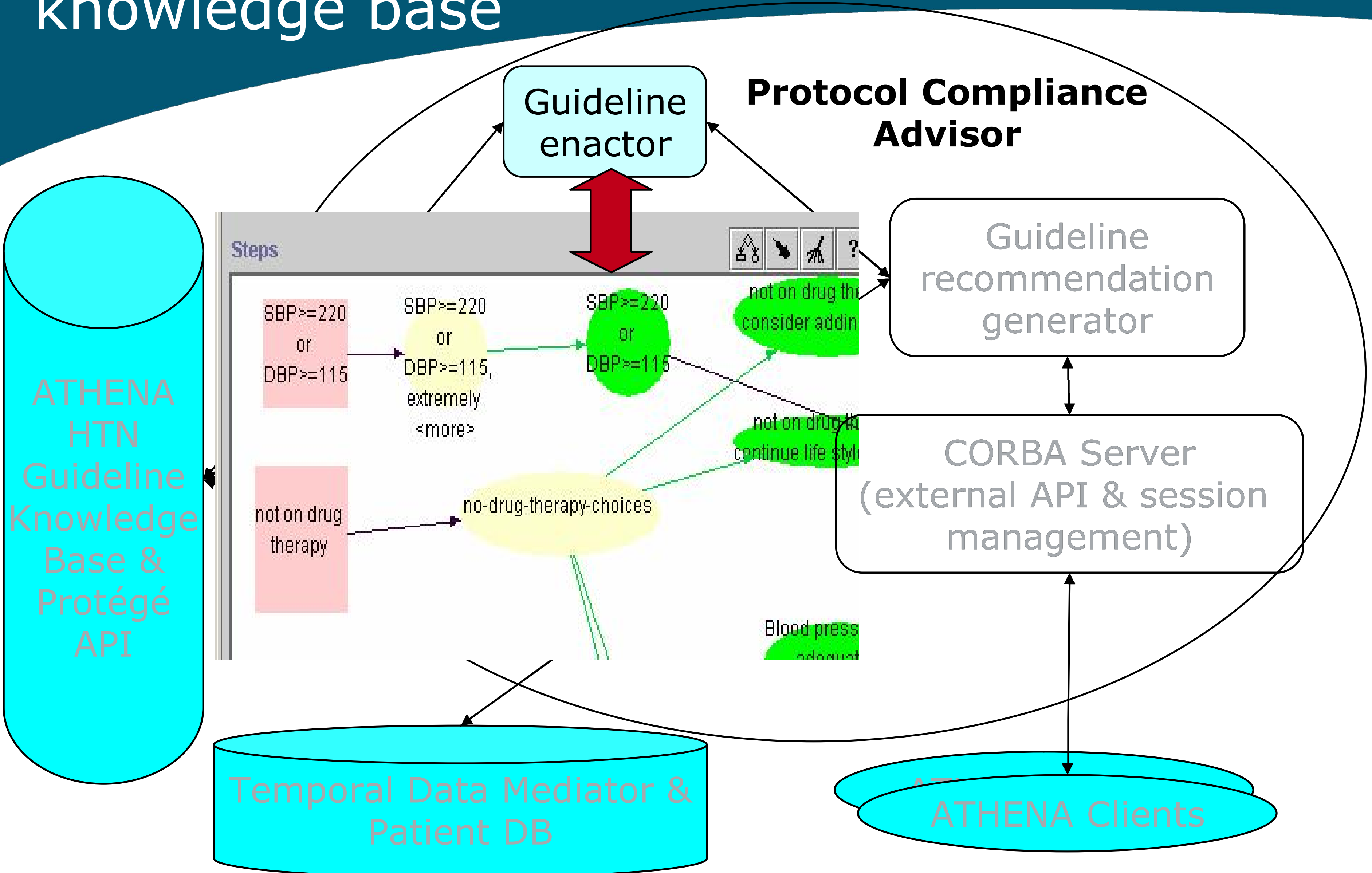

Steps
V
C
SBP>=220 or DBP>=115
SBP>=220 or DBP>=115, extremely <more>
SBP>=220 or DBP>=115
not on drug therapy, continue life style change
not on drug therapy
no-drug-therapy-choices
Blood pressure not adequately controlled; intensify <more>
continue with one-drug regimen
step up choices
on one anti-hypertensive drug
one-drug-therapy-choices
on one drug, consider substituting drug
alpha blocker monotherapy; add drug
Scenario
Choice_St
Case_Step
Action_Ch
Selec

Decision nodes model branch points

Scenario nodes model selected patient states

Action nodes model guideline activities

Example: EON/ATHENA decision-support system adds behaviors to Protégé knowledge base


Guideline enactor
Protocol Compliance Advisor
Guideline recommendation generator
CORBA Server (external API & session management)
ATHENA HTN Guideline Knowledge Base & Protégé API
Temporal Data Mediator & Patient DB
ATHENA Clients
Steps
SBP>=220 or DBP>=115
SBP>=220 or DBP>=115, extremely <more>
SBP>=220 or DBP>=115
not on drug the consider addin
not on drug th continue life styl
not on drug therapy
no-drug-therapy-choices
Blood press adequat

Model-based sofware engineering*: *Using Protégé as a CASE tool with jsave*

swt3

Description

- Create reusable domain/application ontologies and knowledge bases (usually process-oriented)
- Use the **jsave application**** to generate automatically a set of Java implementation classes from Protégé class and slot definitions
    - Protégé instances are also Java instances of their corresponding classes
    - Protégé API methods for frames and instances are inherited
- Write custom methods for the generated Java classes, taking full advantage of Protégé API

- Pros
    - Direct correspondence between ontological model and code
    - Neat way to **add behavior** to Protégé knowledge bases
    - User-written code preserved as Protégé model changes
- Cons
    - Java serialization model doesn't encompass all of Protégé's modeling richness due to limitations in Java (ex: multiple inheritance)

** http://www.sei.cmu.edu/mbse/is.html*
*** http://protégé.stanford.edu/plugins/jsave*

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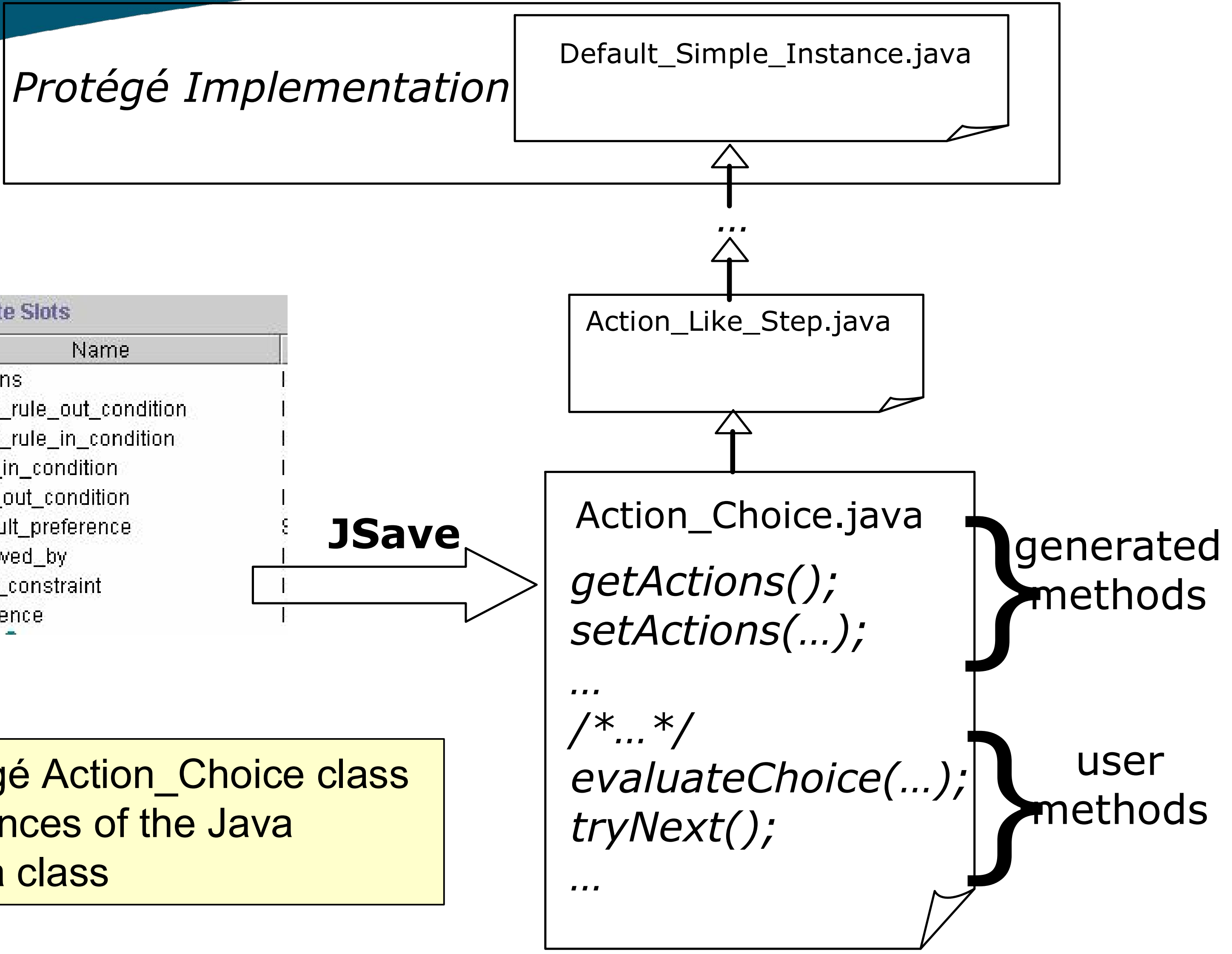
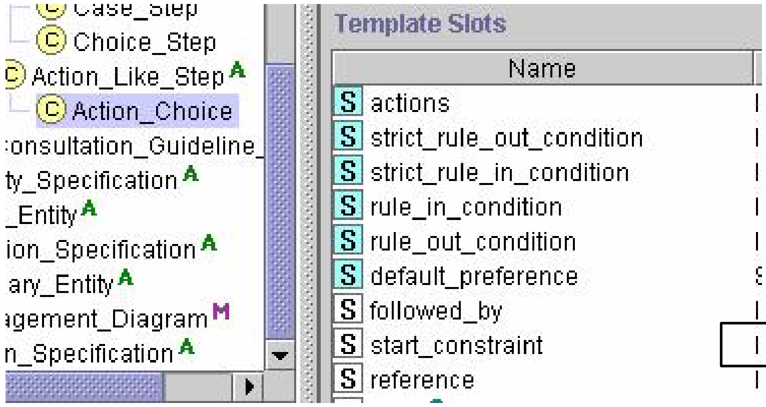
swt3 Typo sofware
Samson Tu, 3/25/2006

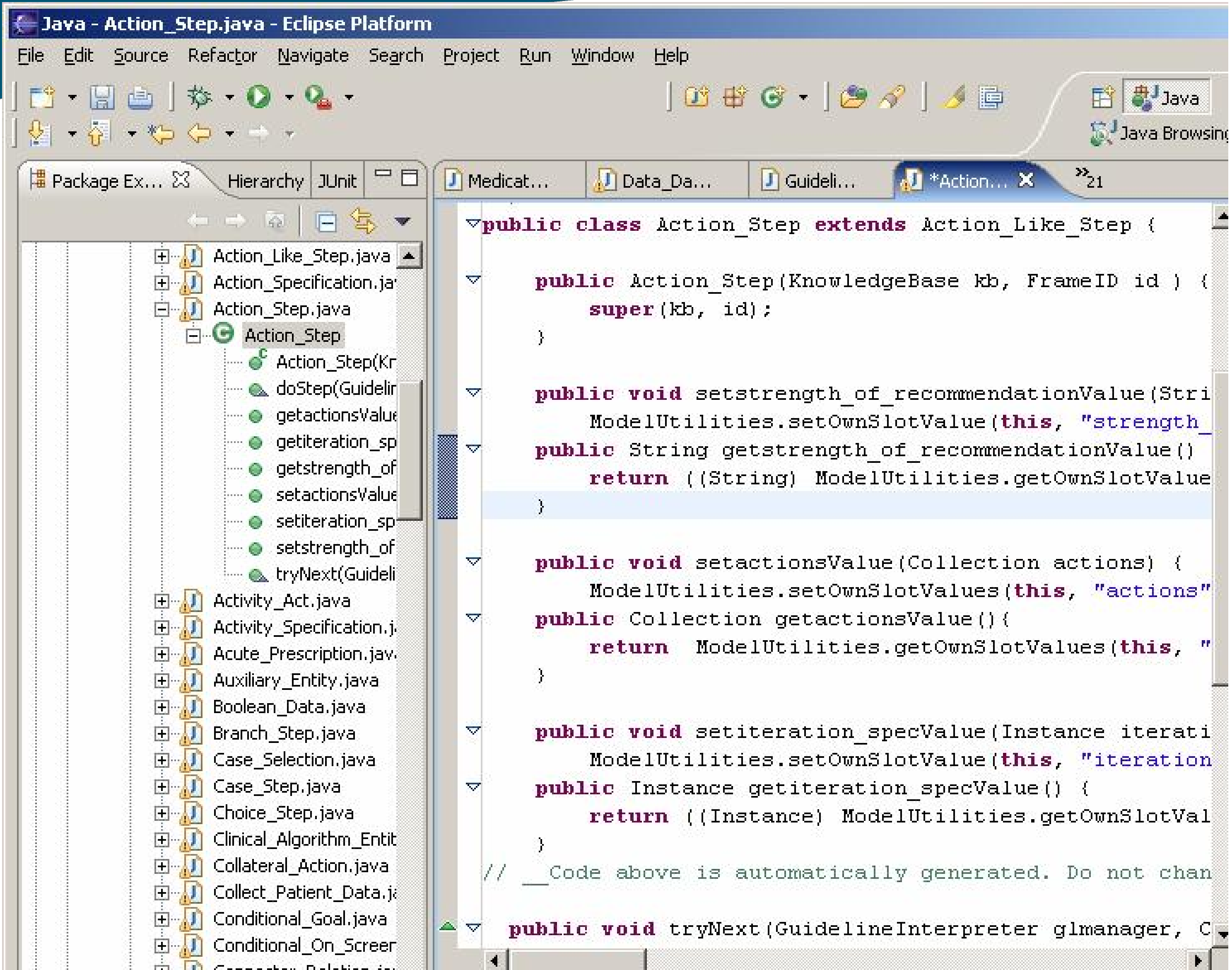
Translating Protégé class definitions to Java classes using JSave





Instances of Protégé Action_Choice class become Java instances of the Java Action_Choice.java class

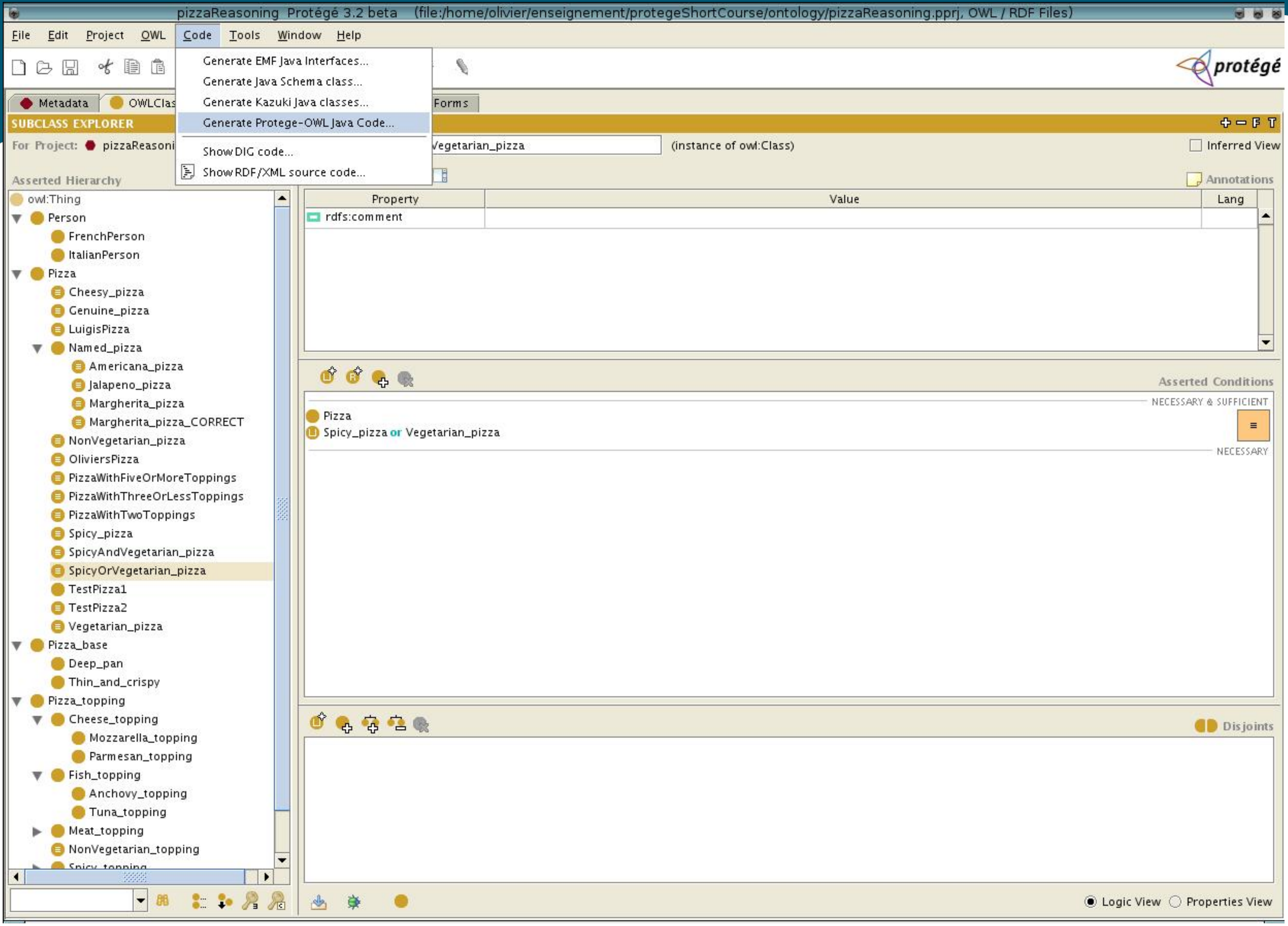
From platform-independent domain model to code: Protégé classes => Java classes


Java - Action_Step.java - Eclipse Platform
File Edit Source Refactor Navigate Search Project Run Window Help
Java
Java Browsing
Package Ex...
Hierarchy
JUnit
Medicat...
Data_Da...
Guideli...
*Action...
»21

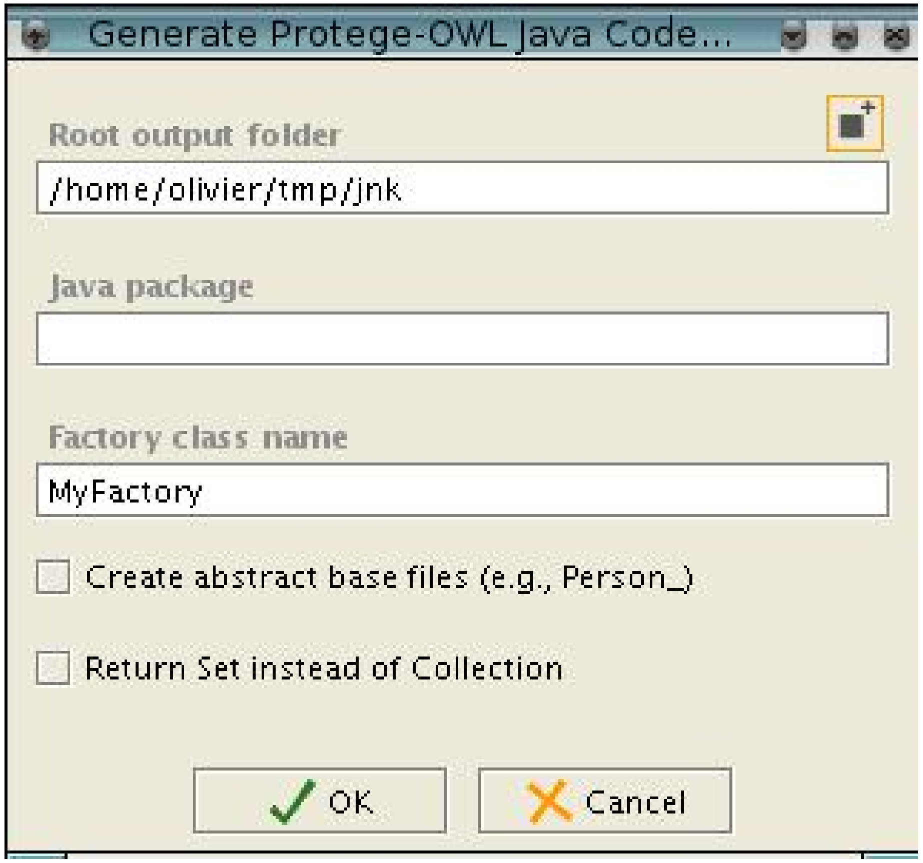
```
Action_Like_Step.java
Action_Specification.ja
Action_Step.java
    Action_Step
        Action_Step(Kr
        doStep(Guidelir
        getactionsValue
        getiteration_sp
        getstrength_of
        setactionsValue
        setiteration_sp
        setstrength_of
        tryNext(Guideli
Activity_Act.java
Activity_Specification.j
Acute_Prescription.jav
Auxiliary_Entity.java
Boolean_Data.java
Branch_Step.java
Case_Selection.java
Case_Step.java
Choice_Step.java
Clinical_Algorithm_Entit
Collateral_Action.java
Collect_Patient_Data.j
Conditional_Goal.java
Conditional_On_Screer
```

```
public class Action_Step extends Action_Like_Step {

    public Action_Step(KnowledgeBase kb, FrameID id ) {
        super(kb, id);
    }

    public void setstrength_of_recommendationValue(Stri
        ModelUtilities.setOwnSlotValue(this, "strength_
    public String getstrength_of_recommendationValue()
        return ((String) ModelUtilities.getOwnSlotValue
    }

    public void setactionsValue(Collection actions) {
        ModelUtilities.setOwnSlotValues(this, "actions"
    public Collection getactionsValue(){
        return ModelUtilities.getOwnSlotValues(this, "
    }

    public void setiteration_specValue(Instance iterati
        ModelUtilities.setOwnSlotValue(this, "iteration
    public Instance getiteration_specValue() {
        return ((Instance) ModelUtilities.getOwnSlotVal
    }
// __Code above is automatically generated. Do not chan

  public void tryNext(GuidelineInterpreter glmanager, C
```

Using automatic Java code generation menu command in Protégé-OWL



Protégé-OWL's Java code generation: *Specifying options*



Root output folder

/home/olivier/tmp/jnk

Java package

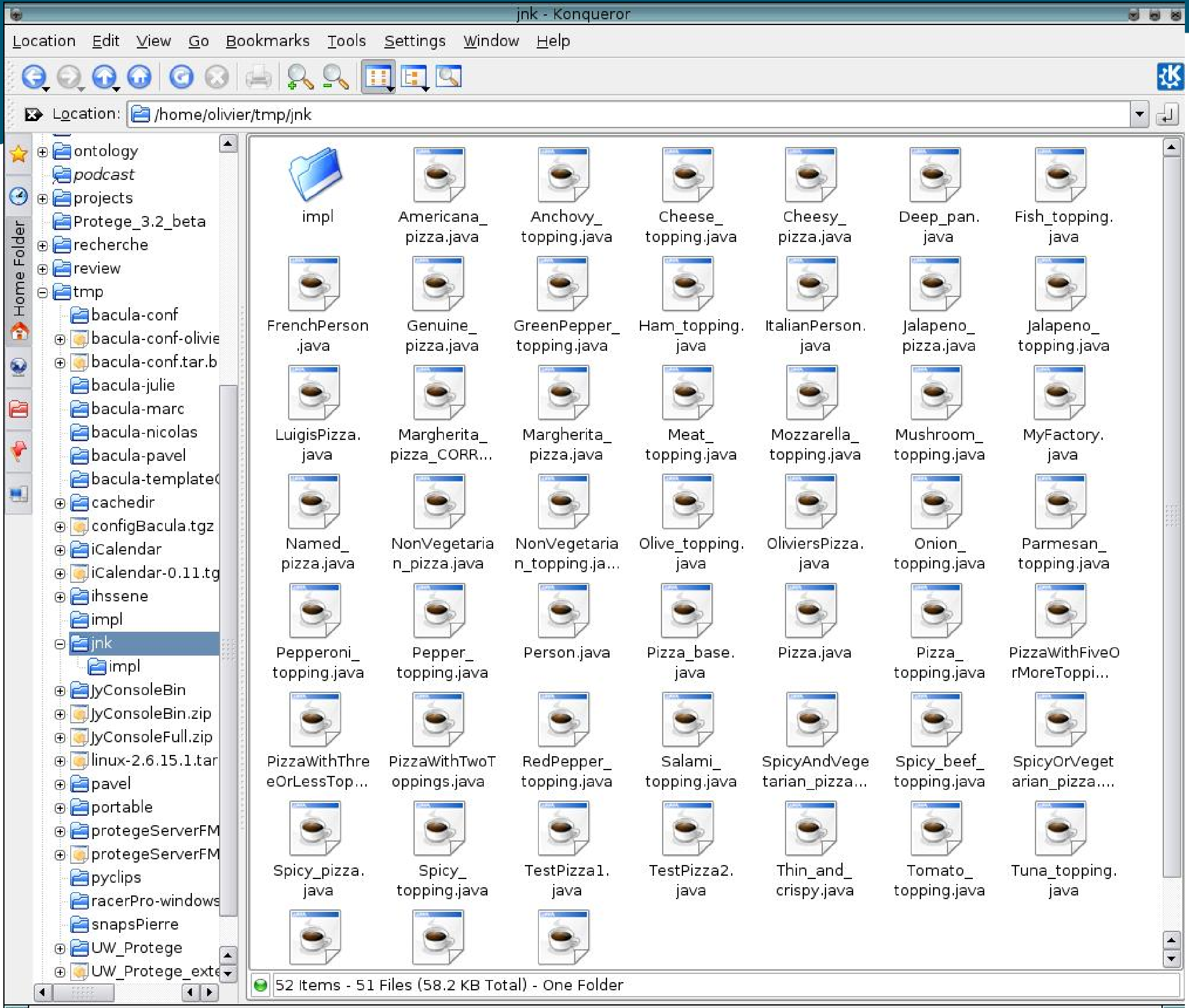
Factory class name

MyFactory

☐ Create abstract base files (e.g., Person_)

☐ Return Set instead of Collection

Protégé-OWL’s Java code generation: *Set of Java classes and interfaces*

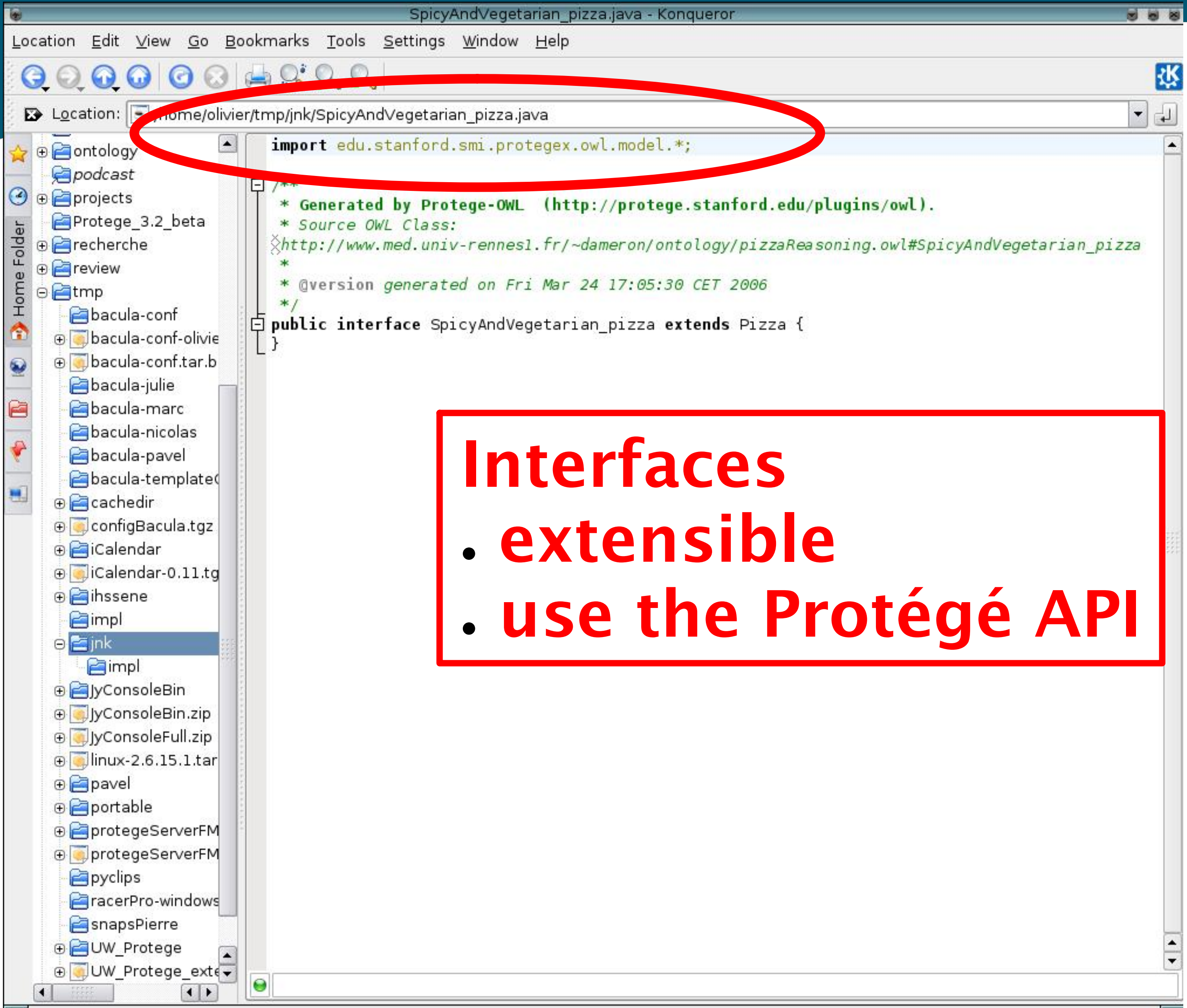

jnk - Konqueror
Location Edit View Go Bookmarks Tools Settings Window Help
Location: /home/olivier/tmp/jnk
Home Folder

ontology
podcast
projects
Protege_3.2_beta
recherche
review
tmp
bacula-conf
bacula-conf-olivie
bacula-conf.tar.b
bacula-julie
bacula-marc
bacula-nicolas
bacula-pavel
bacula-template(
cachedir
configBacula.tgz
iCalendar
iCalendar-0.11.tg
ihssene
impl
jnk
impl
JyConsoleBin
JyConsoleBin.zip
JyConsoleFull.zip
linux-2.6.15.1.tar
pavel
portable
protegeServerFM
protegeServerFM
pyclips
racerPro-windows
snapsPierre
UW_Protege
UW_Protege_exte

impl
Americana_pizza.java
Anchovy_topping.java
Cheese_topping.java
Cheesy_pizza.java
Deep_pan.java
Fish_topping.java
FrenchPerson.java
Genuine_pizza.java
GreenPepper_topping.java
Ham_topping.java
ItalianPerson.java
Jalapeno_pizza.java
Jalapeno_topping.java
LuigisPizza.java
Margherita_pizza_CORR...
Margherita_pizza.java
Meat_topping.java
Mozzarella_topping.java
Mushroom_topping.java
MyFactory.java
Named_pizza.java
NonVegetarian_pizza.java
NonVegetarian_topping.ja...
Olive_topping.java
OliviersPizza.java
Onion_topping.java
Parmesan_topping.java
Pepperoni_topping.java
Pepper_topping.java
Person.java
Pizza_base.java
Pizza.java
Pizza_topping.java
PizzaWithFiveOrMoreToppi...
PizzaWithThreeOrLessTop...
PizzaWithTwoToppings.java
RedPepper_topping.java
Salami_topping.java
SpicyAndVegetarian_pizza...
Spicy_beef_topping.java
SpicyOrVegetarian_pizza....
Spicy_pizza.java
Spicy_topping.java
TestPizza1.java
TestPizza2.java
Thin_and_crispy.java
Tomato_topping.java
Tuna_topping.java

52 Items - 51 Files (58.2 KB Total) - One Folder

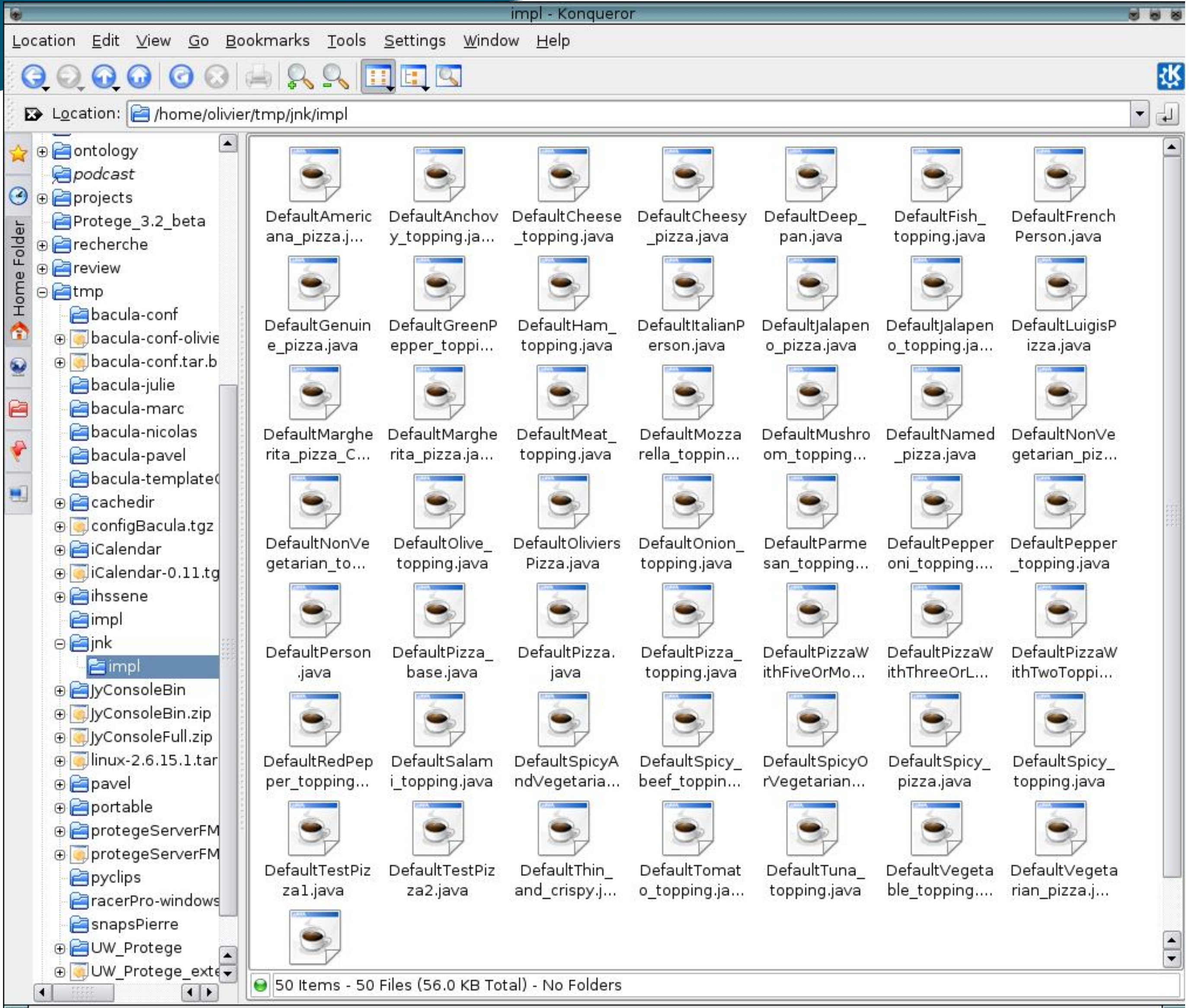
Protégé-OWL's Java code generation: *Inheritance of Protégé-OWL API packages*



```
import edu.stanford.smi.protegex.owl.model.*;

/**
 * Generated by Protege-OWL  (http://protege.stanford.edu/plugins/owl).
 * Source OWL Class:
 http://www.med.univ-rennes1.fr/~dameron/ontology/pizzaReasoning.owl#SpicyAndVegetarian_pizza
 *
 * @version generated on Fri Mar 24 17:05:30 CET 2006
 */
public interface SpicyAndVegetarian_pizza extends Pizza {
}
```

Interfaces
- **extensible**
- **use the Protégé API**

Protégé-OWL's Java code generation:
Set of default implementation classes



impl - Konqueror

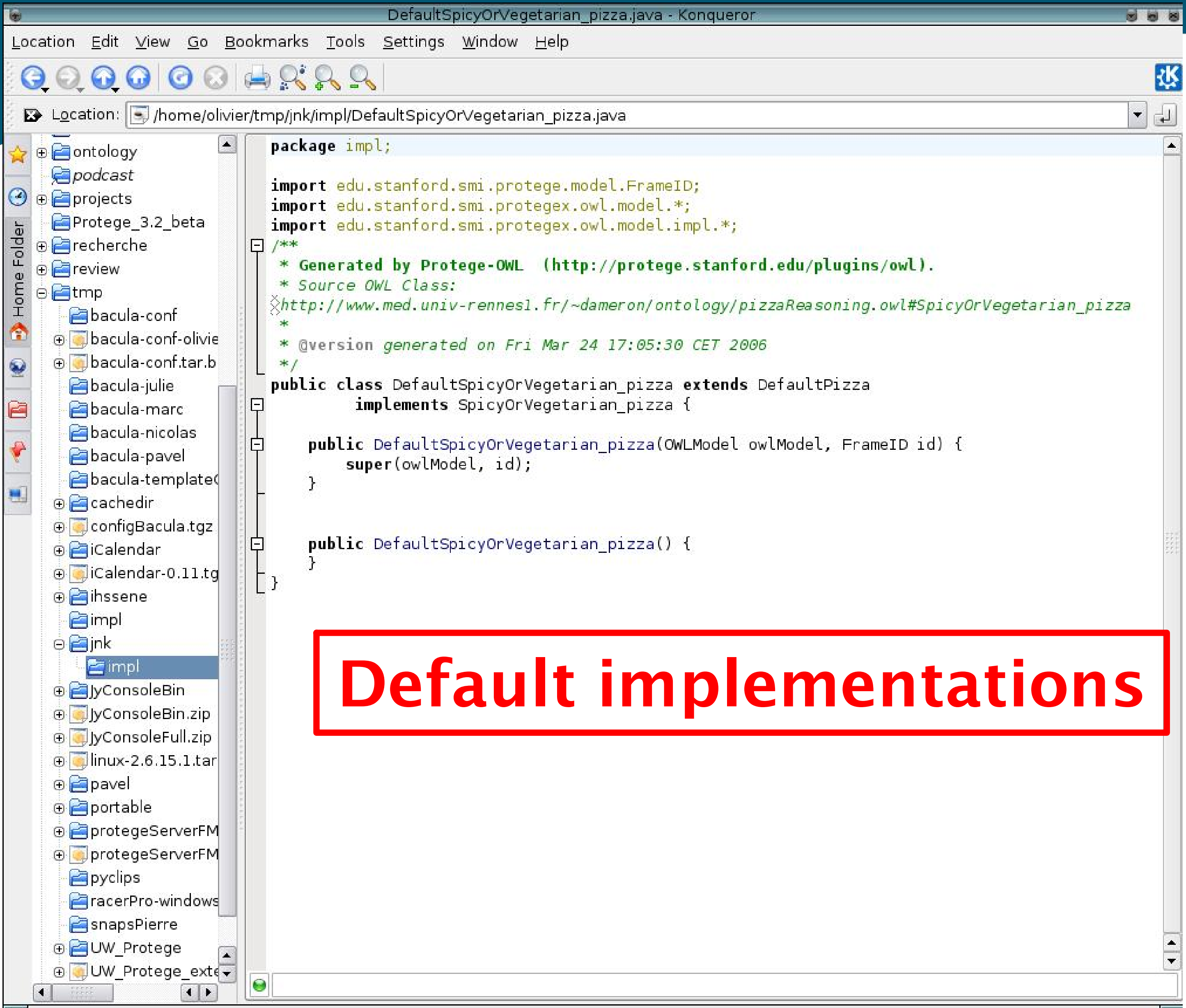
Location: /home/olivier/tmp/jnk/impl

ontology
podcast
projects
Protege_3.2_beta
recherche
review
tmp
bacula-conf
bacula-conf-olivie
bacula-conf.tar.b
bacula-julie
bacula-marc
bacula-nicolas
bacula-pavel
bacula-template(
cachedir
configBacula.tgz
iCalendar
iCalendar-0.11.tg
ihssene
impl
jnk
impl
JyConsoleBin
JyConsoleBin.zip
JyConsoleFull.zip
linux-2.6.15.1.tar
pavel
portable
protegeServerFM
protegeServerFM
pyclips
racerPro-windows
snapsPierre
UW_Protege
UW_Protege_exte

DefaultAmericana_pizza.j...
DefaultAnchovy_topping.ja...
DefaultCheese_topping.java
DefaultCheesy_pizza.java
DefaultDeep_pan.java
DefaultFish_topping.java
DefaultFrenchPerson.java
DefaultGenuine_pizza.java
DefaultGreenPepper_toppi...
DefaultHam_topping.java
DefaultItalianPerson.java
DefaultJalapeno_pizza.java
DefaultJalapeno_topping.ja...
DefaultLuigisPizza.java
DefaultMargherita_pizza_C...
DefaultMargherita_pizza.ja...
DefaultMeat_topping.java
DefaultMozzarella_toppin...
DefaultMushroom_topping...
DefaultNamed_pizza.java
DefaultNonVegetarian_piz...
DefaultNonVegetarian_to...
DefaultOlive_topping.java
DefaultOliviersPizza.java
DefaultOnion_topping.java
DefaultParmesan_topping...
DefaultPepperoni_topping....
DefaultPepper_topping.java
DefaultPerson.java
DefaultPizza_base.java
DefaultPizza.java
DefaultPizza_topping.java
DefaultPizzaWithFiveOrMo...
DefaultPizzaWithThreeOrL...
DefaultPizzaWithTwoToppi...
DefaultRedPepper_topping...
DefaultSalami_topping.java
DefaultSpicyAndVegetaria...
DefaultSpicy_beef_toppin...
DefaultSpicyOrVegetarian...
DefaultSpicy_pizza.java
DefaultSpicy_topping.java
DefaultTestPizza1.java
DefaultTestPizza2.java
DefaultThin_and_crispy.j...
DefaultTomato_topping.ja...
DefaultTuna_topping.java
DefaultVegetable_topping....
DefaultVegetarian_pizza.j...

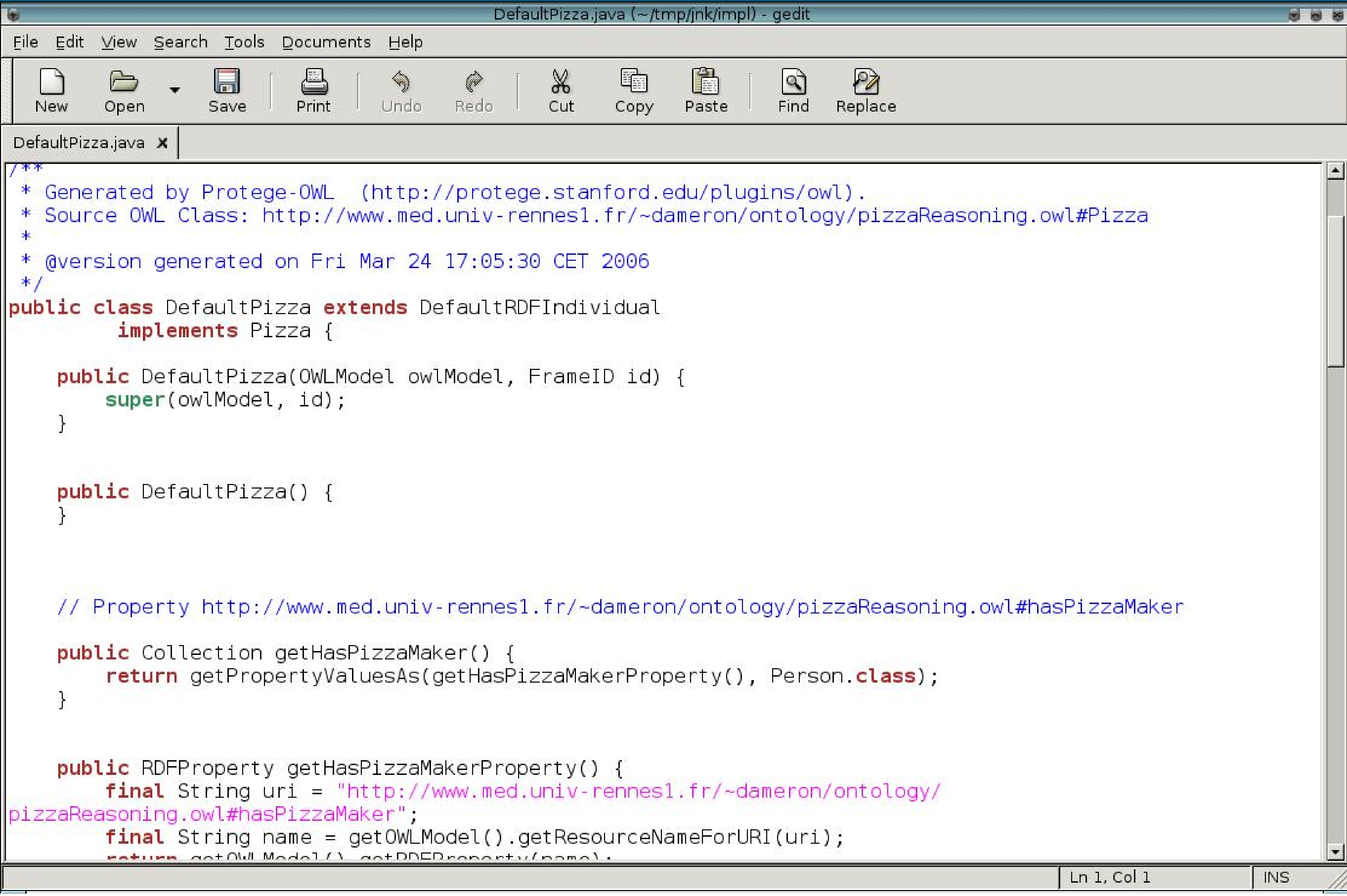
50 Items - 50 Files (56.0 KB Total) - No Folders

Protégé-OWL’s Java code generation: *Default implementation classes*

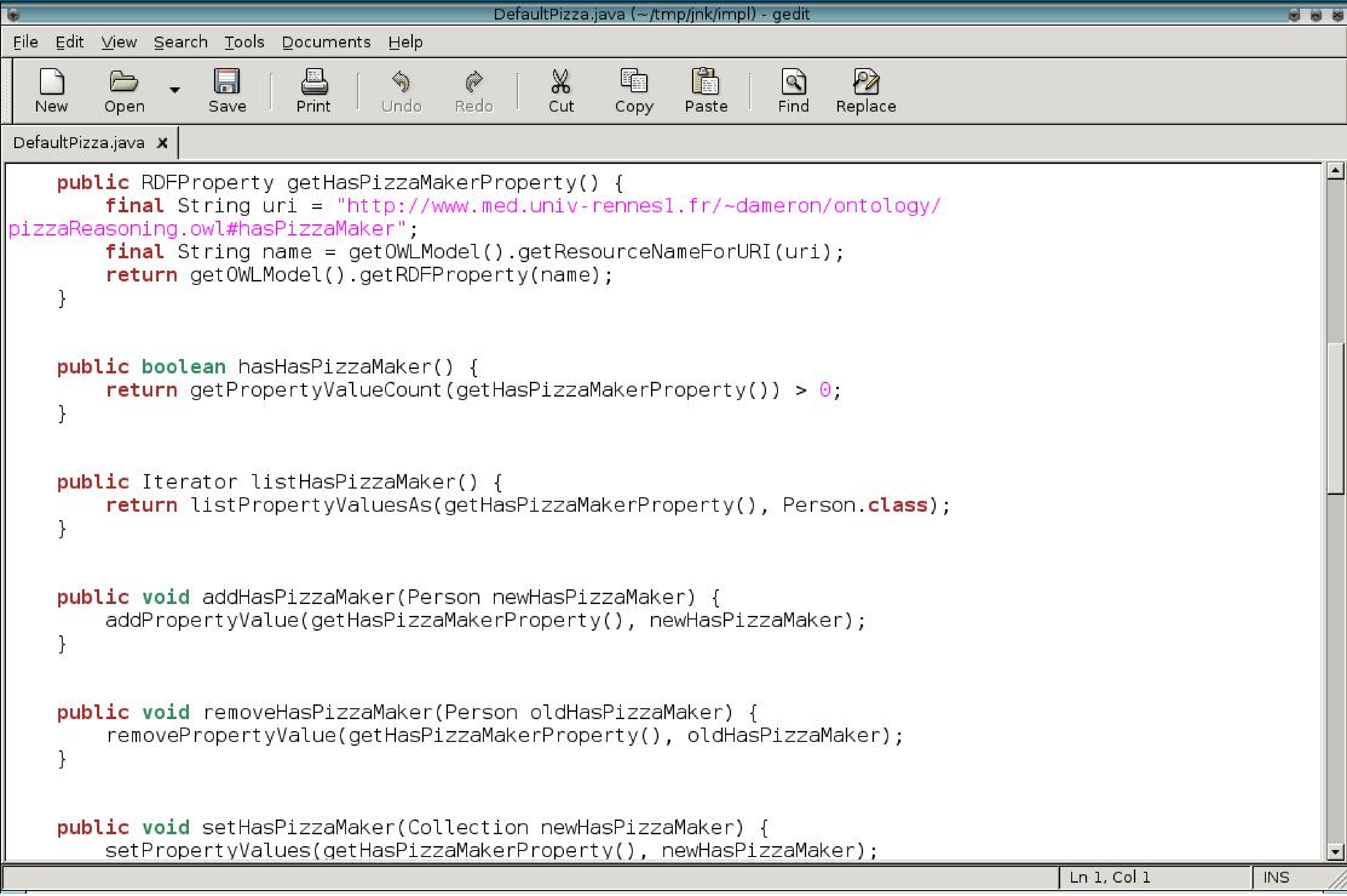


```java
package impl;

import edu.stanford.smi.protege.model.FrameID;
import edu.stanford.smi.protegex.owl.model.*;
import edu.stanford.smi.protegex.owl.model.impl.*;
/**
 * Generated by Protege-OWL  (http://protege.stanford.edu/plugins/owl).
 * Source OWL Class:
http://www.med.univ-rennes1.fr/~dameron/ontology/pizzaReasoning.owl#SpicyOrVegetarian_pizza
 *
 * @version generated on Fri Mar 24 17:05:30 CET 2006
 */
public class DefaultSpicyOrVegetarian_pizza extends DefaultPizza
         implements SpicyOrVegetarian_pizza {

    public DefaultSpicyOrVegetarian_pizza(OWLModel owlModel, FrameID id) {
        super(owlModel, id);
    }


    public DefaultSpicyOrVegetarian_pizza() {
    }
}
```

Default implementations


DefaultPizza.java (~/tmp/jnk/impl) - gedit
File Edit View Search Tools Documents Help
New Open Save Print Undo Redo Cut Copy Paste Find Replace
DefaultPizza.java
Ln 1, Col 1
INS

```
/**
 * Generated by Protege-OWL  (http://protege.stanford.edu/plugins/owl).
 * Source OWL Class: http://www.med.univ-rennes1.fr/~dameron/ontology/pizzaReasoning.owl#Pizza
 *
 * @version generated on Fri Mar 24 17:05:30 CET 2006
 */
public class DefaultPizza extends DefaultRDFIndividual
         implements Pizza {

    public DefaultPizza(OWLModel owlModel, FrameID id) {
        super(owlModel, id);
    }


    public DefaultPizza() {
    }



    // Property http://www.med.univ-rennes1.fr/~dameron/ontology/pizzaReasoning.owl#hasPizzaMaker

    public Collection getHasPizzaMaker() {
        return getPropertyValuesAs(getHasPizzaMakerProperty(), Person.class);
    }


    public RDFProperty getHasPizzaMakerProperty() {
        final String uri = "http://www.med.univ-rennes1.fr/~dameron/ontology/
pizzaReasoning.owl#hasPizzaMaker";
        final String name = getOWLModel().getResourceNameForURI(uri);
```


DefaultPizza.java (~/tmp/jnk/impl) - gedit
File Edit View Search Tools Documents Help
New Open Save Print Undo Redo Cut Copy Paste Find Replace
DefaultPizza.java
Ln 1, Col 1
INS

```
    public RDFProperty getHasPizzaMakerProperty() {
        final String uri = "http://www.med.univ-rennes1.fr/~dameron/ontology/
pizzaReasoning.owl#hasPizzaMaker";
        final String name = getOWLModel().getResourceNameForURI(uri);
        return getOWLModel().getRDFProperty(name);
    }


    public boolean hasHasPizzaMaker() {
        return getPropertyValueCount(getHasPizzaMakerProperty()) > 0;
    }


    public Iterator listHasPizzaMaker() {
        return listPropertyValuesAs(getHasPizzaMakerProperty(), Person.class);
    }


    public void addHasPizzaMaker(Person newHasPizzaMaker) {
        addPropertyValue(getHasPizzaMakerProperty(), newHasPizzaMaker);
    }


    public void removeHasPizzaMaker(Person oldHasPizzaMaker) {
        removePropertyValue(getHasPizzaMakerProperty(), oldHasPizzaMaker);
    }


    public void setHasPizzaMaker(Collection newHasPizzaMaker) {
        setPropertyValues(getHasPizzaMakerProperty(), newHasPizzaMaker);
```

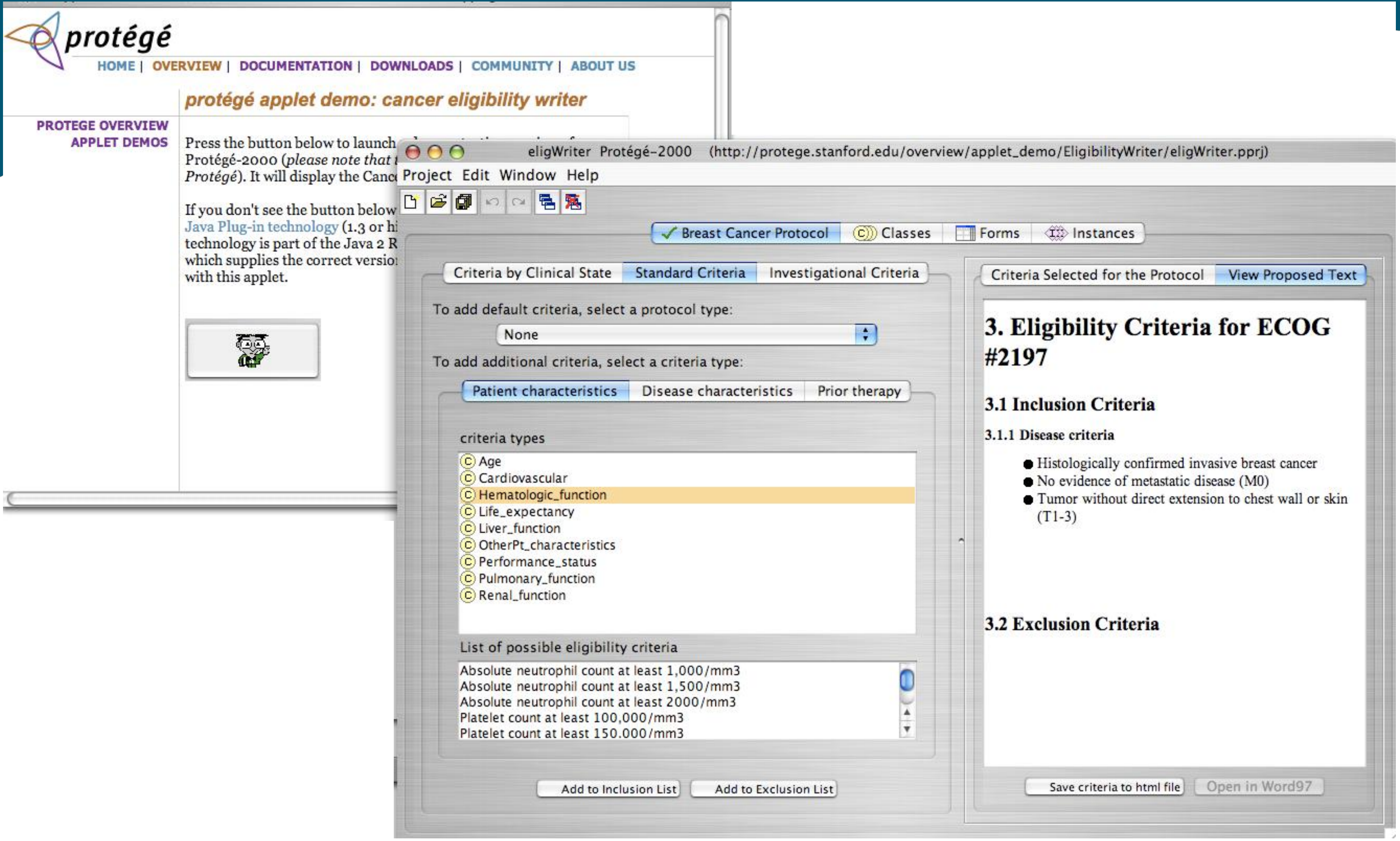
Protégé over the Web

- Applets
- Java WebStart
- Servlets and Java Server Pages
- Protégé RMI server
- Custom server

Applets

- Applets are a standard Web Browser (Internet Explorer, Firefox) plugin for running Java programs inside a browser.
- By default the application runs in a “sandbox”
  - No file system access
- Requires no “application” installation.
- Requires one installation of correct Java version
- Application is only available by going to a web page – no offline capabilities

Examples: Protégé Web site demos



protégé applet demo: cancer eligibility writer

Press the button below to launch
Protégé-2000 (*please note that*
Protégé). It will display the Canc

If you don't see the button below
Java Plug-in technology (1.3 or hi
technology is part of the Java 2 R
which supplies the correct versio
with this applet.

To add default criteria, select a protocol type:

None

To add additional criteria, select a criteria type:

criteria types

- Age
- Cardiovascular
- Hematologic_function
- Life_expectancy
- Liver_function
- OtherPt_characteristics
- Performance_status
- Pulmonary_function
- Renal_function

List of possible eligibility criteria

- Absolute neutrophil count at least 1,000/mm3
- Absolute neutrophil count at least 1,500/mm3
- Absolute neutrophil count at least 2000/mm3
- Platelet count at least 100,000/mm3
- Platelet count at least 150.000/mm3

3. Eligibility Criteria for ECOG #2197

3.1 Inclusion Criteria

3.1.1 Disease criteria

- Histologically confirmed invasive breast cancer
- No evidence of metastatic disease (M0)
- Tumor without direct extension to chest wall or skin (T1-3)

3.2 Exclusion Criteria

http://protege.stanford.edu/overview/applet_demo/EligibilityWriter/eligwriter_demo.html

Java WebStart

- WebStart is a standard Java mechanism for installing and running Java programs on a client.
- Application is “automatically” installed and started when the user hits a URL.
- Improvement on Applets:
  - Handles Java VM updates
  - Handles application updates
  - Allows off line execution
  - Allows application execution without starting browser

Servlets and Java Server Pages (JSP)

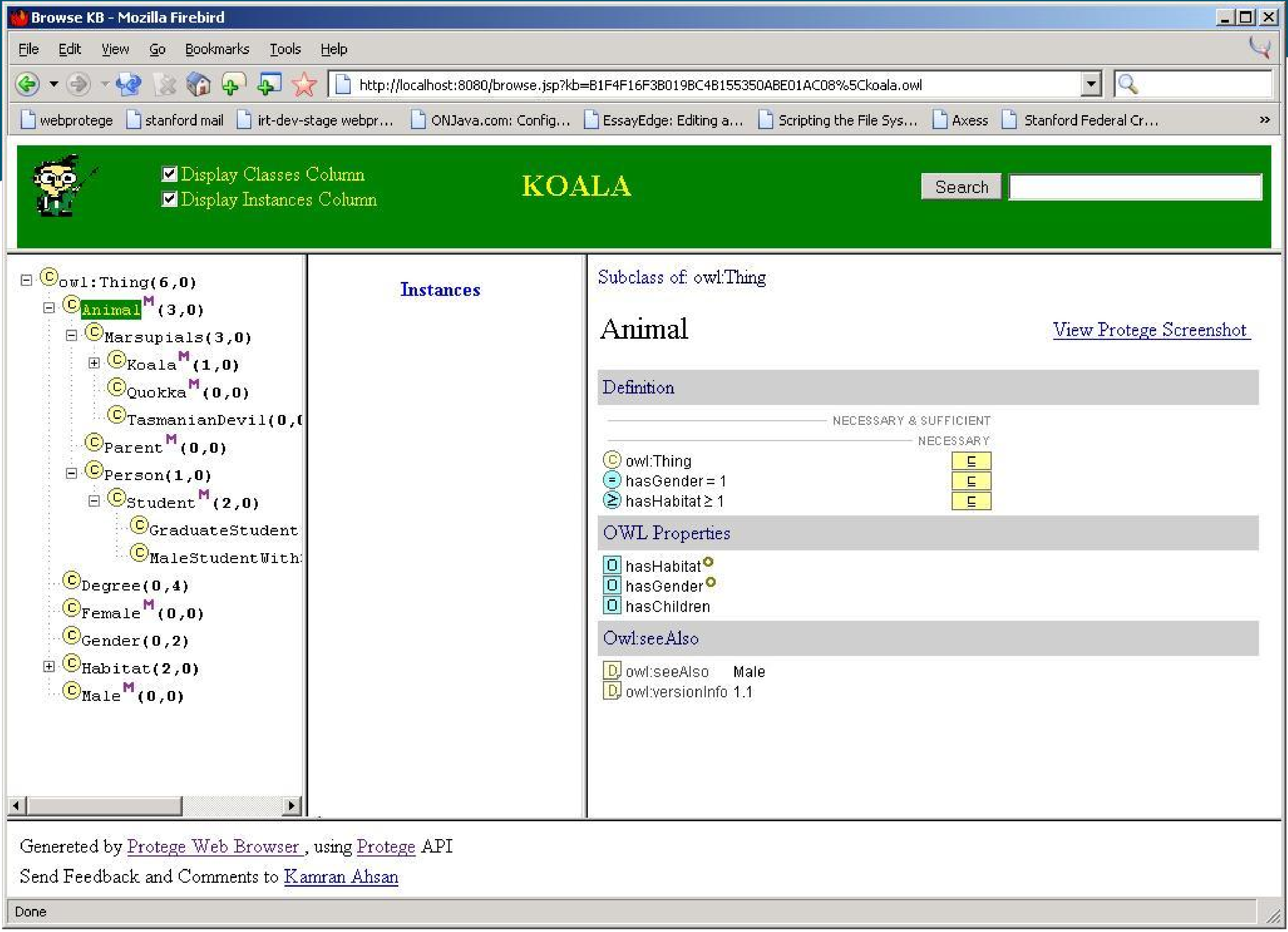
- Servlets are web server plugins written in Java.
  - Called by accessing a particular URL.
  - Control the design and content of the page sent to the caller’s browser

- JSP are code written in a “java-like-language” embedded in a web page. This code can make calls to the web server and typically control the design and/or content of part of the page.

- Typically servlets (directly) and JSP’s (indirectly) call into the Protégé API to access knowledge base elements and use this information to influence the design and content of web pages.

Example: “Protege Web Browser”

Example: Protégé Web Browser



owl:Thing(6,0)
- Animal (3,0)
  - Marsupials(3,0)
    - Koala (1,0)
    - Quokka (0,0)
    - TasmanianDevil(0,(
  - Parent (0,0)
  - Person(1,0)
    - Student (2,0)
      - GraduateStudent
      - MaleStudentWith
- Degree(0,4)
- Female (0,0)
- Gender(0,2)
- Habitat(2,0)
- Male (0,0)

Subclass of: owl:Thing

Animal

View Protege Screenshot

Definition

NECESSARY & SUFFICIENT
NECESSARY

owl:Thing	⊑
hasGender = 1	⊑
hasHabitat ≥ 1	⊑

OWL Properties

hasHabitat
hasGender
hasChildren

Owl:seeAlso

owl:seeAlso	Male
owl:versionInfo	1.1

Genereted by Protege Web Browser , using Protege API
Send Feedback and Comments to Kamran Ahsan

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

Remote Method Invocation (RMI) server

- Standard Java remote procedure call mechanism.
- Used by the Protégé multi-user client.
- Provides programmatic access to Protégé API across the web.
- No need to export project access or database access

Example: Protégé Multiuser Client/Server system (see *http://protege.stanford.edu/doc/multiuser/index.html*)

Custom server

- Wrap the Protégé API (or the part that you want to export) with your own API and then make it available with whatever network protocol you like.

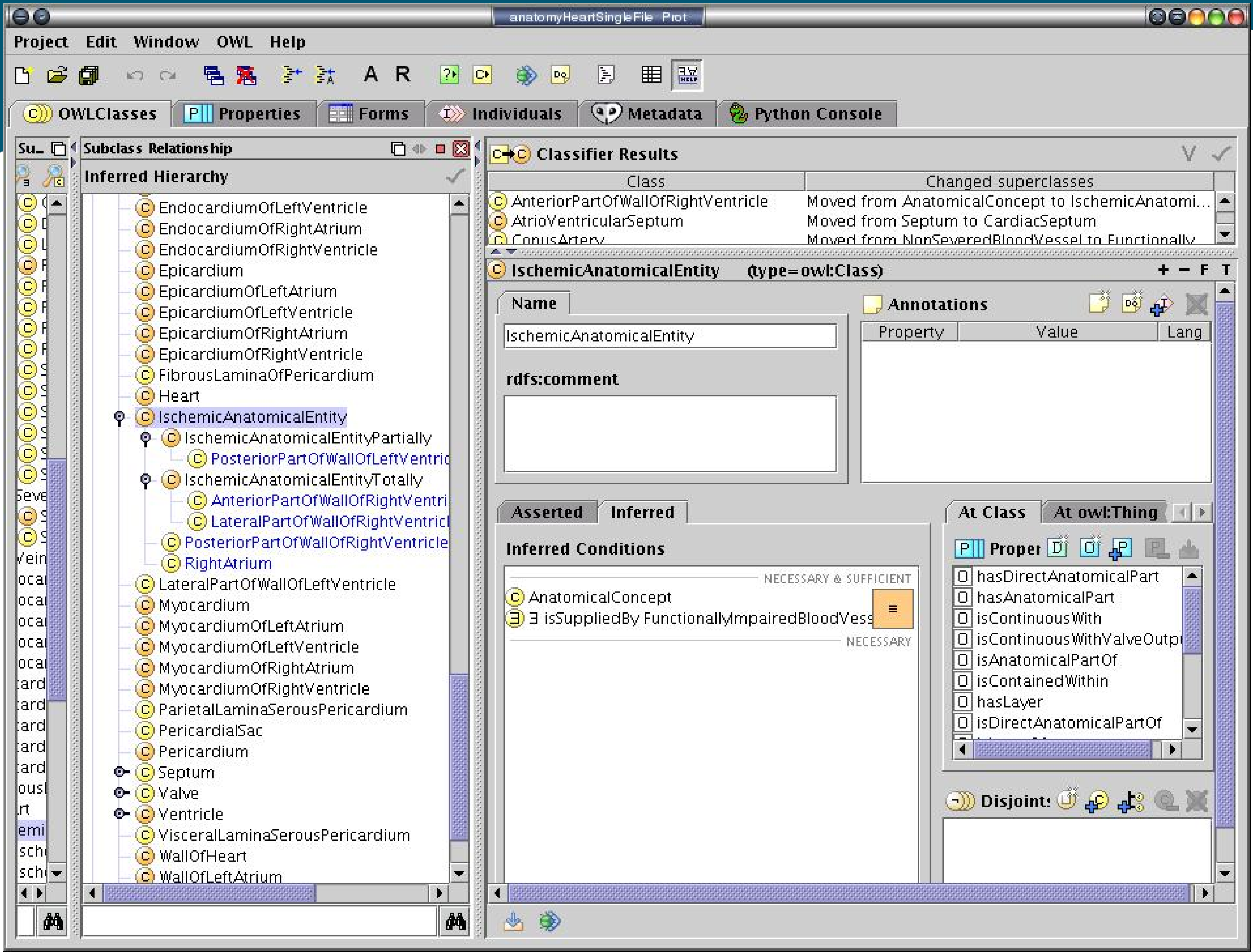
Example: Protégé CORBA Server
(see *http://www.mitre.org/work/tech_transfer/protegeserver/index.html*)

Web Services

- Description
  - Wrap reasoning and ontology-manipulation functions as one or more Web Services
- Pros
  - It is better to have domain knowledge separated from application(s)
    - maintenance of KB is easier
    - maintenance of applications is easier
    - semantic interoperability between applications
- Cons
  - Requires knowledge of Web Services implementation

Example: Virtual Soldier Project - Ontology

(-> Olivier)



EndocardiumOfLeftVentricle
EndocardiumOfRightAtrium
EndocardiumOfRightVentricle
Epicardium
EpicardiumOfLeftAtrium
EpicardiumOfLeftVentricle
EpicardiumOfRightAtrium
EpicardiumOfRightVentricle
FibrousLaminaOfPericardium
Heart
IschemicAnatomicalEntity
IschemicAnatomicalEntityPartially
PosteriorPartOfWallOfLeftVentric
IschemicAnatomicalEntityTotally
AnteriorPartOfWallOfRightVentri
LateralPartOfWallOfRightVentricl
PosteriorPartOfWallOfRightVentricle
RightAtrium
LateralPartOfWallOfLeftVentricle
Myocardium
MyocardiumOfLeftAtrium
MyocardiumOfLeftVentricle
MyocardiumOfRightAtrium
MyocardiumOfRightVentricle
ParietalLaminaSerousPericardium
PericardialSac
Pericardium
Septum
Valve
Ventricle
VisceralLaminaSerousPericardium
WallOfHeart
WallOfLeftAtrium

Class	Changed superclasses
AnteriorPartOfWallOfRightVentricle	Moved from AnatomicalConcept to IschemicAnatomi...
AtrioVentricularSeptum	Moved from Septum to CardiacSeptum
ConusArtery	Moved from NonSeveredBloodVessel to Functionally

IschemicAnatomicalEntity (type=owl:Class)

Name: IschemicAnatomicalEntity

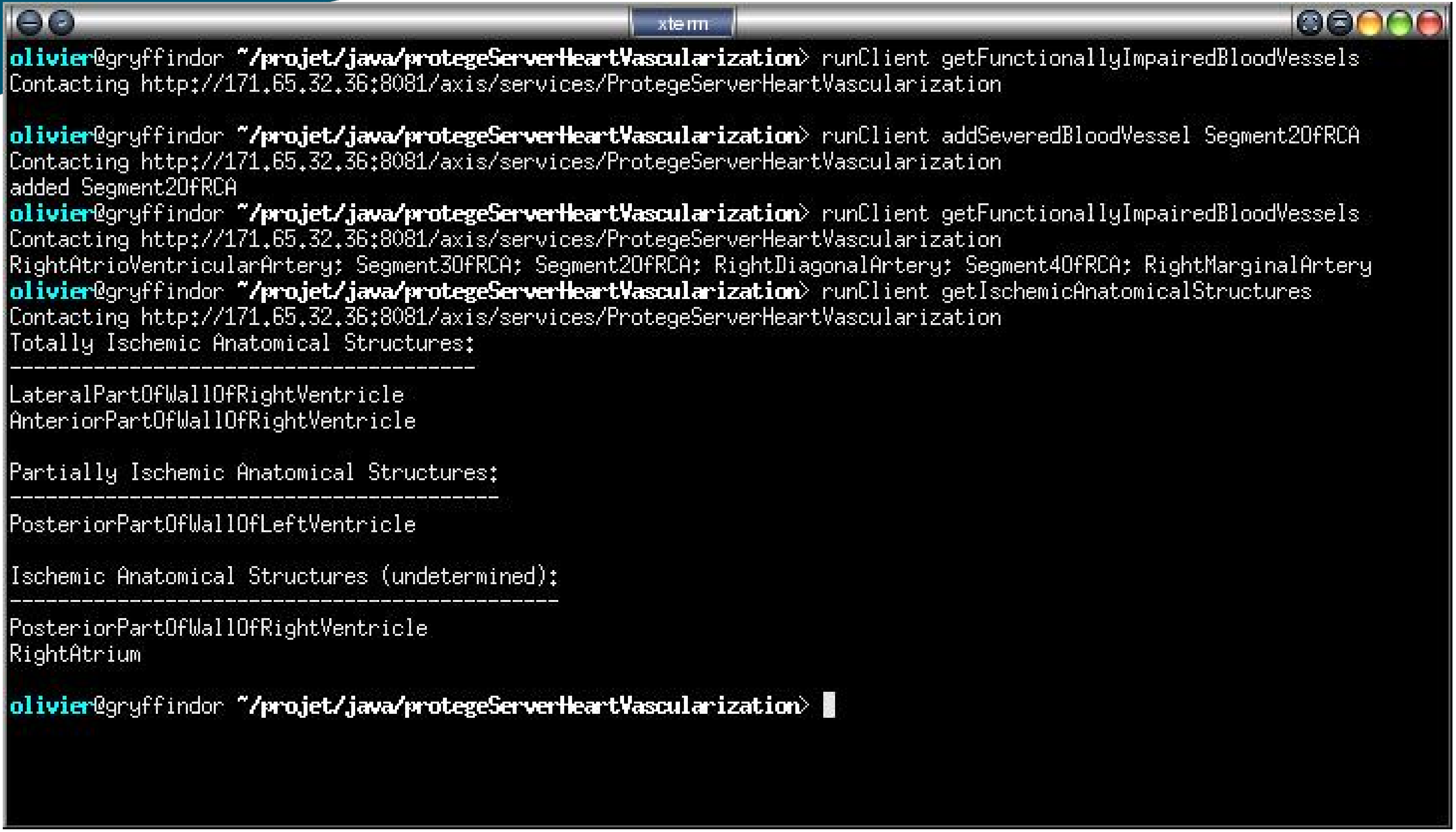
Property	Value	Lang

Inferred Conditions

NECESSARY & SUFFICIENT
AnatomicalConcept
∃ isSuppliedBy FunctionallyImpairedBloodVess
NECESSARY

hasDirectAnatomicalPart
hasAnatomicalPart
isContinuousWith
isContinuousWithValveOutp
isAnatomicalPartOf
isContainedWithin
hasLayer
isDirectAnatomicalPartOf

Example: Virtual Soldier Project - *Determination of ischemic structures*



xterm

```
olivier@gryffindor ~/projet/java/protegeServerHeartVascularization> runClient getFunctionallyImpairedBloodVessels
Contacting http://171.65.32.36:8081/axis/services/ProtegeServerHeartVascularization

olivier@gryffindor ~/projet/java/protegeServerHeartVascularization> runClient addSeveredBloodVessel Segment2OfRCA
Contacting http://171.65.32.36:8081/axis/services/ProtegeServerHeartVascularization
added Segment2OfRCA
olivier@gryffindor ~/projet/java/protegeServerHeartVascularization> runClient getFunctionallyImpairedBloodVessels
Contacting http://171.65.32.36:8081/axis/services/ProtegeServerHeartVascularization
RightAtrioVentricularArtery; Segment3OfRCA; Segment2OfRCA; RightDiagonalArtery; Segment4OfRCA; RightMarginalArtery
olivier@gryffindor ~/projet/java/protegeServerHeartVascularization> runClient getIschemicAnatomicalStructures
Contacting http://171.65.32.36:8081/axis/services/ProtegeServerHeartVascularization
Totally Ischemic Anatomical Structures:
---------------------------------------
LateralPartOfWallOfRightVentricle
AnteriorPartOfWallOfRightVentricle

Partially Ischemic Anatomical Structures:
-----------------------------------------
PosteriorPartOfWallOfLeftVentricle

Ischemic Anatomical Structures (undetermined):
----------------------------------------------
PosteriorPartOfWallOfRightVentricle
RightAtrium

olivier@gryffindor ~/projet/java/protegeServerHeartVascularization> 
```

Summary

- Protégé and databases have places in application building world
- Protégé tab mechanism provides “sandbox” to prototype an application
- Standalone applications are easily built on Protégé
  - Using only the knowledge base
  - Using also some/all of the Protégé UI
  - Using jsave package to generate Java code
- Web applications built on top of Protégé in a wide variety of ways

Outline

- Protégé and Databases
- Protégé Application Designs
  - API Application Designs
  - Web Application Designs

- Higher-Level Access to Protégé Knowledge Bases
  - Reasoning Systems (Algernon, Jess) *-> Eriksson's Tutorial*
  - Scripting Language Interfaces
  - Problem Solving Methods (PSMs)