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HEARTFAID project: Integration of knowledge discovery, knowledge representation, and decision support functionality

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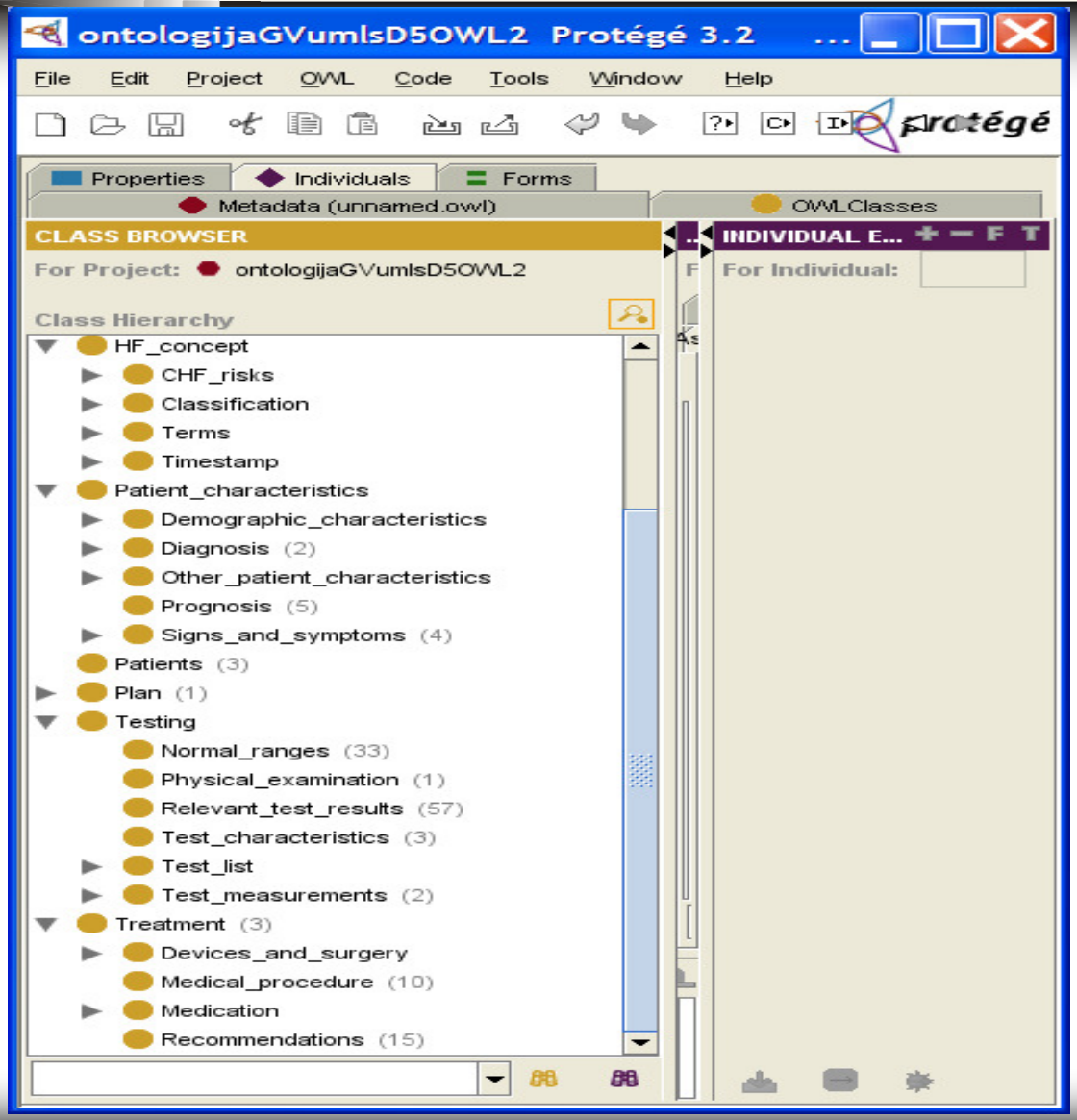
HEARTFAID project title

- A **KNOWLEDGE BASED PLATFORM** of services for supporting medical-clinical management of the heart failure within the elderly population
  - *knowledge representation* and its usage (*decision support*) has the central role
  - knowledge discovery from data additional task

HEARTFAID central problem

- How to present knowledge in a general and systematic way so that it can be used by different services (some that are not even known in advance)
  - This is one of central issues in AI today

HF ontology



Basic elements are classes:

“HF_concept”,

“Patient_characteristics”,

“Testing”,

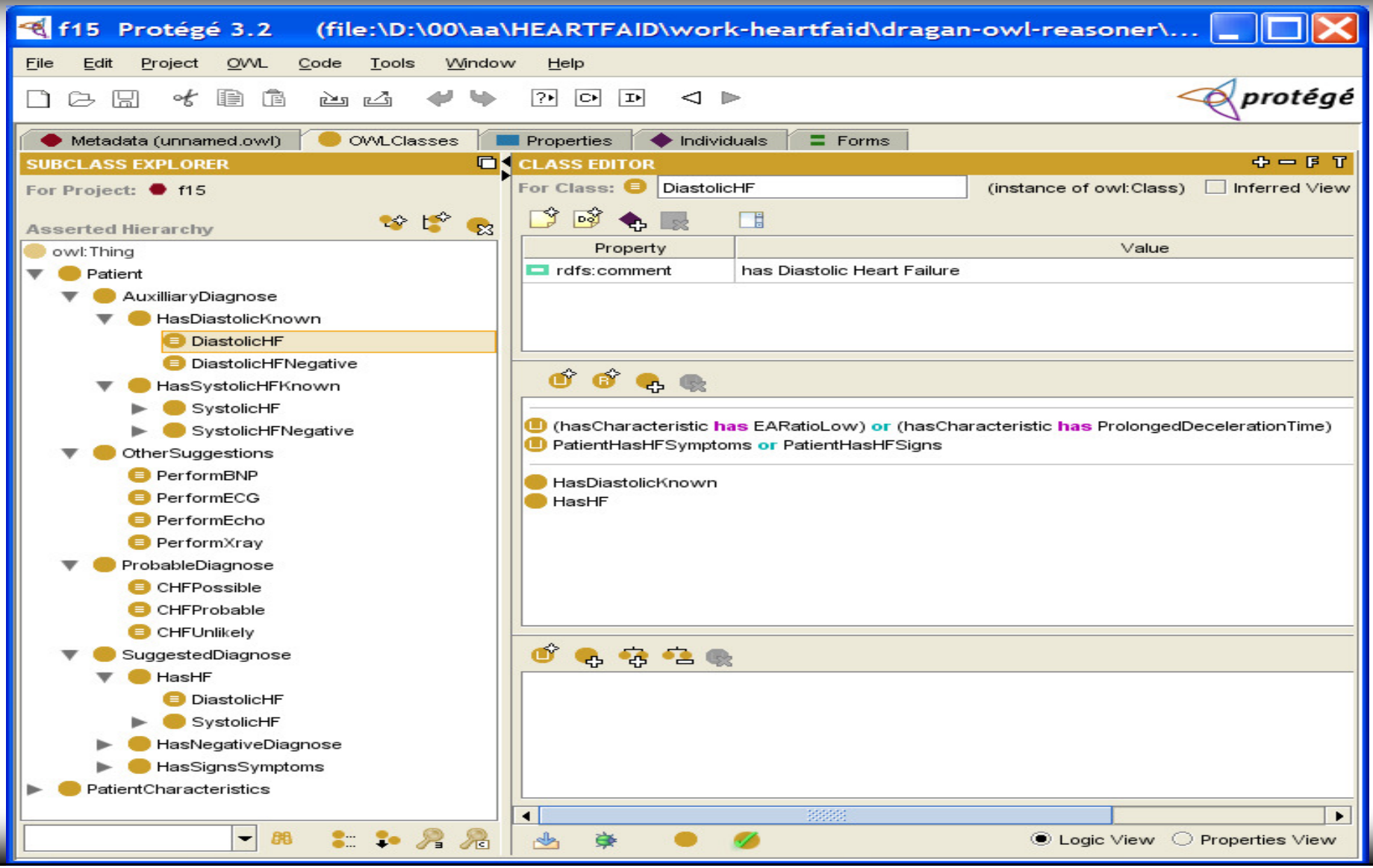
“Treatment”

Protégé tool used to display a part of the HF ontology

Procedural knowledge

- The HF ontology presents the detailed taxonomic overview of complete heart failure domain including relevant relations among concepts. It represents ***descriptive knowledge*** about the domain.
- Platform should also be able to perform some actions, typically in the form of suggestions for patients and medical personnel. The knowledge representing sufficient and necessary conditions that some actions can be done is the so called ***procedural knowledge***.
- Descriptive and procedural knowledge together present the ***knowledge base*** of the HF platform.

Procedural knowledge integrated into HF ontology

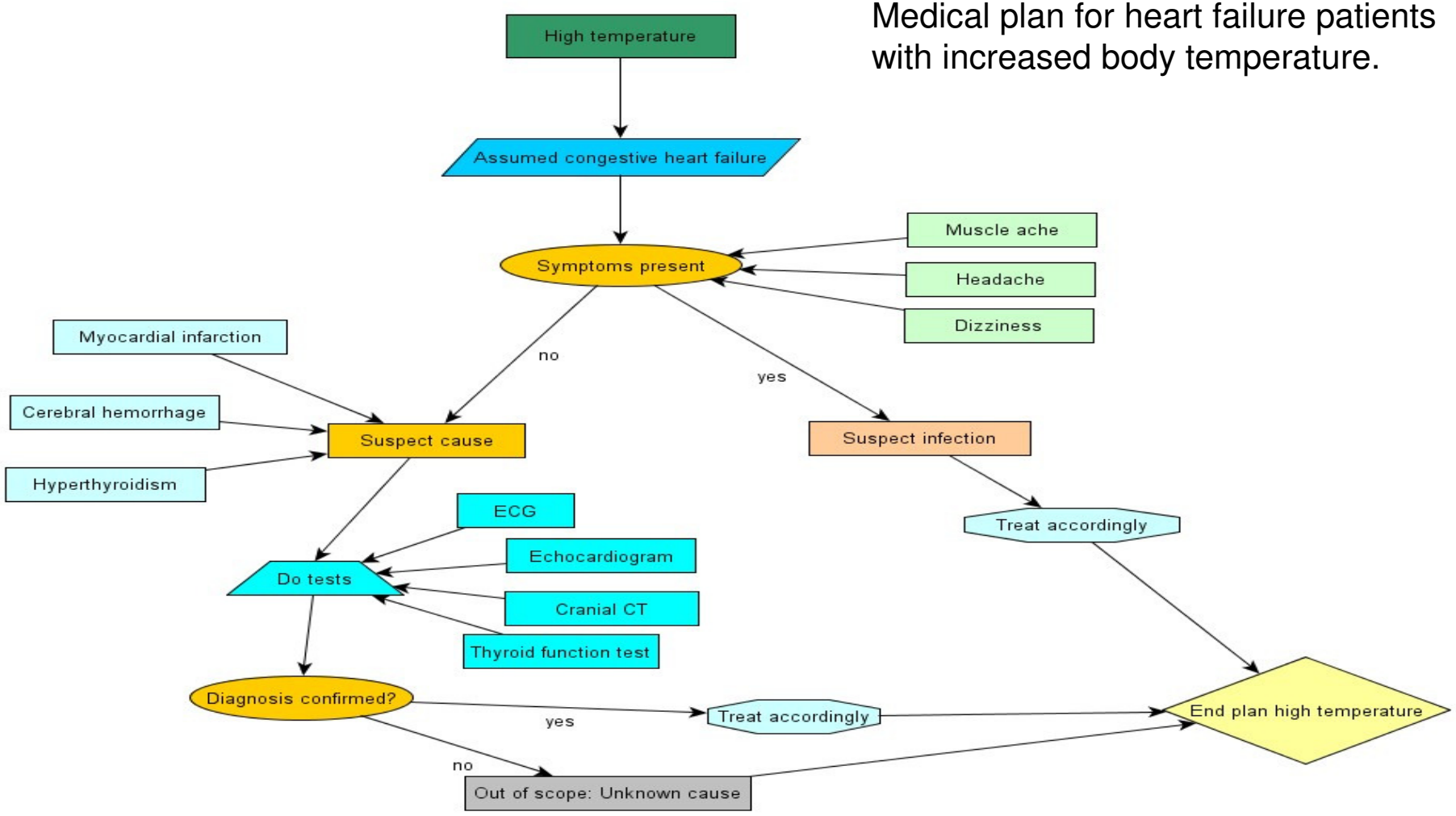


Medical plans

- Medical plans are textual and visual presentations of procedures that take place after detection of some events.
- Events can be any type of health disorder including signs, symptoms, and diagnosis.
- The main characteristic of medical plans is that they are event driven and because of that they present actionable view of the medical knowledge.

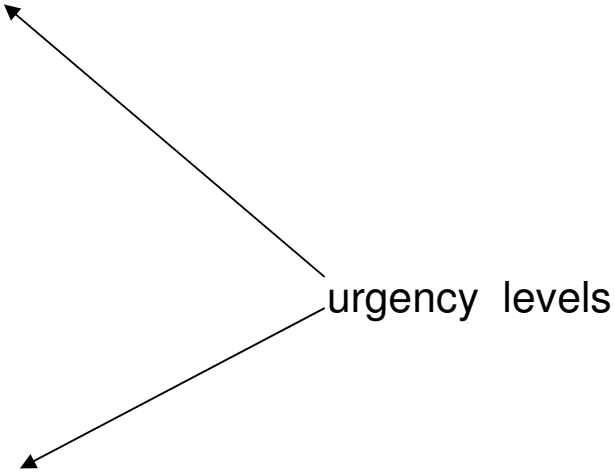
Medical plans

Medical plan for heart failure patients with increased body temperature.



Medical plans

Heart attack	5
Cerebral stroke	5
Ankle edema	3
Dizziness	2
Coughing	1
Dyspnea	3
Paroxysmal nocturnal dyspnea	3
Orthopnea	3
Oliguria	2
Involuntary weight gain	3
.....	



HF system has:

38 interconnected plans for signs, symptoms and diagnosis assessment and treatment

15 plans for medications prescription and dosage

Medical plans

Plan #23
Pulmonary edema
Severity level: 5
Information for this plan has been obtained from the Acute Heart Failure Guidelines and from Congestive Heart failure Guidelines, 2005
Assume congestive heart failure
- **verify** by X-ray
- **it is** severe left heart backward failure, presenting with shortness of breath, dry cough (sometimes frothy sputum), pallor or even cyanosis, cold and clammy skin, normal or elevated blood pressure, systolic function is often preserved, also more than 50% of patients have LVEF>45%, severe respiratory distress, lung crackles (rales) and orthopnea, O2 saturation less than 90%
- **can be caused by** long-term hypertension, especially in older women (65+)
- **possible causes** are: myocardial ischemia or infarction, aortic or mitral valve disease, severe arrhythmias, left heart tumour, severe hypertension, anaemia, thyrotoxicosis, brain tumour or trauma
- **treatment** order is O2, then CPAP or NIPPV, then if necessary mechanical intubation, intravenous administration of antihypertensive agents (vasodilators(nitrates), nitrates are more effective than diuretics, however diuretics can also be used, do not use beta-blockers)
- **consider** coronary angiography if patient does not respond to treatment
- **consider** ultrafiltration for temporary relief
End plan #23

Medical plans

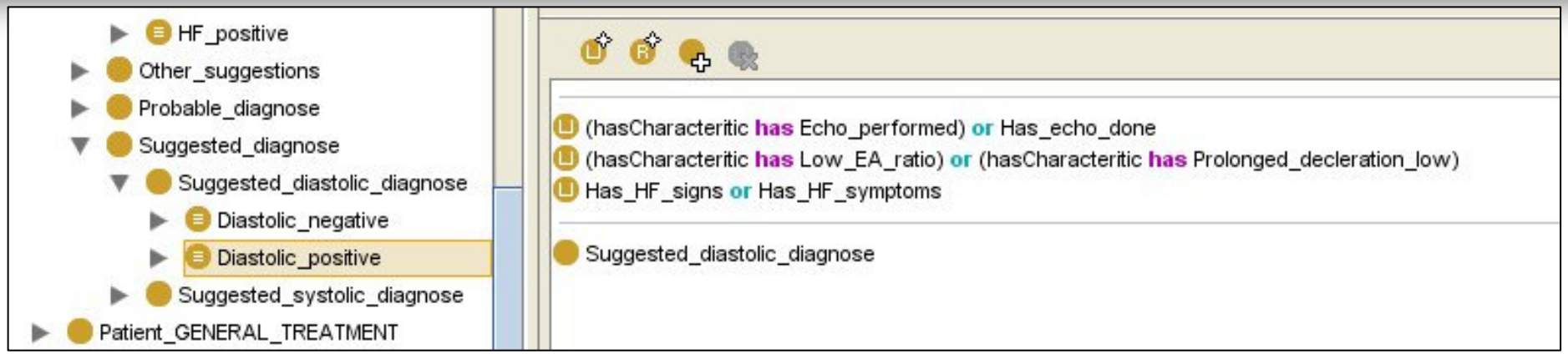
- The syntax of the medical plans highly resembles the traditional ***workflow management***. The difference is that the medical plans will not be executed by machines; they are written in an almost free graph/text form with main purpose to be fully understandable by humans. Their main characteristic is that they are ***event driven*** and their main advantage is a clear systematization of the medical procedures and interconnections among them.

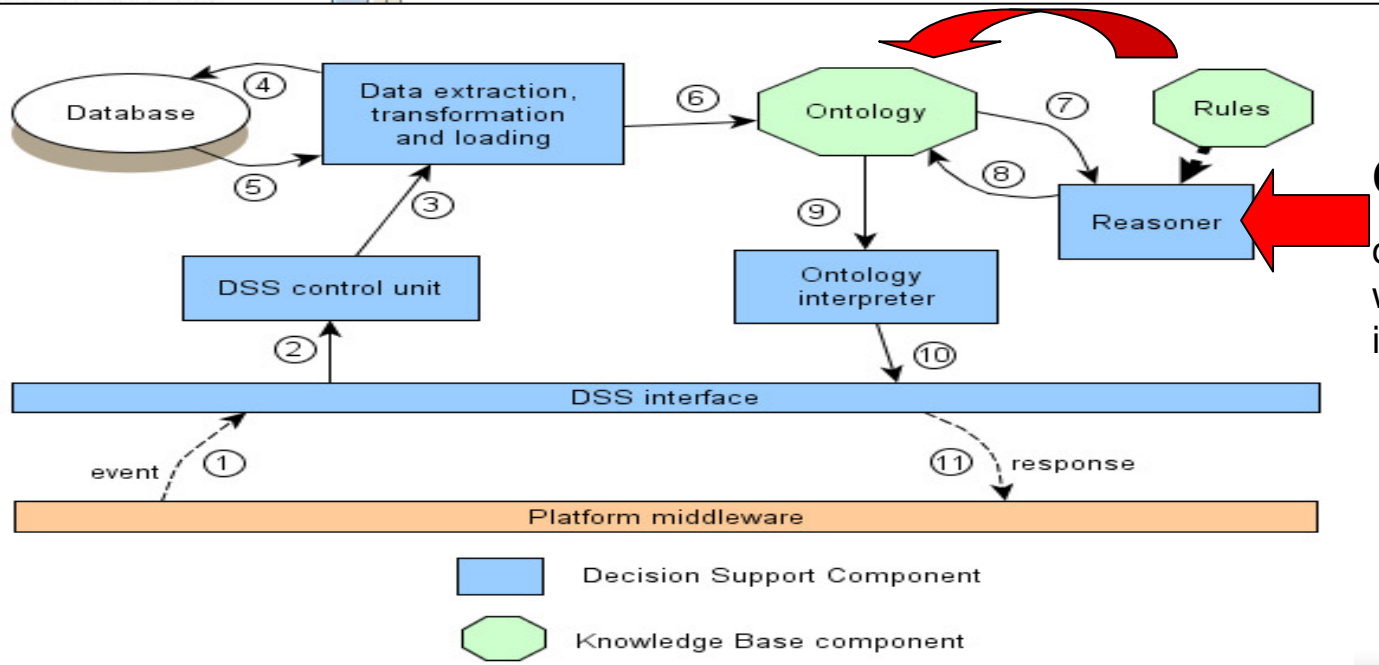
- In the Heartfaid platform medical plans are only a ***middle step*** between experts and the guideline modelling tools which persuade the experts to clearly state the procedure they would normally perform when facing a specific problem.

Lessons learnt

1. Semantic web is great for knowledge representation – excellent choice
2. OWL + SWRL not a good combination (open world assumption!)
3. Integration of procedural knowledge into OWL – ***successful combination***

Conceptualization of procedural knowledge

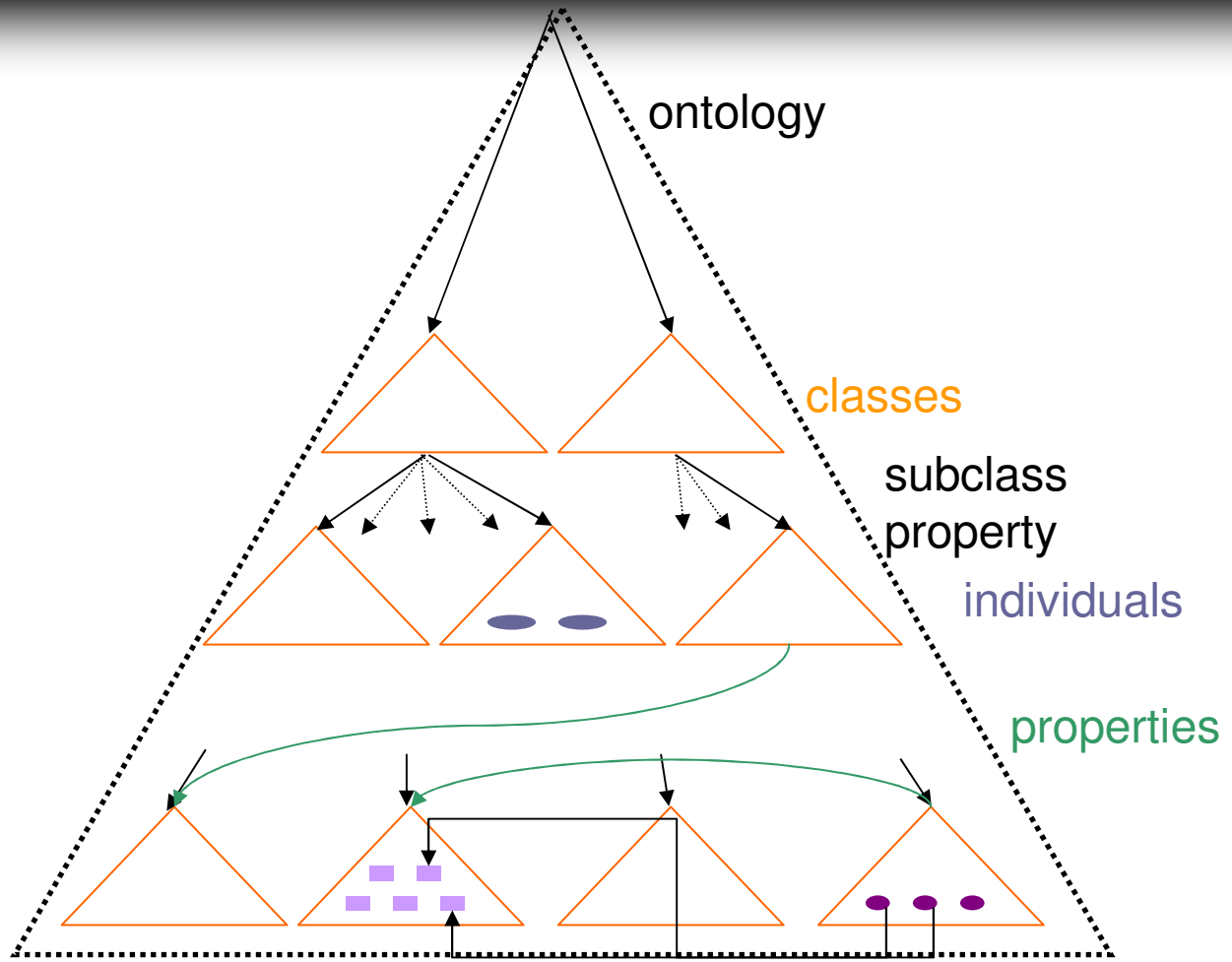




COSI

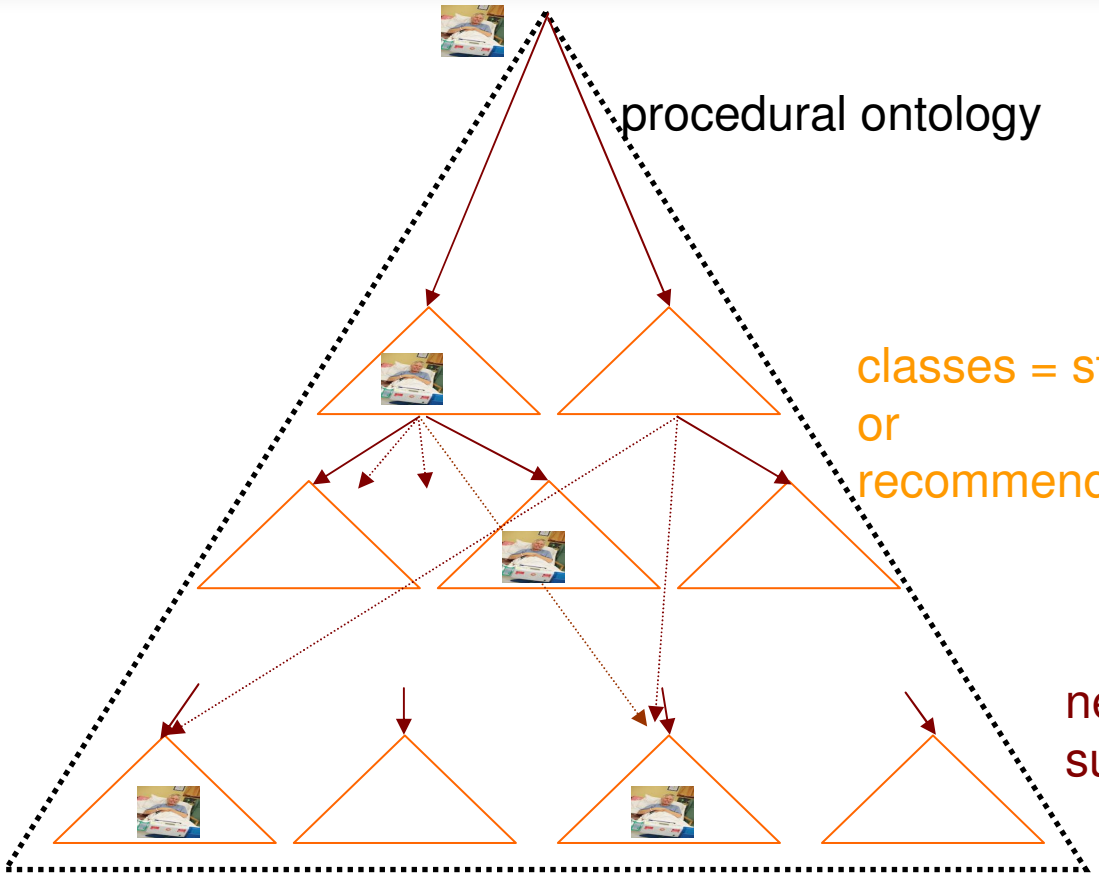
closed world OWL interpreter

Descriptive ontology



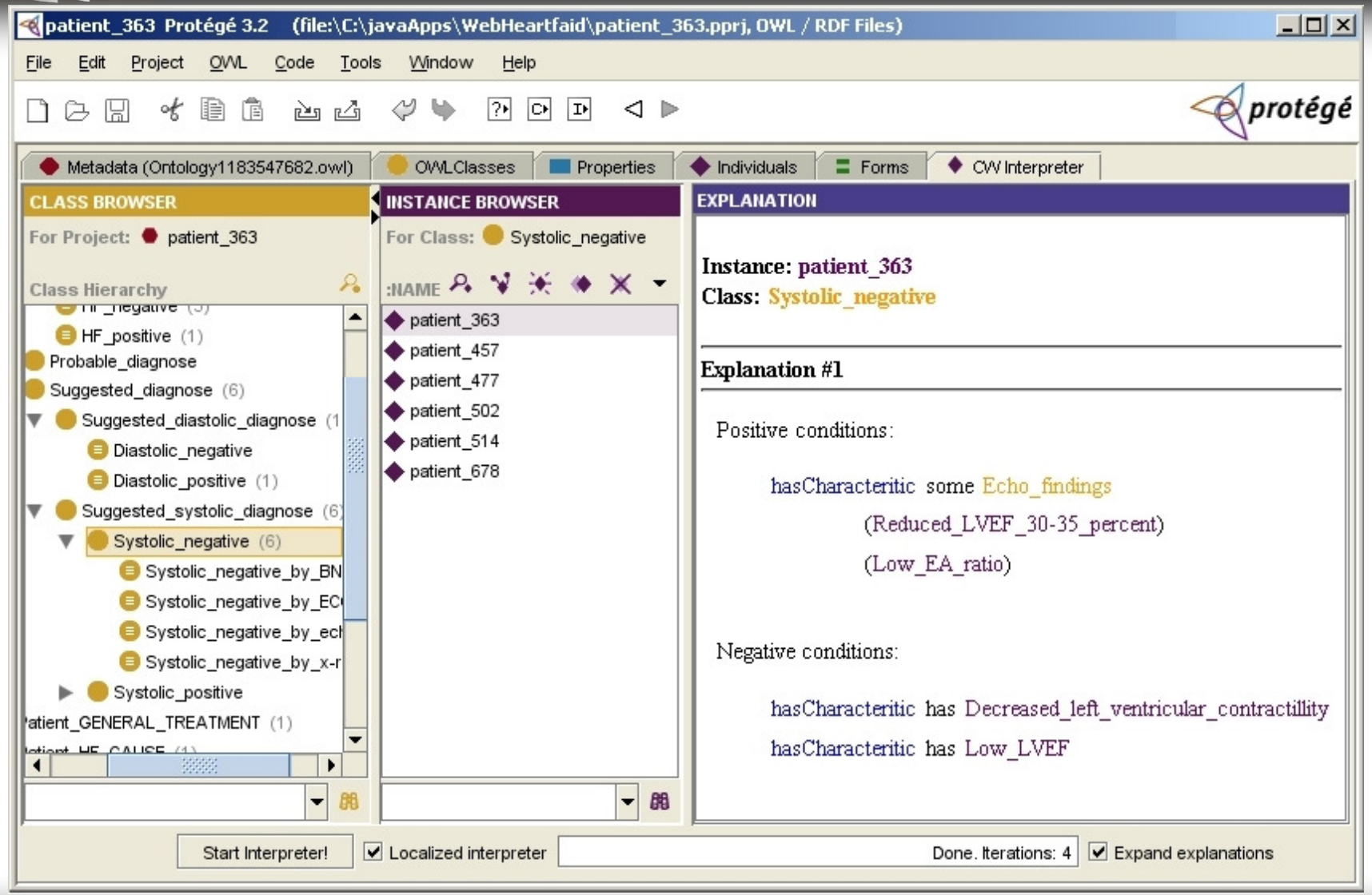
individual "Valvular_heart_disease" from the class "Heart_valve_diseases" is “indicated by” the individual "Dyspnea" from the class of "Signs_and_symptoms".

Procedural knowledge conceptualization

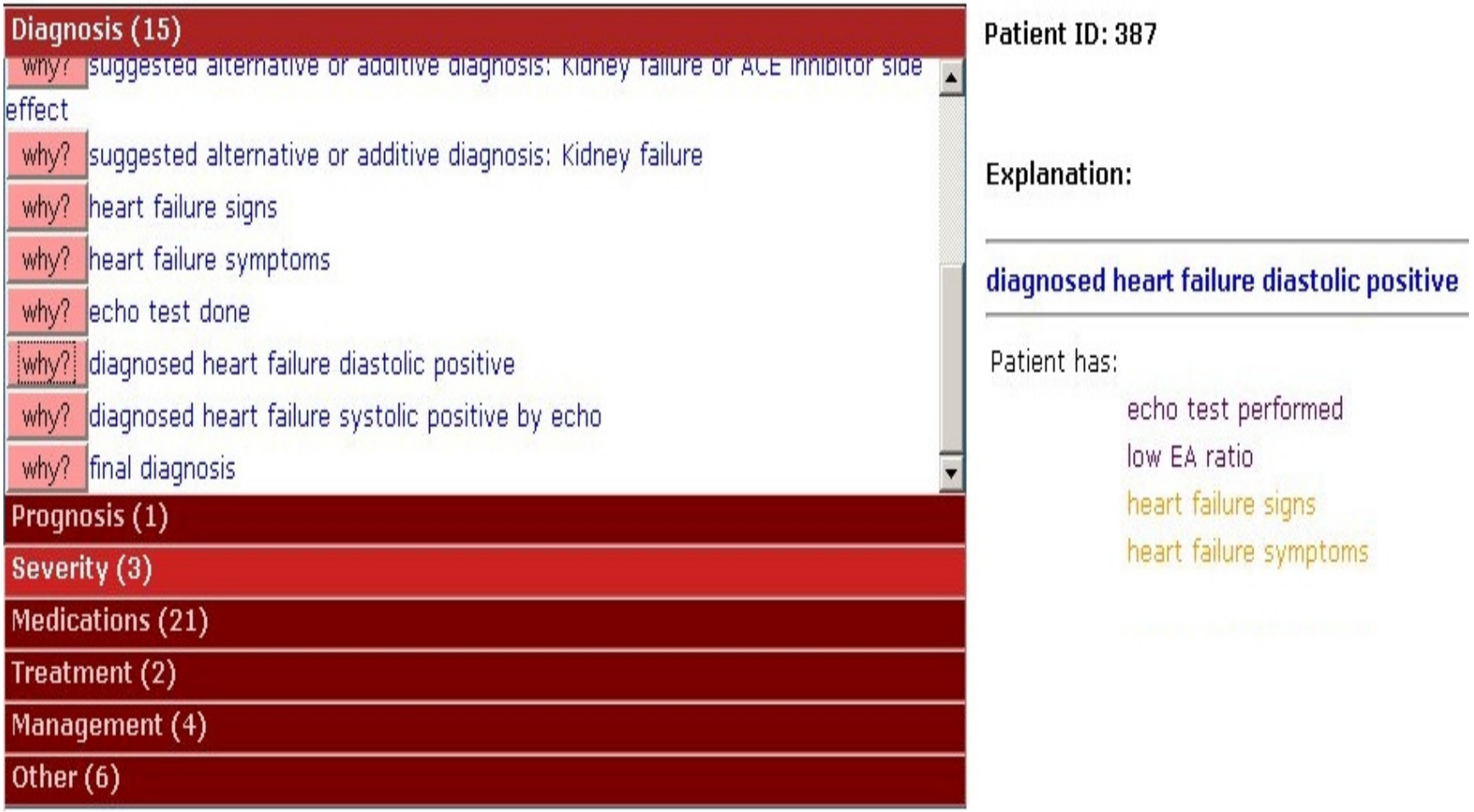


Patient is in the classes: systolic HF, ACE inhibitors suggested, bad prognosis, suggest treatment, ….

COSI – Closed world OWL interpreter



COSI – Closed world OWL interpreter



Achievements

1

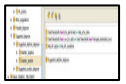
We have developed HF ontology

- it is public on http://lis.irb.hr/heartfaid/ontology/
- the ontology has been requested by Stanford University Medical Center for research in the study on “risk factors for congestive heart failure
- the ontology has been requested by HeartCycle FP7 project
- it means a long term result valuable also outside Heartfaid project

Achievements

2

We have developed procedural HF related knowledge (10 sets of rules)



-Novelty of this project: we have integrated procedural knowledge into the ontological form !

-Brand new: we have developed COSI (Closed world OWL syntax interpreter) for decision support purposes which is now used for the platform DSS !

- we can use the same methodology on any domain

Achievements

3

We have developed a complete set of medical plans for HF domain.

- it is public on http://lis.irb.hr/heartfaid/plans/
- they are not used for reasoning
- topic of the future work

Thank you for your attention!