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How Ontologies can Improve Semantic Interoperability in Health Care

KR4HC – ProHealth'13
Murcia, Spain, June 1st, 2013

Semantic Interoperability

"*... integrating resources that were developed using different* ***vocabularies*** *and different* ***perspectives*** *on the data. To achieve semantic interoperability, systems must be able to exchange data in such a way that the precise meaning of the data is readily accessible and the data itself can be translated by any system into a form that it understands.*"

Jeff Heflin and James Hendler (2000) Semantic Interoperability on the Web
http://www.cs.umd.edu/projects/plus/SHOE/pubs/extreme2000.pdf

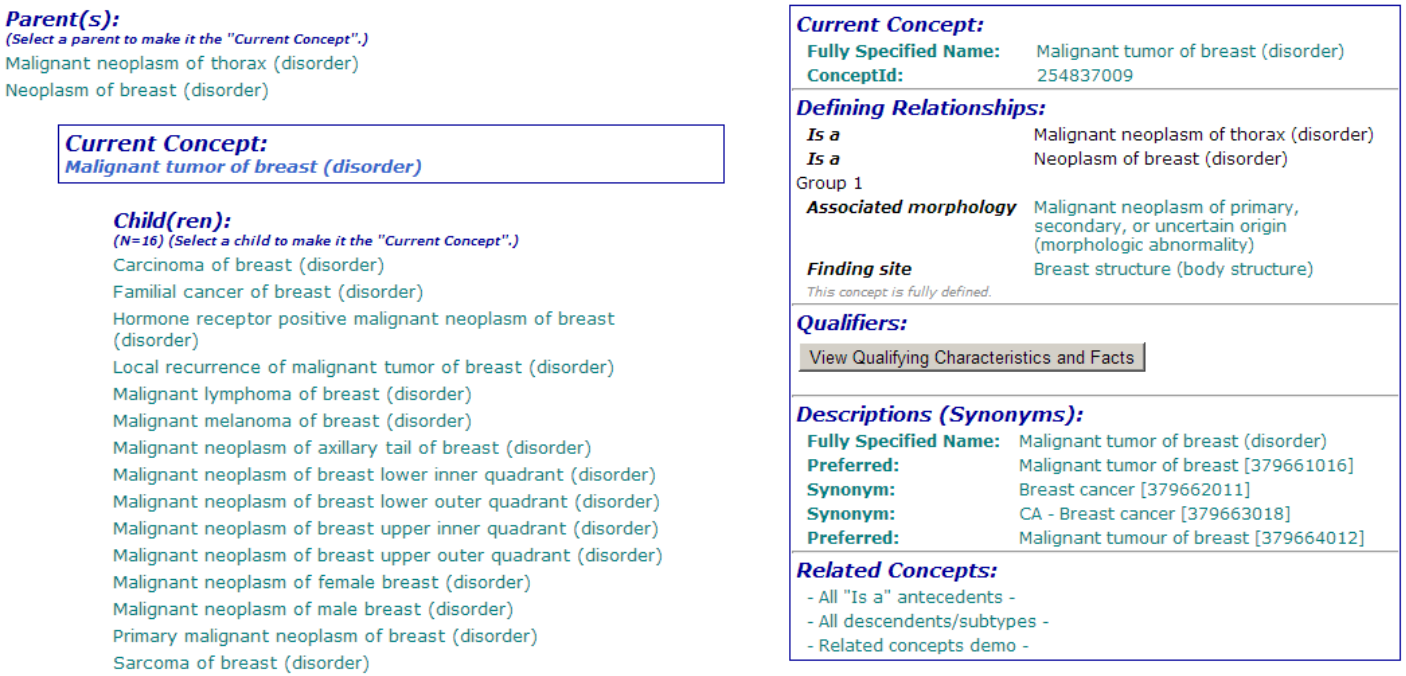
Semantic Standards

*"… integrating resources that were developed using different **vocabularies** and different **perspectives** … "*

- "**Vocabularies**": Terminologies / classifications / ontologies
  - Provide codes that denote types of clinical entities (84114007 |heart failure|): ICD, SNOMED CT.
- "**Perspectives**": EHR information models
  - Provide standardized structure (section, entry, cluster, etc.) and context (past history, order, …) for clinical data: openEHR, ISO 13606, HL7 CDA.

Semantic Standards

- "**Vocabularies**": Terminologies / classifications / ontologies
  - Provide codes that denote types of clinical entities (84114007 |heart failure|): ICD, SNOMED CT.



Parent(s):
(Select a parent to make it the "Current Concept".)
Malignant neoplasm of thorax (disorder)
Neoplasm of breast (disorder)

Current Concept:
Malignant tumor of breast (disorder)

Child(ren):
(N=16) (Select a child to make it the "Current Concept".)
Carcinoma of breast (disorder)
Familial cancer of breast (disorder)
Hormone receptor positive malignant neoplasm of breast (disorder)
Local recurrence of malignant tumor of breast (disorder)
Malignant lymphoma of breast (disorder)
Malignant melanoma of breast (disorder)
Malignant neoplasm of axillary tail of breast (disorder)
Malignant neoplasm of breast lower inner quadrant (disorder)
Malignant neoplasm of breast lower outer quadrant (disorder)
Malignant neoplasm of breast upper inner quadrant (disorder)
Malignant neoplasm of breast upper outer quadrant (disorder)
Malignant neoplasm of female breast (disorder)
Malignant neoplasm of male breast (disorder)
Primary malignant neoplasm of breast (disorder)
Sarcoma of breast (disorder)

Current Concept:
Fully Specified Name: Malignant tumor of breast (disorder)
ConceptId: 254837009

Defining Relationships:
Is a Malignant neoplasm of thorax (disorder)
Is a Neoplasm of breast (disorder)
Group 1
Associated morphology Malignant neoplasm of primary, secondary, or uncertain origin (morphologic abnormality)
Finding site Breast structure (body structure)
This concept is fully defined.

Qualifiers:
View Qualifying Characteristics and Facts

Descriptions (Synonyms):
Fully Specified Name: Malignant tumor of breast (disorder)
Preferred: Malignant tumor of breast [379661016]
Synonym: Breast cancer [379662011]
Synonym: CA - Breast cancer [379663018]
Preferred: Malignant tumour of breast [379664012]

Related Concepts:
- All "Is a" antecedents -
- All descendents/subtypes -
- Related concepts demo -

Semantic Standards

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```
SECTION[at0000] matches {  -- History of problem / condition
  members cardinality matches {1..*; unordered} matches {
    ENTRY[at0001] matches {  -- Problem / Condition
      items cardinality matches {1..*; unordered } matches {
        ELEMENT[at0002] matches {  -- Diabetes Mellitus
          value matches {
            SIMPLE_TEXT[at0003] matches {  -- SIMPLE_TEXT
              originalText matches {"Yes","No","Unknown"}
            }
          }
        }
      }…}}}
```

Semantic Standards

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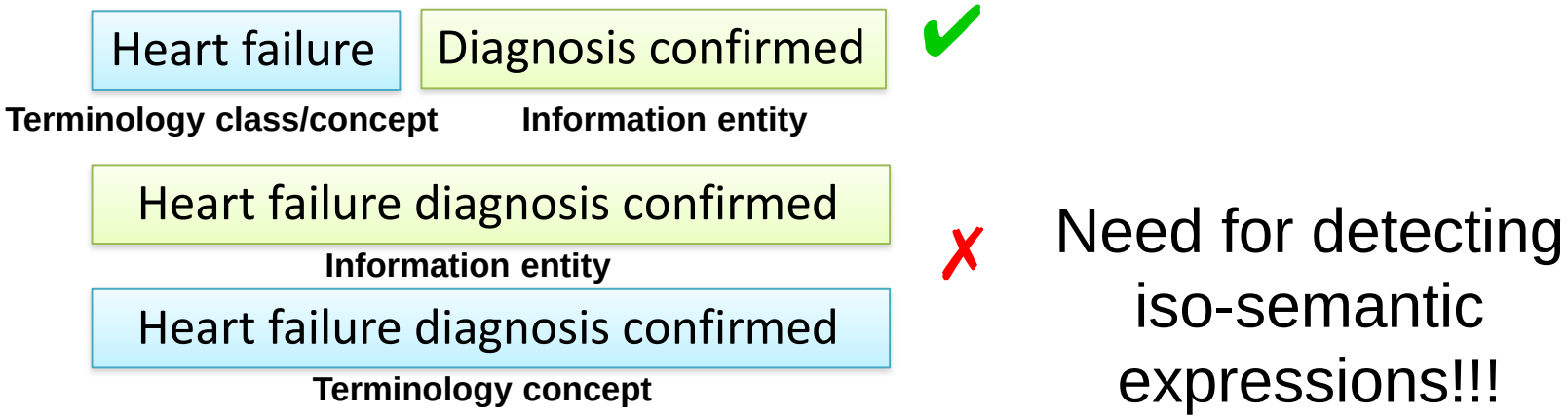


Need for detecting iso-semantic expressions!!!

Overlap Terminologies / Information Models

Clinical Terminologies

- Terminologies to be used without information models

Clinical Information Models

openEHR

CEN/ISO 13606

HL7

- Clinical Information models to be used without or with inexpressive terminologies

- Contextual statements (negation, plans, beliefs…) within terminologies
  - SNOMED CT context model
  - ICD 11 content model
- Local terminology within IMs
- Postcoordination within IMs

Consequence: Plurality of isosemantic encodings

- The same meaning is represented by…

"*Suspected heart failure caused by ischaemic heart disease*"

… single codes in different terminologies

"*Finding with explicit context*" and
DueTo some "*Ischaemic heart disease*" and
FindingContext some "*Suspected*"

… postcoordinated expressions in different terminologies

Diagnosis: "Heart Failure"
Certainty: "Suspected"
Etiology: "Ischaemic heart disease"

… different combinations between terminologies and information models

SemanticHealthNet

ABOUT | DELIVERABLES | WORKPLAN | CONSORTIUM | CONTACT US

About

SemanticHealthNet will develop a scalable and sustainable pan-European organisational and governance process for the semantic interoperability of clinical and biomedical knowledge, to help ensure that EHR systems are optimised for patient care, public health and clinical research across healthcare systems and institutions.

Through a clinically-driven workplan, exemplified in cardiovascular medicine, *SemanticHealthNet* will capture the needs for evidence-based, patient-centred integrated care and for public health, encapsulating existing European consensus in the management of chronic heart failure and cardiovascular prevention. Experts in EHR architectures, clinical data structures, terminologies and ontology will combine, tailor and pilot their best-of-breed resources in response to the needs articulated by clinicians and public health physicians.

These exemplars will be cross-referenced with other domains and stakeholder perspectives via Clinical and Industrial Advisory Boards and interactions with other projects in Topic 5.3. The project will generalise and formalise the methods and best practices in how to combine and adapt informatics resources to support semantic interoperability, and how these can be developed and supported at scale. Health authorities, clinical professionals, ministries, vendors, purchasers, insurers are involved to ensure the project approach and results are realistically adoptable and viable, building on the SemanticHEALTH and CALLIOPE roadmaps.

A business model to justify strategic investments, including the opportunity costs for key stakeholders such as SDOs, industry, will be defined. This, and links with epSOS II and the eHealth Governance Initiative, will inform the shape of the Virtual Organisation that this Network will establish to sustain semantic interoperability developments and their adoption.

The consortium comprises more than 40 internationally recognised experts, including from USA and Canada, ensuring a global impact.

SEMANTICHEALTHNET

Call: FP7-ICT-2011-7
Grant agreement for: Network of Excellence (NoE)
Project acronym: SemanticHealthNet
Project full title: Semantic Interoperability for Health Network
Grant agreement no.: 288408
Budget: 3.222.380 EURO
Funding: 2.945.364 EURO
Start: 01.12.2011
End: 30.11.2014

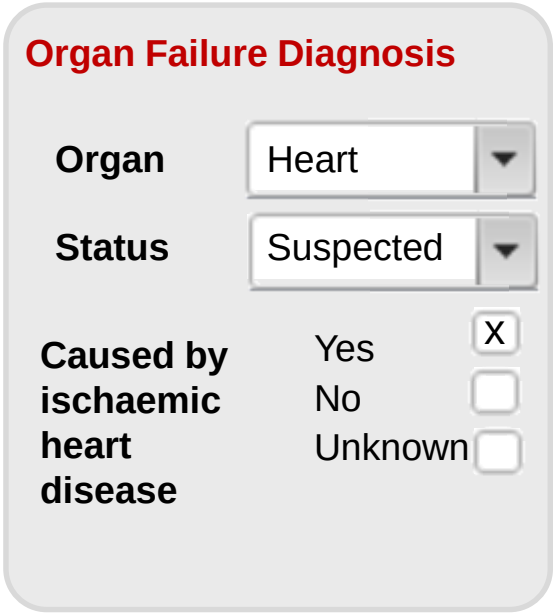
SUPPORTED BY

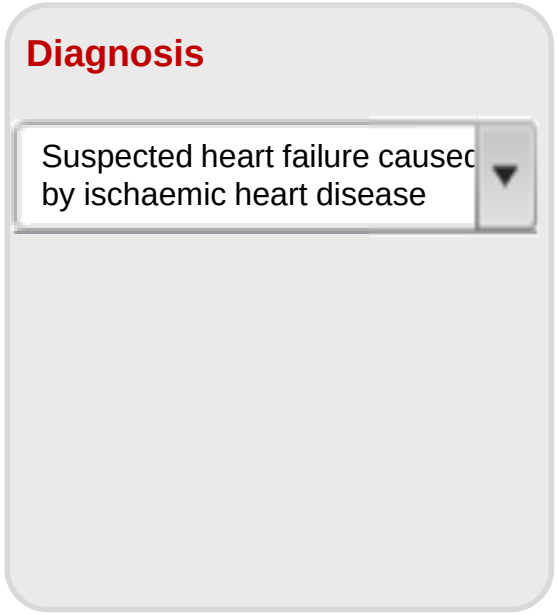
SEVENTH FRAMEWORK PROGRAMME

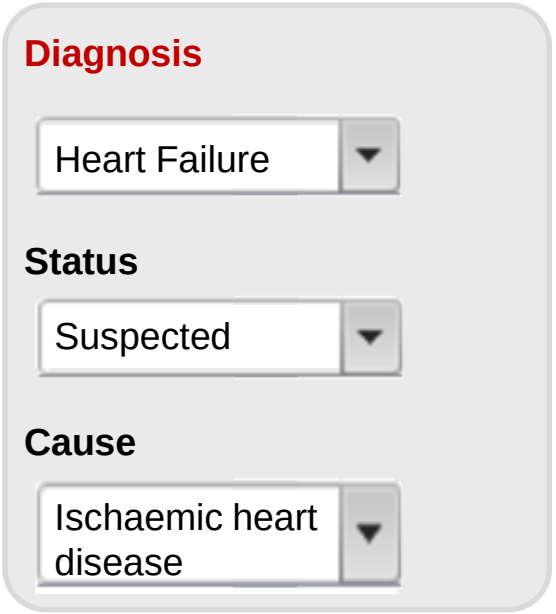
The SemanticHealthNet project is partially funded by the European Commission.

Challenge of SemanticHealthNet NoE

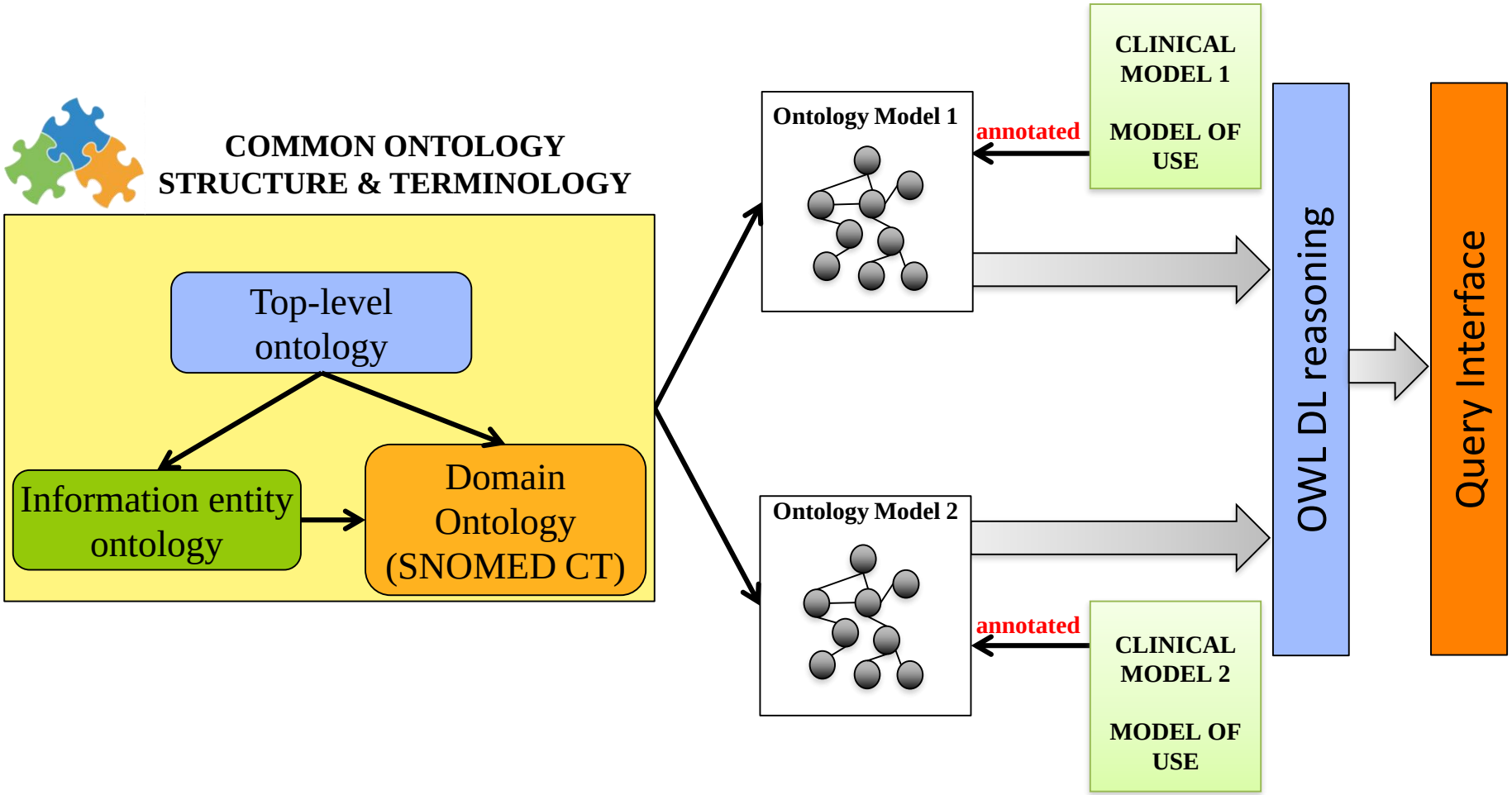
- Create interoperability between isosemantic but heterogeneous representations of structured clinical content
- Target: optimise clinical queries and exchange of data
- Method: Formal ontologies and description logics (OWL DL)



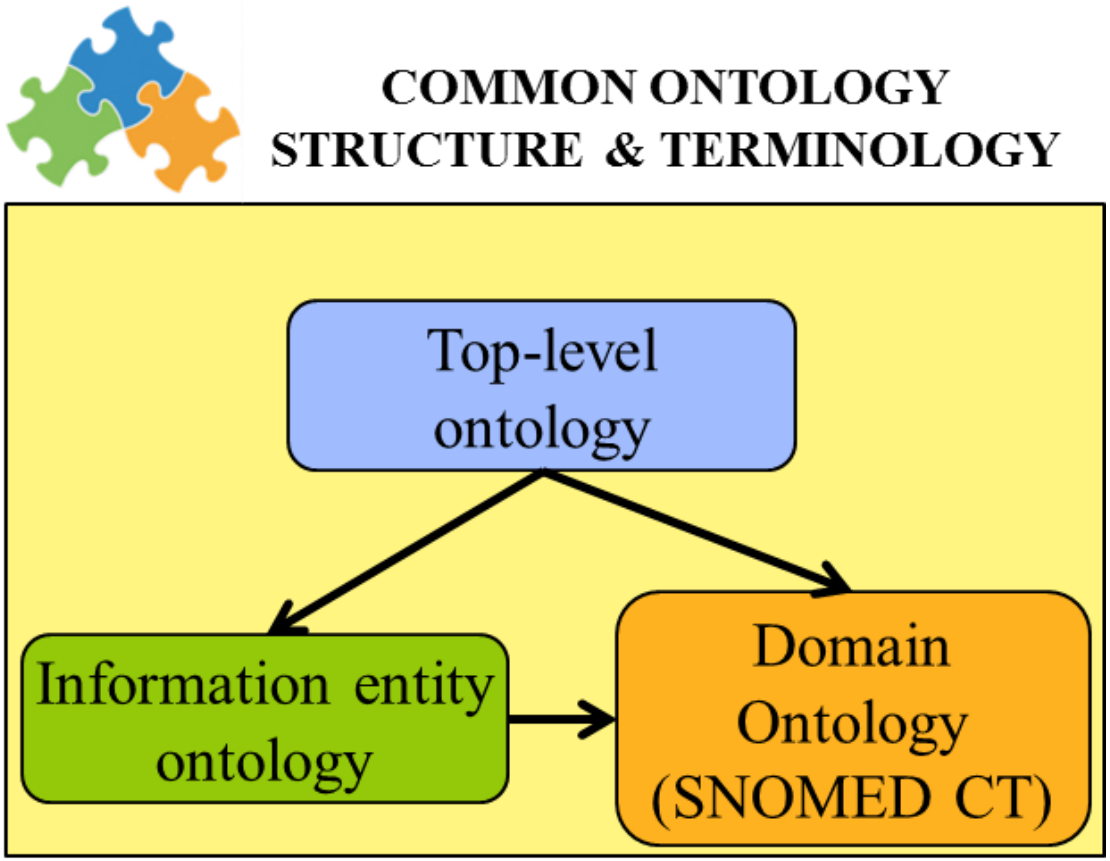




Semantic interoperability by ontology annotations



Ontologies for SemanticHealthNet



Different views on (formal) ontologies

- Computer science view
  - Ontologies are purpose-oriented formal models of meaning (conceptualizations)
- Cognitive / linguistic view
  - Ontologies are concept systems or systems of semantic reference (no clear distinction from thesauri)
  - Also adopted by parts of the Semantic Web community
  - Not clearly distinguished from knowledge representation in general
- Philosophy view (scientific realism)
  - Ontology is the study of what there is
  - Formal Ontologies give precise mathematical formulations of the properties and relations of certain entities.

Quine O. On what there is. In: Gibson R. Quintessence - Basic Readings from the Philosophy of W. V. Quine. Cambridge: Belknap Press, Harvard University, 2004.
Schulz S, Stenzhorn H, Boeker M, Smith B: Strengths and limitations of formal ontologies in the biomedical domain. RECIIS - Electronic Journal in Communication, Information and Innovation in Health, 2009; 3 (1): 31-45:

Basic principles we subscribe to

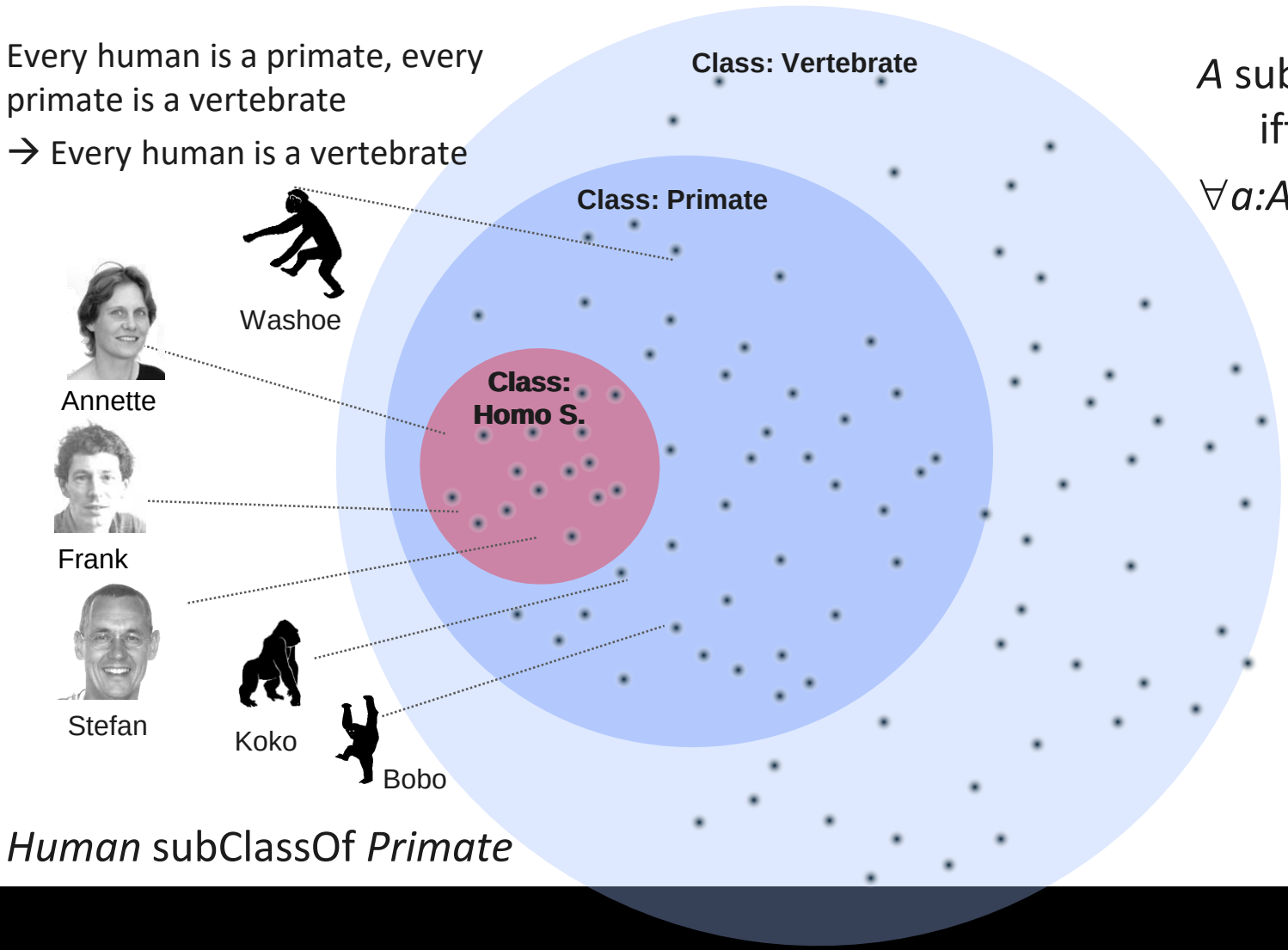
- Ontologies as formal systems (using appropriate language)
- Ontological commitment supported by
  - disjoint upper-level categories (process, object, …)
  - closed set of basic relations
  - constraining axioms
- Clear division between classes and individuals
- Equivalence and Subsumption statements
- Aristotelian definitions (genus – differentia)
- Naming conventions
- Design patterns und guidelines

→ *towards "evidence-based" ontology engineering*

Class-individual distinction not discretionary

Every human is a primate, every primate is a vertebrate

→ Every human is a vertebrate



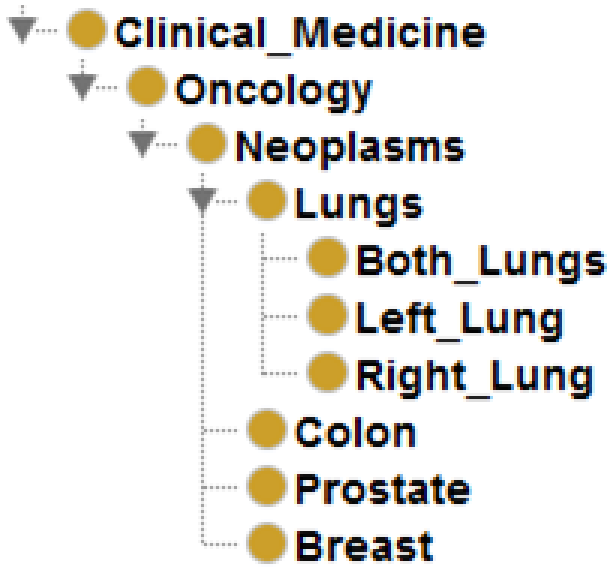
A subClassOf *B*

iff

$\forall a{:}A(a) \rightarrow B(a)$

Human subClassOf *Primate*

Intuitive taxonomies ≠ good taxonomies

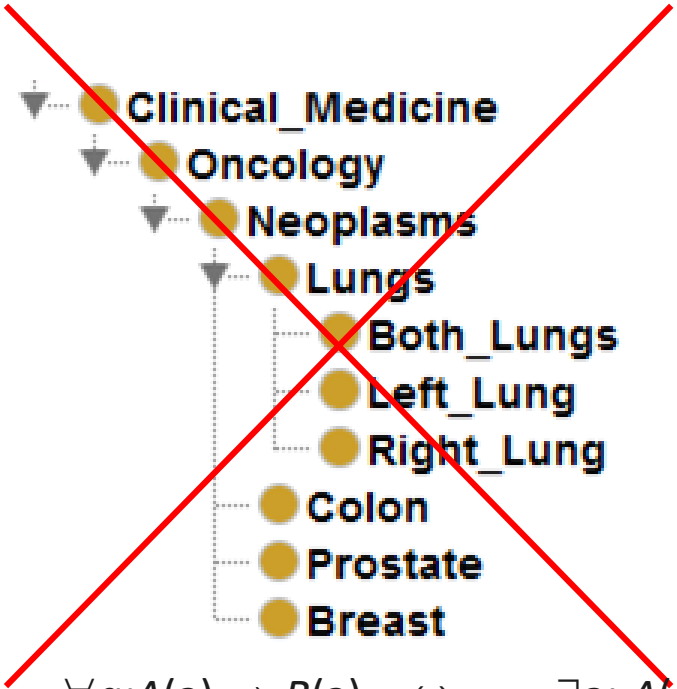


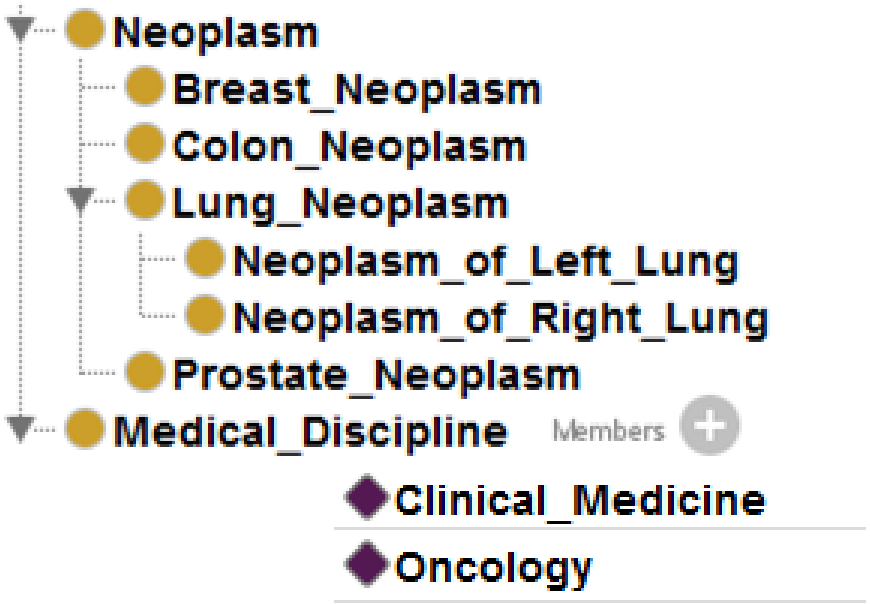
$\forall a{:}A(a) \rightarrow B(a) \quad \Leftrightarrow \quad \neg\exists a{:}\, A(a) \wedge \neg\, B(a)$

Test :

- *there is no neoplasms that is not an oncology*
- *there is no prostate that is not a neoplasm*
- *there is no oncology that is not a clinical medicine*

Intuitive taxonomies ≠ good taxonomies





$\forall a{:}A(a) \rightarrow B(a) \quad \Leftrightarrow \quad \neg\exists a{:}\, A(a) \wedge \neg\, B(a)$

Test :

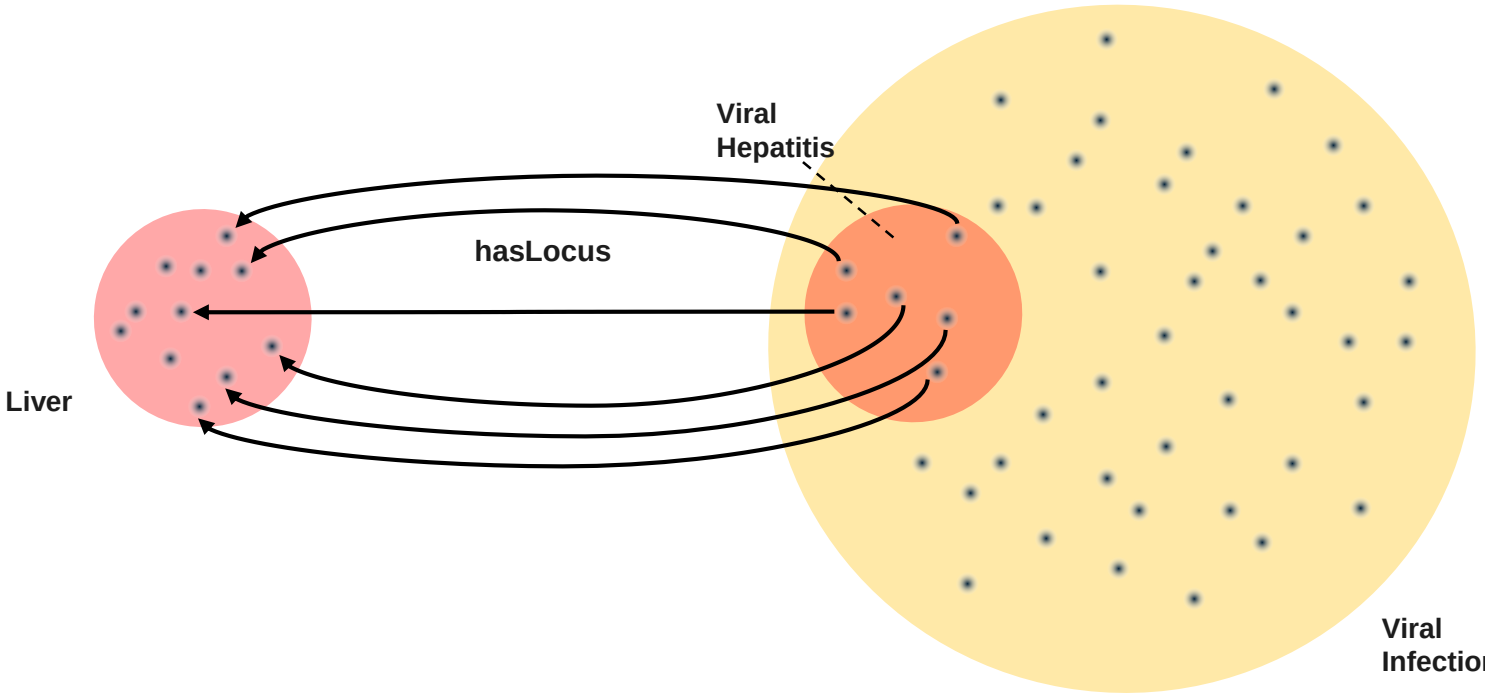
- *oncology is an instance of a medical discipline*
- *there is no prostate neoplasm that is not a neoplasm*

Labelling !

http://en.wikipedia.org/wiki/OntoClean

Schober D, Smith B, Lewis SE, Kusnierczyk W, Lomax J, Mungall C, Taylor CF, Rocca-Serra P, Sansone SA. Survey-based naming conventions for use in OBO Foundry ontology development. BMC Bioinformatics. 2009 Apr 27;10:125. doi: 10.1186/1471-2105-10-125.

Aristotelian Definitions do not permit exceptions



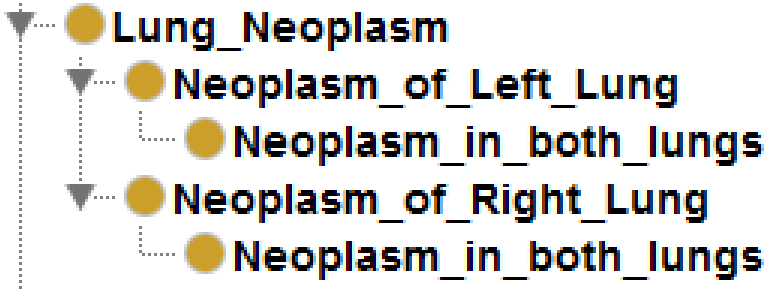
FOL: $\forall x{:}Hepatitis(x) \leftrightarrow ViralInfection(x) \wedge \exists \text{Liver}{:}C(z) \wedge \textbf{hasLocus}(x,z)$

OWL-DL: *ViralHepatitis* equivalentTo *ViralInfection* and **hasLocus some** *Liver*

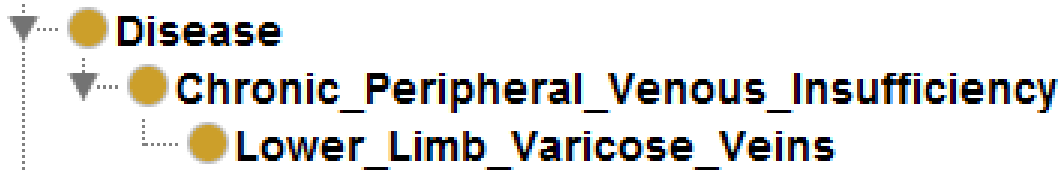
Test :

- *There is no viral hepatitis that is not located in a liver*
- *There in no viral hepatitis that is not a viral infection*

Always investigate the ontological commitment



- Which are exactly the instances?
- Does the label tell us what is meant?
- Is there an implicit context?

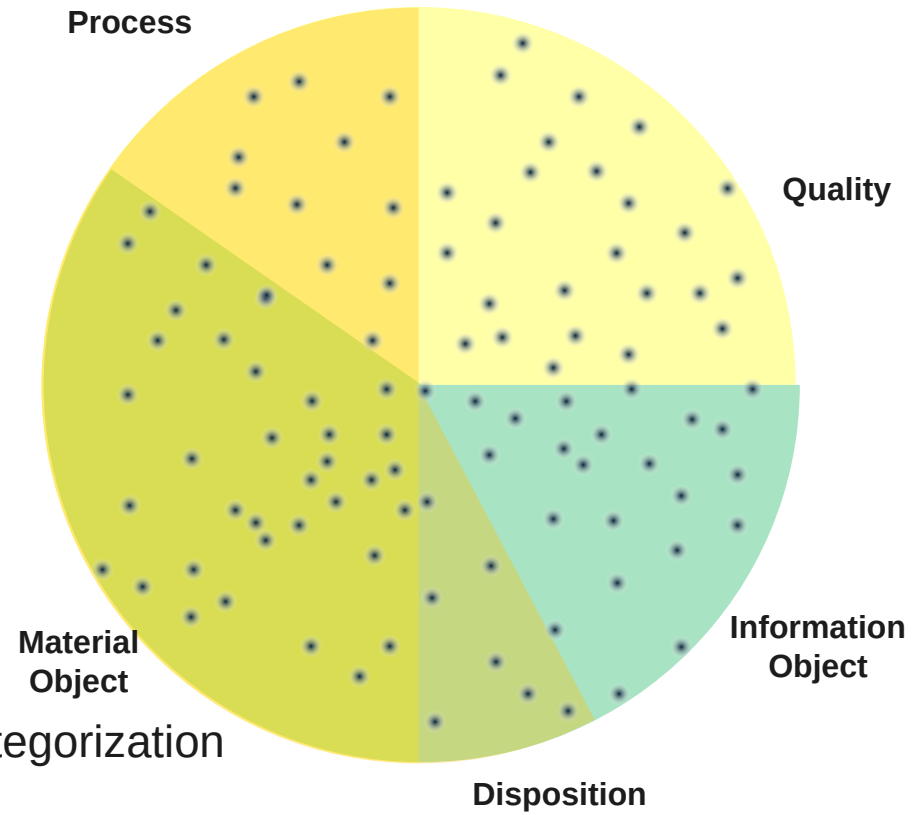


Test :

- *There is no neoplasm in both lungs that is not a neoplasm in the left lung* OR
  There is no patient with neoplasm in both lungs that is not a patient with the neoplasm in the left lung
- *There is no varicose vein in the lower limb that is not a chronic peripheral venous insufficiency* OR
  There is no patient with varicose lower limb veins that is not a patient with a chronic peripheral venous insufficiency

Upper level ontologies partition the domain into disjoint and exhaustive categories

- Particular
  - Quality
    - Benign
    - Malignant
  - Information_Object
    - Medical_Discipline
  - Disposition
    - Chronic_Peripheral_Venous_Insufficiency
  - Material_Object
    - Lower_Limb_Varicose_Veins
    - Neoplasm
      - Breast_Neoplasm
      - Colon_Neoplasm
      - Lung_Neoplasm
      - Prostate_Neoplasm
  - Process
    - Growth



- Upper level ontologies enforce a strict categorization
- Constraints on upper-level categories
- Upper level ontology for the biomedical domain **BioTop**

BioTopLite provides a small set of toplevel classes, relations, and axioms

Toplevel Categories

- particular
  - condition
    - disposition
    - function
    - 'material object'
    - process
  - 'immaterial object'
  - 'information object'
  - quality
  - role
  - 'temporal region'
  - 'value region'

- Precise formulations about generic and defining properties of basic categories of a domain
- Logical Framework (Description logics)
- OWL – DL (Web Ontology Language) complete and decidable language - compromise between expressiveness and performance (EXPTIME)

Basic relations

- 'has participant'
- 'has timestamp'
- includes
- 'is included in'
- 'is preceded by'
- 'is projection of'
- 'is represented by'
- 'participates in'
- precedes
- 'projects onto'
- represents

Constraining axioms

- 'has part' only process
- 'has participant' some Thing
- 'is bearer of' only 'process quality'
- 'is part of' only process
- 'projects onto' only 'temporal region'
- 'projects onto' some 'temporal region'
- 'realization of' only disposition
- includes only (process or 'process quality')

- Automated reasoning enables checking consistency, equivalence and subsumption
- Ontologies play an increasing role in new generation of biomedical

Elena Beißwanger, Stefan Schulz, Holger Stenzhorn and Udo Hahn
BioTop: An Upper Domain Ontology for the Life Sciences - A Description of its Current Structure, Contents, and Interfaces to OBO Ontologies
in Applied Ontology, Volume 3, Issue 4, Pages 205-212, IOS Press, Amsterdam, December 2008

Ontology development should be guideline-based

Guideline on Developing Good Ontologies in the Biomedical Domain with Description Logics

URL: http://www.purl.org/goodod/guideline

Version 1.0
December 2012

Send feedback to:
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Schulz S[1,3], Seddig-Raufie D[1], Grewe N[2], Röhl J[2],
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11th December 2012

http://purl.org/googod/guideline

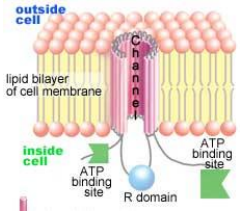
Formal ontologies vs. human conceptualizations

- Built around taxonomies of classes
  - ATTENTION: our intuitive way of hierarchically organize terms is not strictly taxonomic (e.g. Anatomy)
- State what is true for all individual members of a class (instances of a type)
- Requires to distinguish between classes and individuals
  - ATTENTION: human language is often misleading, e.g. "London is a big city" vs. "The liver is a big organ"
- Individuals commit to upper-level categories
  - ATTENTION: our thinking fuses mutually dependent entities that belong to different categories, e.g. Cancer (growth process vs. mass of malignant tissue)
- Upper level categories should be made explicit
  - Explicit upper level ontology – common understanding
  - Implicit upper level ontology of each of us – misunderstanding

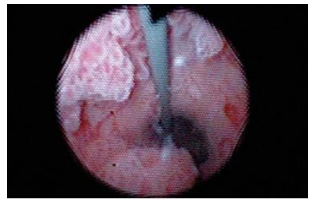
Beware of creating "Nontologies"

- OWL syntax without description logics semantics
- Formal reasoning leads to incorrect entailments
- Examples: NCI thesaurus, Radlex
- Many other ontologies contain problematic axioms that contradict the intended meaning
- Example (NCI thesaurus):

Calcium-Activated_Chloride_Channel-2 subClassOf
Gene_Product_Expressed_In_Tissue some *Lung* and
Gene_Product_Expressed_In_Tissue some *Mammary_Gland* and
Gene_Product_Expressed_In_Tissue some *Trachea*



Ureter_Small_Cell_Carcinoma subclassOf
Disease_May_Have_Finding some *Pain*



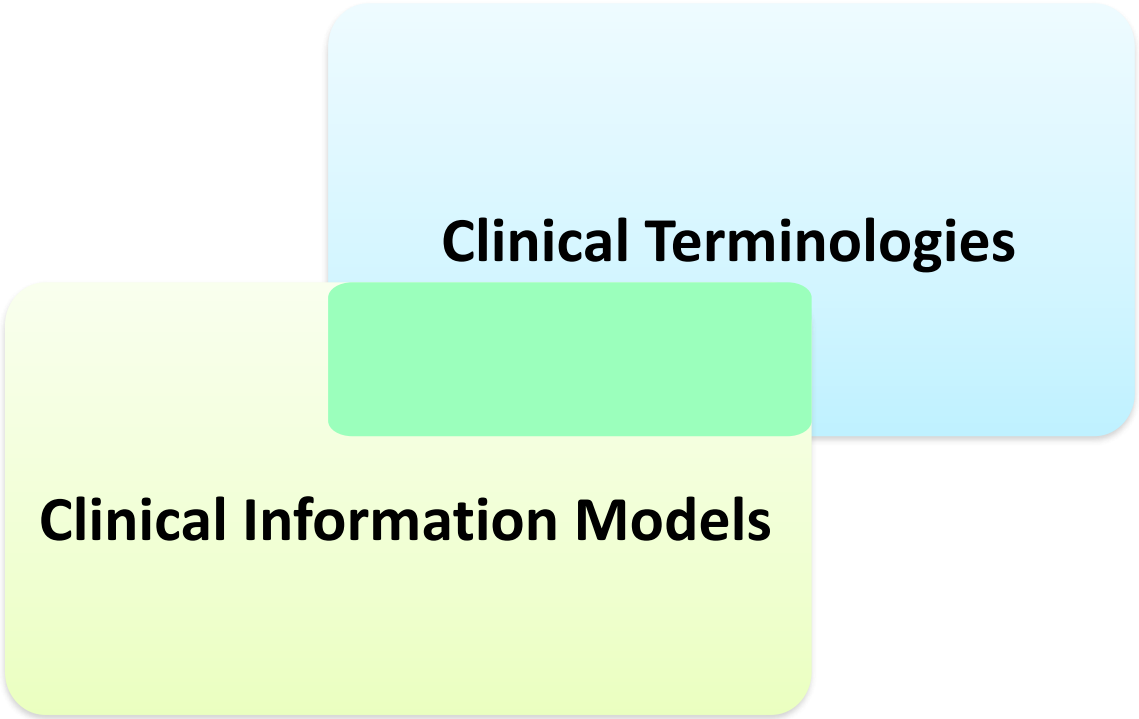
Schulz S, Schober S, Tudose I, Stenzhorn H: The Pitfalls of Thesaurus Ontologization – the Case of the NCI Thesaurus. AMIA Annu Symp Proc, 2010: 727-731

Large parts of knowledge are not ontological

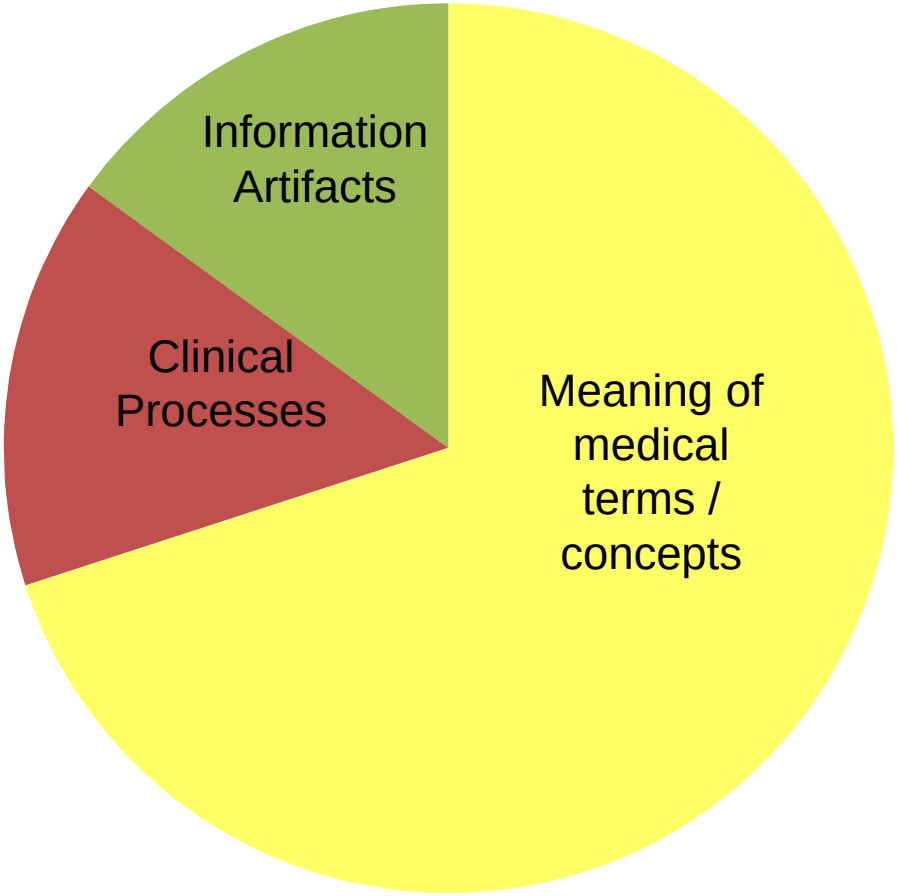
- Ontology ≠ Knowledge representation
  - "*There are very few interesting items of knowledge that are truly ontological in this strict sense*" (Alan Rector)
  - antinomy: *ὄντος* (being → ontology) vs. *ἐπιστήμη* (knowledge → epistemology)
- Ontology is not appropriate for
  - Default knowledge
    - "The hand has 5 fingers" (unless otherwise stated)
  - Probabilistic knowledge
    - Mesothelioma is a rare cancer
  - Contingent knowledge
    - Aspirin prevents myocardial infarction
    - Jaundice is a typical symptom of hepatitis
- Can ontology represent clinical information?

Alan Rector. Barriers, approaches and research priorities for integrating biomedical ontologies, 2008.
http://www.semantichealth.org/DELIVERABLES/SemanticHEALTH_D6_1.pdf

Can formal ontology represent both information and clinical information?



Ontologies used and created in SemanticHealthNet



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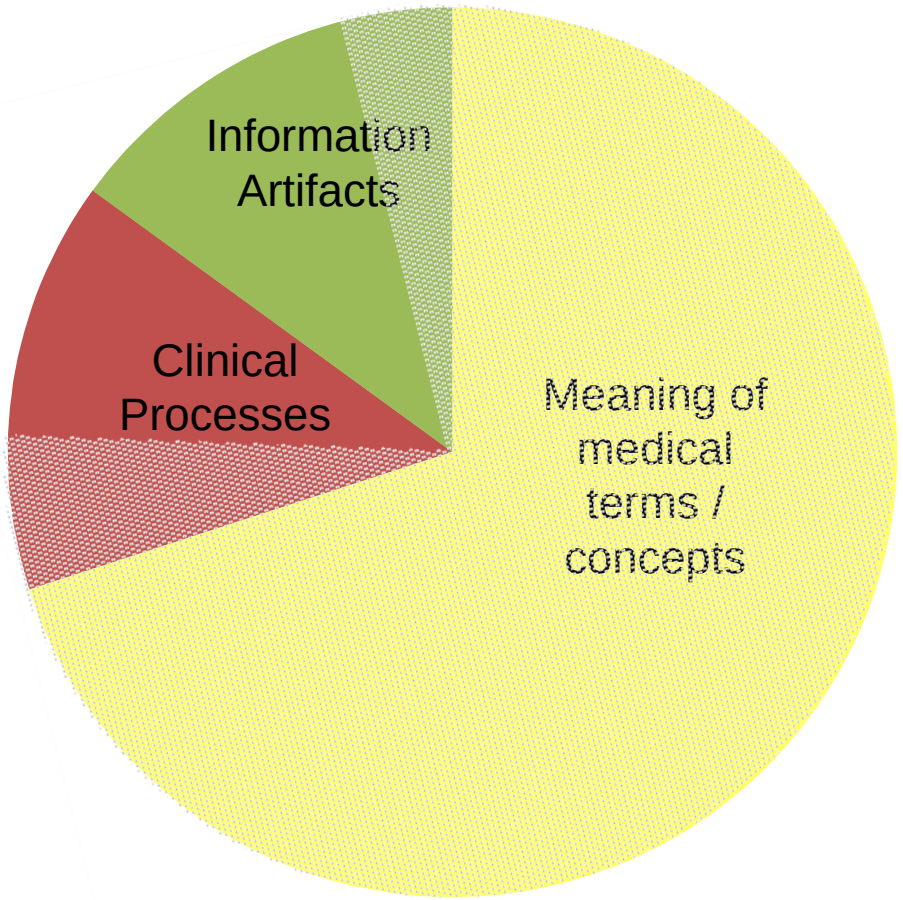
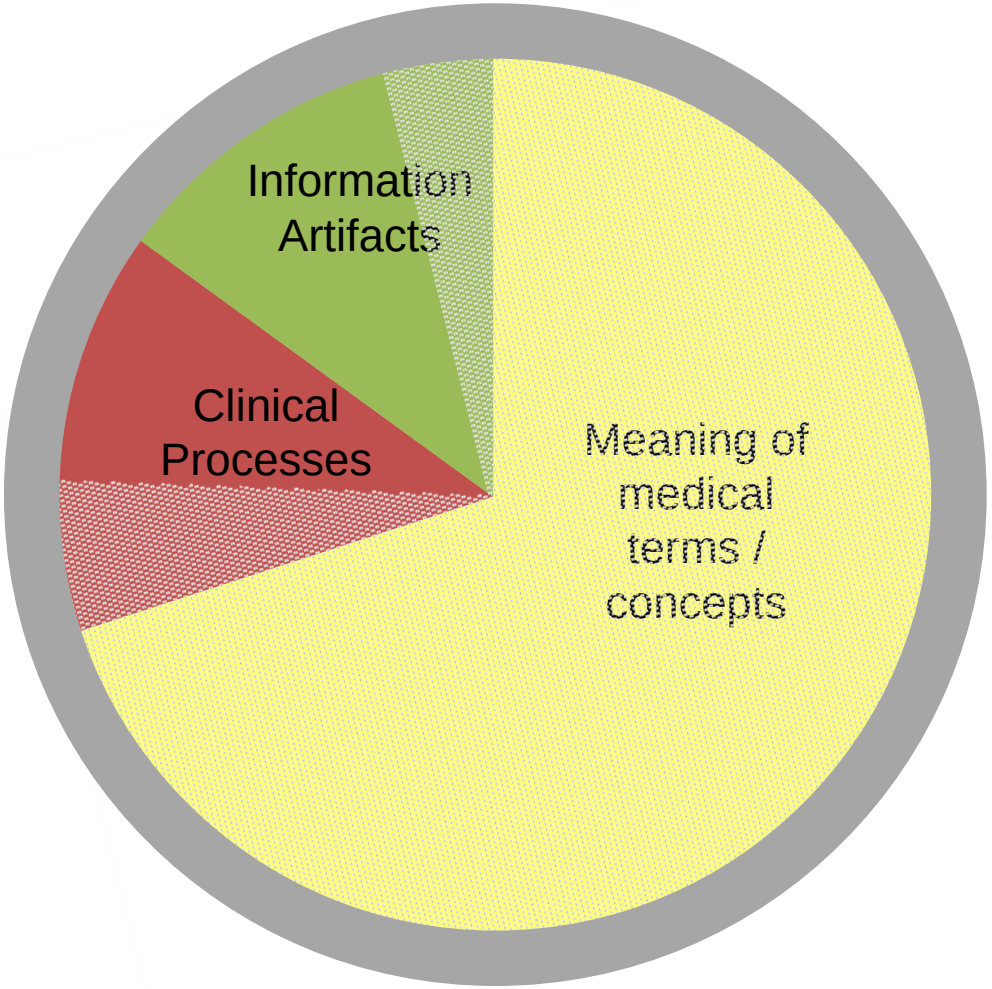


SNOMED CT Domain Ontology

Ontologies used and created in SemanticHealthNet

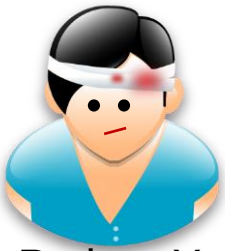


SNOMED CT Domain Ontology

BioTopLite Upper Level Ontology

Basic representational pattern for terminology binding

Demographics
Time stamps
Metadata



Patient X

- **Example: Diagnosis (statement about clinical condition)**

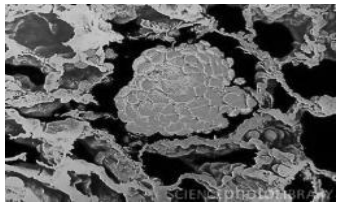
EHR

WHAT?

WHO?

WHEN?

Neoplasia



Basic representational pattern for terminology binding

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Time stamps
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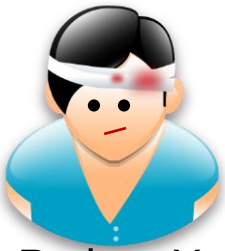


Patient X

- **Example: Diagnosis (statement about clinical condition)**

OWL annotation of an information item

InformationEntity and
hasQuality *InformationItemQuality* and
isAboutSituation only (*ClinicalSituation* and …)

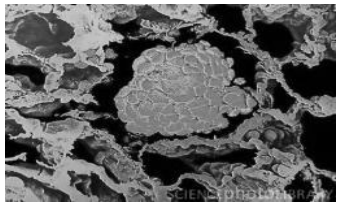
EHR

WHAT?

WHO?

WHEN?

Neoplasia



Example:

“Suspected heart failure caused by ischaemic heart disease”

Example:

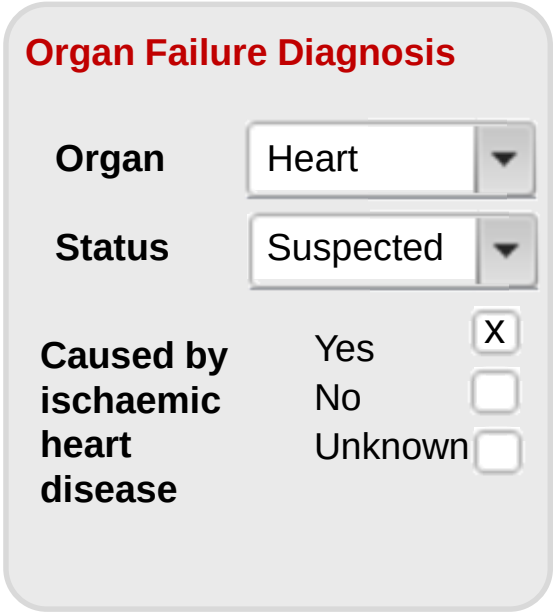
"Suspected heart failure caused by ischaemic heart disease"

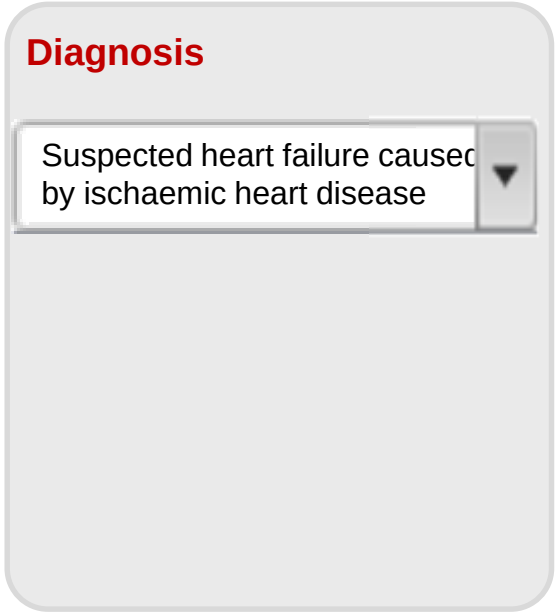
- One code or postcoordinated expression in SNOMED CT
- Reference to two kinds of disorders (**ontological** types / concepts)
- Semantic relation between both
- **Epistemic** context: represents state of knowledge about a clinical situation
- Not clear whether there is really some heart failure at all!

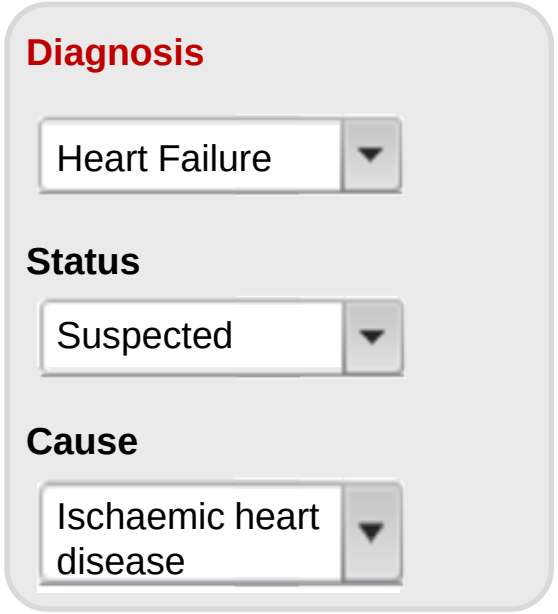
- Many entries in EHRs must not be interpreted as factual statements
- Blending of ontological and epistemic information in one code characteristic for many clinical terminologies

“Suspected heart failure caused by ischaemic heart disease”

- Three heterogeneous representations of the same statement
- Three different atomic information entities

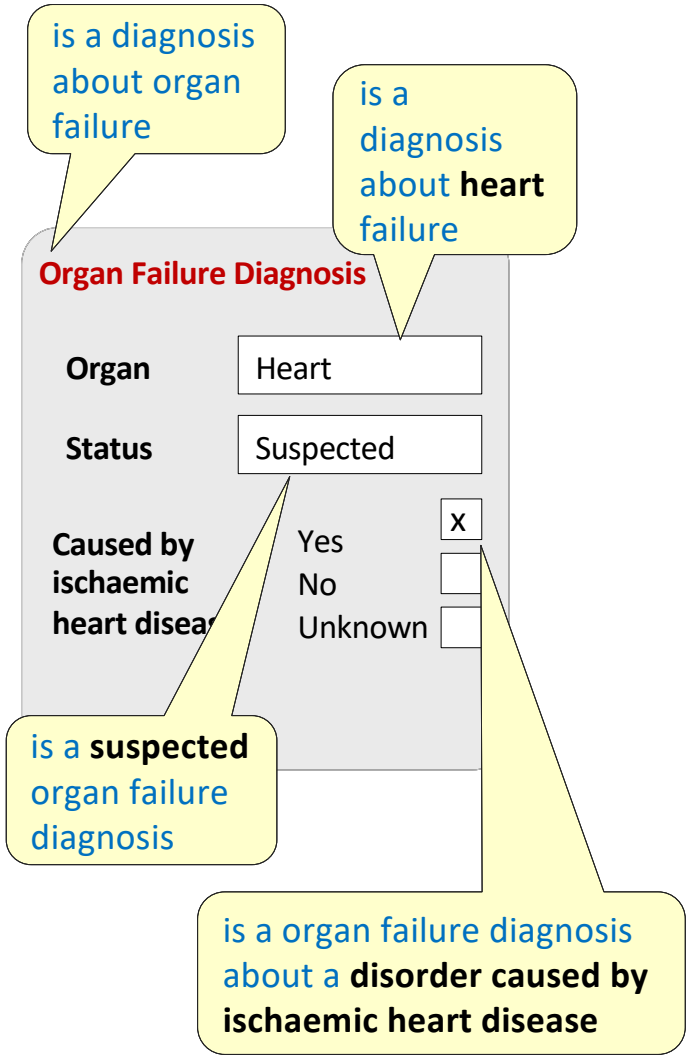






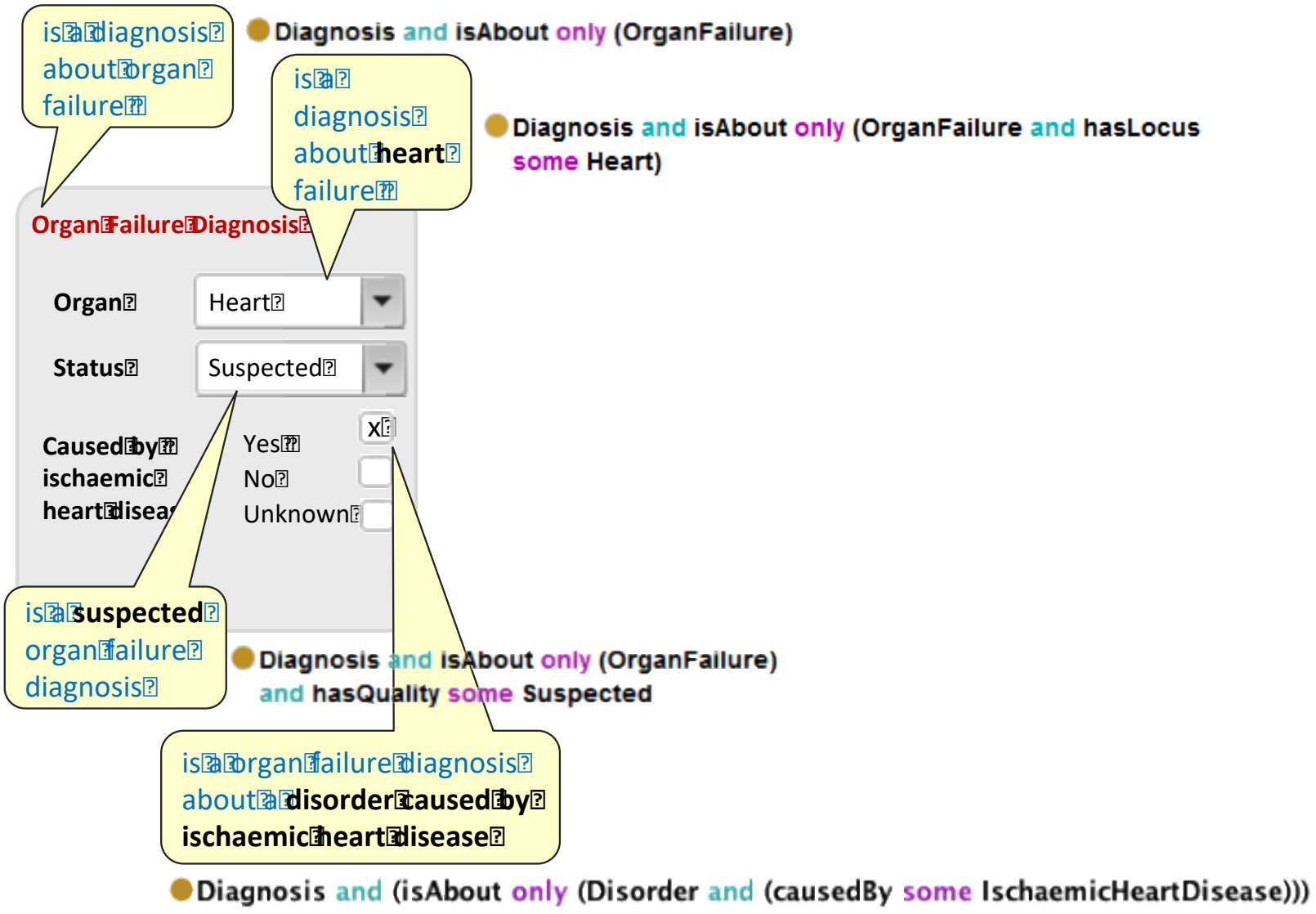
“Suspected heart failure caused by ischaemic heart disease”

Annotation 1

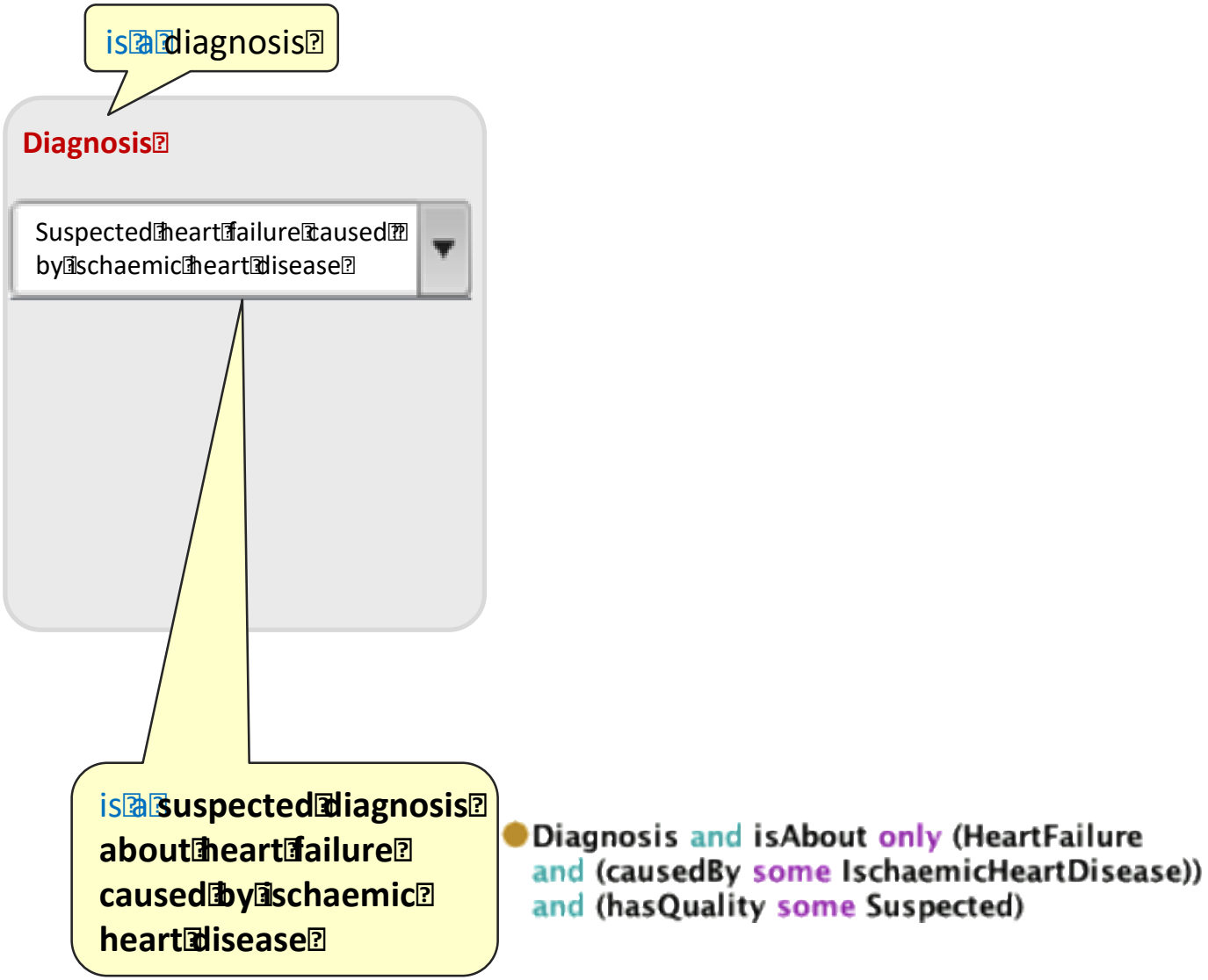


“Suspected heart failure caused by ischaemic heart disease”

Annotation 1

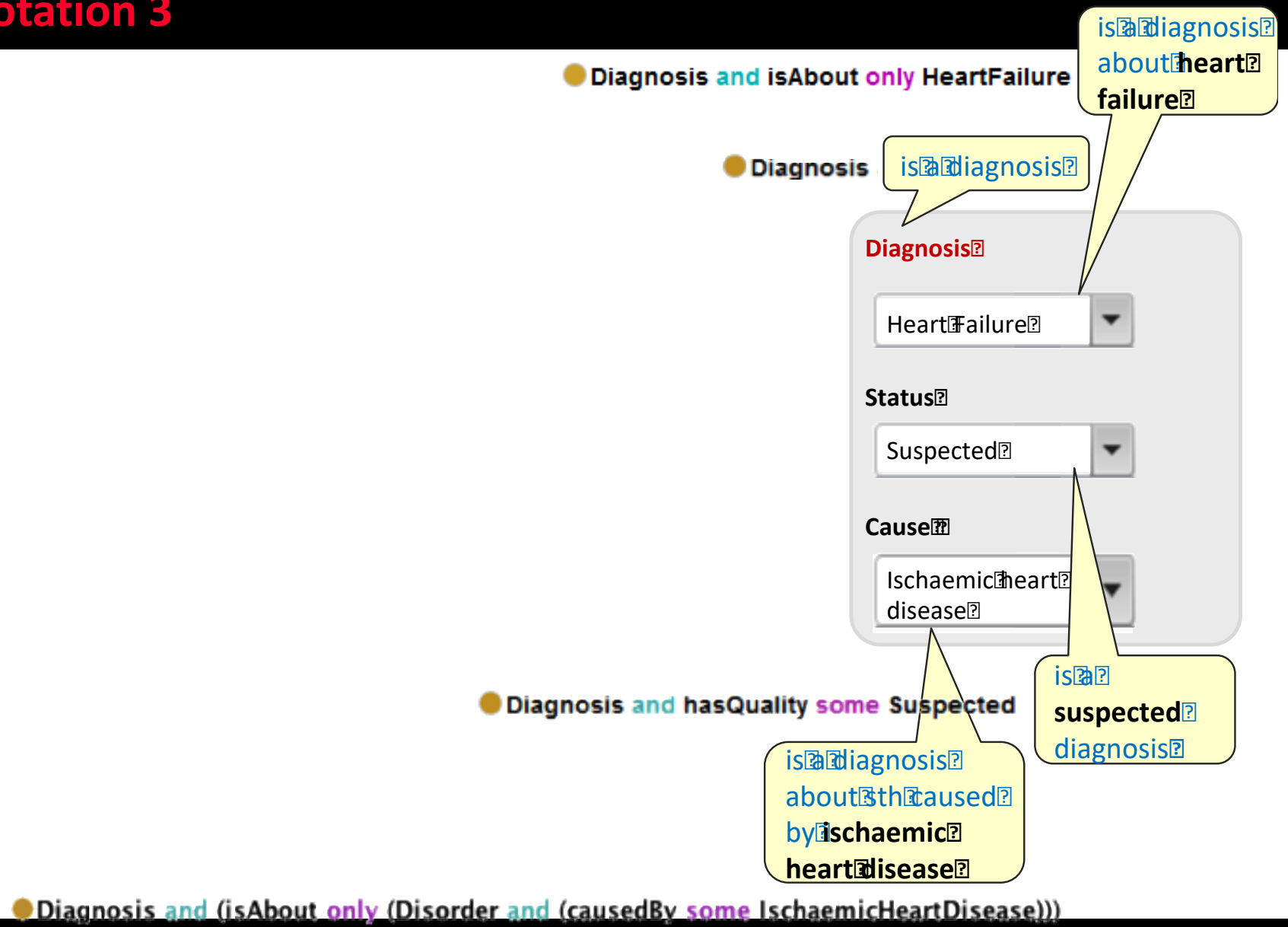


“Suspected heart failure caused by ischaemic heart disease”
Annotation 2



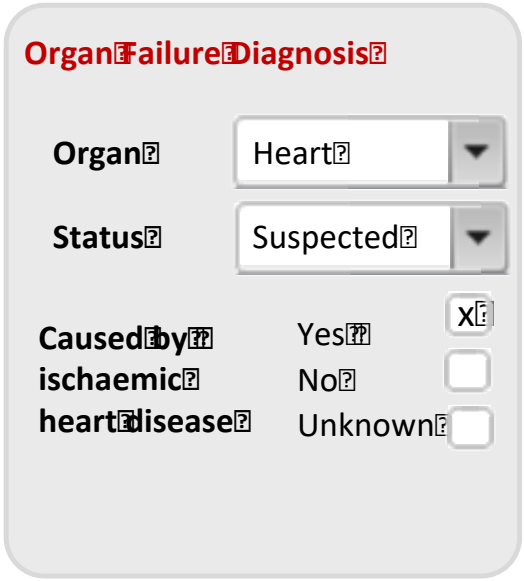
“Suspected heart failure caused by ischaemic heart disease”

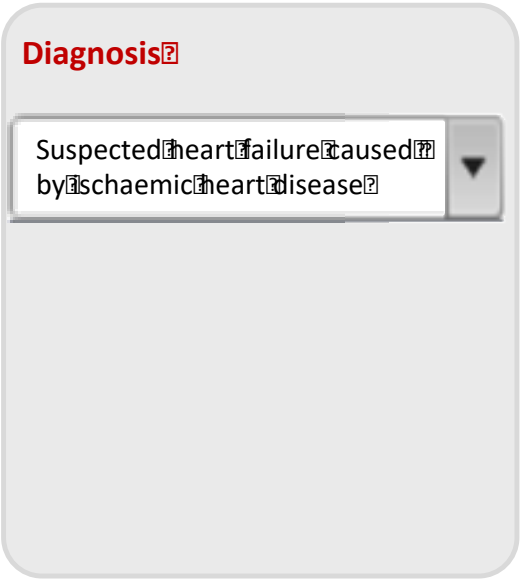
Annotation 3

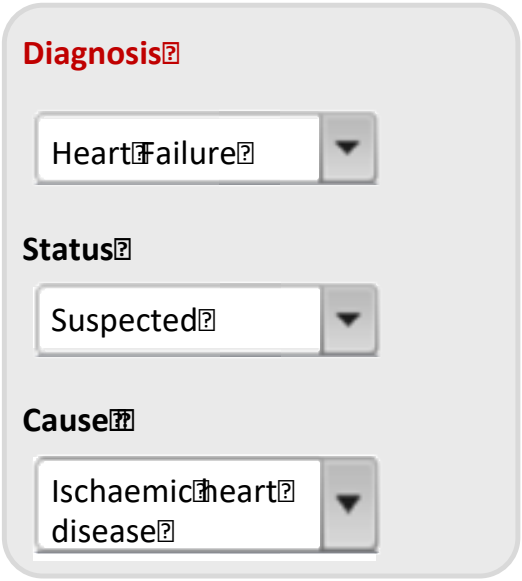


One diagnosis instance for each model

- Diagnosis_2 Type Diagnosis
- Diagnosis_2 Type Diagnosis and (hasQuality some Suspected) and (isAbout only (HeartFailure and (causedBy some IschaemicHeartDisease)))



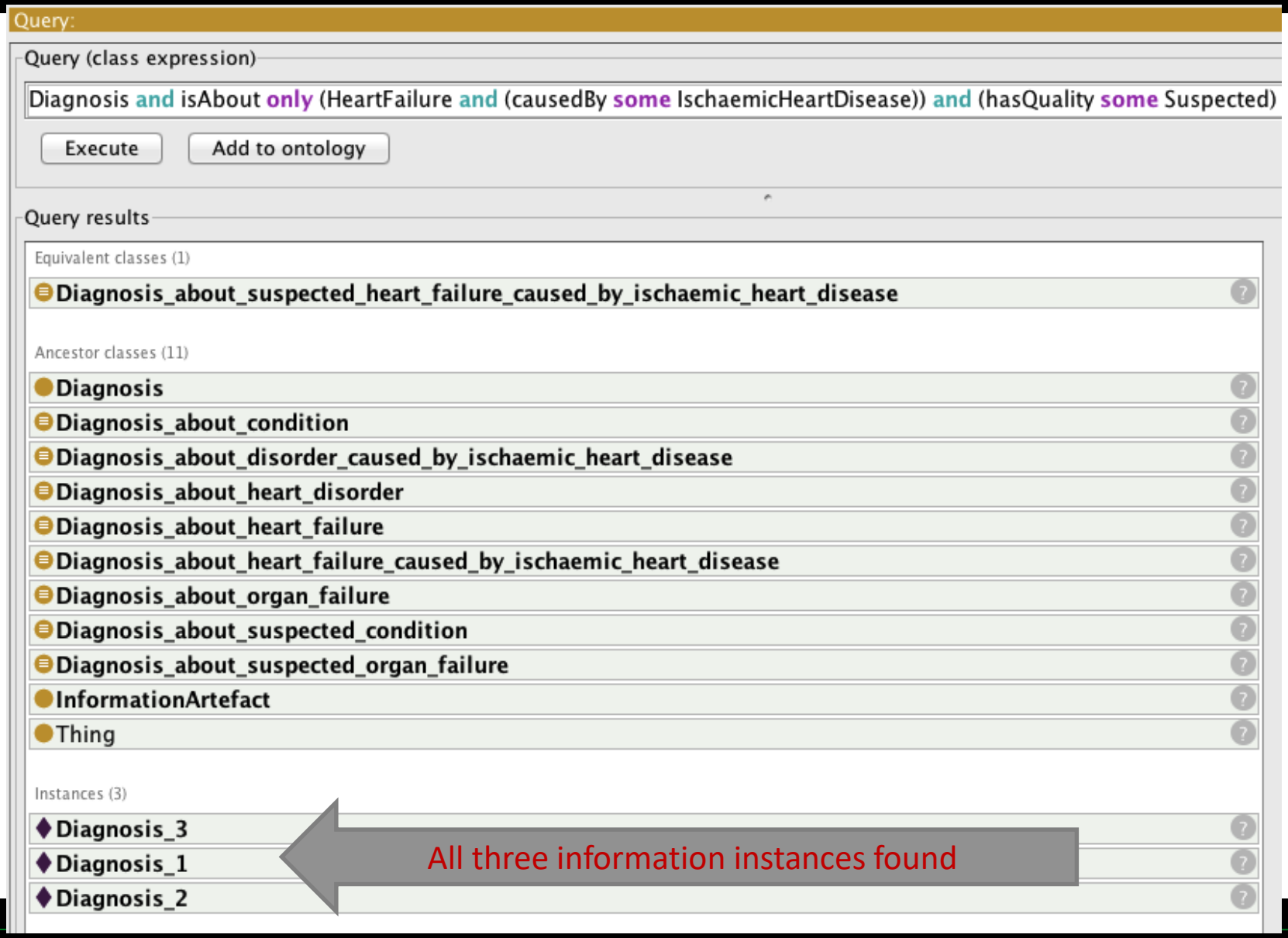




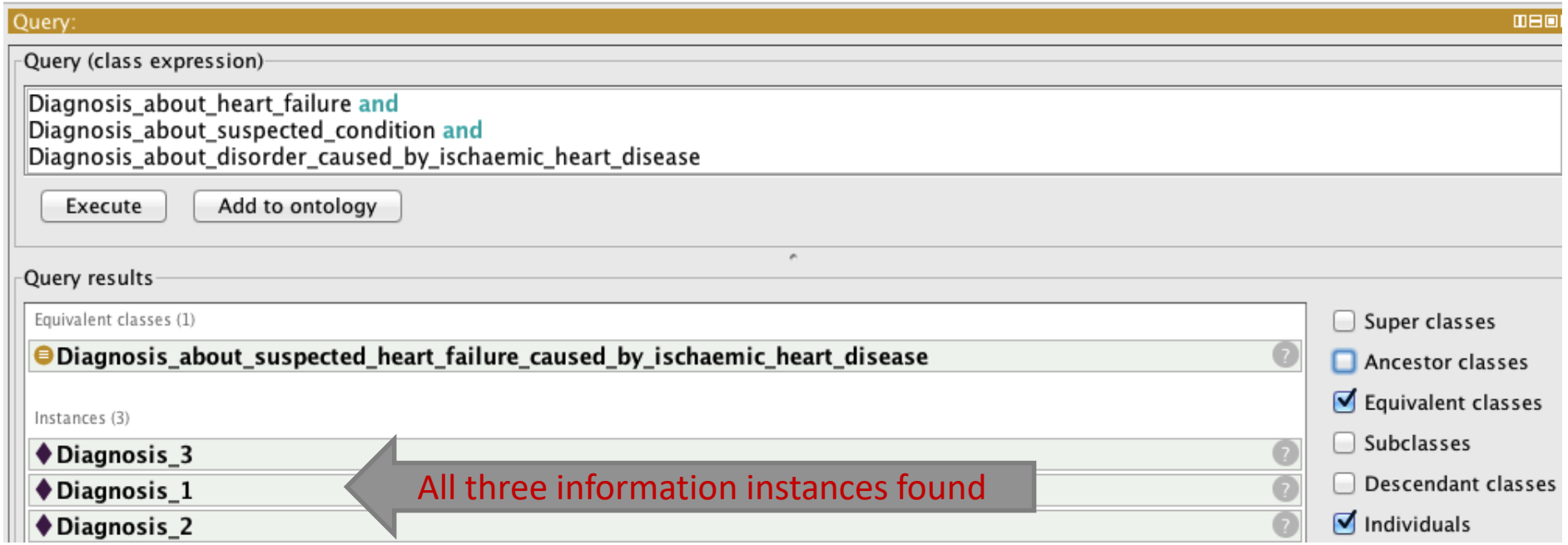
- Diagnosis_1 Type Diagnosis and (isAbout only (Disorder and (causedBy some IschaemicHeartDisease)))
- Diagnosis_1 Type Diagnosis and (isAbout only OrganFailure)
- Diagnosis_1 Type Diagnosis and (hasQuality some Suspected)
- Diagnosis_1 Type Diagnosis and (isAbout only (OrganFailure and (hasLocus some Heart)))
- Diagnosis_1 Type Diagnosis

- Diagnosis_3 Type Diagnosis and (isAbout only HeartFailure)
- Diagnosis_3 Type Diagnosis and (hasQuality some Suspected)
- Diagnosis_3 Type Diagnosis and (isAbout only (Disorder and (causedBy some IschaemicHeartDisease)))
- Diagnosis_3 Type Diagnosis

Query 1


Query:
Query (class expression)
Diagnosis and isAbout only (HeartFailure and (causedBy some IschaemicHeartDisease)) and (hasQuality some Suspected)
Execute
Add to ontology
Query results
Equivalent classes (1)
Diagnosis_about_suspected_heart_failure_caused_by_ischaemic_heart_disease
Ancestor classes (11)
Diagnosis
Diagnosis_about_condition
Diagnosis_about_disorder_caused_by_ischaemic_heart_disease
Diagnosis_about_heart_disorder
Diagnosis_about_heart_failure
Diagnosis_about_heart_failure_caused_by_ischaemic_heart_disease
Diagnosis_about_organ_failure
Diagnosis_about_suspected_condition
Diagnosis_about_suspected_organ_failure
InformationArtefact
Thing
Instances (3)
Diagnosis_3
Diagnosis_1
Diagnosis_2
All three information instances found

Query 2


Query:
Query (class expression)
Diagnosis_about_heart_failure and
Diagnosis_about_suspected_condition and
Diagnosis_about_disorder_caused_by_ischaemic_heart_disease
Execute
Add to ontology
Query results
Equivalent classes (1)
Diagnosis_about_suspected_heart_failure_caused_by_ischaemic_heart_disease
Instances (3)
Diagnosis_3
Diagnosis_1
Diagnosis_2
All three information instances found
Super classes
Ancestor classes
Equivalent classes
Subclasses
Descendant classes
Individuals

Open issues (I)

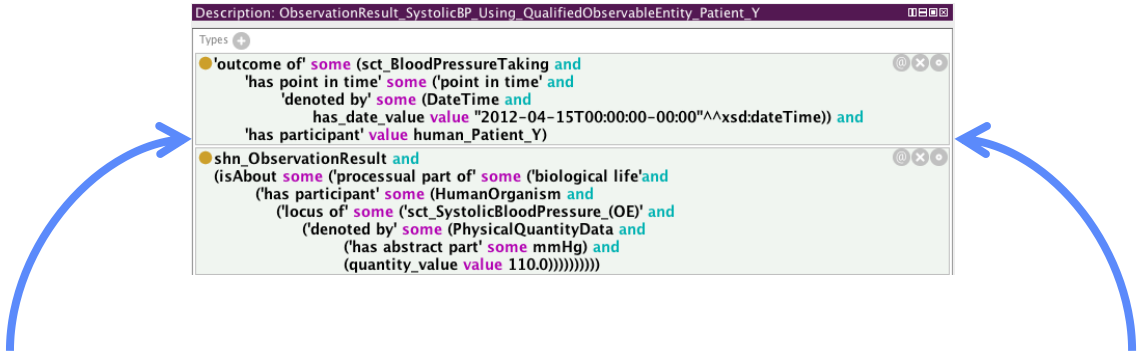
- Accept semantic resources as they are (including what is considered “bad practice” by some), or more prescriptive approach (enforce distinction between terminology and information model)
- Is OWL appropriate to provide appropriate patterns to express “second-order” statements? Alternatives?
- Does the required expressivity (OWL DL + concrete domains) render the framework intractable?
- Query languages: DL, SPARQL, combinations?
- Semantic annotation of formal clinical guidelines?

Open issues (II)

- Is it realistic that IM developers will invest efforts into correctly use OWL for IM annotations?
- Education, training, modification of engineering and maintenance workflows?
- Will the ontological foundation of clinical terminologies be reliable and quality assured?
- To which extent semantic standards will be adopted at all?
- Possibility to use approach for semantic interpretation of text-mined content

Which are the main scenarios of use?

- Semantic abstraction for querying
  as demonstrated: using ontology based representation and querying (generic)
- Semantically-enriched data transfer: via semantic abstraction difficult. Rule-based approach (non-generic) ?



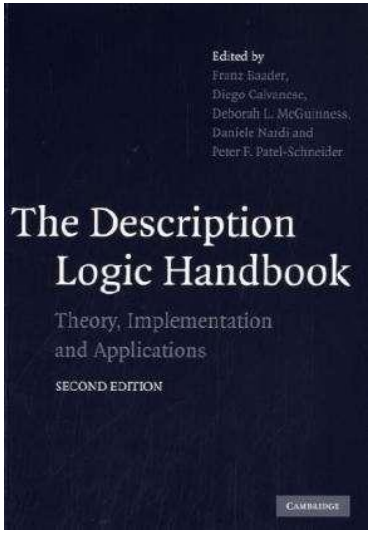

```
SECTION[at0000] matches {  -- History of problem / condition
  members cardinality matches {1..*; unordered} matches {
    ENTRY[at0001] matches {  -- Problem / Condition
      items cardinality matches {1..*; unordered } matches {
        ELEMENT[at0002] matches {  -- Diabetes Mellitus
          value matches {
            SIMPLE_TEXT[at0003] matches {  -- SIMPLE_TEXT
              originalText matches {"Yes","No","Unknown"}
            }
          }
        }
      }…}}}
```

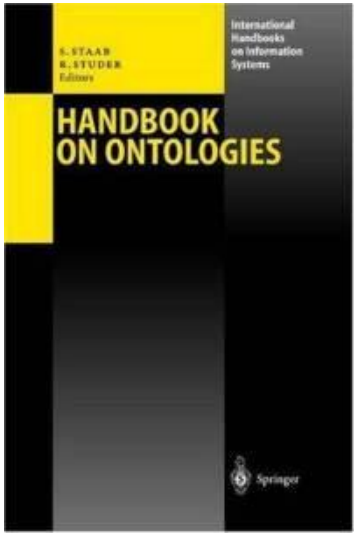
T1

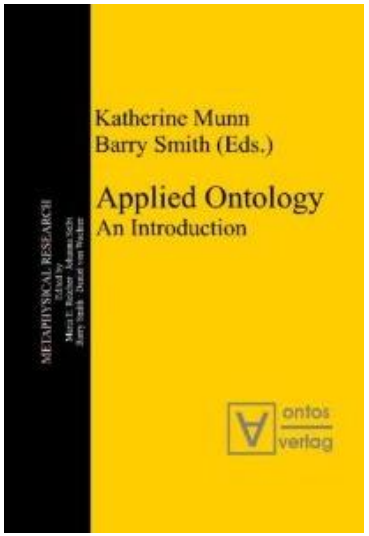
T2

```
EVALUATION[at0000.1] matches { -- Diagnosis
  data matches {
    ITEM_TREE[at0001] matches {  -- structure
      items cardinality matches {1..*; ordered} matches {
        ELEMENT[at0002.1] matches { -- Diagnosis
          value matches {
            DV_CODED_TEXT matches {
              defining_code matches {[ac0.1]} -- Any term that 'is_a' diagnosis
        }}}
        ELEMENT[at0.32] occurrences matches {0..1} matches { --Status
          value matches {
```

Further readings







Ontology on the Web

- Description Logics: http://dl.kr.org/
- Protégé: http://protege.stanford.edu/
- Bioontology: http://www.bioontology.ch/
- Buffalo Ontology Site: http://ontology.buffalo.edu/smith/
- OBO Foundry: http://obofoundry.org/
- Bioportal: http://bioportal.bioontology.org/
- SNOMED CT: http://www.ihtsdo.org/snomed-ct/ http://terminology.vetmed.vt.edu/sct/menu.cfm
- CO-ODE (Pizza ontology): http://www.co-ode.org/
- GoodOD Guideline: http://www.iph.uni-rostock.de/GoodOD-Guideline.1299.0.html

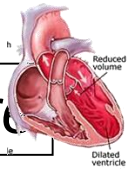
CLINICAL INFORMATION PATTERNS (WHAT, HOW)

- **PAST HISTORY OF CONDITION / SITUATION:**

shn:InformationEntity and **shn:isAboutSituation** only (*btl:BiologicalLife* and **btl:hasProcessualPart** some *shn:ClinicalSituation*)

- **PRIMARY DIAGNOSIS OF CONDITION / SITUATION:**

sct:HeartFailure



shn:InformationEntity and **shn:isAboutSituation** only *shn:ClinicalSituation* and **btl:outcomeOf** some *sct:DiagnosticProcedure*

- **SYMPTOM RECORD**

sct:SwollenAnkle

shn:InformationEntity and **shn:isAboutSituation** only *shn:ClinicalSituation* and **btl:outcomeOf** some *sct:EvaluationForSignsAndSymptoms*

I. QUERY EXPRESSIVITY

Confirmed viral encephalitis diagnosis

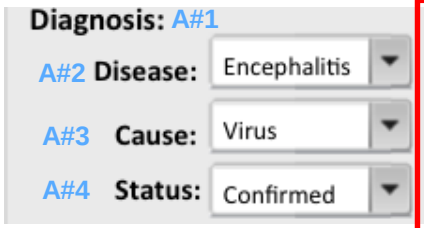
- The ability to support **pre/post-coordination**

A#1: *shn:Diagnosis* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:DiagnosticProcedure*

Individual: *Diagnosis_A* **Types** A#1 and A#2 and A#3 and A#4

45170000 | *encephalitis* |

FORM A:



A#2: *shn:EncephalitisDiagnosis* **equivalentTo**
*shn:*Diagnosis and **shn:isAboutSituation** only *sct:EncephalitisSituation*

A#3: *shn:DiseaseDiagnosedVirusCause* **equivalentTo**
*shn:*Diagnosis and **shn:isAboutSituation** only (*shn:ClinicalSituation*
and **btl:causedBy**
some *sct:Virus*)

A#4: *shn:DiagnosisConfirmedStatus* **equivalentTo**
*shn:*Diagnosis and **shn:hasInformationObjectAttribute** some *shn:Confirmed*

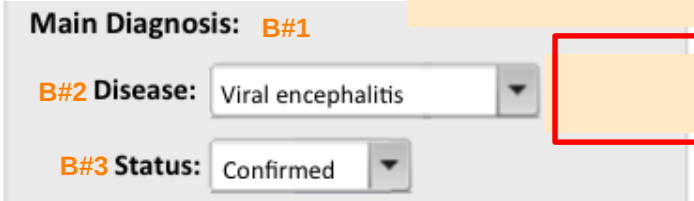
=

34476008 | *viral encephalitis* |

Individual: *Diagnosis_B* **Types** B#1 and B#2 and B#3

B#1: *shn:Diagnosis* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:DiagnosticProcedure*

FORM B:



B#2: *shn:ViralEncephalitisDiagnosis* **equivalentTo**
*shn:*Diagnosis and **shn:isAboutSituation** only *sct:ViralEncephalitisSituation*

B#3: *shn:DiagnosisConfirmedStatus* **equivalentTo**
*shn:*Diagnosis and **shn:hasInformationObjectAttribute** some *shn:Confirmed*

#QUERY: Give me all the patients with viral encephalitis diagnosed!!
>> Diagnosis_A
>> Diagnosis_B

II. SUBSUMPTION TESTING

Headache vs. Generalised headache

- A **specific condition** means also a more **general** one

A#1: *shn:Symptom* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:EvaluationSignsAndSymptoms*

Form A

Symptoms: A#1
Fever: Yes [x] No [ ] Unknown [ ]
A#2 **Headache:** Yes [x] No [ ] Unknown [ ]

25064002 | *headache* |

A#2: *shn:HeadacheSymptom* **equivalentTo**
shn:Symptom and **shn:isAboutSituation** only sct:*Headache*

Individual: *Symptom_Headache A* **Types** A#1 and A#2

B#1: *shn:Symptom* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:EvaluationSignsAndSymptoms*

Form B

Signs and Symptoms: B#1
Temperature value: 39 ºC
B#2 **Headache:** Yes [x] No [ ] Unknown [ ]

162299003 | *generalised headache* |

B#2: *shn:GeneralisedHeadacheSymptom* **equivalentTo**
shn:Symptom and **shn:isAboutSituation** only sct:Generalised*Headache*

Individual: *Symptom_Headache B* **Types** B#1 and B#2

Descriptions
- *Lang: en-GB*
  - F generalized headache (finding)
  - P generalised headache

Definition: Primitive
- is a
  - D headache
- finding site
  - D head structure

#QUERY: Give me all the patients that have headache symptom!!!
>> Symptom_Headache_A
>> Symptom_Headache_B

III.CONTEXT AWARENESS

Fever

- Awareness of the **context**, independently of where it is represented (structure / terminology)

A#1: *shn:Symptom* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:EvaluationSignsAndSymptoms*

248427009 | *fever symptoms* |

Form A

Symptoms: A#1
Fever: Yes [x] No [ ] Unknown [ ]
A#2 **Headache:** Yes [x] No [ ] Unknown [ ]

A#2: *shn:FeverSymptom* **equivalentTo**
shn:Symptom and **shn:isAboutSituation** only sct:*FeverSituation*

Individual: *Symptom_Fever A* **Types** A#1 and A#2

B#1: *shn:Symptom* **equivalentTo**
shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*
and **btl:outcomeOf** some *sct:EvaluationSignsAndSymptoms*

Form B

Signs and Symptoms: B#1
Temperature value: 39 ºC
B#2 **Headache:** Yes [x] No [ ] Unknown [ ]

Individual: *Symptom_Fever B* **Types** B#1 and B#2

271897009 | *O/E - fever* |

B#2: shn:SymptomTemperature39
shn:ObservationResult and **shn:isAboutQuality** only (*shn:Temperature*
and **btl:inheresIn** some *shn:corePartBody*
and **btl:qualityLocated** only
ationSignsAndSymptoms
ableValue value 39

CGI axiom:

if (*Temperature*
subClassOf *shn:FeverSymptom*

#QUERY: Give me all the patients that have fever symptom!!!
>> Symptom_Fever_A
>> Symptom_Fever_B