

Ontology Content Patterns as Bridge for the Semantic Representation of Clinical Information

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Three Kinds of Artefacts



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► Focus on clinical information representation

BOUNDARY
PROBLEM

EHR Information Models

ISO 13606, openEHR, HL7
RIM, DCM, etc.

OVERLAPPING AREA

Medical Terminologies / Ontologies

SNOMED CT, ICD, LOINC, etc.



Clinical Models

ISO 13606 / openEHR archetypes,
DCMs, HL7 CDA, Intermountain
CEM, etc.

Clinical Model

Clinical Model

Clinical Model

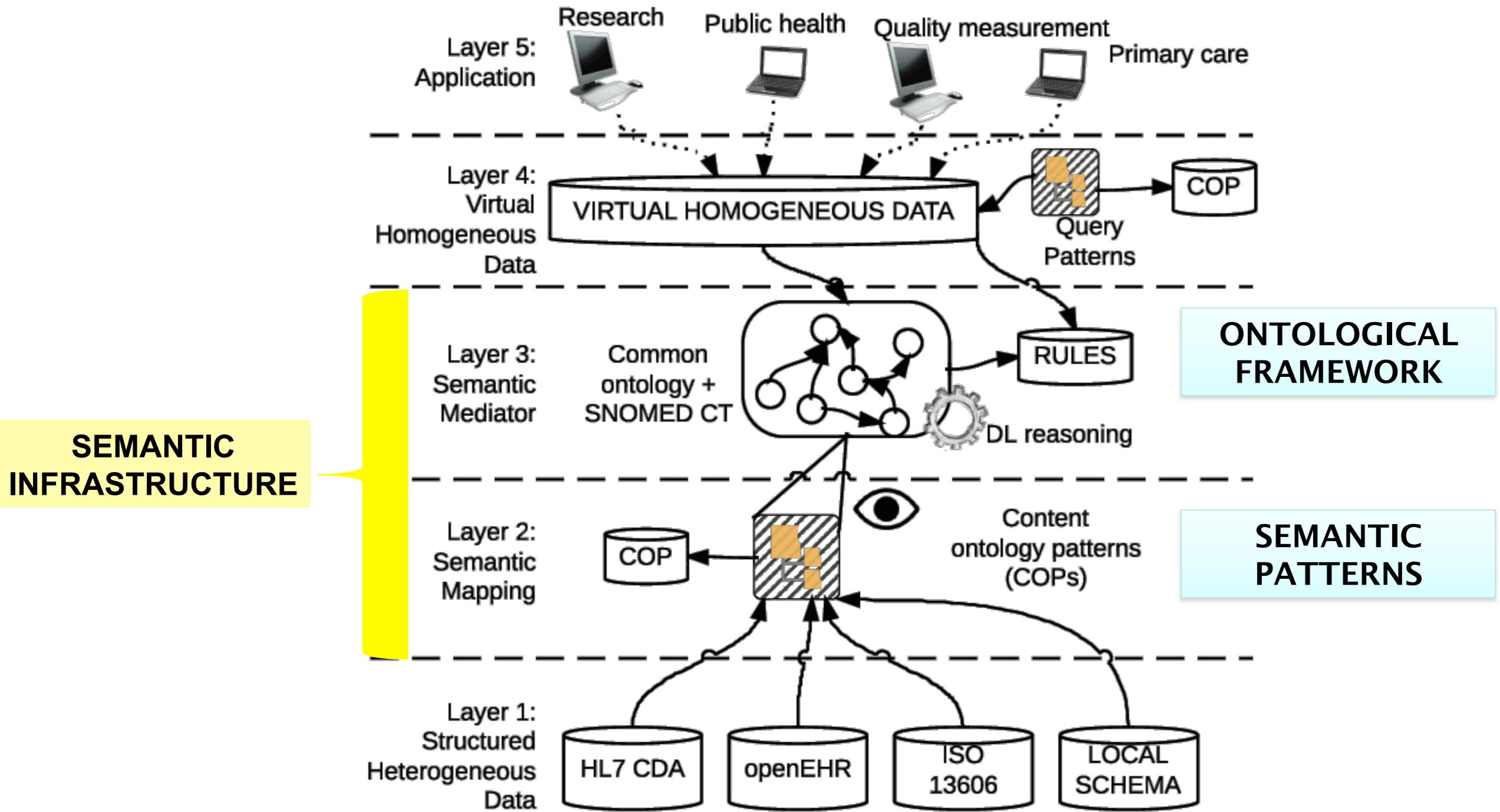
Clinical Model

ISO-SEMANTIC MODELS

Methods



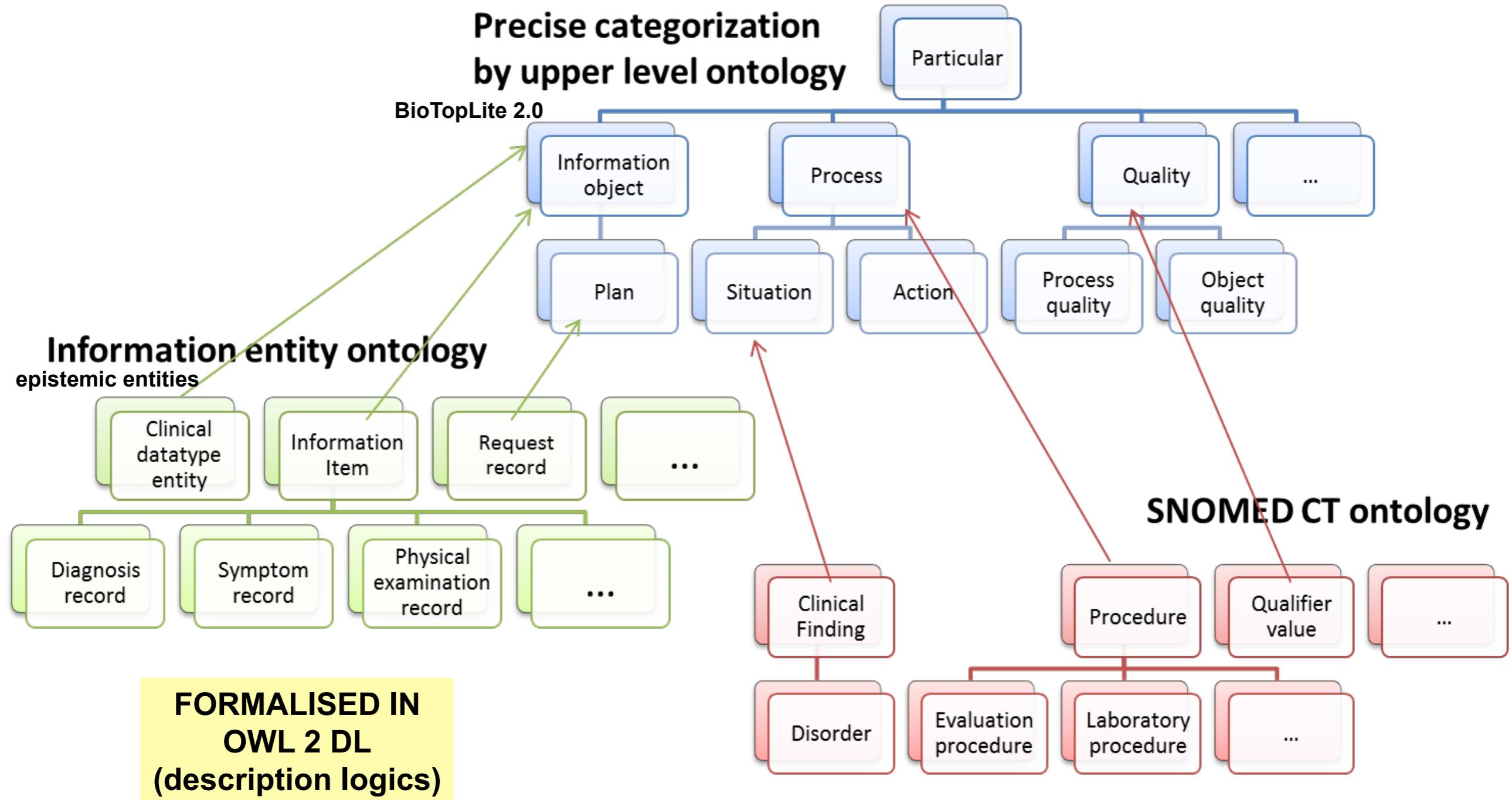
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Ontological Framework



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Medical Application Systems



HOMOGENEOUS DATA ACCESS POINT

SEMANTIC INFRASTRUCTURE



EHR - OpenEHR

Patient: Franz Müller
DoB: 17/01/1965
Encounter: 23/08/98

Tobacco Use Summary
- Cigarette smoker, 14 /d

STRUCTURED HETEROGENEOUS DATA



EHR - HL7 CDA

Patient: Franz Müller
DoB: 17/01/1965
Encounter: 23/08/2001

Social history
- Heavy cigarette tobacco smoker

Ontological Framework (III)



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EHR

Patient: Franz Müller
 DoB: 17/01/1965
 Encounter: 23/08/98

Tobacco Use Summary
 - Cigarette smoker, 14 /d



OWL DL

--Smoking status
InformationItem
 and **isAboutSituation** only *sct:TobaccoSmokingSituation*
 and **isOutcomeOf** some *sct:HistoryTaking*

-- Form
InformationItem
 and **isAboutSituation** only *sct:CigaretteTobaccoSmoking*
 and **isOutcomeOf** some *sct:HistoryTaking*

-- Amount
ObservationResult
 and **isAboutQuality** some (*MassIntake*
 and **inheresIn** some *sct:CigaretteTobaccoSmokingSituation*
 and **projectsOnTo** some (*ValueRegion*
 and **isRepresentedBy** only (**hasValue** value 14
 and **hasInformationAttribute** some *sct:PerDay*)))

openEHR archetype

```

EVALUATION[at0000] matches { -- Tobacco Use Summary
    data matches {
        ITEM_TREE[at0001] matches {           -- Tree
            items cardinality matches {0..*; unordered} matches {
                ELEMENT[at0002] occurrences matches {0..1} matches {
                    -- Smoking Status
                    value matches {
                        DV_CODED_TEXT matches {
                            defining_code matches {
                                [local:::
                                    at0003,      -- Current Smoker
                                    at0027,      -- Never Smoked
                                    at0005]      -- Ex-smoker
                            }]}
                    }
                CLUSTER[at0029] occurrences matches {0..*} matches {
                    -- Smoking Details
                    items cardinality matches {1..*; unordered} matches {
                        ELEMENT[at0028] occurrences matches {0..1} matches {
                            -- Form
                            value matches {
                                DV_TEXT matches {*}})}
                        ELEMENT[at0030] occurrences matches {0..1} matches {
                            -- Typical smoked amount
                            value matches {
                                C_DV_QUANTITY <
                                    property = <[openehr:::382]>
                                    list = <
                                        ["1"] = <
                                            units = <"/d">
                                            magnitude = <|>=0.0|>
                                            precision = <|0|>
                                        >>}>...>>}}>...>>}}>
    }
}

```

Ontological Framework (IV)



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Primary Care



EHR

Patient: Franz Müller
DoB: 17/01/1965
Encounter: 23/08/2001

Social history

- Heavy cigarette tobacco smoker

OWL DL

--**Current Heavy tobacco smoker**
InformationItem
and **isAboutSituation** only *sct:HeavyCigaretteSmokingSituation*
and **isOutcomeOf** some *sct:Evaluation*

HL7 CDA model compliant with ‘Meaningful Use’

```
<section>
  <!-- Social History Section templateId -->
  <templateId root="2.16.840.1.113883.10.20.22.2.17"/>
  <code code="29762-2" codeSystem="2.16.840.1.113883.6.1"
        displayName="Social history"/>
  <title>Social History</title>
  <text>Began smoking daily on 4/10/2011.</text>
  <entry>
    <observation classCode="OBS" moodCode="EVN">
      <templateId root="2.16.840.1.113883.10.20.22.4.78"/>
      <code code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
      <statusCode code="completed"/>
      <effectiveTime>
        <!-- Date the person began smoking -->
        <low value="20110410"/>
      </effectiveTime>
      <value xsi:type="CD" code="428071000124103"
            codeSystem="2.16.840.1.113883.6.96"
            displayName="Current Heavy tobacco smoker" />
    </observation>
```

‘Meaningful Use’:
 > = 10 cigarettes / day

Semantic Patterns



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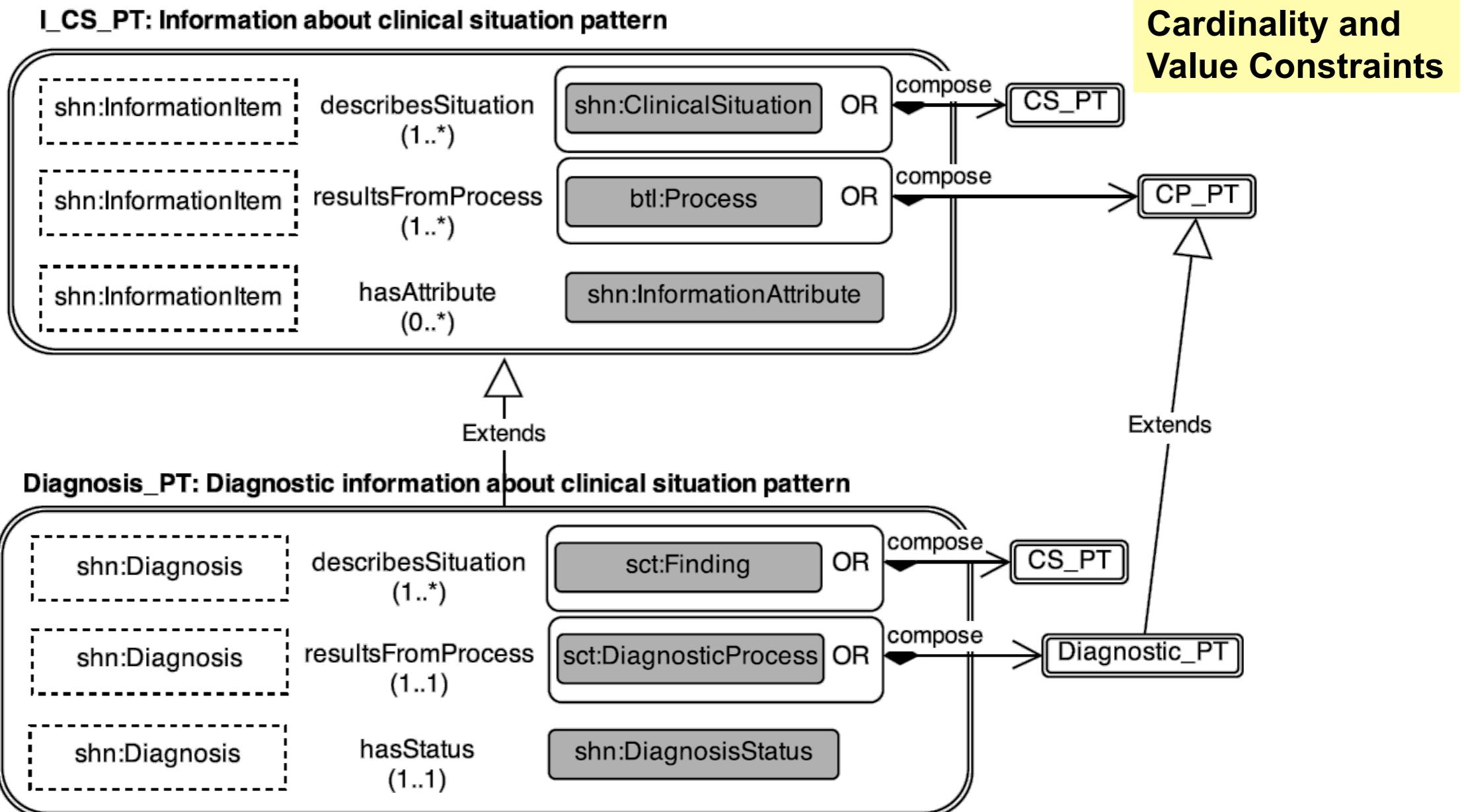
- ▶ User-friendly **abstractions** that provide a **more intuitive** and **closer to natural language** representation
- ▶ Prevent modelers from a in-depth **ontology and description logics** modeling knowledge and skills
- ▶ Represent **recurring content modelling tasks** by following a standardized structure
 - E.g. who does what, when and where?, which objects take part in a certain event?, etc.
- ▶ Defined wrt. a **reference ontology** (particular view on it)
- ▶ They can be **specialised** and **composed**

Semantic Patterns (II)



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- ▶ Represented as a set of constrained Subject–Predicate–Object (SPO) triples.



Semantic Patterns OWL DL Representation



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► Use of DL reasoning for:

- Detection of iso-semantic information across models
- Advanced query of clinical information

► OWL 2 DL transformation:

- SUB and OBJ into OWL DL classes
- Predicates into OWL DL expressions

| Predicate | OWL DL expression | |
|------------------------|-------------------|---|
| 'describes situation' | SUBJ | subClassOf shn:isAboutSituation only OBJ |
| 'results from process' | SUBJ | subClassOf btl:isOutcomeOf some OBJ |
| 'has attribute' | SUBJ | subClassOf btl:hasInformationAttribute some OBJ |
| 'has observed value' | SUBJ | subClassOf <i>btl:Quality</i> and btl:projectsOnto some OBJ |
| 'has units' | SUBJ | subClassOf btl:isRepresentedBy only <i>(shn:hasInformationAttribute</i> some OBJ) |

shn:InformationItem 'describes situation' *shn:ClinicalSituation*



shn:InformationItem and **shn:isAboutSituation** only *shn:ClinicalSituation*

Advanced Query of Clinical Information



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Hospital



Patient: Franz Müller
DoB: 17/01/1965
Encounter: 23/08/98

Tobacco Use Summary
- Cigarette smoker, 14 /d

Primary Care



Patient: Franz Müller
DoB: 17/01/1965
Encounter: 23/08/2001

Social History
- Heavy cigarette tobacco smoker

OWL DL Representation

-- Smoking status

InformationItem

and **isAboutSituation** only *sct:TobaccoSmokingSituation*
and **isOutcomeOf** some *sct:HistoryTaking*

-- Current Heavy tobacco smoker

InformationItem

and **isAboutSituation** only *sct:HeavyCigaretteSmokingSituation*
and **isOutcomeOf** some *sct:Evaluation*

-- Form

InformationItem

and **isAboutSituation** only *sct:CigaretteTobaccoSmoking*
and **isOutcomeOf** some *sct:HistoryTaking*

-- Amount

ObservationResult

and **isAboutQuality** some (*MassIntake*
and **inheresIn** some *sct:CigaretteTobaccoSmokingSituation*
and **projectsOnTo** some (*ValueRegion*
and **isRepresentedBy** only (**hasValue** value 14
and **hasInformationAttribute** some *sct:PerDay*)))

Advanced Query of Clinical Information (II)



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| | |
|-----|--|
| #Q1 | <p><i>shn:InformationItem</i> and btl:isOutcomeOf some <i>sct:HistoryTaking</i> and shn:isAboutSituation only <i>sct:TobaccoSmokingSituation</i></p> |
|-----|--|



--Smoking status

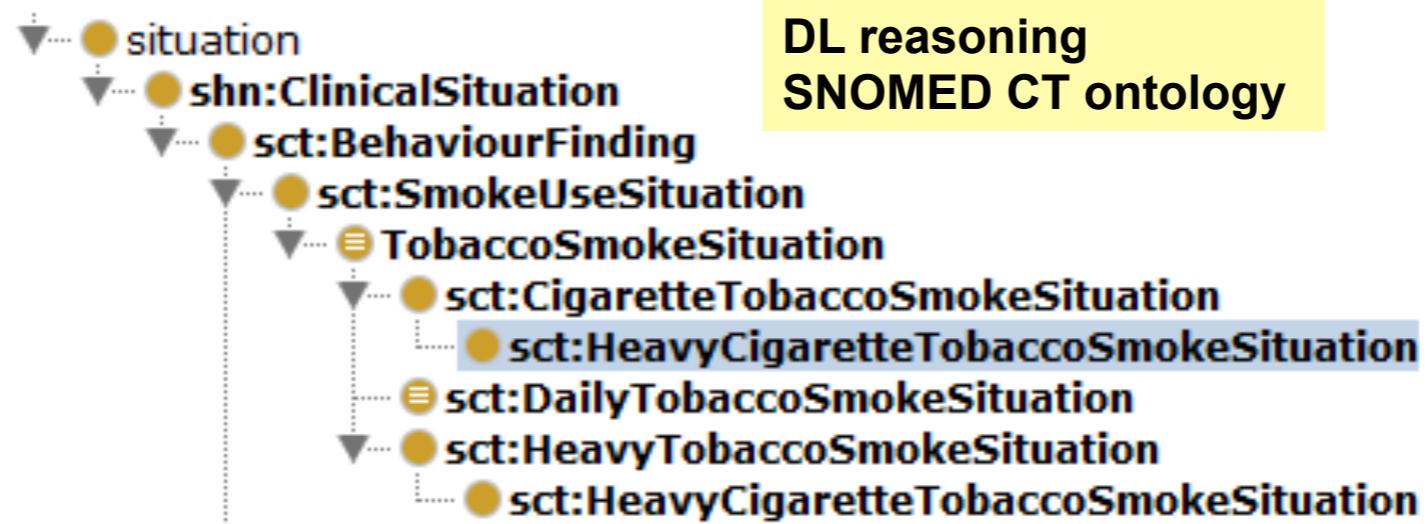
InformationItem

and **isAboutSituation** only *sct:TobaccoSmokingSituation*
and **isOutcomeOf** some *sct:HistoryTaking*

--Current Heavy tobacco smoker

InformationItem

and **isAboutSituation** only *sct:HeavyCigaretteSmokingSituation*
and **isOutcomeOf** some *sct:Evaluation*



DL reasoning
SNOMED CT ontology

Advanced Query of Clinical Information (III)



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| | |
|-----|---|
| #Q2 | <i>shn:InformationItem</i> and btl:isOutcomeOf some <i>shn:Evaluation</i> and shn:isAboutSituation <i>only sct:HeavyTobaccoSmokingSituation</i> |
| #Q3 | <i>shn:InformationItem</i> and btl:isOutcomeOf some <i>shn:Evaluation</i> and shn:isAboutSituation <i>only sct:HeavyTobaccoSmokingSituation</i> and shn:isAboutSituation <i>only sct:CigaretteTobaccoSmokingSituation</i> |

-- Amount
ObservationResult
 and **isAboutQuality** some (*MassIntake*
 and **inheresIn** some *sct:CigaretteTobaccoSmokingSituation*
 and **projectsOnTo** some (*ValueRegion*
 and **isRepresentedBy** *only (hasValue value 14*
 and **hasInformationAttribute** some *sct:PerDay))*)

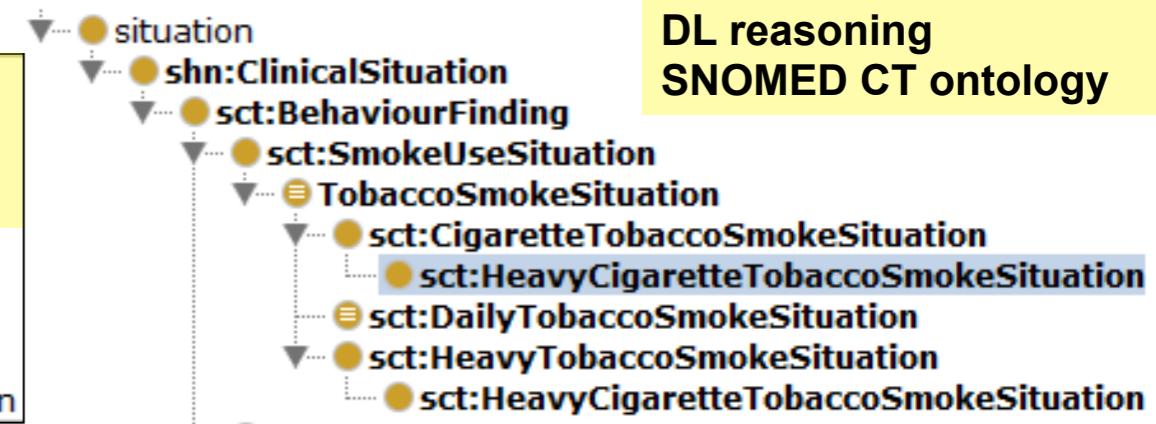


-- Current Heavy tobacco smoker
InformationItem
 and **isAboutSituation** *only sct:HeavyCigaretteSmokingSituation*
 and **isOutcomeOf** some *sct:Evaluation*



shn:ObservationResult
and shn:isAboutQuality *some (mass_intake*
 and 'inheres in' *some sct:CigaretteTobaccoSmokeSituation*
 and 'projects onto' *some ('value region'*
 and 'is represented by' *only*
 (*shn:hasInformationObjectAttribute* *some sct:PerDay*
 and *shn:hasValue* *some int[>= 10]))*

Local system rules.
 Vary across
 institutions



SubClassOf
shn:InformationItem **and shn:isAboutSituation** *only sct:HeavyCigaretteTobaccoSmokeSituation*

Advanced Query of Clinical Information (IV)



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| | |
|-----|--|
| #Q4 | <pre>shn:ObservationResult and shn:isAboutQuality only (shn:MassIntake and btl:inheresIn some sct:CigaretteTobaccoSmokingSituation and btl:projectsOnto some (btl:ValueRegion and btl:isRepresentedBy only (shn:hasInformationAttribute some sct:PerDay shn:hasValue some int[>15])))</pre> |
|-----|--|

-- Amount
ObservationResult
and **isAboutQuality** some (*MassIntake*
and **inheresIn** some *sct:CigaretteTobaccoSmokingSituation*
and **projectsOnTo** some (*ValueRegion*
and **isRepresentedBy** only (**hasValue** value 14
and **hasInformationAttribute** some *sct:PerDay*)))



--**Current Heavy tobacco smoker**
InformationItem
and **isAboutSituation** only *sct:HeavyCigaretteSmokingSituation*
and **isOutcomeOf** some *sct:Evaluation*



The query does not
retrieve any record

| | |
|--|---|
| <pre>shn:ObservationResult and shn:isAboutQuality some (mass_intake and 'inheres in' some sct:CigaretteTobaccoSmokeSituation and 'projects onto' some ('value region' and 'is represented by' only (shn:hasInformationObjectAttribute some sct:PerDay and shn:hasValue some int[>= 10])))</pre> | Local system rules. Vary across institutions |
|--|---|

SubClassOf
shn:InformationItem **and** shn:isAboutSituation **only** sct:HeavyCigaretteTobaccoSmokeSituation

Conclusions



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- ▶ The use of **EHR standards and terminologies** does not guarantee semantic interoperability
- ▶ SemanticHealthNet proposes an **intermediate semantic layer** able to deal with the present clinical information heterogeneity
- ▶ We hypothesize that clinical models information can be represented by the **specialisation and composition of a set of limited top-level semantic patterns**
- ▶ The proposed infrastructure faces **two main kinds of challenges** (human & computational)
- ▶ **Compromises between performance and functionality** might be required

Danke!

