

SNOMED CT: Ontologies in support of global interoperation of the EHR

SNOMED CT Showcase

October 31, 2019

November 1, 2019

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SERIOUS MEDICINE. EXTRAORDINARY CARE.™

Interoperation Use Case

- US tourist in Australia stricken with acute febrile illness presents to local physician, providing a CDA record summary to the physician for medical history.
- November 1 Session 2:
 - What are the patient's problems?
 - Does the patient have history of infections?
 - Is the patient allergic to planned treatment?



Clinical finding in SNOMED CT

- The largest of the 19 top-level hierarchies with over 100,000 concepts



- ▣ SNOMED CT Concept
 - ⊕ Body structure
 - ⊕ Clinical finding
 - ⊕ Environment or geographical location
 - ⊕ Event
 - ⊕ Observable entity
 - ⊕ Organism
 - ⊕ Pharmaceutical / biologic product
 - ⊕ Physical force
 - ⊕ Physical object
 - ⊕ Procedure
 - ⊕ Qualifier value
 - ⊕ Record artifact
 - ⊕ SNOMED CT Model Component
 - ⊕ Situation with explicit context
 - ⊕ Social context
 - ⊕ Special concept
 - ⊕ Specimen
 - ⊕ Staging and scales
 - ⊕ Substance

Clinical finding concepts

- Represent the result of a clinical observation, assessment or judgment
- Includes both finding and disorder concepts e.g. Abnormal fetal heart rate (finding), Diabetes mellitus (disorder)
- Characteristics of findings
 - Can represent both normal and abnormal states
 - May exist at a single point in time
 - Cannot be temporally separated from the observation (e.g. no “abnormal heart rate absent”)
- Characteristics of disorders
 - Represent an abnormal state
 - Have an underlying pathological process
 - Exist over a period of time
 - Can be present when their manifestations are not evident (e.g. patient with hypertension may have normal blood pressure readings)



Clinical finding concept model – defining attributes

- Associated morphology ←
- Associated with
 - Causative agent ←
 - Due to
 - Temporally related to
 - After
 - Before
 - During
- Clinical course
- Has realization ←
- Episodicity
- Interprets
- Has interpretation
- Pathological process ←
- Occurrence
- Finding site ←
- Finding method
- Finding informer
- Severity



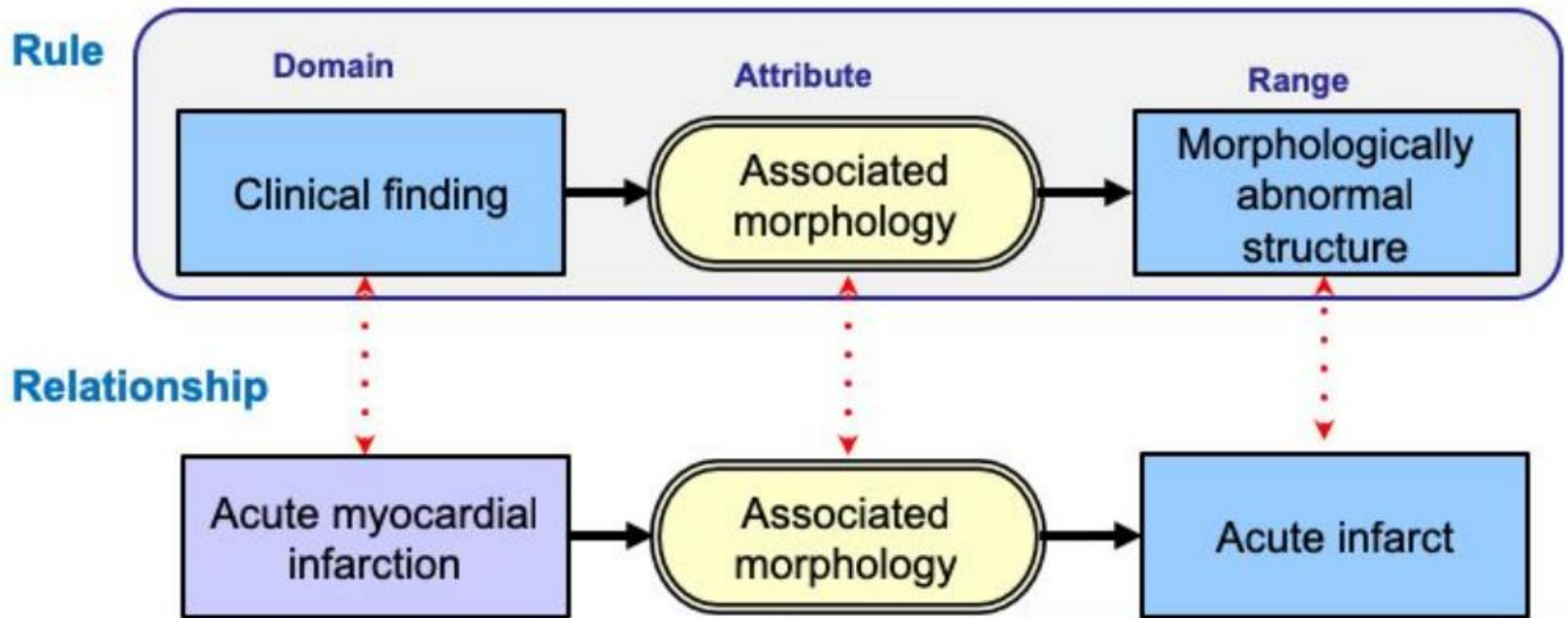
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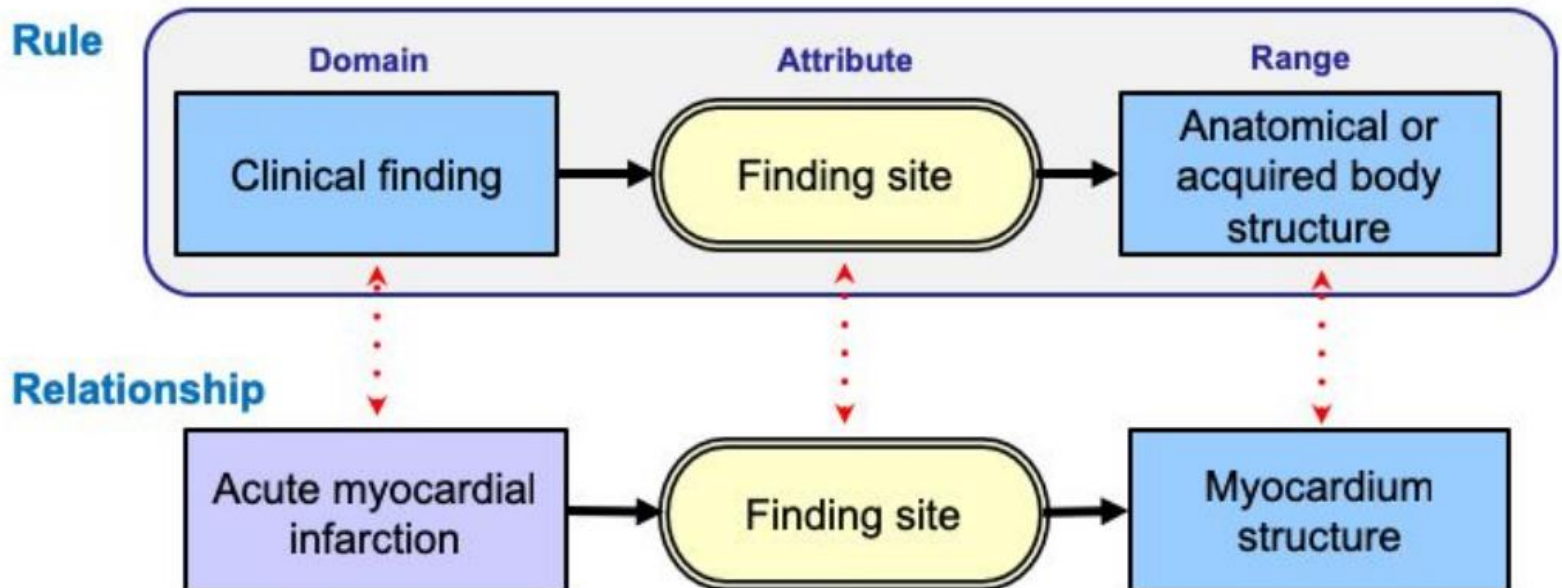
Associated morphology

- Specifies morphological changes characteristic of the disease

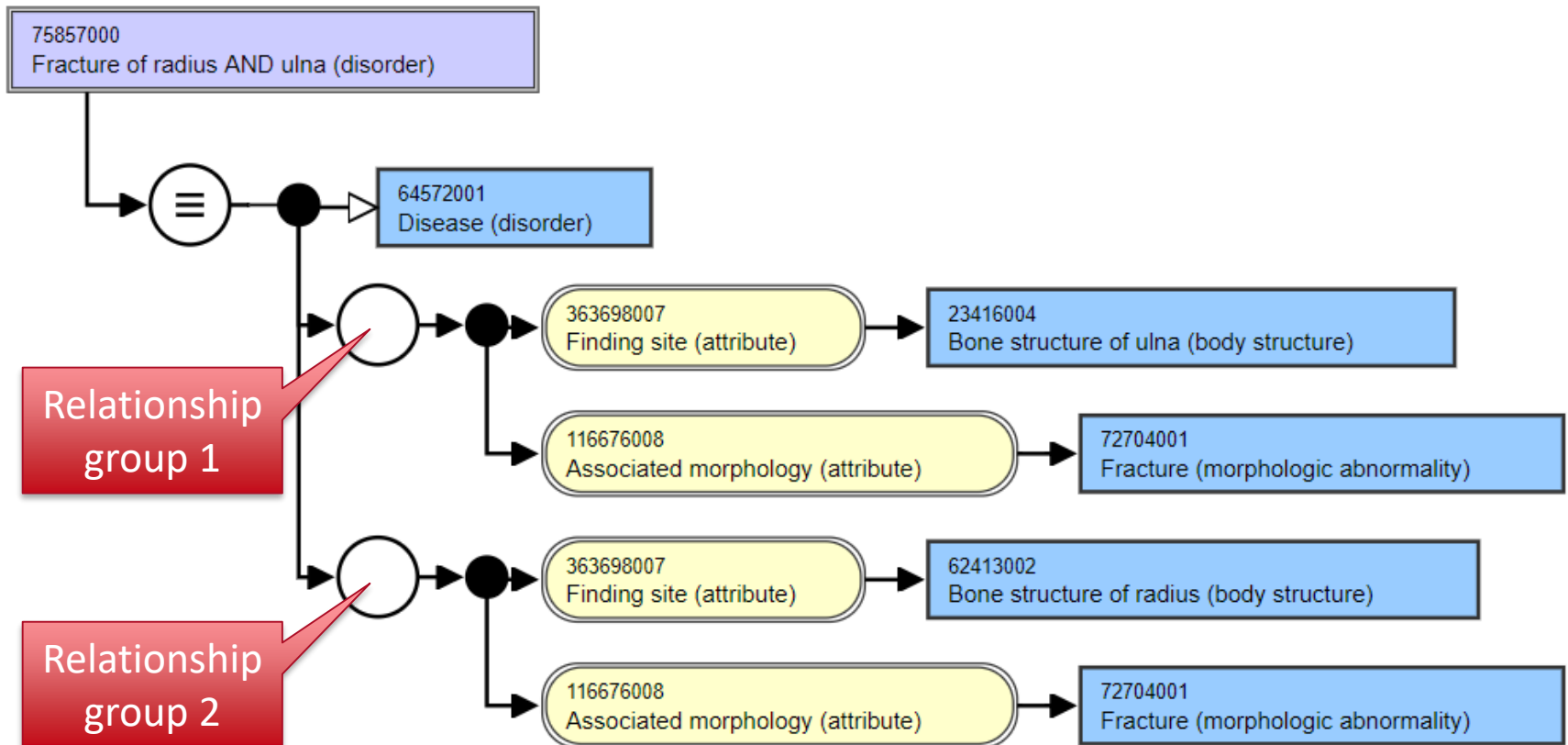


Finding site

- Specifies body site affected

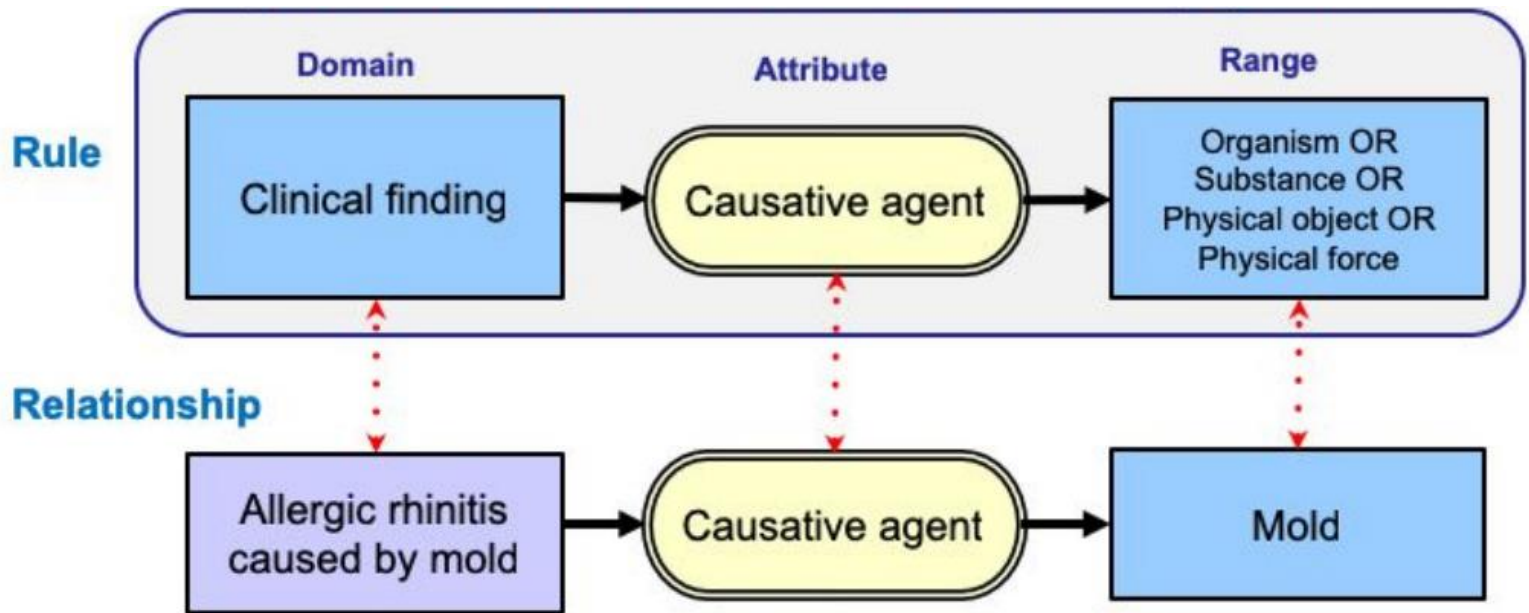


Relationship grouping



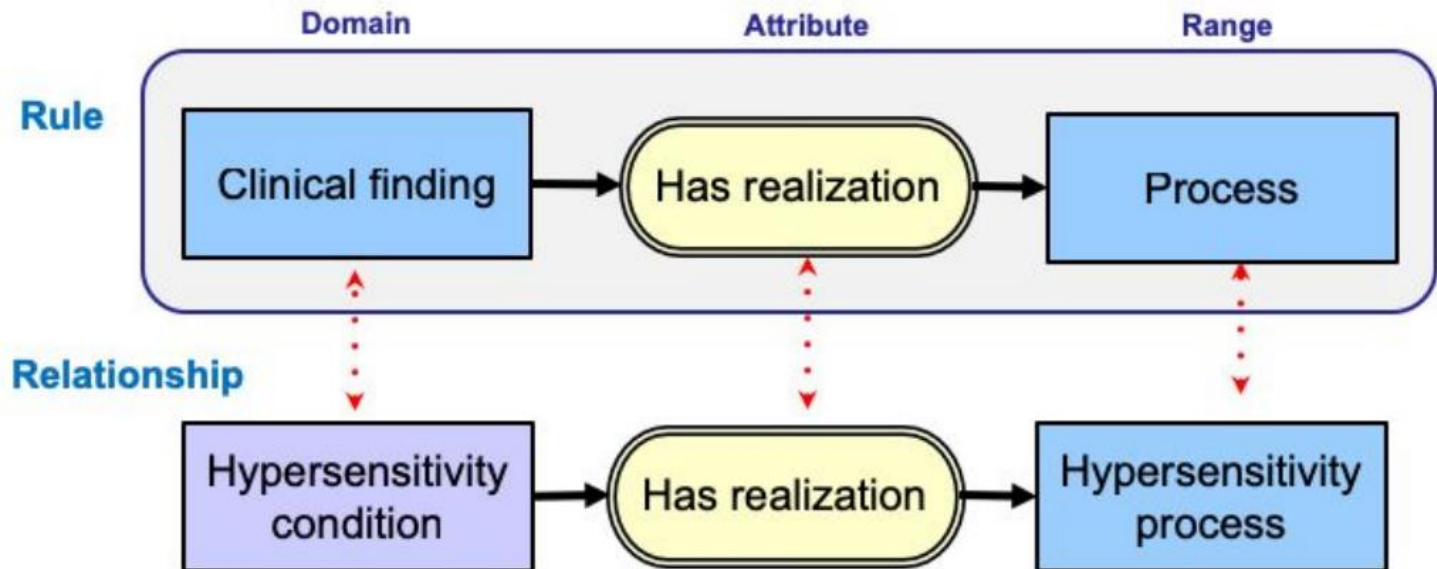
Causative agent

- Identifies the direct causative agent

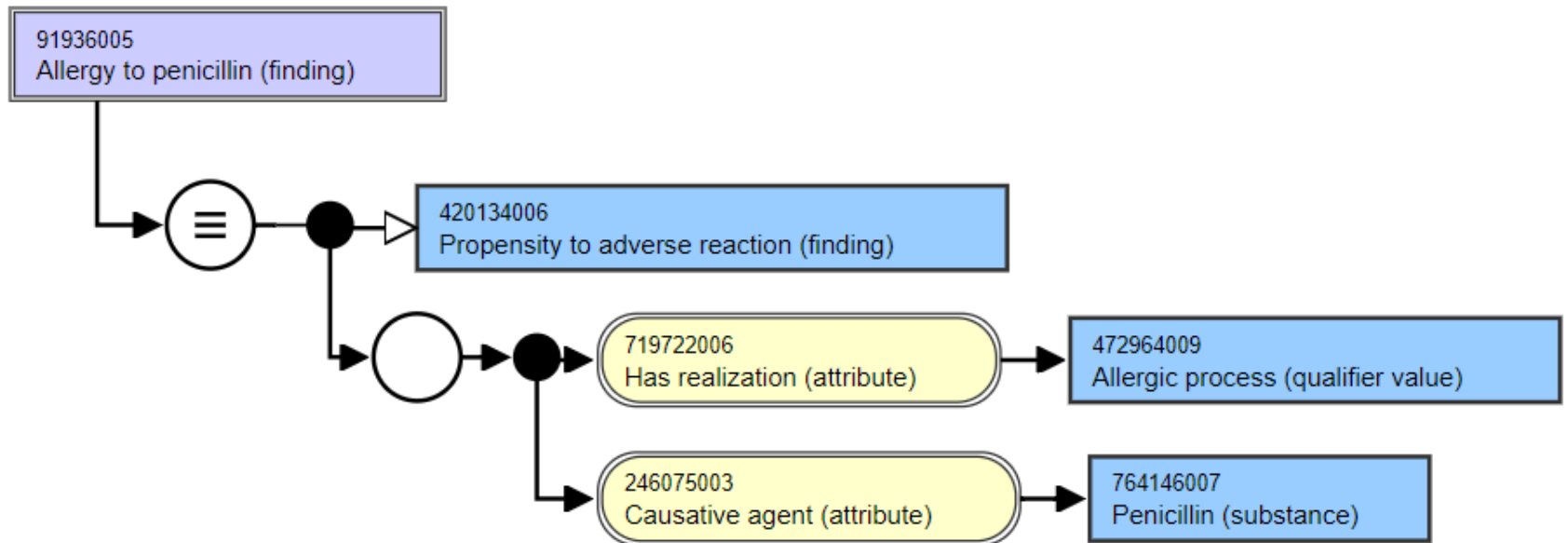


Has realization

- Specifies the process of activity that is the consequence of realization of the function

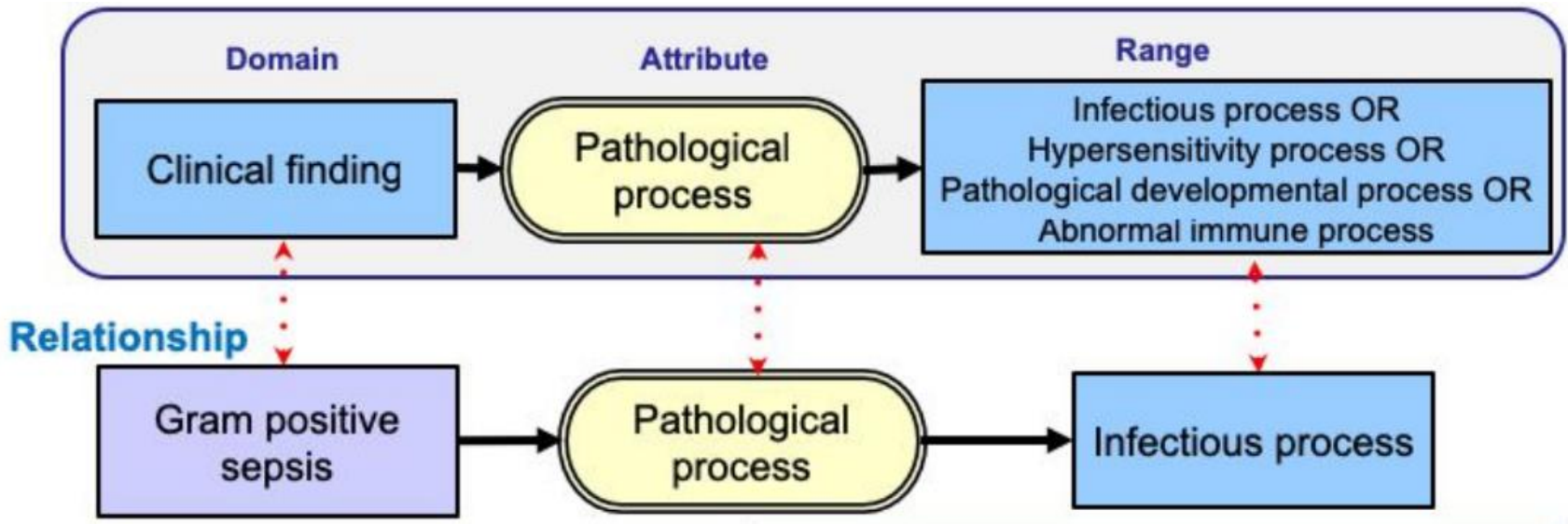


Allergy



Pathological process

- Provides information about the underlying pathological process



Interoperability use case

- Mr. Jones, 75 years old, a retired school teacher, joined a round-the-world cruise and disembarked at Sydney, Australia for a city tour
- He had developed a fever of 38.5 degrees Celsius the night before, a mild cough and some pain in urination
- His fever persisted during the day, he vomited a few times and was feeling weak
- The tour guide decided to take Mr. Jones to a medical clinic that was experienced in the care of traveling tourists



Interoperable electronic health record

- The clinic's EHR was able to accept Mr. Jones's summary medical information on a thumb drive, formatted according to the HL7 C-CDA (consolidated clinical document architecture) standard, this includes:
 - Medical problems
 - Medications
 - Allergies
 - Laboratory tests and results
 - Procedures
 - Etc.
- Most of the information is encoded in standard terminologies e.g. SNOMED CT, LOINC and RxNorm in the North American realm



FirstName J LastName "NickName"

Clinical Summary, generated on Feb. 28, 2019

Patient Demographics - Male; born Jan. 00, 1940

| Patient Address | Communication | Language | Race / Ethnicity | Marital Status |
|--------------------------------|---|---------------------|-------------------|----------------|
| 1234 Street OMAHA, NE 681XX | NNN-NNN-NNNN (Mobile) NNN-NNN-NNNN (Home) notme@gmail.com | English (Preferred) | Unknown / Unknown | Married |

Allergies

| Active Allergy | Reactions | Severity | Noted Date | Comments |
|--------------------------------|---------------------|----------|------------|-------------------------------|
| Gabapentin | Falls | Low | | |
| Lisinopril | Hyperkalemia | High | 09/18/2010 | |
| Pioglitazone | Nausea And Vomiting | Low | | |
| Propoxyphene | See Comments | | | Due to medication interaction |
| Rosiglitazone | Muscle inflammation | Low | 04/19/2010 | |
| Triamterene-Hydrochlorothiazid | Nausea | Low | | |

Current Medications

| Prescription | Sig. | Disp. | Refills | Start Date | End Date | Status |
|--|--|------------|---------|------------|----------|--------|
| EDEMA WEAR Indications: Durable Medical Equipment | Wear daily as needed | 1 each | 0 | 07/06/2010 | | Active |
| COCK-UP WRIST SPLINTS Indications: Durable Medical Equipment | 1 each. | 1 each | 0 | 08/24/2010 | | Active |
| DME MISC Indications: Durable Medical Equipment | Dx (ICD code preferred): CHF, legally blind Duration: 99 yrs (lifetime) | 1 Units | 0 | 11/19/2010 | | Active |
| miscellaneous medical supply Misc Indications: Durable Medical Equipment | Hip protectors to use daily for osteoporosis. | 2 each | 1 | 05/14/2010 | | Active |
| atorvastatin (LIPITOR) 40 mg tablet | Take 1 tablet (40 mg total) by mouth 1 (one) time a day. | 90 tablet | 3 | 05/17/2010 | | Active |
| furosemide (LASIX) 20 mg tablet | Take 3 tablets (60 mg total) by mouth 2 (two) times a day. | 540 tablet | 3 | 05/17/2010 | | Active |
| nitroGLYCERIN (NITROSTAT) 0.4 mg SL tablet Indications: Atherosclerosis of other coronary artery bypass graft without angina pectoris | Place 1 tablet (0.4 mg total) under the tongue every 5 (five) minutes as needed for Chest pain. Go to ER after 1st dose. | 25 tablet | 3 | 05/17/2010 | | Active |
| pantoprazole (PROTONIX) 40 mg tablet Indications: Heartburn | Take 1 tablet (40 mg total) by mouth every morning before breakfast. | 90 tablet | 3 | 06/07/2010 | | Active |

CDA Problem Coding

```
<observation classCode="OBS" moodCode="EVN">
  <templateId root="2.16.840.1.113883.10.20.22.4.4"></templateId>
  <templateId extension="2015-08-01" root="2.16.840.1.113883.10.20.22.4.4"></templateId>
  <id extension="847809" root="1.2.840.114350.1.13.310.2.7.2.768076"></id>
  <code code="64572001" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMED CT" displayName="Condition">
    <translation code="75323-6" codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC" displayName="Condition"></translation>
  </code>
  <text>
    <reference value="#problem75name"></reference>
  </text>
  <statusCode code="completed"></statusCode>
  <effectiveTime>
    <low nullFlavor="UNK"></low>
  </effectiveTime>
  <value code="38341003" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMED CT" displayName="Hypertension">
    <originalText>
      <reference value="#problem75name"></reference>
    </originalText>
    <translation code="I10" codeSystem="2.16.840.1.113883.6.90" codeSystemName="ICD-10-CM" displayName="Hypertension"></translation>
    <translation code="401.9" codeSystem="2.16.840.1.113883.6.103" codeSystemName="ICD-9CM" displayName="Hypertension"></translation>
    <translation code="86491" codeSystem="2.16.840.1.113883.3.247.1.1" codeSystemName="Intelligent Medical Objects"></translation>
  </value>
```



Medical assessment

- Dr. Smart saw Mr. Jones. Her impression was that he was suffering from some acute infection. The clinic EHR allowed Dr. Smart to ask questions based on what's known about Mr. Jones from the C-CDA record:
 - Was Mr. Jones known to suffer from an infection in the past, which may have recurred?
 - Was Mr. Jones suffering from some form of immunosuppression? This would
 - make him susceptible to infection
 - affect the choice of treatment



Infectious diseases

- to find any infectious diseases, the EHR issued a query to the SNOMED CT problem list:
 - Descendant of Disease (disorder), and
 - Defining attribute Pathological process (attribute) = Infectious process (qualifier value)
- (6725 concepts)



Infectious Disease?

DL query:

Query (class expression)

'Clinical finding (finding)'

and ('Role group (attribute)' some ('Pathological process (attribute)' some 'Infectious process (qualifier value)'))

Execute

Add to ontology

Query results

Subclasses (7032 of 7033)

- ASCUS with positive high risk HPV (finding)
- Abdominal actinomycosis (disorder)
- Abortive poliomyelitis (disorder)
- Abrasion and/or friction burn of abdominal wall with infection (disorder)
- Abrasion and/or friction burn of ankle with infection (disorder)
- Abrasion and/or friction burn of anus with infection (disorder)
- Abrasion and/or friction burn of axilla with infection (disorder)
- Abrasion and/or friction burn of back with infection (disorder)
- Abrasion and/or friction burn of breast with infection (disorder)
- Abrasion and/or friction burn of buttock with infection (disorder)
- Abrasion and/or friction burn of cheek with infection (disorder)
- Abrasion and/or friction burn of chest wall with infection (disorder)
- Abrasion and/or friction burn of ear with infection (disorder)
- Abrasion and/or friction burn of elbow with infection (disorder)
- Abrasion and/or friction burn of face with infection (disorder)



Infectious diseases

- to find any infectious diseases, the EHR issued a query to the SNOMED CT problem list:
 - Descendant of Disease (disorder), and
 - Defining attribute Pathological process (attribute) = Infectious process (qualifier value)
- (6725 concepts)
- Mr. Jones had indeed suffered from Lower urinary tract infectious disease (disorder) in the past



Immunosuppression?

- In problem list, look for
 - 'Patient immunocompromised (finding)'
 - or
 - 'Patient immunosuppressed (finding)'
 - or
 - 'Immunodeficiency disorder (disorder)'(362 concepts)
- Additionally, in medications list, see whether Mr. Jones was on any immunosuppressants or steroids
 - Combined SNOMED CT and RxNorm query discussed yesterday



Immunodeficiency state or disorder

Active ontology x Entites x Individuals by class x DL Query x

Class hierarchy: Patient immunocompromised (finding)

Asserted

DL query:

Query (class expression)

```
'Patient immunocompromised (finding)'  
or  
'Patient immunosuppressed (finding)'  
or  
'Immunodeficiency disorder (disorder)'
```

Execute Add to ontology

Query results

Equivalent classes (0 of 0)

Subclasses (362 of 362)

- 18-p syndrome with associated immunodeficiency (disorder)
- Absent thumb with short stature and immunodeficiency syndrome (disorder)
- Acquired immune deficiency syndrome (disorder)
- Acquired immune deficiency syndrome complicating childbirth (disorder)
- Acquired neutrophilia (disorder)
- Activated PI3K-delta syndrome (disorder)
- Acute neutrophilia (disorder)
- Adenosine deaminase deficiency (disorder)
- Adult-onset immunodeficiency (disorder)
- Agammaglobulinemia, microcephaly, craniosynostosis, severe dermatitis syndrome (disorder)
- Age-related immunodeficiency (disorder)
- Agranulocytosis (disorder)
- Agranulocytosis associated with acquired immunodeficiency syndrome (disorder)
- Agranulocytosis co-occurrent with human immunodeficiency virus infection (disorder)
- Alloimmune neonatal neutropenia (disorder)
- Alternative pathway deficiency (disorder)
- Anaphylotoxin inactivator deficiency (disorder)
- Anhidrotic ectodermal dysplasia with immune deficiency (disorder)
- Anhidrotic ectodermal dysplasia, immunodeficiency, osteopetrosis, lymphedema syndrome (disorder)
- Anti-haemophilus influenzae B polysaccharide antibody deficiency (disorder)
- Anti-meningococcal polysaccharide A antibody deficiency (disorder)

A hierarchical tree view of medical findings. The root node is 'Patient immunocompromised (finding)'. It branches into numerous sub-nodes, including 'Electroencephalogram finding (finding)', 'Electrolytes abnormal (finding)', 'Electromyography finding (finding)', 'Elliptocytosis (finding)', 'Endocrine finding (finding)', 'Endoscopy finding (finding)', 'Extracellular Gram-negative diplococcus (finding)', 'Extractable nuclear antigen negative (finding)', 'Fecal occult blood: negative (finding)', 'Fecal reducing substances abnormal (finding)', 'Fecal starch granules normal (finding)', 'Feces examined - normal (finding)', 'Fernandez reaction to lepromin (finding)', 'Fetoplacental hormones abnormal (finding)', 'Finding of acid-base balance (finding)', 'Finding of antimicrobial susceptibility (finding)', 'Finding of blood hematinic levels (finding)', 'Finding of bone marrow megakaryocytes (finding)', 'Finding of cellular component of blood (finding)', 'Finding of cerebrospinal fluid cell content (finding)', 'Finding of cerebrospinal fluid: chemical content - general (finding)', 'Finding of erythrocyte sedimentation rate (finding)', 'Finding of fecal starch (finding)', 'Finding of glucose level (finding)', 'Finding of Heaf test (finding)', 'Finding of hematocrit (finding)', 'Finding of hemoglobin concentration, dipstick (finding)', 'Finding of human immunodeficiency virus status (finding)', 'Finding of immune status (finding)', 'Finding of Hepatitis B status (finding)', 'Finding of Rubella status (finding)', 'Immunity to Lyme disease by positive serology (finding)', 'Immunity to measles and mumps and rubella by positive serology (finding)', 'Immunity to polio by positive serology (finding)', 'Immunity to tetanus by positive serology (finding)', 'Measles immune (finding)', 'Measles non-immune (finding)', 'Mumps immune (finding)', 'Mumps non-immune (finding)', and 'Patient immunocompromised (finding)'. The 'Patient immunocompromised (finding)' node is highlighted in blue.

Immunosuppression?

- In problem list, look for
 - 'Patient immunocompromised (finding)'
or
 - 'Patient immunosuppressed (finding)'
or
 - 'Immunodeficiency disorder (disorder)''(362 concepts)
- In medications list, see whether Mr. Jones was on any immunosuppressants or steroids
 - Combined SNOMED CT and RxNorm query (more on this later)
- 370391006|Patient immunosuppressed (finding)| in problem list of the CDA document



Diagnosis

- Urine microscopy came back positive for white blood cells
- Dr. Smart thought that the most likely diagnosis was urinary tract infection
- She considered prescribing MACRODANTIN© (Australian brand name for nitrofurantoin) but has to check whether Mr. Jones was allergic



Allergy checking

- Mr. Jones's allergy list included:
 - MACROBID© (US brand name for nitrofurantoin) - which would have been missed
- Luckily, the EHR did another query for Mr. Jones's problems:
 - Propensity to adverse reactions (disorder), and
 - Has realization (attribute) = Allergic process (qualifier value) (>July 2019 ed), and
 - Causative agent (attribute) = Nitrofurantoin (substance)
- There was indeed an entry of Allergy to nitrofurantoin (finding) among Mr. Jones's problems

Relation
grouped



Treatment

- Dr. Smart changed the prescription to BACTRIM© (Australian brand name for Trimethoprim + Sulfamethoxazole) after checking for allergies
- Mr. Jones received the prescription, and was advised to drink a lot of water
- His fever subsided and the urinary symptoms disappeared the following day
😊



Interoperation Use Case

- In preparation to writing a prescription for an antibiotic, does the patient have kidney disease?
- ...Allergic to diabetic medications?



Interprets

- Specifies the testing procedure or test result that defines the 'Evaluation finding'
- Rule:
 - Domain: Clinical finding
 - Attribute: Interprets
 - Range: {Observable_entity| Lab_procedure| Evaluation_procedure}
- Example: Renal insufficiency(finding) => Interprets => Measurement of renal function (procedure)



Has interpretation

- Specifies the testing result or conclusion that defines the 'Evaluation finding'
- Rule:
 - Domain: Clinical finding
 - Attribute: Has interpretation
 - Range: Findings values (qualifier)|Test result per observable definition
- Example: Renal insufficiency(finding) => Has interpretation => Impaired (qualifier)



Renal insufficiency 169 cases

Active ontology x Entities x Individuals by class x DL Query x

Class hierarchy: Chronic kidney disease due to type 2 diabetes mellitus (disorder)

DL query:

Asserted

Query (class expression)

```
'Clinical finding (finding)'  
and 'Role group (attribute)' some ('Interprets (attribute)' some 'Measurement of renal function (procedure)')  
and 'Role group (attribute)' some ('Has interpretation (attribute)' some 'Impaired (qualifier value)')
```

Execute Add to ontology

Query results

Subclasses (168 of 169)

- Acute drug-induced renal failure (disorder)
- Acute kidney failure stage 1 (disorder)
- Acute kidney failure stage 2 (disorder)
- Acute kidney failure stage 3 (disorder)
- Acute kidney injury due to circulatory failure (disorder)
- Acute kidney injury due to hypovolemia (disorder)
- Acute kidney injury due to sepsis (disorder)
- Acute milk alkali syndrome (disorder)
- Acute nontraumatic kidney injury (disorder)
- Acute postoperative renal failure (disorder)
- Acute renal failure caused by angiotensin-converting-enzyme inhibitor (disorder)
- Acute renal failure caused by contrast agent (disorder)
- Acute renal failure due to acute cortical necrosis (disorder)
- Acute renal failure due to crush syndrome (disorder)
- Acute renal failure due to ischemia (disorder)
- Acute renal failure due to obstruction (disorder)
- Acute renal failure due to procedure (disorder)
- Acute renal failure due to tubular necrosis (disorder)
- Acute renal failure following molar AND/OR ectopic pregnancy (disorder)

Query for

- Direct superclasses
- Superclasses
- Equivalent classes
- Direct subclasses
- Subclasses
- Instances

Result filters

Name contains

Display owl:Thing
(in superclass results)

Display owl:Nothing
(in subclass results)

Recurrent umbilical hernia (disorder)
Recurrent vesicular dermatitis caused by human herpes simplex virus (disorder)
Recurrent vulvitis (disorder)
Reducible umbilical hernia (disorder)
Reduction deformities of brain (disorder)
Reduction deformity of lower limb (disorder)
Reduction deformity of upper limb (disorder)
Redundant prepuce (disorder)
Reflux nephropathy of left kidney due to vesicoureteral reflux (disorder)
Reflux nephropathy of right kidney due to vesicoureteral reflux (disorder)
Reflux of urine (disorder)
Refractory acute lymphoid leukemia (disorder)
Refractory anemia with ringed sideroblasts associated with marked thrombocytosis (disorder)
Refractory neutropenia (disorder)
Regional congenital anomaly (disorder)
Reinfection tuberculosis (disorder)
Reiter's disease (disorder)
Relapse pulmonary tuberculosis (disorder)
Relapsing fever (disorder)
Relapsing pancreatitis (disorder)
Relapsing viral hepatitis (disorder)
Renal agenesis (disorder)
Renal anasarca (disorder)
Renal artery occlusion (disorder)
Renal artery stenosis (disorder)
Renal artery stenosis of transplanted kidney (disorder)
Renal artery stenosis of unknown cause (disorder)
Renal candidiasis (disorder)
Renal cell carcinoma (disorder)
Renal coccidiosis (disorder)
Renal dysplasia (disorder)
Renal dysplasia due to fetal exposure to angiotensin converting enzyme inhibitor (disorder)
Renal hypersensitivity caused by drug (disorder)
Renal impairment (disorder)
Acute renal impairment (disorder)
Cardiorenal syndrome (disorder)



Allergy to Diabetic Medication

Active ontology x Entities x Individuals by class x DL Query x

Class hierarchy: Allergy to acetohexamide (finding)

Inferred

DL query:

Query (class expression)

```
'Propensity to adverse reaction (finding)'  
and ('Role group (attribute)' some ('Causative agent (attribute)' some 'Sulfonylurea (substance)')  
or  
(('Role group (attribute)' some ('Causative agent (attribute)' some 'Insulin (substance)')))
```

Execute Add to ontology

Query results

Subclasses (19 of 19)

- Allergy to acetohexamide (finding)
- Allergy to biphasic isophane insulin (finding)
- Allergy to chlorpropamide (finding)
- Allergy to glibenclamide (finding)
- Allergy to glibornuride (finding)
- Allergy to gliclazide (finding)
- Allergy to glipizide (finding)
- Allergy to gliquidone (finding)
- Allergy to glymidine (finding)
- Allergy to human insulin (finding)
- Allergy to insulin (finding)
- Allergy to isophane insulin (finding)
- Allergy to protamine zinc insulin (finding)
- Allergy to sulfonylurea (finding)
- Allergy to tolazamide (finding)
- Allergy to tolbutamide (finding)
- Allergy to torasemide (finding)
- Allergy to zinc insulin (finding)
- owl:Nothing

- Allergy to nevirapine (finding)
- Allergy to nikethamide (finding)
- Allergy to nonionic surfactant (finding)
- Allergy to opioid receptor antagonist (finding)
- Allergy to opium alkaloid (finding)
- Allergy to orciprenaline (finding)
- Allergy to organic phosphorus compound (finding)
- Allergy to orris root (finding)
- Allergy to oxatamide (finding)
- Allergy to paraffin (finding)
- Allergy to penicillin (finding)
- Allergy to perfluorochemical (finding)
- Allergy to phenindamine (finding)
- Allergy to pheniramine (finding)
- Allergy to phenol (finding)
- Allergy to phosphodiesterase inhibitor (finding)
- Allergy to phospholipid (finding)
- Allergy to plant fiber (finding)
- Allergy to podophyllotoxin (finding)
- Allergy to pollen (finding)
- Allergy to polyvinyl alcohol (finding)
- Allergy to promethazine (finding)
- Allergy to propamide (finding)
- Allergy to pyrethroid (finding)
- Allergy to pyrimethamine (finding)
- Allergy to radiopharmaceutical (finding)
- Allergy to risperidone (finding)
- Allergy to ritodrine (finding)
- Allergy to rubber (finding)
- Allergy to salicylate (finding)
- Allergy to salicylic acid (finding)
- Allergy to scorpion venom (finding)
- Allergy to serum (finding)
- Allergy to silicone (finding)
- Allergy to silver nitrate (finding)
- Allergy to sodium aurothiomalate (finding)
- Allergy to spider venom (finding)
- Allergy to sulfonamide (finding)
- Allergy to sulfonylurea (finding)
- Allergy to acetohexamide (finding)



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