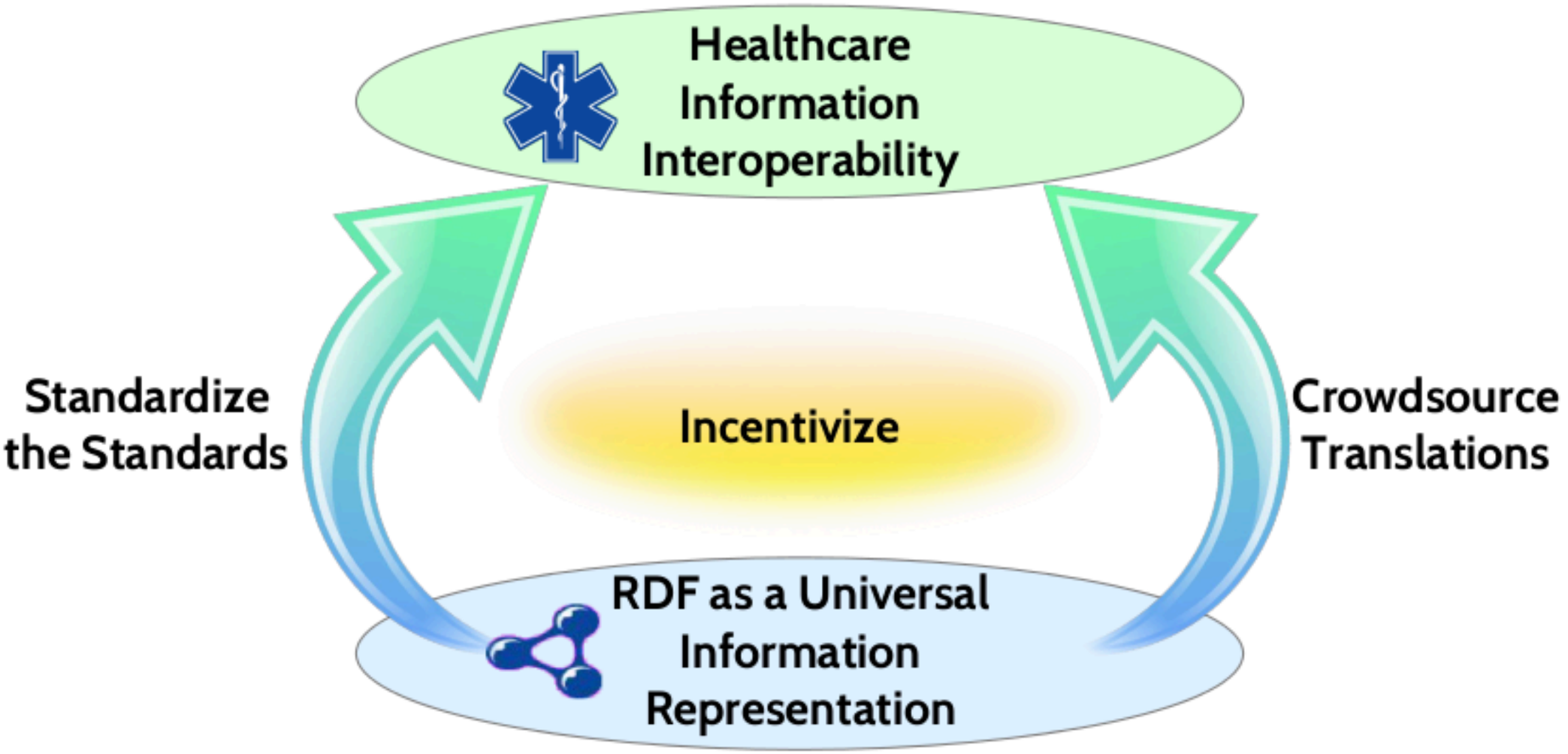
FHIR RDF as a Bridge to the Semantic Web in Healthcare

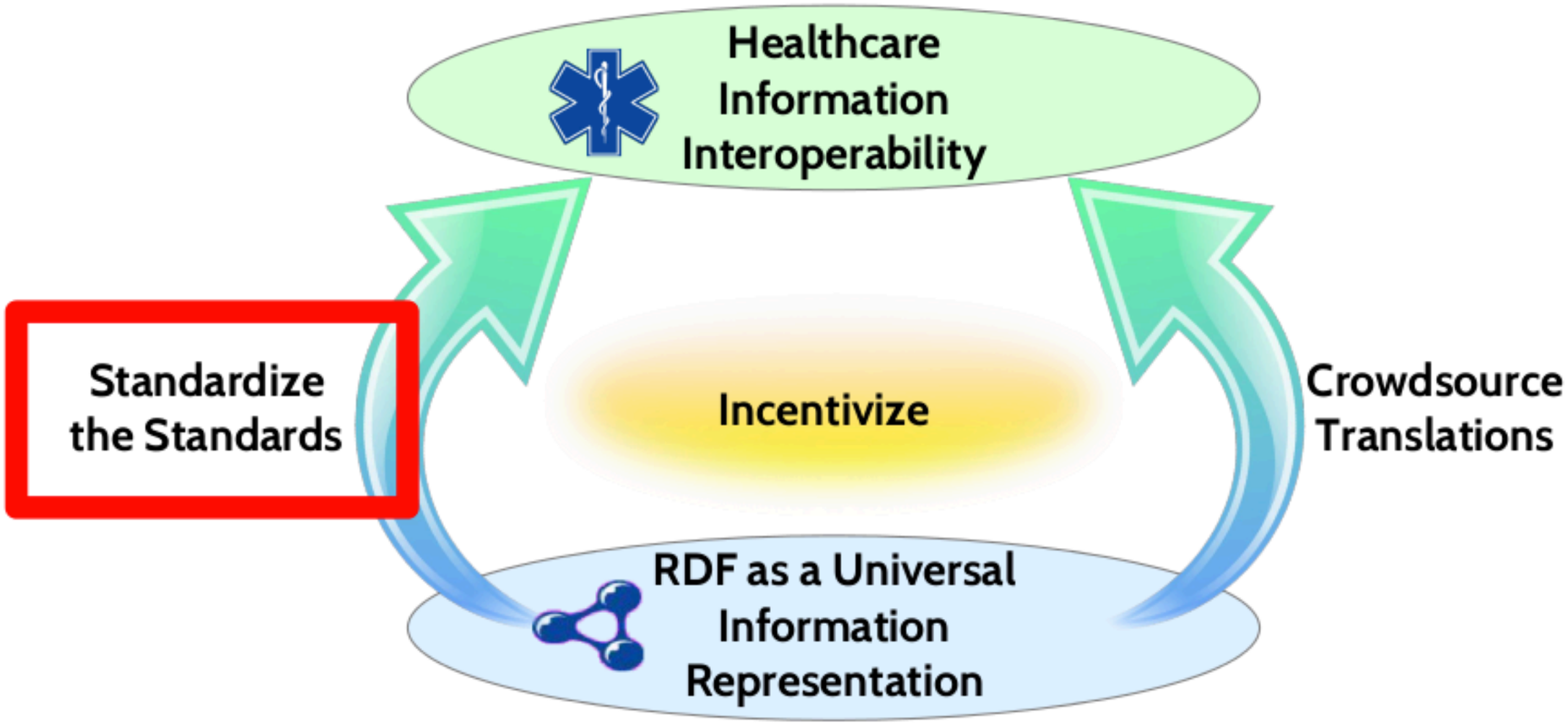
Harold Solbrig
Mayo Clinic

Interoperability Roadmap



http://YosemiteProject.org/

Interoperability Roadmap



http://YosemiteProject.org/

Outline

- FHIR and RDF
- Using FHIR RDF with a DL Reasoner
- Caveats, Issues, Next Steps

FHIR®©

Fast Healthcare Interoperability Resources

www.hl7.org/FHIR/

FHIR® FHIR Release 3 (STU)

Home | Getting Started | Documentation | Resources | Profiles | Extensions | Operations | Terminologies

Home

This is the Current officially released version of FHIR, which is Release 3 (STU) with 1 technical errata.
For a full list of available versions, see the Directory of published versions.

0 Welcome to FHIR®

First time here?
See the executive summary, the developer's introduction, clinical introduction, or architect's introduction, and then the FHIR overview / roadmap & Timelines. See also the open license (and don't miss the full Table of Contents or you can search this specification).

Technical Corrections:

- Apr-19 2017: Corrections to invariants & generated conformance resources, and add note about isSummary

Level 1 Basic framework on which the specification is built

Foundation	Base Documentation, XML, JSON, REST API + Search, Data Types, Extensions

Level 2 Supporting Implementation, and binding to external specifications

Implementer Support	Security & Privacy	Conformance	Terminology	Linked Data
Downloads, Common Use Cases, Testing	Security, Consent, Provenance, AuditEvent	StructureDefinition, CapabilityStatement, ImplementationGuide, Profiling	CodeSystem, ValueSet, ConceptMap, Terminology Svc	RDF

Level 3 Linking to real world concepts in the healthcare system

Administration	Patient, Practitioner, Device, Organization, Location, Healthcare Service

Level 4 Record-keeping and Data Exchange for the healthcare process

Clinical	Diagnostics	Medications	Workflow
Allergy, Problem, CarePlan, DetectedIssue	Observation, Report, Specimen	Order, Dispense, Administration	Task, Appointment, Schedule, Referral

FHIR Resource Definition

http://hl7.org/fhir/diagnosticreport.html

www.hl7.org/FHIR/diagnosticreport.html

Search

10.2.4 Resource Content

Structure | UML | XML | JSON | Turtle | R2 Diff | All

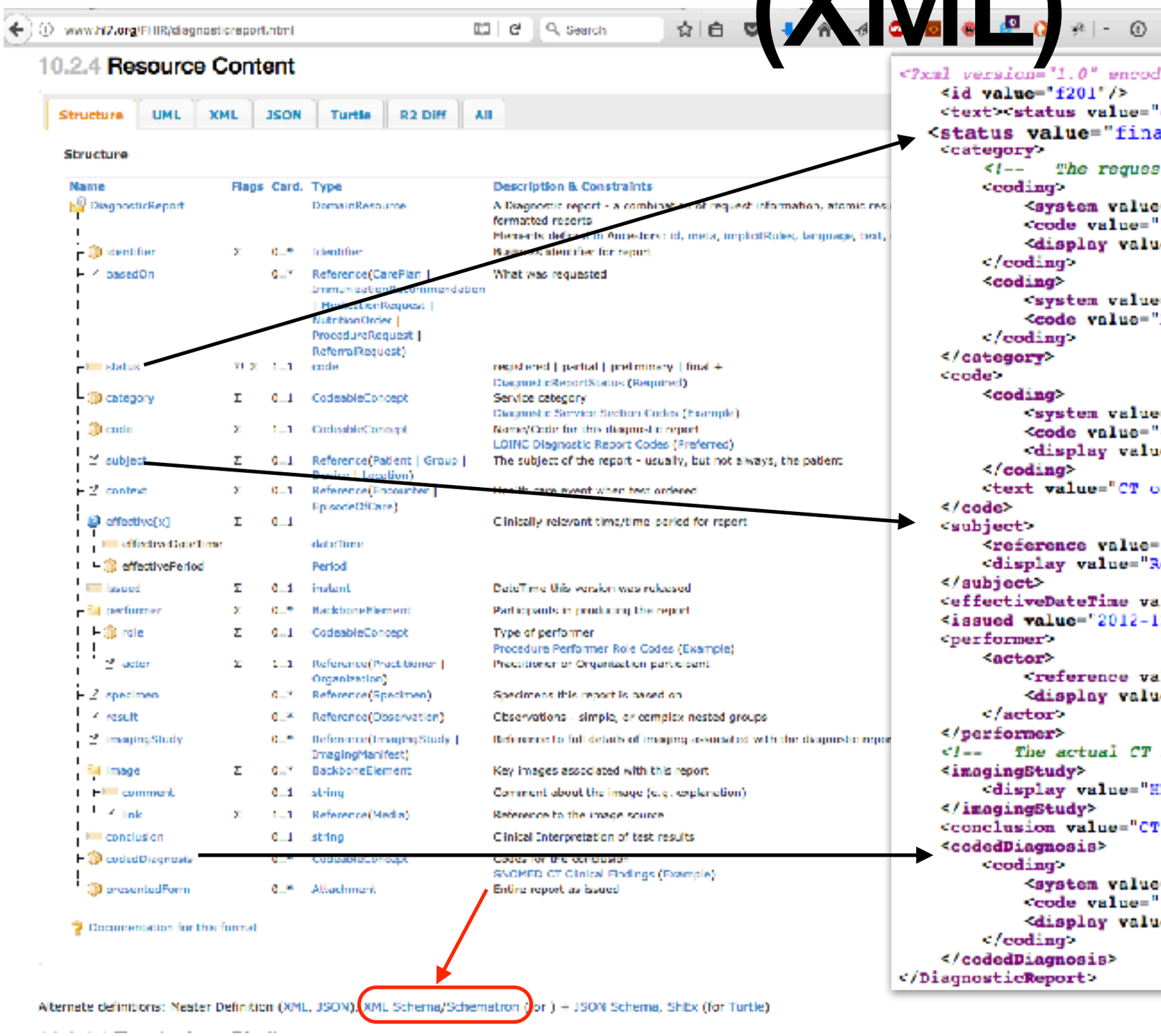
Structure

Name	Flags	Card.	Type	Description & Constraints
DiagnosticReport			DomainResource	A Diagnostic report - a combination of request information, atomic results, images, interpretation, as well as formatted reports Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	Business identifier for report
basedOn		0..*	Reference(CarePlan | ImmunizationRecommendation | MedicationRequest | NutritionOrder | ProcedureRequest | ReferralRequest)	What was requested
status	?!Σ	1..1	code	registered | partial | preliminary | final +
category	Σ	0..1	CodeableConcept	Service category Diagnostic Service Section Codes (Example)
code	Σ	1..1	CodeableConcept	Name/Code for this diagnostic report LOINC Diagnostic Report Codes (Preferred)
subject	Σ	0..1	Reference(Patient | Group | Device | Location)	The subject of the report - usually, but not always, the patient
context	Σ	0..1	Reference(Encounter | EpisodeOfCare)	Health care event when test ordered
effective[x]	Σ	0..1		Clinically relevant time/time-period for report
effectiveDateTime			dateTime	
effectivePeriod			Period	
issued	Σ	0..1	instant	DateTime this version was released
performer	Σ	0..*	BackboneElement	Participants in producing the report
role	Σ	0..1	CodeableConcept	Type of performer Procedure Performer Role Codes (Example)
actor	Σ	1..1	Reference(Practitioner | Organization)	Practitioner or Organization participant
specimen		0..*	Reference(Specimen)	Specimens this report is based on
result		0..*	Reference(Observation)	Observations - simple, or complex nested groups
imagingStudy		0..*	Reference(ImagingStudy | ImagingManifest)	Reference to full details of imaging associated with the diagnostic report
image	Σ	0..*	BackboneElement	Key images associated with this report
comment		0..1	string	Comment about the image (e.g. explanation)
link	Σ	1..1	Reference(Media)	Reference to the image source
conclusion		0..1	string	Clinical Interpretation of test results
codedDiagnosis		0..*	CodeableConcept	Codes for the conclusion SNOMED CT Clinical Findings (Example)
presentedForm		0..*	Attachment	Entire report as issued

Documentation for this format

Alternate definitions: Nester Definition (XML, JSON), XML Schema/Schematron (for) + JSON Schema, ShEx (for Turtle)

FHIR Resource Instance (XML)




```
<?xml version="1.0" encoding="UTF-8"?><DiagnosticReport xmlns="http://hl7.org/fhir">
    <id value="f201"/>
    <text><status value="generated"/><div xmlns="http://www.w3.org/1999/xhtml"><p><b>Gen
  <status value="final"/>
    <category>
        <!--   The request was honored by the Department of Radiology   -->
        <coding>
            <system value="http://snomed.info/sct"/>
            <code value="394914008"/>
            <display value="Radiology"/>
        </coding>
        <coding>
            <system value="http://hl7.org/fhir/v2/0074"/>
            <code value="RAD"/>
        </coding>
    </category>
    <code>
        <coding>
            <system value="http://snomed.info/sct"/>
            <code value="429858000"/>
            <display value="Computed tomography (CT) of head and neck"/>
        </coding>
        <text value="CT of head-neck"/>
    </code>
    <subject>
        <reference value="Patient/f201"/>
        <display value="Roel"/>
    </subject>
    <effectiveDateTime value="2012-12-01T12:00:00+01:00"/>
    <issued value="2012-12-01T12:00:00+01:00"/>
    <performer>
        <actor>
            <reference value="Organization/f203"/>
            <display value="Blijdorp MC"/>
        </actor>
    </performer>
    <!--   The actual CT imagenot available -  following reference used to demonstrate t
    <imagingStudy>
        <display value="HEAD and NECK CT DICOM imaging study"/>
    </imagingStudy>
    <conclusion value="CT brains: large tumor sphenoid/clivus."/>
    <codedDiagnosis>
        <coding>
            <system value="http://snomed.info/sct"/>
            <code value="188340000"/>
            <display value="Malignant tumor of craniopharyngeal duct"/>
        </coding>
    </codedDiagnosis>
</DiagnosticReport>
```

http://www.hl7.org/fhir/diagnosticreport-example-f201-brainct.xml

FHIR Resource Instance (JSON)

www.hl7.org/FHIR/diagnosticreport.html

10.2.4 Resource Content

Structure | UML | XML | JSON | Turtle | R2 Diff | All

Structure

Name	Flags	Card.	Type	Description & Constraints
DiagnosticReport			DomainResource	A Diagnostic report - a combination of request information, atomic results, images, interpreted report
identifier	Σ	0..*	Identifier	Business identifier for report
basedOn		0..*	Reference(CarePlan | ImmunizationRecommendation | MedicationRequest | NutritionOrder | ProcedureRequest | ReferralRequest)	What was requested
status	?! Σ	1..1	code	registered | partial | preliminary | final +
category	Σ	0..1	CodeableConcept	Service category
code	Σ	1..1	CodeableConcept	Name/Code for this diagnostic report
subject	Σ	0..1	Reference(Patient | Group | Device | Location)	The subject of the report - usually, but not always, the patient
context	Σ	0..1	Reference(Encounter | EpisodeOfCare)	Health care event when test ordered
effective[x]	Σ	0..1		Clinically relevant time/time-period for report
effectiveDateTime			dateTime	
effectivePeriod			Period	
issued	Σ	0..1	instant	DateTime this version was released
performer	Σ	0..*	BackboneElement	Participants in producing the report
role	Σ	0..1	CodeableConcept	Type of performer
actor	Σ	1..1	Reference(Practitioner | Organization)	Practitioner or Organization participant
specimen		0..*	Reference(Specimen)	Specimens this report is based on
result		0..*	Reference(Observation)	Observations - simple, or complex nested groups
imagingStudy		0..*	Reference(ImagingStudy | ImagingManifest)	Reference to full details of imaging associated with the diagnostic report
image	Σ	0..*	BackboneElement	Key images associated with this report
comment		0..1	string	Comment about the image (e.g. explanation)
link	Σ	1..1	Reference(Media)	Reference to the image source
conclusion		0..1	string	Clinical Interpretation of test results
codedDiagnosis		0..*	CodeableConcept	Codes for the conclusion
presentedForm		0..*	Attachment	Entire report as issued

Documentation for this format

Alternate definitions: Native Definition (XML, JSON), XML Schema/Schematron (for), JSON Schema, ShEx (for Turtle)


```
"resourceType": "DiagnosticReport",
"id": "f201",
"text": {
    "status": "generated",
    "div": "<div xmlns=\"http://www.w3.org/1999/xhtml\"><p><b>Generat
    <p><b>status</b>: final</p><p><b>category</b>: Radiology <span>
    (given as 'Radiology'); (http://hl7.org/fhir/v2/0074 code 'RAD'
    Details : {SNOMED CT code '429858000' = 'Computed tomography (
    and neck'})</span></p><p><b>subject</b>: <a>Roel</a></p><p><b>e
    2:00:00 PM</p><h3>Performers</h3><table><tr><td>-</td><td><b>M
    </table><p><b>imagingStudy</b>: HEAD and NECK CT DICOM imaging
    sphenoid/clivus.</p><p><b>codedDiagnosis</b>: Malignant tumor o
    = 'Malignant tumor of craniopharyngeal duct', given as 'Maligna
},
"status": "final",
"category": {
    "coding": [
        {
            "system": "http://snomed.info/sct",
            "code": "394914008",
            "display": "Radiology"
        },
        {
            "system": "http://hl7.org/fhir/v2/0074",
            "code": "RAD"
        }
    ]
},
"code": {
    "coding": [
        {
            "system": "http://snomed.info/sct",
            "code": "429858000",
            "display": "Computed tomography (CT) of head and neck"
        }
    ],
    "text": "CT of head-neck"
},
"subject": {
    "reference": "Patient/f201",
    "display": "Roel"
},
"effectiveDateTime": "2012-12-01T12:00:00+01:00",
"issued": "2012-12-01T12:00:00+01:00",
"performer": [
    {
        "actor": {
            "reference": "Organization/f203",
            "display": "Blijdorp MC"
        }
    }
],
"imagingStudy": [
    {
        "display": "HEAD and NECK CT DICOM imaging study"
    }
],
"conclusion": "CT brains: large tumor sphenoid/clivus.",
"codedDiagnosis": [
    {
        "coding": [
            {
                "system": "http://snomed.info/sct",
                "code": "188340000",
                "display": "Malignant tumor of craniopharyngeal duct"
            }
        ]
    }
]
}
```


http://www.hl7.org/fhir/diagnosticreport-example-f201-brainct.json

FHIR Resource Instance (RDF)

www.hl7.org/FHIR/diagnosticreport.html

10.2.4 Resource Content

Structure | UML | XML | JSON | Turtle | R2 Diff | All

Structure

Name	Flags	Card.	Type	Description & Constraints
DiagnosticReport			DomainResource	A Diagnostic report - a combination of request information, atomic results, images, interp… formatted reports Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extensi…
identifier	?!	0..*	Identifier	Business identifier for report
basedOn		0..*	Reference(CarePlan | ImmunizationRecommendation | MedicationRequest | NutritionOrder | ProcedureRequest | ReferralRequest)	What was requested
status	?! Σ	1..1	code	registered | partial | preliminary | final + … DiagnosticReportStatus (Required)
category	Σ	0..1	CodeableConcept	Service category Diagnostic Service Section Codes (Example)
code	?!	1..1	CodeableConcept	Name/Code for this diagnostic report LOINC Diagnostic Report Codes (Preferred)
subject	Σ	0..1	Reference(Patient | Group | Device | Location)	The subject of the report - usually, but not always, the patient
context	?!	0..1	Reference(Encounter | EpisodeOfCare)	Health care event when test ordered
effective[x]	Σ	0..1		Clinically relevant time/time-period for report
effectiveDateTime			dateTime	
effectivePeriod			Period	
issued	Σ	0..1	instant	DateTime this version was released
performer	?!	0..*	BackboneElement	Participants in producing the report
role	Σ	0..1	CodeableConcept	Type of performer Procedure Performer Role Codes (Example)
actor	Σ	1..1	Reference(Practitioner | Organization)	Practitioner or Organization participant
specimen		0..*	Reference(Specimen)	Specimens this report is based on
result		0..*	Reference(Observation)	Observations - simple, or complex nested groups
imagingStudy		0..*	Reference(ImagingStudy | ImagingManifest)	Reference to full details of imaging associated with the diagnostic report
image	Σ	0..*	BackboneElement	Key images associated with this report
comment		0..1	string	Comment about the image (e.g. explanation)
link	?!	1..1	Reference(Media)	Reference to the image source
conclusion		0..1	string	Clinical Interpretation of test results
codedDiagnosis		0..*	CodeableConcept	Codes for the conclusion SNOMED CT Clinical Findings (Example)
presentedForm		0..*	Attachment	Entire report as issued

Documentation for this format

Alternate definitions: Master Definition (XML, JSON), XML Schema/Schematron (for …) – JSON Schema, ShEx (for Turtle)

```
@prefix fhir: <http://hl7.org/fhir/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix sct: <http://snomed.info/id/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

# - resource -------------------------------------------------------------------

<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f201"];
  fhir:DomainResource.text [
     fhir:Narrative.status [ fhir:value 'generated' ];
     fhir:Narrative.div "<div xmlns=\"http://www.w3.org/1999/xhtml\"><p><b>Generated Narrative with
<p><b>Status</b>: final</p><p><b>Category</b>: Radiology <span>(Details : {SNOMED CT code '394914008'
'Radiology'}; {http://hl7.org/fhir/v2/0074 code 'RAD' = 'Radiology'}</span></p><p><b>code</b>: CT of
'429858000' = 'Computed tomography (CT) of head and neck', given as 'Computed tomography (CT) of he
<a>Basel</a></p><p><b>effective</b>: 01/12/2012 12:00:00 PM</p><p><b>issued</b>: 01/12/2012 12:00:01
<b>Actor</b></td></tr><tr><td>*</td><td><a>Dijkzorg MC</a></td></tr></table><p><b>imagingStudy</b>:
<p><b>conclusion</b>: CT brains: large tumor sphenoid/clivus.</p><p><b>codedDiagnosis</b>: Malignan
{SNOMED CT code '188340000' = 'Malignant tumor of craniopharyngeal duct', given as  Malignant tumor
  ];
  fhir:DiagnosticReport.status [ fhir:value "final"];
  fhir:DiagnosticReport.category [
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:394914008;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "394914008" ];
       fhir:Coding.display [ fhir:value "Radiology" ]
     ], [
       fhir:index 1;
       fhir:Coding.system [ fhir:value "http://hl7.org/fhir/v2/0074" ];
       fhir:Coding.code [ fhir:value "RAD" ]
     ]
  ];
  fhir:DiagnosticReport.code [
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:429858000;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "429858000" ];
       fhir:Coding.display [ fhir:value "Computed tomography (CT) of head and neck" ]
     ];
     fhir:CodeableConcept.text [ fhir:value "CT of head-neck" ]
  ];
  fhir:DiagnosticReport.subject [
     fhir:link <http://hl7.org/fhir/Patient/f201>;
     fhir:Reference.reference [ fhir:value "Patient/f201" ];
     fhir:Reference.display [ fhir:value "Roel" ]
  ];
  fhir:DiagnosticReport.effectiveDateTime [ fhir:value "2012-12-01T12:00:00+01:00"^^xsd:dateTime];
  fhir:DiagnosticReport.issued [ fhir:value "2012-12-01T12:00:00+01:00"^^xsd:dateTime];
  fhir:DiagnosticReport.performer [
     fhir:index 0;
     fhir:DiagnosticReport.performer.actor [
       fhir:link <http://hl7.org/fhir/Organization/f203>;
       fhir:Reference.reference [ fhir:value "Organization/f203" ];
       fhir:Reference.display [ fhir:value "Dijkzorg MC" ]
     ]
  ];
  fhir:DiagnosticReport.imagingStudy [
     fhir:index 0;
     fhir:Reference.display [ fhir:value "HEAD and NECK CT DICOM imaging study" ]
  ];
  fhir:DiagnosticReport.conclusion [ fhir:value "CT brains: large tumor sphenoid/clivus."];
  fhir:DiagnosticReport.codedDiagnosis [
     fhir:index 0;
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:188340000;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "188340000" ];
       fhir:Coding.display [ fhir:value "Malignant tumor of craniopharyngeal duct" ]
     ]
  ] .
```

http://www.hl7.org/fhir/diagnosticreport-example-f201-brainct.ttl

RDF Turtle Syntax

```
@prefix fhir: <http://hl7.org/fhir/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix sct: <http://snomed.info/id/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

# - resource -------------------------------------------------------- ----------

<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f201" ];
  fhir:DomainResource.text [
     fhir:Narrative.status [ fhir:value "generated" ];
  fhir:DiagnosticReport.status [ fhir:value "final"];
  fhir:DiagnosticReport.category [
    fhir:CodeableConcept.coding [
      fhir:index 0;
      a sct:394914008;
      fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
      fhir:Coding.code [ fhir:value "394914008" ];
      fhir:Coding.display [ fhir:value "Radiology" ]
    ], [
      fhir:index 1;
      fhir:Coding.system [ fhir:value "http://hl7.org/fhir/v2/0074" ];
      fhir:Coding.code [ fhir:value "RAD" ]
    ]
];
fhir:DiagnosticReport.code [
    fhir:CodeableConcept.coding [
      fhir:index 0;
      a sct:429858000;
      fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
      fhir:Coding.code [ fhir:value "429858000" ];
      fhir:Coding.display [ fhir:value "Computed tomography (CT) of head and neck" ]
    ];
    fhir:CodeableConcept.text [ fhir:value "CT of head-neck" ]
];
```

Prefixes

‘a’ == rdf:type

subject predicate object ;
predicate object ;

‘[…]’ == Blank Node

subject predicate object ,
object ,

Syntax “maturity”

2.6.1 XML Representation of Resources

Implementable Technology Specifications Work Group	Maturity Level: 5	Ballot Status: Trial Use

http://www.hl7.org/fhir/xml.html

Implementable Technology Specifications Work Group	Maturity Level: 5	Ballot Status: Trial Use

http://www.hl7.org/fhir/json.html

FHIR Infrastructure Work Group	Maturity Level: 2	Ballot Status: Trial Use

http://www.hl7.org/fhir/rdf.html

0. the resource or profile (artifact) has been published on the current build. This level is synonymous with *Draft*.
1. PLUS the artifact produces no warnings during the build process and the responsible WG has indicated that they consider the artifact substantially complete and ready for implementation
2. PLUS the artifact has been tested and successfully exchanged between at least three independently developed systems leveraging at least 80% of the core data elements using semi-realistic data and scenarios based on at least one of the declared scopes of the resource (e.g. at a connectathon). These interoperability results must have been reported to and accepted by the FMG
3. PLUS the artifact has been verified by the work group as meeting the *Trial Use* Quality Guidelines and has been subject to a round of formal balloting; has at least 10 implementer comments recorded in the tracker drawn from at least 3 organizations resulting in at least one substantive change
4. PLUS the artifact has been tested across its scope (see below), published in a formal publication (e.g. a FHIR Release), and implemented in multiple prototype projects. As well, the responsible work group agrees the resource is sufficiently stable to require implementer consultation for subsequent non-backward compatible changes.
5. PLUS the artifact has been published in two formal publication release cycles at FMM1+ (i.e. *Trial Use* level) and has been implemented in at least 5 independent production systems in more than one country
6. "*Normative*": the artifact is now considered stable

FHIR RDF Rendering

Requirement: RDF Rendering must be fully “round-trippable”:

Which is why:

```
fhir:Person.active [ fhir:value "true"^^xsd:boolean].
```

instead of:

```
fhir:Person.active "true"^^xsd:boolean.
```

FHIR RDF Rendering Preserving Extensions

Boolean, like all FHIR elements, is extensible. Processing for:

```
fhir:Person.active [ fhir:value "true"^^xsd:boolean].
```

and:

```
fhir:Person.active [
   fhir:Element.extension [
      fhir:index 0;
      fhir:Extension.url [ fhir:value "http://example.org/fhir/boolean/Certainty" ];
      fhir:Extension.valueDecimal [ fhir:value "0.75"^^xsd:decimal ]
    ];
    fhir:value "true"^^xsd:boolean] .
```

should be the same.

“Round Tripability”

```
{
  "resourceType": "DiagnosticReport",
  "id": "f201",
  "text": {
    "status": "generated"
```

```
"category": {
  "coding": [
    {
      "system": "http://snomed.info/sct",
      "code": "394914008",
      "display": "Radiology"
    },
    {
      "system": "http://hl7.org/fhir/v2/0074",
      "code": "RAD"
    }
  ]
},
```

JSON

```
<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f201"];
  fhir:DomainResource.text [
     fhir:Narrative.status [ fhir:value "generated" ];
     fhir:Narrative.div "<div xmlns=\"http://www.w3.org/1999/xhtml\">(deleted)</div>"
  ];
  fhir:DiagnosticReport.status [ fhir:value "final"];
  fhir:DiagnosticReport.category [
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:394914008;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "394914008" ];
       fhir:Coding.display [ fhir:value "Radiology" ]
     ], [
       fhir:index 1;
       fhir:Coding.system [ fhir:value "http://hl7.org/fhir/v2/0074" ];
       fhir:Coding.code [ fhir:value "RAD" ]
     ]
  ];
  fhir:DiagnosticReport.code [
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:429858000;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "429858000" ];
       fhir:Coding.display [ fhir:value "Computed tomography (CT) of head and neck" ]
     ];
     fhir:CodeableConcept.text [ fhir:value "CT of head-neck" ]
  ];
  fhir:DiagnosticReport.subject [
     fhir:link <http://hl7.org/fhir/Patient/f201>;
     fhir:Reference.reference [ fhir:value "Patient/f201" ];
     fhir:Reference.display [ fhir:value "Roel" ]
  ];
  fhir:DiagnosticReport.effectiveDateTime [ fhir:value "2012-12-01T12:00:00+01:00"^^xsd
```

RDF

Identify root documents

Preserve order in lists

RDF Rendering Extensions

```
"category": {
  "coding": [
    {
      "system": "http://snomed.info/sct",
      "code": "394914008",
      "display": "Radiology"
    },
    {
      "system": "http://hl7.org/fhir/v2/0074",
      "code": "RAD"
    }
  ]
},
```

JSON

```
"subject": {
  "reference": "Patient/f201",
  "display": "Roel"
},
```

JSON

```
fhir:DiagnosticReport.category [
   fhir:CodeableConcept.coding [
     fhir:index 0;
     a sct:394914008;
     fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
     fhir:Coding.code [ fhir:value "394914008" ];
     fhir:Coding.display [ fhir:value "Radiology" ]
   ], [
     fhir:index 1;
     fhir:Coding.system [ fhir:value "http://hl7.org/fhir/v2/0074" ];
     fhir:Coding.code [ fhir:value "RAD" ]
   ]
];
```

Concept URI

Reference URI

```
fhir:DiagnosticReport.subject [
   fhir:link <http://hl7.org/fhir/Patient/f201>;
   fhir:Reference.reference [ fhir:value "Patient/f201" ];
   fhir:Reference.display [ fhir:value "Roel" ]
];
```

Reference Type

```
<http://hl7.org/fhir/Patient/f201> a fhir:Patient .
```

Ontology and *import* declaration

```
# - ontology header ------------------------------------------------

<http://hl7.org/fhir/DiagnosticReport/f201.ttl> a owl:Ontology;
  owl:imports fhir:fhir.ttl;
  owl:versionIRI <http://build.fhir.org/DiagnosticReport/f201.ttl> .
```

<http://snomed.info/id/394914008>

RDF

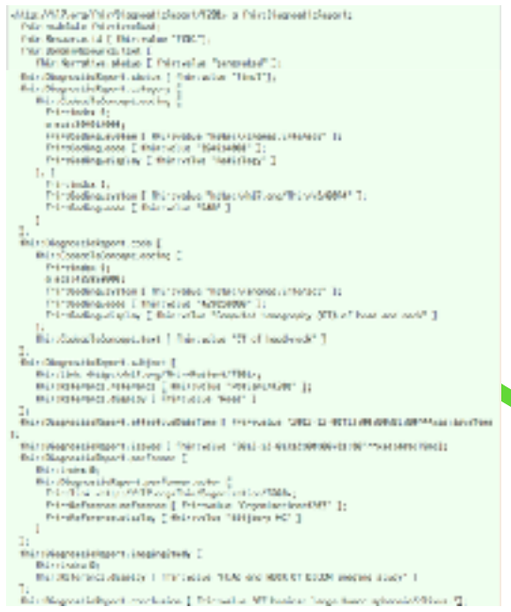
Concept URI’s

For this (or any linked data to work) both the data and the ontology have to use the same URI’s

Progress is being made:

- SNOMED International has a standard:
    - http://snomed.info/id/(concept code)
    - Spec: https://confluence.ihtsdotools.org/display/DOCURI/URI+Standard
- WHO has a standard
    - http://id.who.int/icd/release/10/(code)
    - Spec: https://icdaccessmanagement.who.int/docs/APIdoc-md.html

Using FHIR RDF With a DL Reasoner



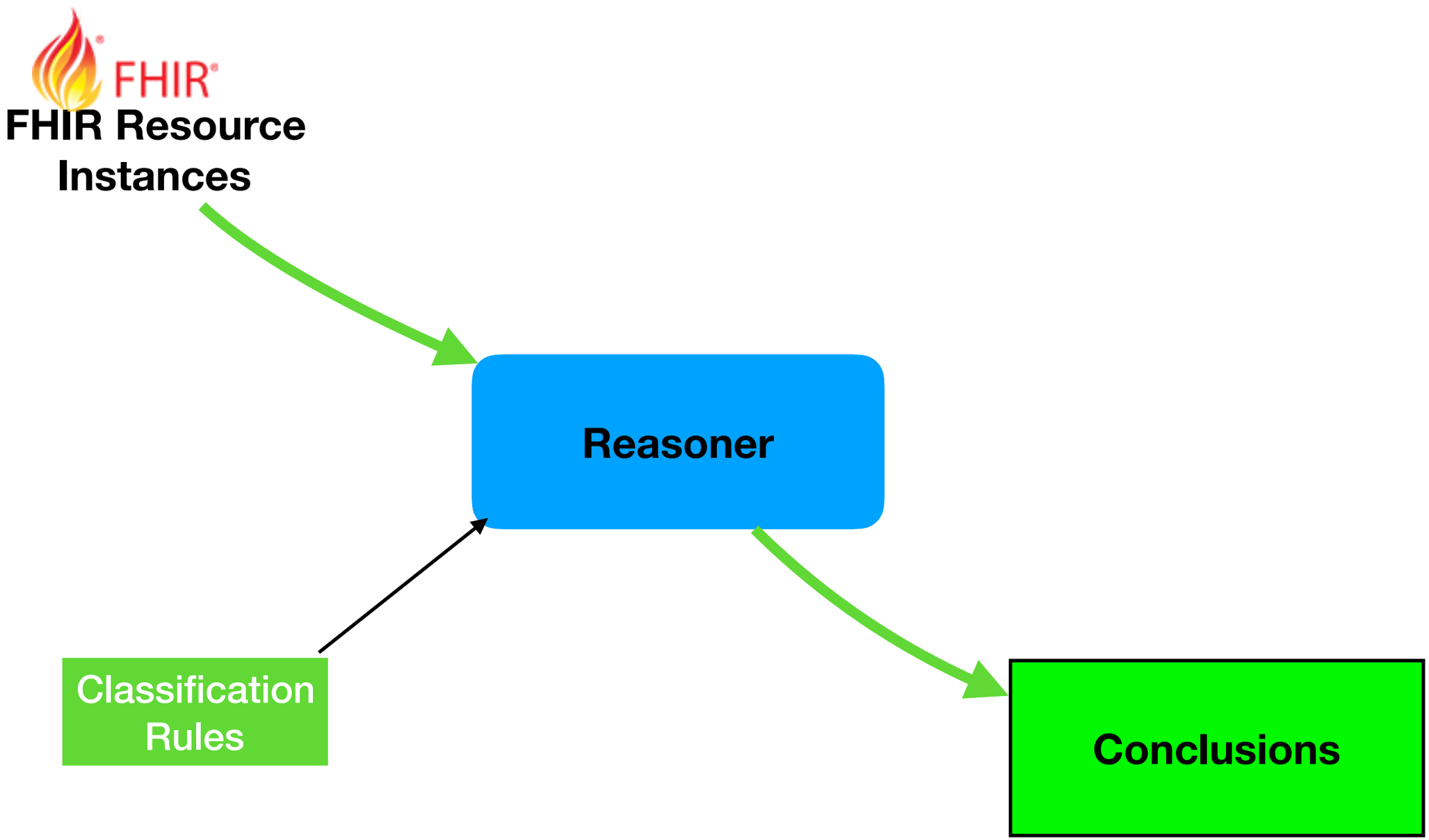
FHIR DiagnosticReport Instance

Reasoner

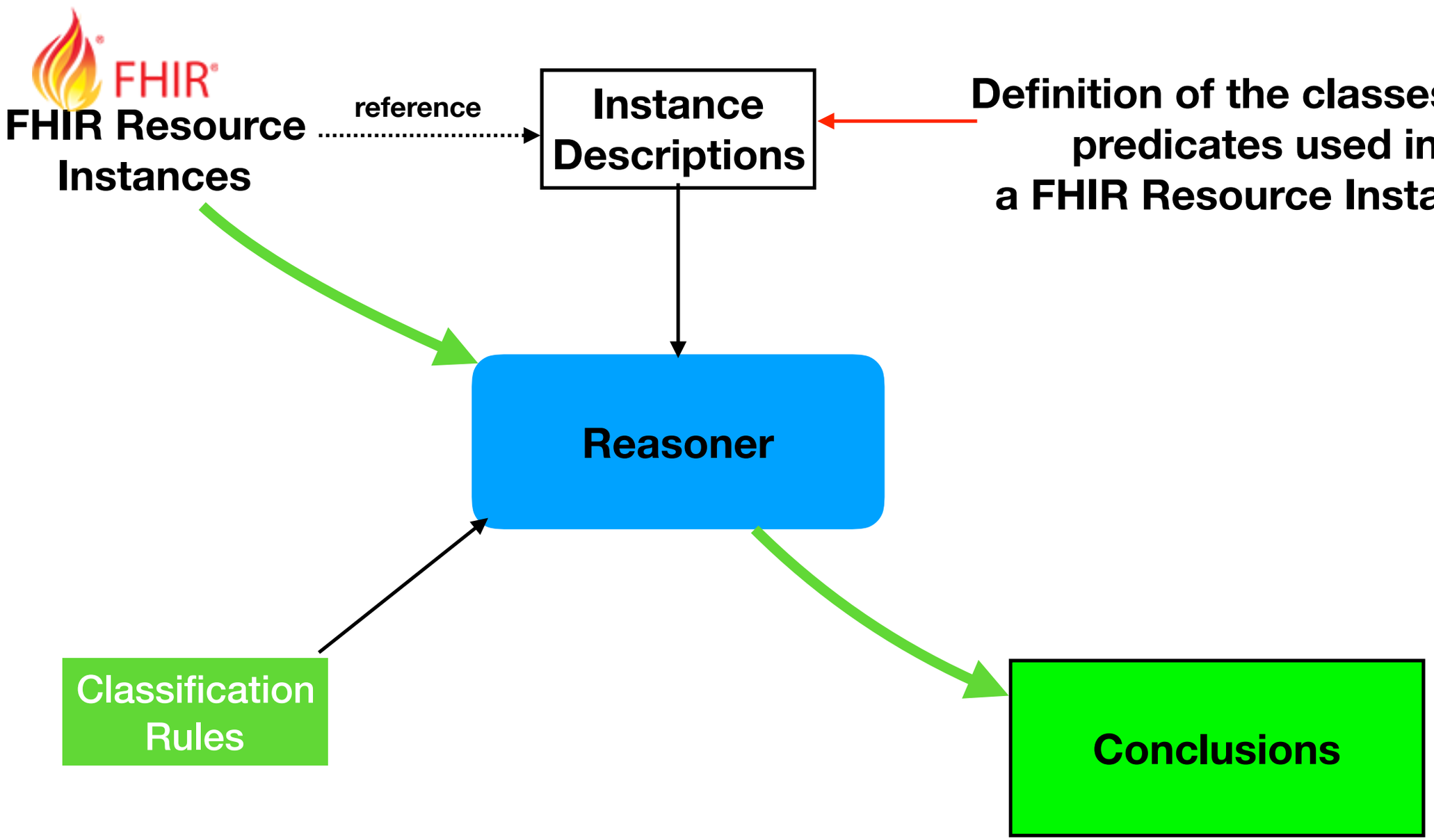
Class `CancerDiagnosis` == any DiagnosticReport w/ a dx of a type of malignant neoplasm

Instance is (or is not) an instance of Class `CancerDiagnosis`

Using FHIR RDF With a DL Reasoner



Using FHIR RDF With a DL Reasoner



Instance Descriptions
The FHIR Metadata Vocabulary

Example FHIR resource (data record)

```
<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
   fhir:DiagnosticReport.subject [
      fhir:link <http://hl7.org/fhir/Patient/f201>;
      fhir:Reference.reference [ fhir:value "Patient/f201" ];
      fhir:Reference.display [ fhir:value "Roel" ]
   ];
  fhir:DiagnosticReport.code [
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:429858000;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "429858000" ];
       fhir:Coding.display [ fhir:value "Computed tomography (CT) of head and neck" ]
     ];
     fhir:CodeableConcept.text [ fhir:value "CT of head-neck" ]
  ];
 fhir:DiagnosticReport.codedDiagnosis [
     fhir:index 0;
     fhir:CodeableConcept.coding [
       fhir:index 0;
       a sct:188340000;
       fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
       fhir:Coding.code [ fhir:value "188340000" ];
       fhir:Coding.display [ fhir:value "Malignant tumor of craniopharyngeal duct" ]
     ]
```

Instance Descriptions
The FHIR Metadata Vocabulary

```
<http://hl7.org/fhir/DiagnosticReport/f201> a
   fhir:DiagnosticReport.subject [
      fhir:link <http://hl7.org/fhir/Patient/f
      fhir:Reference.reference [ fhir:value "P
      fhir:Reference.display [ fhir:value "Roe
   ];
   fhir:DiagnosticReport.code [
      fhir:CodeableConcept.coding [
        fhir:index 0;
        a sct:429858000;
        fhir:Coding.system [ fhir:value "http:/
        fhir:Coding.code [ fhir:value "4298580
        fhir:Coding.display [ fhir:value "Compu
      ];
      fhir:CodeableConcept.text [ fhir:value "C
   ];
   fhir:DiagnosticReport.codedDiagnosis [
      fhir:index 0;
      fhir:CodeableConcept.coding [
        fhir:index 0;
        a sct:188340000;
        fhir:Coding.system [ fhir:value "http://snomed.info/sct"
        fhir:Coding.code [ fhir:value "188340000" ];
        fhir:Coding.display [ fhir:value "Malignant tumor of cran
      ]
```

```
fhir:DiagnosticReport
        a                owl:Class ;
        rdfs:comment     "The findings and interpretation of diagnostic  tests performed on patients, groups
of patients, devices, and locations, and/or specimens derived from these. The report includes clinical contex
t such as requesting and provider information, and some mix of atomic results, images, textual and coded inte
rpretations, and formatted representation of diagnostic reports." ;
        rdfs:label       "DiagnosticReport" ;
        rdfs:subClassOf  fhir:DomainResource , w5:clinical.diagnostics ;
```

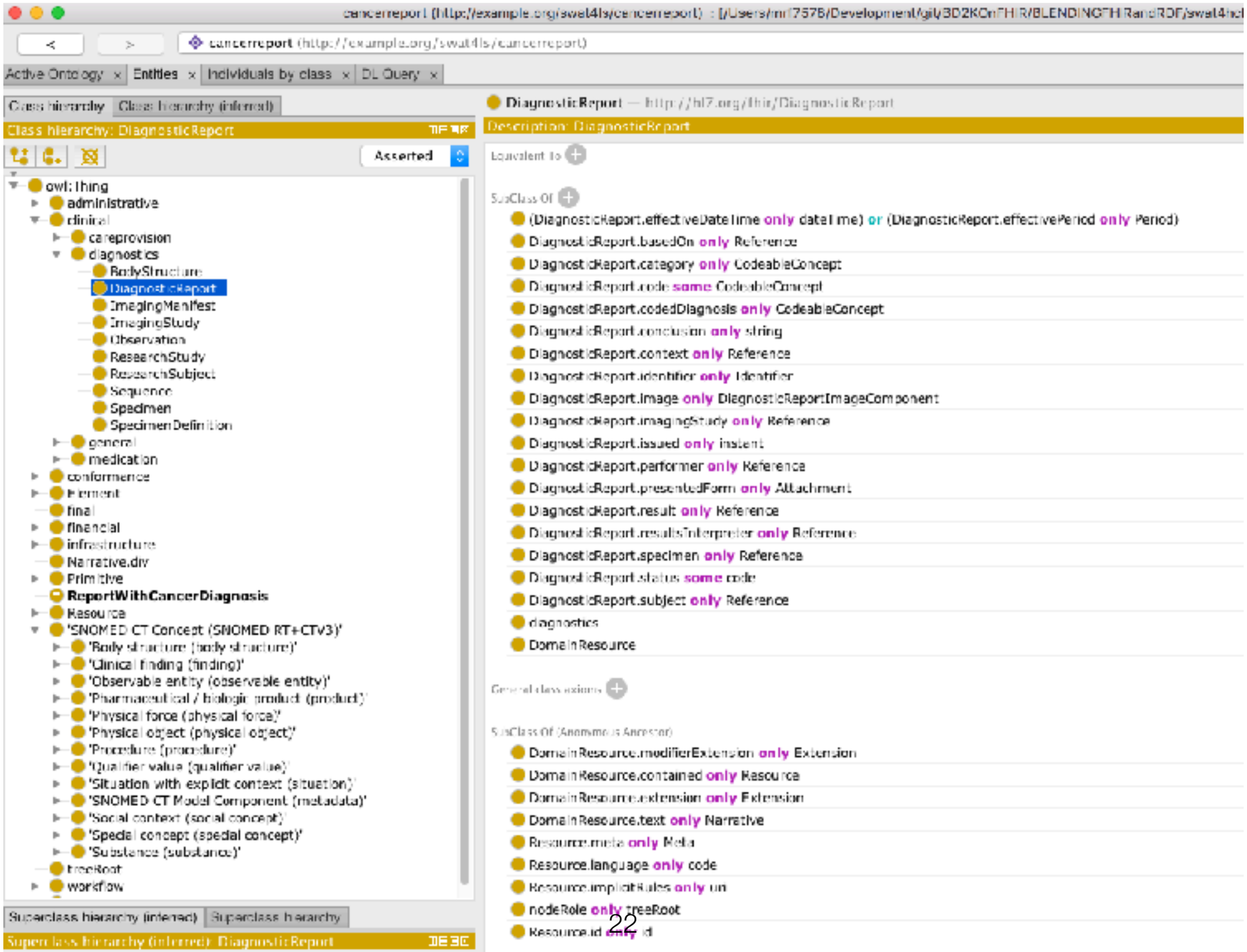
http://hl7.org/fhir/fhir.ttl

```
fhir:DiagnosticReport.code
        a                owl:ObjectProperty ;
        rdfs:comment     "A code or name that describes this diagnostic report." ;
        rdfs:domain      fhir:DiagnosticReport ;
        rdfs:label       "DiagnosticReport.code" ;
        rdfs:range       fhir:CodeableConcept ;
        rdfs:subPropertyOf  w5:what ;
        dc:title         "Name/Code for this diagnostic report" .
```

```
fhir:DiagnosticReport.codedDiagnosis
        a                owl:ObjectProperty ;
        rdfs:comment     "Codes for the conclusion." ;
        rdfs:domain      fhir:DiagnosticReport ;
        rdfs:label       "DiagnosticReport.codedDiagnosis" ;
        rdfs:range       fhir:CodeableConcept ;
        dc:title         "Codes for the conclusion" .
```

```
fhir:value  a        owl:DatatypeProperty ;
        rdfs:label   "fhir:value" ;
        dc:title     "Terminal data value" .
```

FMV Definition of DiagnosticReport



The Ontology Header

```
# - resource -------------------------------------------------------------

<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f201"];
  fhir:DomainResource.text [
```

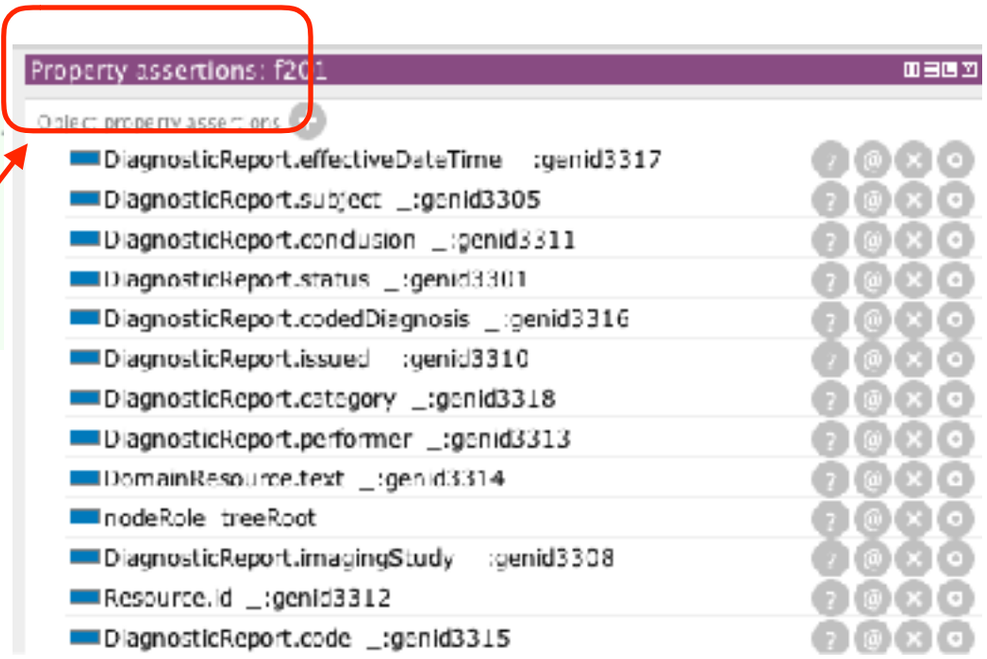
```
# - ontology header ------------------------------------------------------

#<http://hl7.org/fhir/DiagnosticReport/f201.ttl> a owl:Ontology;
#  owl:imports fhir:fhir.ttl.
```

If the resource itself doesn't include the FHIR Metadata Vocabulary…
… the OWL tooling assumes that *everything* is an annotation

Why the Ontology Header

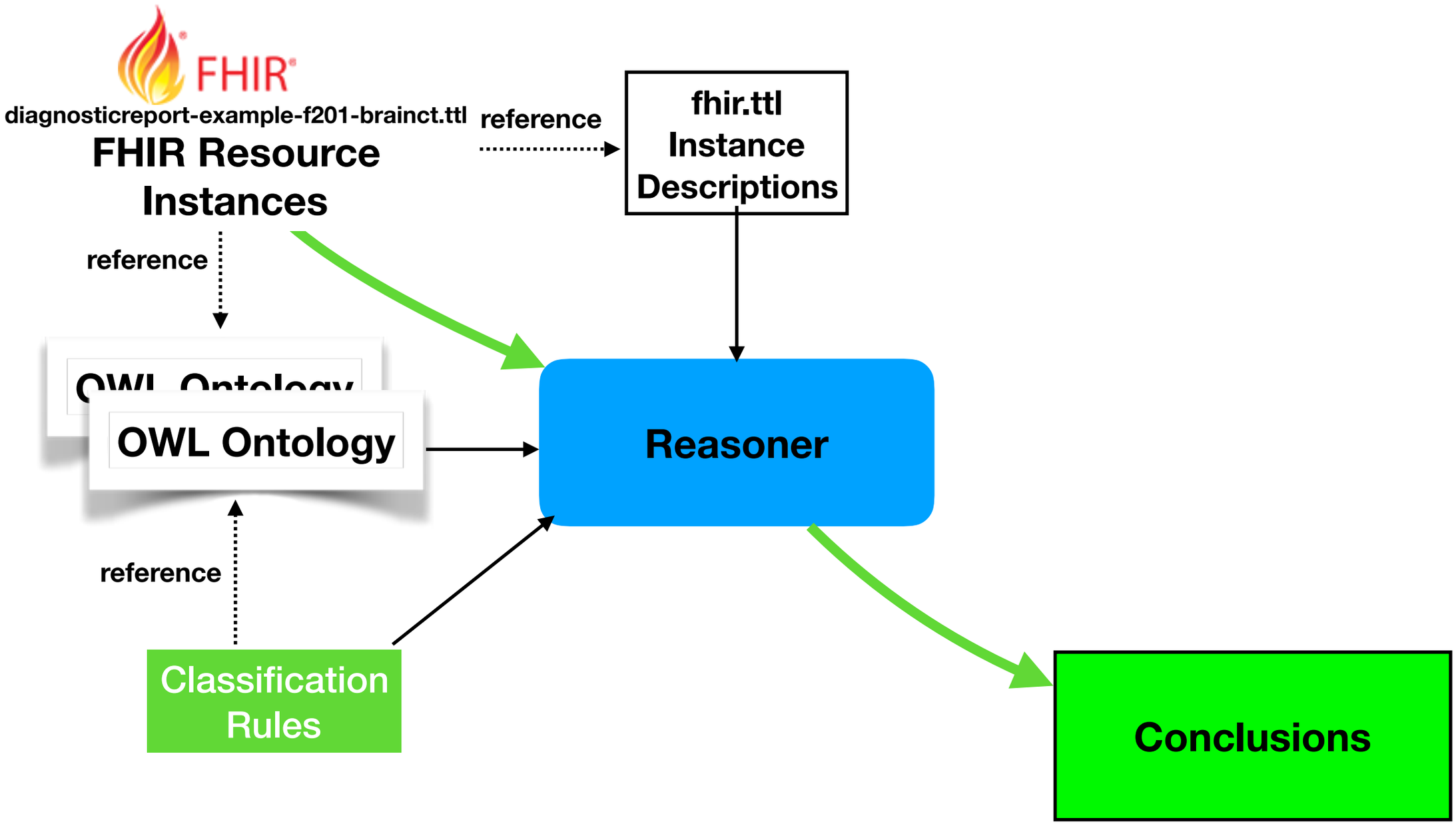
```
# - resource ------------------------------------------------------------

<http://hl7.org/fhir/DiagnosticReport/f201> a fhir:DiagnosticReport;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f201"];
  fhir:DomainResource.text [
```

```
# - ontology header ------------------------------------------------------

<http://hl7.org/fhir/DiagnosticReport/f201.ttl> a owl:Ontology;
  owl:imports fhir:fhir.ttl.
```

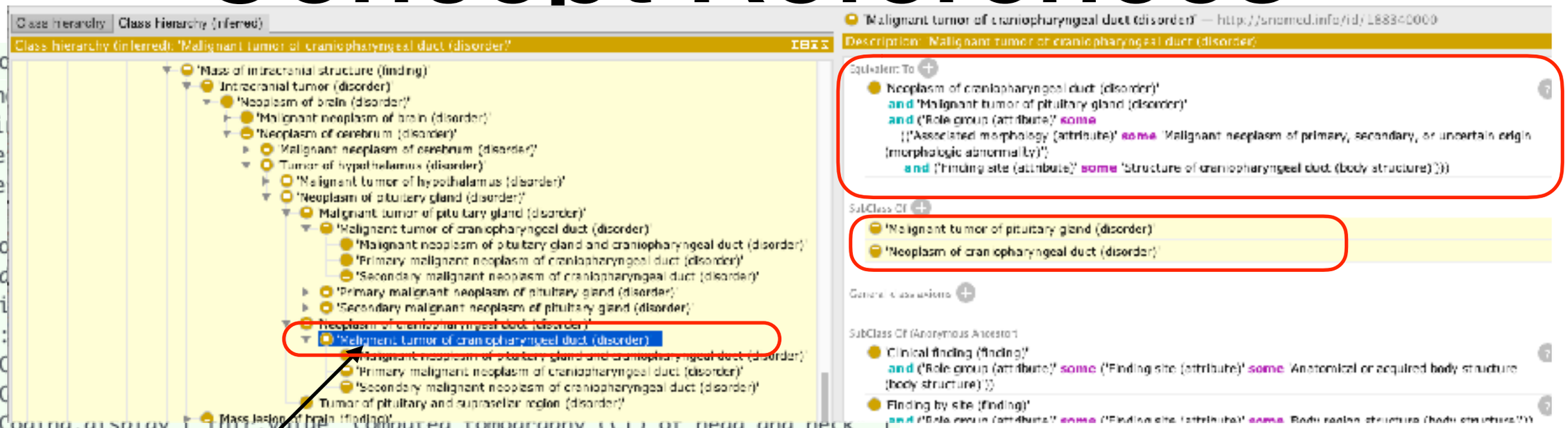


With the import statement, the data is interpreted correctly

Using FHIR RDF With a DL Reasoner



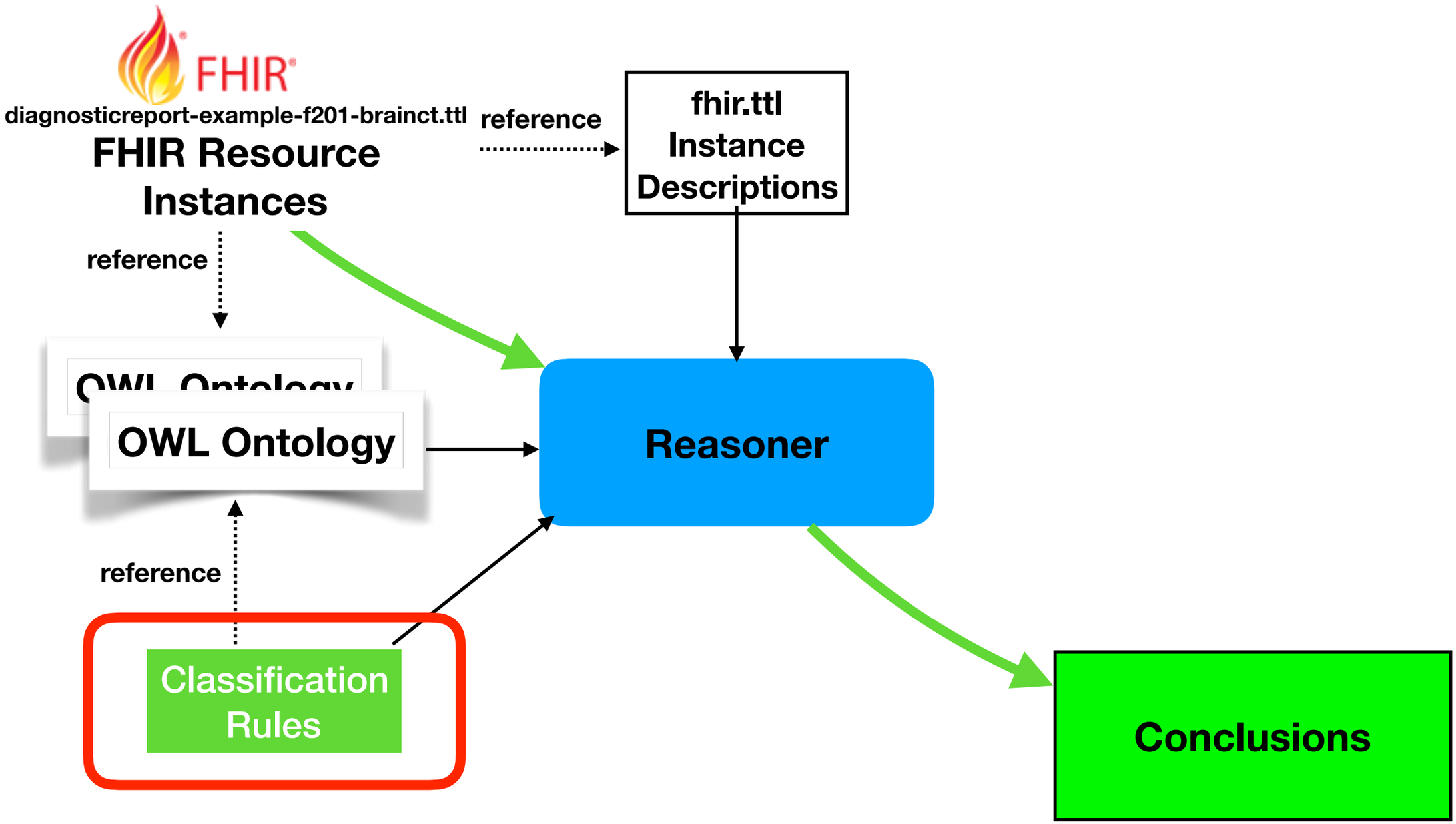
FHIR Resource Instance Concept References




```
<http://hl7.o
  fhir:Diagn
    fhir:li
    fhir:Re
    fhir:Re
  ];
 fhir:Diagno
    fhir:Coo
      fhir:i
      a sct:
      fhir:C
      fhir:C
      fhir:Coding.display [ fhir:value "Computed tomography (CT) of head and neck" ]
    ];
    fhir:CodeableConcept.text [ fhir:value "CT of head neck" ]
];
 fhir:Diagn
    fhir:index 0;
    fhir:CodeableConcept.coding [
      fhir:index 0;
      a sct:188340000;
      fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
      fhir:Coding.code [ fhir:value "188340000" ];
      fhir:Coding.display [ fhir:value "Malignant tumor of craniopharyngeal duct" ]
    ]
```

http://snomed.info/id/188340000

Using FHIR RDF With a DL Reasoner



Sample Classification Rule

```
Ontology(<http://example.org/swat4ls/cancerreport>
Import(<http://snomed.info/sct/900000000000207008>)
Import(<http://hl7.org/fhir/fhir.ttl>)
Import(<http://hl7.org/fhir/DiagnosticReport/f201.ttl>)

Declaration(ObjectProperty(fhir:DiagnosticReport.codedDiagnosis.coding))
SubObjectPropertyOf(
  ObjectPropertyChain(fhir:DiagnosticReport.codedDiagnosis
fhir:CodeableConcept.coding) fhir:DiagnosticReport.codedDiagnosis.coding)

Declaration(Class(:ReportWithCancerDiagnosis))
EquivalentClasses(:ReportWithCancerDiagnosis
ObjectSomeValuesFrom(fhir:DiagnosticReport.codedDiagnosis.coding sct:363346000))

)
```

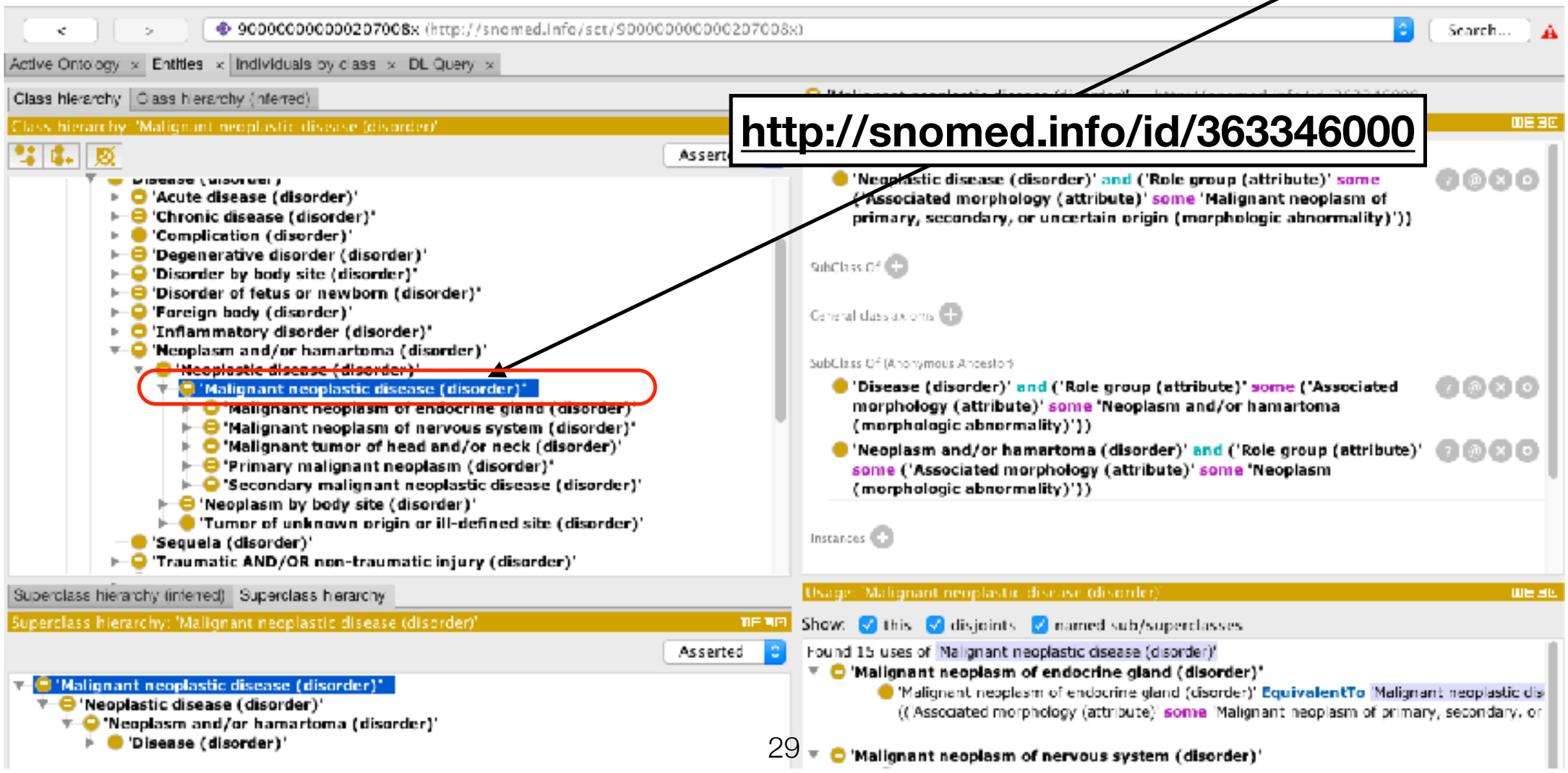
SNOMED CT
FHIR.TTL
Sample Data

OWL Functional Syntax

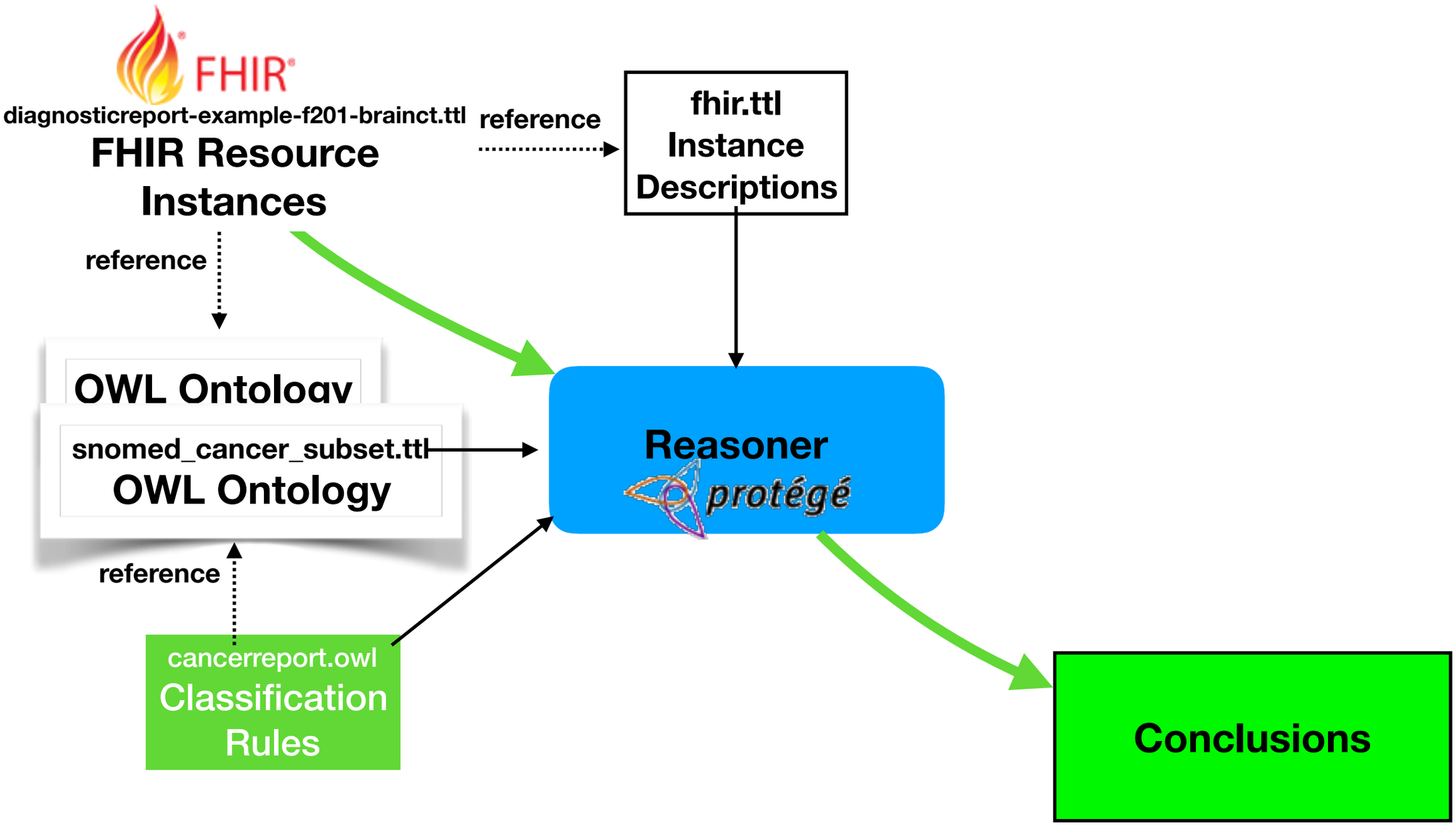
Classification Rules
Concept Reference

Declaration(Class(:ReportWithCancerDiagnosis))
EquivalentClasses(:ReportWithCancerDiagnosis
ObjectSomeValuesFrom(fhir:DiagnosticReport.codedDiagnosis.coding sct:363346000))

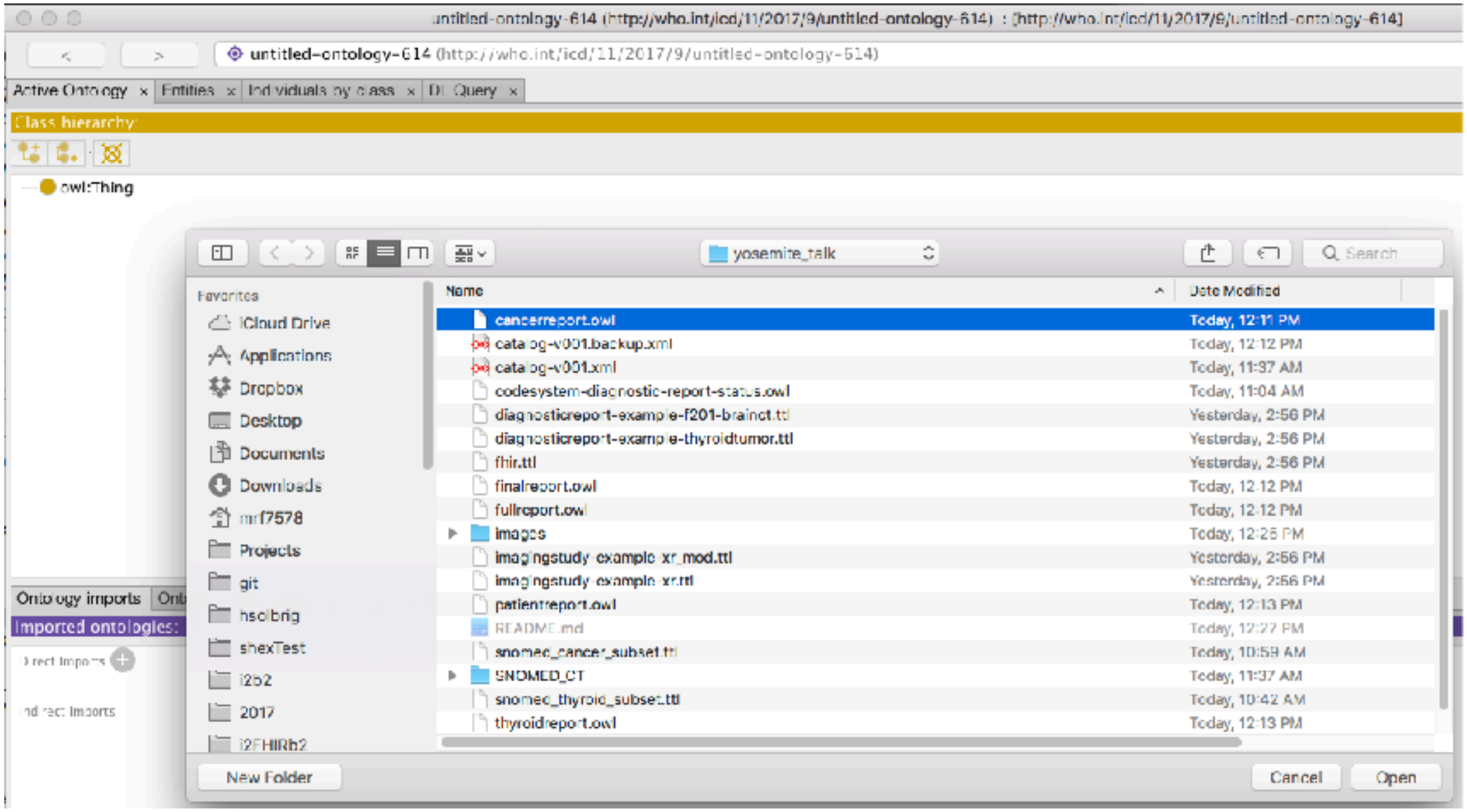
)



Using FHIR RDF With a DL Reasoner



Load the Classification Rules



https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/cancerreport.owl

Verify the Imports

Ontology imports | Ontology Prefixes | General class axioms

Imported ontologies:

Direct Imports

<http://hl7.org/fhir/DiagnosticReport/f201.ttl>
f201.ttl
Ontology IRI: <http://hl7.org/fhir/DiagnosticReport/f201.ttl>
Location: /Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/diagnosticreport-example-f201-brainct.ttl

<http://snomed.info/sct/900000000000207008cancer_subset>
900000000000207008cancer_subset
Ontology IRI: <http://snomed.info/sct/900000000000207008cancer_subset>
Location: /Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/snomed_cancer_subset.ttl

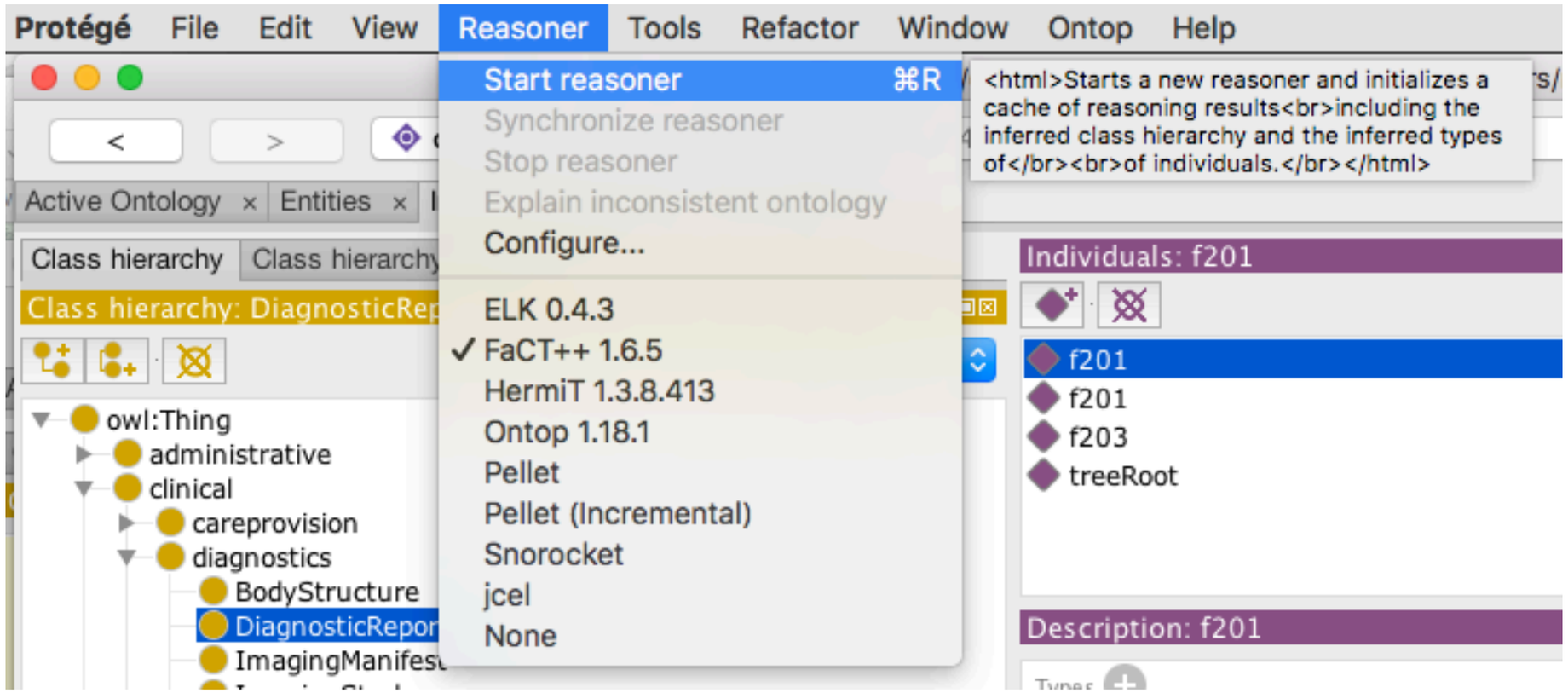
<http://hl7.org/fhir/fhir.ttl>
fhir.ttl
Ontology IRI: <http://hl7.org/fhir/fhir.ttl>
Location: /Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/fhir.ttl

Indirect Imports

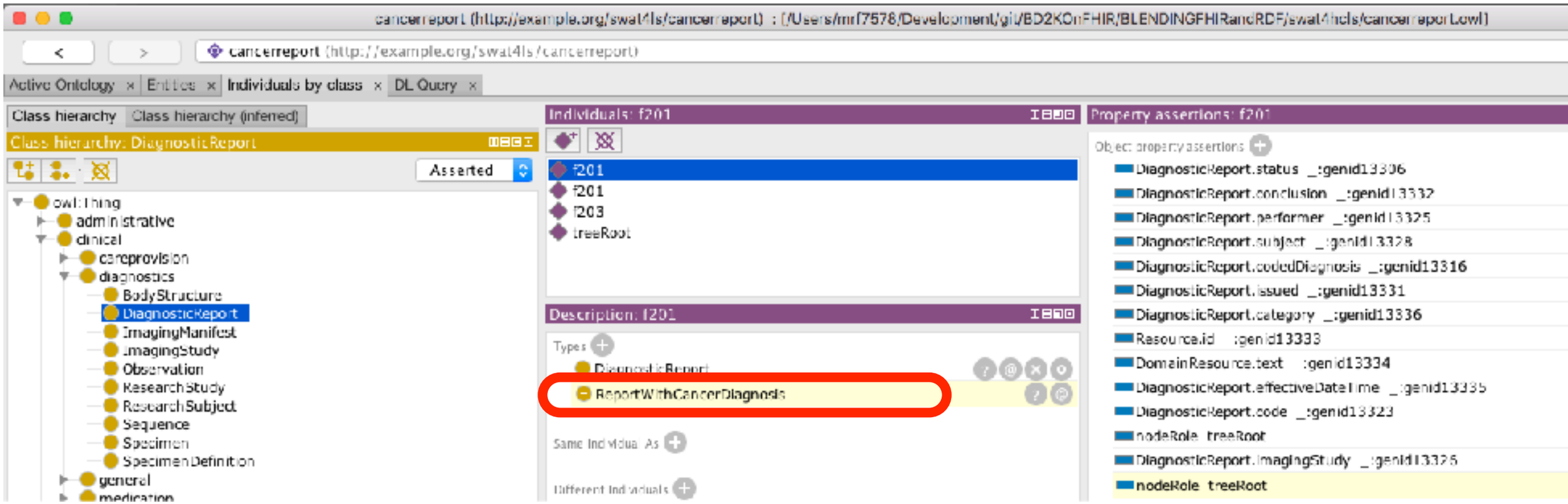
<http://hl7.org/fhir/fhir.ttl>
fhir.ttl
Ontology IRI: <http://hl7.org/fhir/fhir.ttl>
Location: /Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/fhir.ttl

<http://hl7.org/fhir/w5#>
w5
Ontology IRI: <http://hl7.org/fhir/w5#>
Location: /Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/w5.ttl

Run the Reasoner



Result


cancerreport (http://example.org/swat4ls/cancerreport) : [/Users/mrf7578/Development/gil/BD2KOnFHIR/BLENDINGFHIRandRDF/swat4hcls/cancerreport.owl]
cancerreport (http://example.org/swat4ls/cancerreport)
Active Ontology
Entities
Individuals by class
DL Query
Class hierarchy
Class hierarchy (inferred)
Class hierarchy: DiagnosticReport
Asserted
owl:Thing
administrative
clinical
careprovision
diagnostics
BodyStructure
DiagnosticReport
ImagingManifest
ImagingStudy
Observation
ResearchStudy
ResearchSubject
Sequence
Specimen
SpecimenDefinition
general
medication
Individuals: f201
f201
f201
f203
treeRoot
Description: f201
Types
DiagnosticReport
ReportWithCancerDiagnosis
Same Individual As
Different Individuals
Property assertions: f201
Object property assertions
DiagnosticReport.status _:genid13306
DiagnosticReport.conclusion _:genid13332
DiagnosticReport.performer _:genid13325
DiagnosticReport.subject _:genid13328
DiagnosticReport.codedDiagnosis _:genid13316
DiagnosticReport.issued _:genid13331
DiagnosticReport.category _:genid13336
Resource.id :genid13333
DomainResource.text :genid13334
DiagnosticReport.effectiveDateTime _:genid13335
DiagnosticReport.code _:genid13323
nodeRole treeRoot
DiagnosticReport.imagingStudy _:genid13326
nodeRole treeRoot

Restrict to Patients


```
Declaration(ObjectProperty(fhir:DiagnosticReport.subject.link))
SubObjectPropertyOf(
  ObjectPropertyChain(fhir:DiagnosticReport.subject fhir:link)
fhir:DiagnosticReport.subject.link)

Declaration(Class(:PatientReport))
EquivalentClasses(:PatientReport
   ObjectSomeValuesFrom(fhir:DiagnosticReport.subject.link fhir:Patient))

)
```

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/patientreport.owl

Finalized Reports Only

Code	Display	Definition
registered	Registered	The existence of the report is registered, but there is nothing yet available.
partial	Partial	This is a partial (e.g. initial, interim or preliminary) report: data in the report may be incomplete or unverified.
preliminary	Preliminary	Verified early results are available, but not all results are final.
final	Final	The report is complete and verified by an authorized person.
amended	Amended	Subsequent to being final, the report has been modified. This includes any change in the results, diagnosis, narrative text, report that has been issued.
corrected	Corrected	Subsequent to being final, the report has been modified to correct an error in the report or referenced results.
appended	Appended	Subsequent to being final, the report has been modified by adding new content. The existing content is unchanged.
cancelled	Cancelled	The report is unavailable because the measurement was not started or not completed (also sometimes called "aborted").
entered-in-error	Entered in Error	The report has been withdrawn following a previous final release. This electronic record should never have existed, though world decisions were based on it. (If real-world activity has occurred, the status should be "cancelled" rather than "entere
unknown	Unknown	The authoring system does not know which of the status values currently applies for this request. Note: This concept is no

```
Declaration(Class(:FinalizedReport))
EquivalentClasses(:FinalizedReport ObjectSomeValuesFrom
  (fhir:DiagnosticReport.status DataSomeValuesFrom
    (fhir:value DataOneOf("amended" "appended" "corrected" "final"))))
```

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/finalreport_data.owl

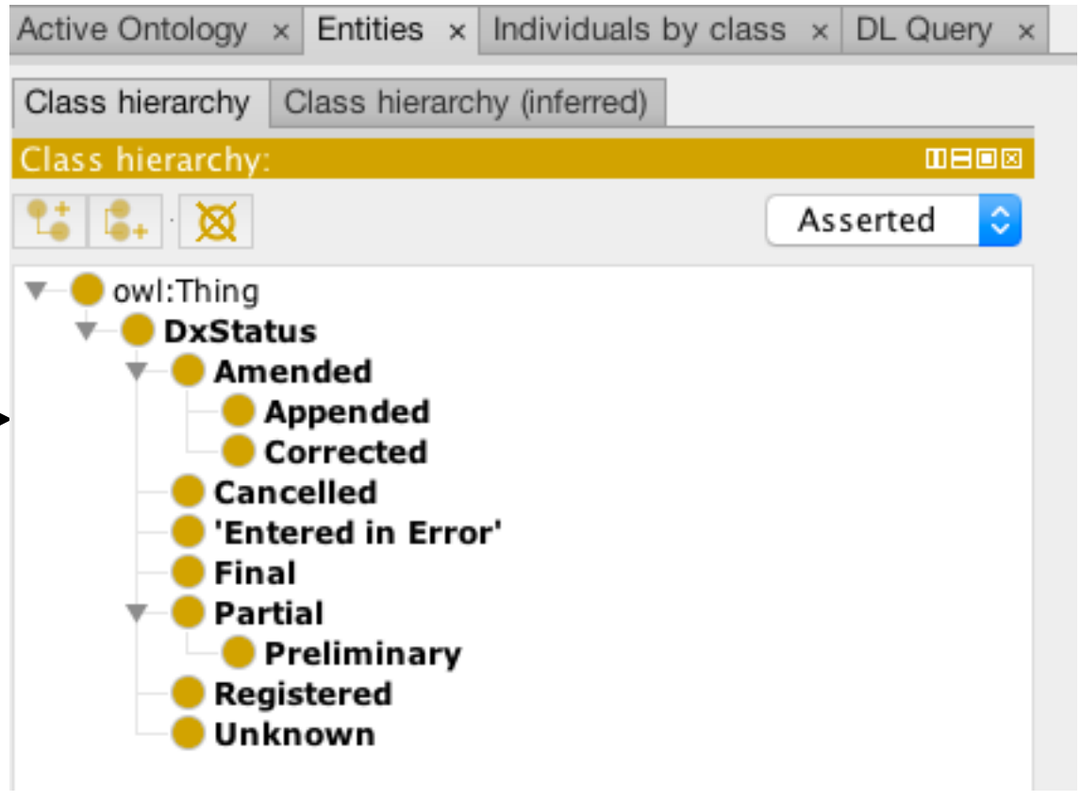
Finalized Reports Only

Approach is “brittle”:

- Code system hierarchy is replicated as flattened strings
- No link to fact that system is being used
- DataProperty constraints potentially make reasoner more complex

Finalized Reports
Proposed Solution

```
@prefix fhir:   <http://hl7.org/fhir/> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl:    <http://www.w3.org/2002/07/owl#> .
@prefix diagnostic-report-status: <http://hl7.org/fhir/diagnostic-report-
@prefix xsd:    <http://www.w3.org/2001/XMLSchema> .
@prefix skos:   <http://www.w3.org/2004/02/skos/core#> .
@prefix rdfs:   <http://www.w3.org/2000/01/rdf-schema#> .
@prefix w5:     <http://hl7.org/fhir/w5#> .

diagnostic-report-status:root
        a owl:Class ;
        rdfs:label "DxStatus" ;
        skos:definition "Diagnostic Report Status Values" ;
        skos:prefLabel "DxStatus" .

diagnostic-report-status:partial
        a               owl:Class ;
        rdfs:subClassOf  diagnostic-report-status:root ;
        rdfs:label       "Partial" ;
        skos:definition  "This is a partial (e.g. initial, interim or pre
 may be incomplete or unverified." ;
        skos:prefLabel   "Partial" .

diagnostic-report-status:cancelled
        a               owl:Class ;
        rdfs:subClassOf  diagnostic-report-status:root ;
        rdfs:label       "Cancelled" ;
        skos:definition  "The report is unavailable because the measurem
(also sometimes called \"aborted\")." ;
        skos:prefLabel   "Cancelled" .
```



1) OWL representation (and URIs!) for *all* code systems …

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/codesystem-diagnostic-report-status.owl

Finalized Reports
Proposed Solution (cont)

```
];
fhir:DiagnosticReport.status [
      a diagnostic-report-status:final;
      fhir:value "final"];
```

2) Revise FHIR RDF specification to allow rdf:type **on *all* codes**

```
Import(<http://hl7.org/fhir/diagnostic-report-status/>)
      …
Declaration(Class(:FinalStatus))
SubClassOf(diagnostic-report-status:final :FinalStatus)
SubClassOf(diagnostic-report-status:amended :FinalStatus)

Declaration(Class(:FinalReport))
EquivalentClasses(:FinalReport
ObjectSomeValuesFrom(fhir:DiagnosticReport.status :FinalStatus))
```

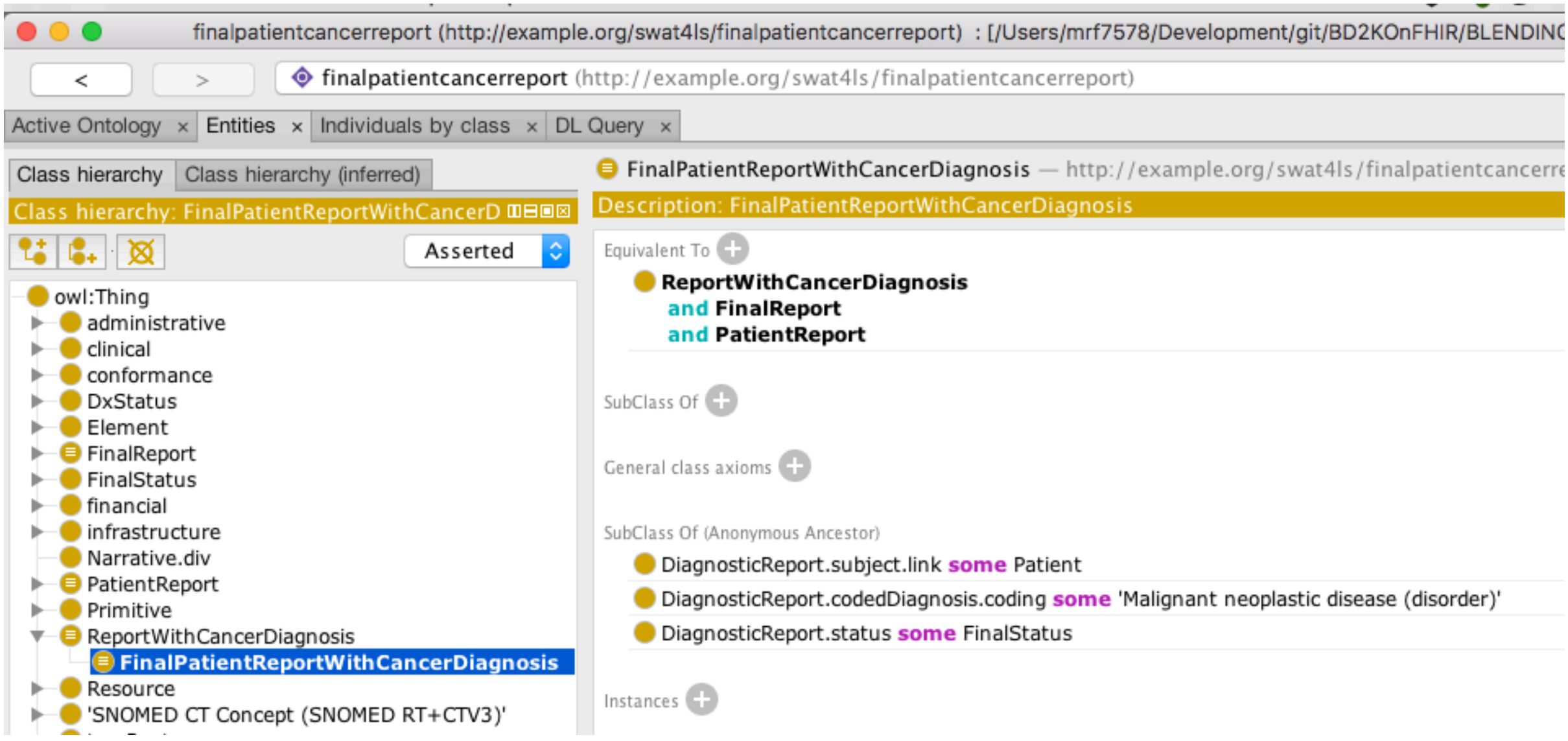
https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/finalreport.owl

Finalized Patient Reports having a Cancer Dx

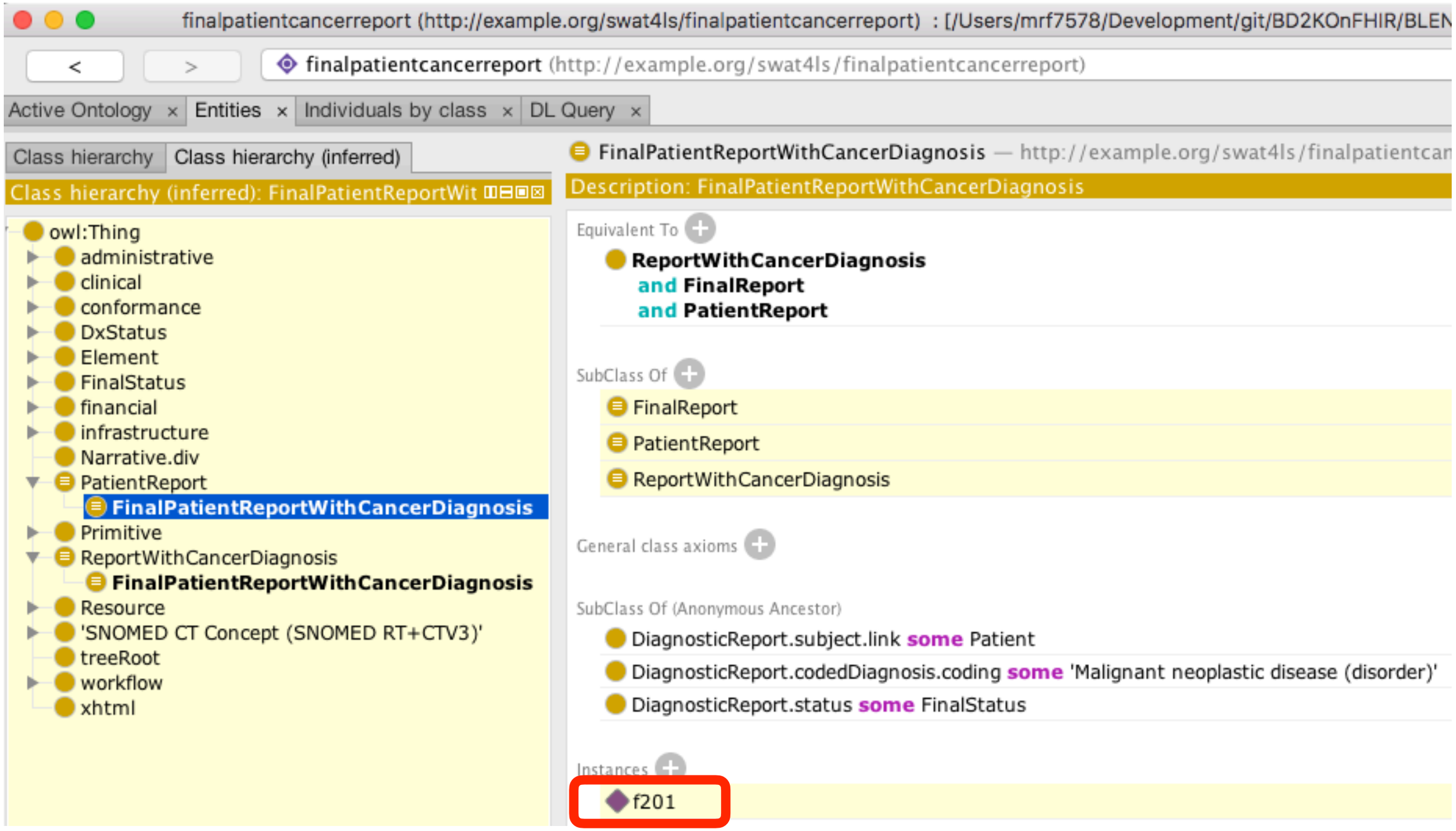
```
Import(<http://example.org/swat4ls/patientreport>)
Import(<http://example.org/swat4ls/cancerreport>)
Import(<http://example.org/swat4ls/finalreport>)

# Class declaration
Declaration(Class(:FinalPatientReportWithCancerDiagnosis))
AnnotationAssertion(dc:title :FinalPatientReportWithCancerDiagnosis
                "The set of diagnoses that are instances of malignant neoplastic disease
(sct:363346000)")
EquivalentClasses(:FinalPatientReportWithCancerDiagnosis
      ObjectIntersectionOf
      (<http://example.org/swat4ls/patientreport/PatientReport>
       <http://example.org/swat4ls/cancerreport/ReportWithCancerDiagnosis>
       <http://example.org/swat4ls/finalreport/FinalReport>))

)
```

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/fullreport.owl

Definition


finalpatientcancerreport (http://example.org/swat4ls/finalpatientcancerreport) : [/Users/mrf7578/Development/git/BD2KOnFHIR/BLENDINC
finalpatientcancerreport (http://example.org/swat4ls/finalpatientcancerreport)
Active Ontology
Entities
Individuals by class
DL Query
Class hierarchy
Class hierarchy (inferred)
Class hierarchy: FinalPatientReportWithCancerD
Asserted
owl:Thing
administrative
clinical
conformance
DxStatus
Element
FinalReport
FinalStatus
financial
infrastructure
Narrative.div
PatientReport
Primitive
ReportWithCancerDiagnosis
FinalPatientReportWithCancerDiagnosis
Resource
'SNOMED CT Concept (SNOMED RT+CTV3)'
FinalPatientReportWithCancerDiagnosis — http://example.org/swat4ls/finalpatientcancerre
Description: FinalPatientReportWithCancerDiagnosis
Equivalent To
ReportWithCancerDiagnosis
and FinalReport
and PatientReport
SubClass Of
General class axioms
SubClass Of (Anonymous Ancestor)
DiagnosticReport.subject.link some Patient
DiagnosticReport.codedDiagnosis.coding some 'Malignant neoplastic disease (disorder)'
DiagnosticReport.status some FinalStatus
Instances

Result


finalpatientcancerreport (http://example.org/swat4ls/finalpatientcancerreport) : [/Users/mrf7578/Development/git/BD2KOnFHIR/BLEN
finalpatientcancerreport (http://example.org/swat4ls/finalpatientcancerreport)
Active Ontology
Entities
Individuals by class
DL Query
Class hierarchy
Class hierarchy (inferred)
Class hierarchy (inferred): FinalPatientReportWit
owl:Thing
administrative
clinical
conformance
DxStatus
Element
FinalStatus
financial
infrastructure
Narrative.div
PatientReport
FinalPatientReportWithCancerDiagnosis
Primitive
ReportWithCancerDiagnosis
FinalPatientReportWithCancerDiagnosis
Resource
'SNOMED CT Concept (SNOMED RT+CTV3)'
treeRoot
workflow
xhtml
FinalPatientReportWithCancerDiagnosis — http://example.org/swat4ls/finalpatientcan
Description: FinalPatientReportWithCancerDiagnosis
Equivalent To
ReportWithCancerDiagnosis
and FinalReport
and PatientReport
SubClass Of
FinalReport
PatientReport
ReportWithCancerDiagnosis
General class axioms
SubClass Of (Anonymous Ancestor)
DiagnosticReport.subject.link some Patient
DiagnosticReport.codedDiagnosis.coding some 'Malignant neoplastic disease (disorder)'
DiagnosticReport.status some FinalStatus
Instances
f201

Post-Coordinated Expressions

```
fhir:DiagnosticReport.conclusion [ fhir:value "CT brains: tumor of the left lobe of the thyroid gland."];
fhir:DiagnosticReport.codedDiagnosis [
   fhir:index 0;
   fhir:CodeableConcept.coding [
     fhir:index 0;
     a sct:363346000;
     a [ a owl:Restriction ;
         owl:onProperty sct:609096000 ;
         owl:someValuesFrom [ a owl:Restriction ;
             owl:onProperty sct:363698007 ;
             owl:someValuesFrom sct:170784008 ] ] ;
     fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
     fhir:Coding.code [ fhir:value "363346000:{363698007=170784008}" ];
     fhir:Coding.display [ fhir:value "Malignant tumor of left lobe of thyroid gland" ]
   ]
] .
```

Transformation rules for OWL equivalent

One possible format for compositional expression

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/diagnosticreport-example-thyroidtumor.ttl

Thyroid Disease Classifier

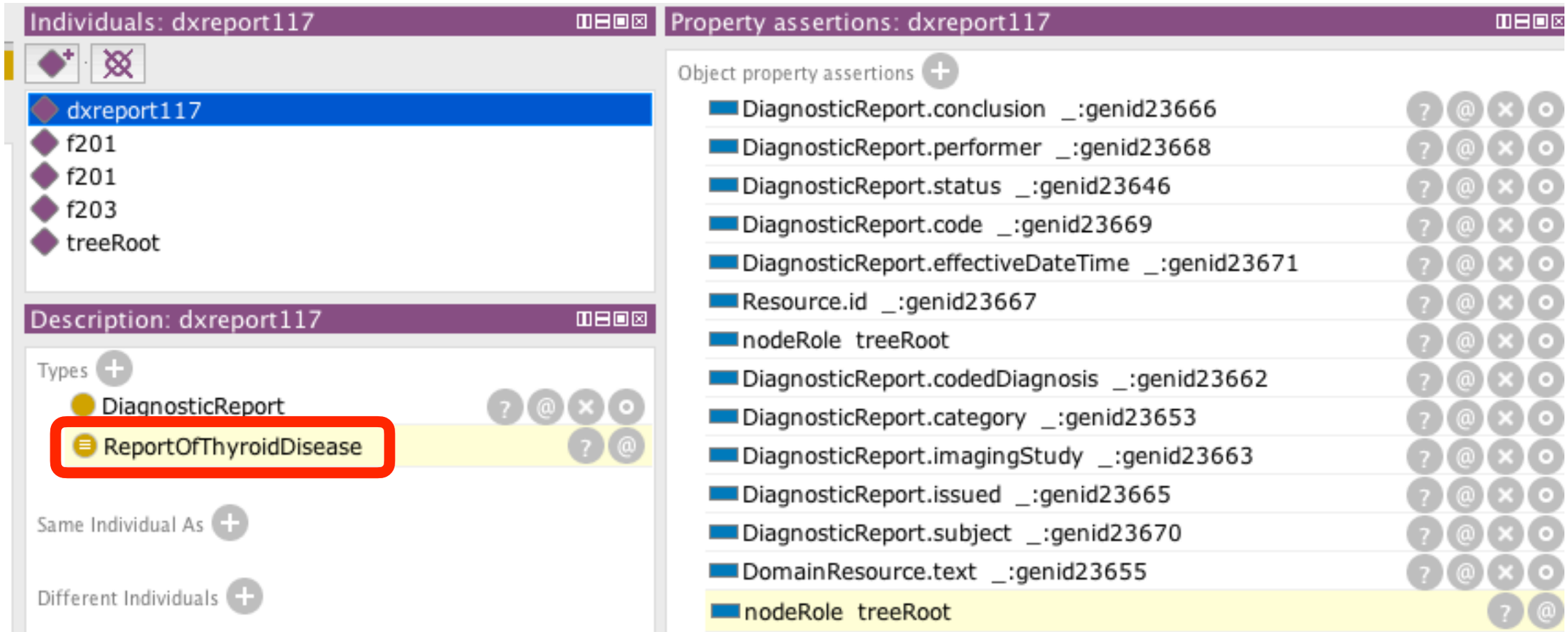
...

Declaration(Class(:ReportOfThyroidDisease))
AnnotationAssertion(dc:title :ReportOfThyroidDisease
"Thyroid Disease Dx - disorder of the thyroid gland (sct:14304000)")
EquivalentClasses(:ReportOfThyroidDisease
ObjectSomeValuesFrom(fhir:DiagnosticReport.codedDiagnosis.coding sct:14304000))

)

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/thyroidreport.owl

Result


Individuals: dxreport117
dxreport117
f201
f201
f203
treeRoot
Description: dxreport117
Types
DiagnosticReport
ReportOfThyroidDisease
Same Individual As
Different Individuals
Property assertions: dxreport117
Object property assertions
DiagnosticReport.conclusion _:genid23666
DiagnosticReport.performer _:genid23668
DiagnosticReport.status _:genid23646
DiagnosticReport.code _:genid23669
DiagnosticReport.effectiveDateTime _:genid23671
Resource.id _:genid23667
nodeRole treeRoot
DiagnosticReport.codedDiagnosis _:genid23662
DiagnosticReport.category _:genid23653
DiagnosticReport.imagingStudy _:genid23663
DiagnosticReport.issued _:genid23665
DiagnosticReport.subject _:genid23670
DomainResource.text _:genid23655
nodeRole treeRoot

What *doesn't* work

```
fhir:ImagingStudy.description [ fhir:value "XR Wrist 3+ Views"];
fhir:ImagingStudy.series [
   fhir:index 0;
   fhir:ImagingStudy.series.uid [ fhir:value "urn:oid:2.16.124.113543.6003.1154777499.30246.19789
   fhir:ImagingStudy.series.number [ fhir:value "3"^^xsd:nonNegativeInteger ];
   fhir:ImagingStudy.series.modality [
     fhir:Coding.system [ fhir:value "http://nema.org/dicom/dicm" ];
     fhir:Coding.code [ fhir:value "DX" ]
   ];
   fhir:Imag
   fhir:ImagingStudy.series.numberOfInstances [ fhir:value "2"^^xsd:nonNegativeInteger ];
   fhir:ImagingStudy.series.availability [ fhir:value "ONLINE" ];
   fhir:ImagingStudy.series.endpoint [
     fhir:index 0;
     fhir:link <http://hl7.org/fhir/Endpoint/example-wadors>;
     fhir:Reference.reference [ fhir:value "Endpoint/example-wadors" ]
   ];
   fhir:ImagingStudy.series.bodySite [
     a sct:7467003;
     fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
     fhir:Coding.code [ fhir:value "7467003" ];
     fhir:Coding.display [ fhir:value "Wrist joint structure" ]
   ];
   fhir:ImagingStudy.series.laterality [
     a sct:7771000;
     fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
     fhir:Coding.code [ fhir:value "7771000" ];
     fhir:Coding.display [ fhir:value "Left" ]
   ];
   fhir:ImagingStudy.series.started [ fhir:value "2011-01-01T11:01:20+03:00"^^xsd:dateTime ];
```

Does laterality modify bodySite? Is it an independent attribute?

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/imagingstudy-exmple.xr.ttl

What we need

```
fhir:ImagingStudy.series.bodySite [
  a sct:7467003;
  a [owl:Restriction;
     owl:onProperty sct:272741003;
     owl:someValuesFrom sct:7771000];
  fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
  fhir:Coding.code [ fhir:value "7467003" ];
  fhir:Coding.display [ fhir:value "Wrist joint structure" ]
];
fhir:ImagingStudy.series.laterality [
  a sct:7771000;
  fhir:Coding.system [ fhir:value "http://snomed.info/sct" ];
  fhir:Coding.code [ fhir:value "7771000" ];
  fhir:Coding.display [ fhir:value "Left" ]
];
```

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk/imagingstudy-exmple.xr.ttl

Why the imaging study doesn’t work

There is a tacit ontological model included in the data (this is always the case…)

The modelers know that the laterality attribute modifies the body site — it isn’t an image of a ‘left’, it is an image of the left wrist.

Transformation is necessary

- Watch the work that Grahame Grieve and Linda Bird are doing on SNOMED model alignment
- Keep an eye on what is happening in the Shape Expressions (ShEx) mapping group

Issues and Discussion

- FHIR Metadata Vocabulary
    - Uses types not recognized in OWL spec (xsd:date, xsd:time, etc)
    - Value Set references not yet included
    - Include path expressions?
- FHIR and RDF
    - URI's for all concept codes
    - OWL rendering of all code systems
    - RDF Profile? URI's, links and link types aren't RDF specific
- Reasoner
    - ELK and Snorocket don't work — have to use FaCT++
        - FaCT++ is too slow for complete SNOMED CT, so we're generating subsets
        - Snorocket community willing to address issues
    - Production environment would need pre-classified SNOMED w/ queries (ala. CTS2 approach)
- Some issues wrt. CONNEG (content negotiation)

Summary

- FHIR RDF allows seamless integration with DL reasoners
- DL reasoners can be applied to many, but not all(!) classification tasks
- Still some “rough edges”, but approach appears to be solid and useable in a production level environment

Credits

This study is supported in part by NIH grants U01 HG009450 and U01 CA18094.

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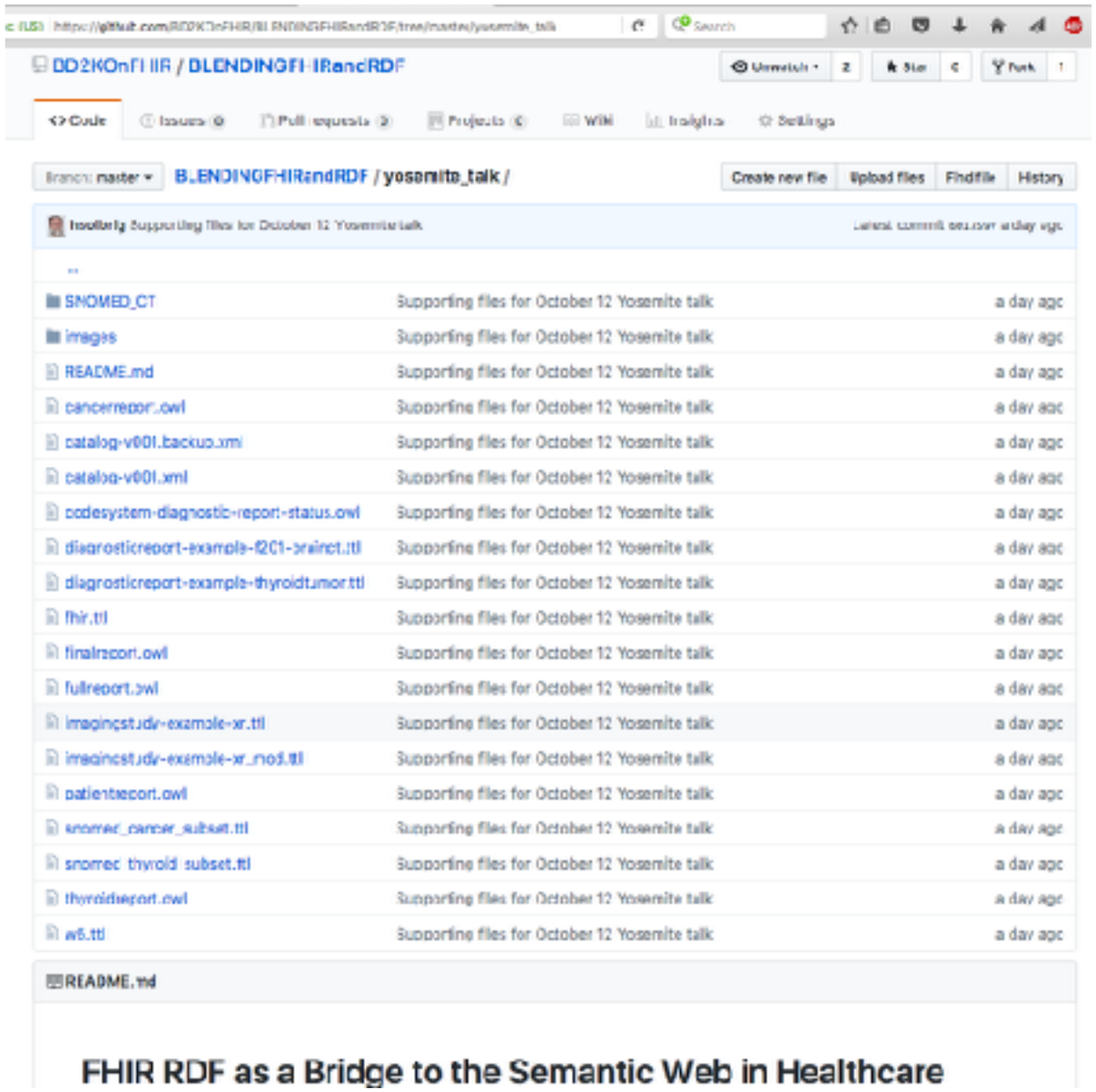
Eric Prud'hommeaux
David Booth
Dr. Guoqian Jiang

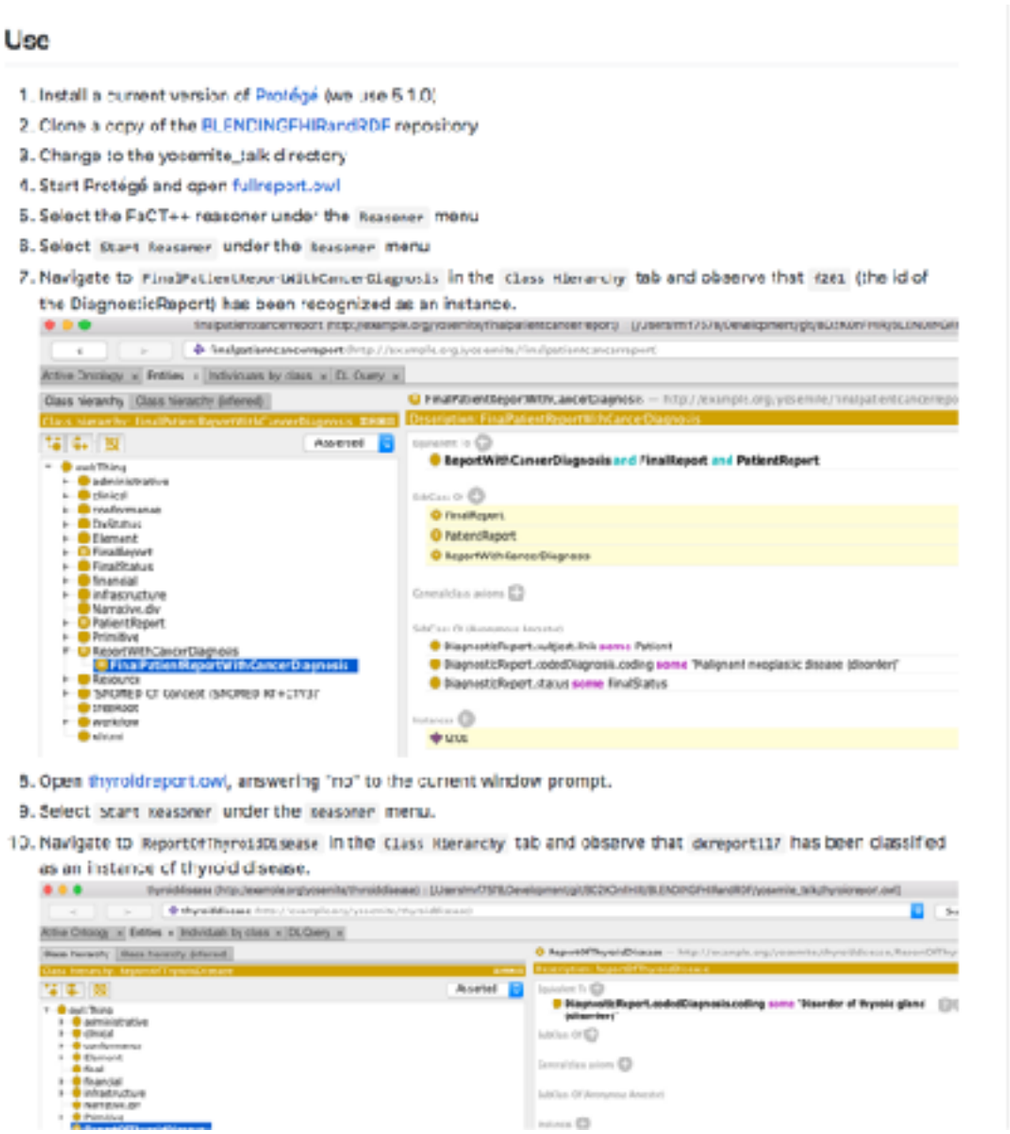
The HCLS team

Presentation Materials

Materials for this talk, along with this slide deck can be found at:

https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/yosemite_talk





Questions

solbrig.harold@mayo.edu