

FHIR RDF Sample side by side comparisons

1

2

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36			

37 **Legend**

38 Most of the RDF is generated by verbatim logic (e.g. An unidentified element becomes an anonymous individual
39 - blank node).

- 40 Where RDF is generated by special transformation it is **marked in red**
- 41 Where RDF is inferred by a reasoner it is **marked in green**.

42 1 Default Mapping

43 In general the mapping between types, elements in XML and Classes, individuals in RDF is generally the same.
44 This section defines that default mapping and other section describe deviations from the default mapping.

45 1.1 Instance mapping

46 In XML the element instances are nested using tags.

47 1.1.1 Element

48 An XML element corresponds to a RDF/OWL individual. In many cases unless the element has identity the
49 mapping is to an anonymous individual. Where identity has been given to the element then it maps to a named
50 individual.

51 1.1.2 XML Tag

52 The XML tag is mapped to an Object Property Assertion of the Object Property defined for the tag name.

53 1.1.3 XML Attribute

54 An XML attribute represents a simple type and in FHIR is always “value”. FHIR datatypes have attributes of XSD
55 datatypes.

```
56    fhir:CodingBase.display [ a fhir:string; fhir:value "Admin"] ;
```

57 Shows an anonymous individual in [] of datatype fhir:string with value data property “Admin”.

58 1.2 Default Type mapping

59 1.2.1 Complex type to Class

60 A Complex type in XSD maps to an owl:Class. The elements of the Complex type map to Object Properties.

61 Sequences do not get represented in RDF/OWL but the ordering can be declared with annotation properties
62 (see later section on ordering).

63 1.2.2 Nested elements

64 An XML tag is unique within the namespace that it is declared in. FHIR does not use global declarations. The XML
65 tag is mapped to an Object Property where the name is prefixed with the Class name in which it was declared. A
66 tag “bar” declared in a complex type “Foo” would become an Object Property “Foo.bar”. This is aligned with the
67 structural definition mechanism in FHIR.

68 1.2.3 Datatypes

69 In RDF the value attribute of a datatype is a Data Property named “value” with undefined range. Each FHIR data
70 type has a restriction on the range of the Data Property (see section on Datatypes).

71 1.3 Structural Definition Mapping

72 A structural definition includes element definitions.

73 **1.3.1 Structural Definition Example**

```
74 <?xml version="1.0" encoding="UTF-8"?>
75
76 <StructureDefinition xmlns="http://hl7.org/fhir">
77   <id value="example"/>
78   <text>
79   ---
80   </text>
81   <url value="http://hl7.org/fhir/StructureDefinition/example"/>
82   <name value="Example Lipid Profile"/>
83   <publisher value="Grahame Grieve"/>
84   <contact>
85     <telecom>
86       <system value="url" />
87       <value value="grahame@healthintersections.com.au" />
88     </telecom>
89   </contact>
90   <description value="Describes how the lab report is used for a standard Lipid Profile - Cholesterol,  
91 Triglyceride and Cholesterol fractions. Uses LOINC codes"/>
92   <status value="draft"/>
93   <date value="2012-05-12"/>
94   <type value="constraint"/>
95   <abstract value="false"/>
96   <snapshot>
97     <element>
98     <----->
99     </element>
100    </snapshot>
101 </StructureDefinition>
```

102

103 **1.3.2 Element XML example**

104 The following is the Element Definition for fhir:Reference:

```
105 <entry>
106   <fullUrl value="http://hl7.org/fhir/DataElement/Reference"/>
107   <resource>
108     <DataElement>
109       <id value="Reference"/>
110       <meta>
111         <lastUpdated value="2015-12-31T00:38:37.614+00:00"/>
112       </meta>
113       <url value="http://hl7.org/fhir/DataElement/Reference"/>
114       <status value="draft"/>
115       <experimental value="true"/>
116       <stringency value="fully-specified"/>
117       <element>
118         <path value="Reference"/>
119         <short value="A reference from one resource to another"/>
120         <definition value="A reference from one resource to another."/>
121         <min value="0"/>
122         <max value="*"/>
123         <type>
124           <code value="Element"/>
125         </type>
126         <constraint>
127           <extension url="http://hl7.org/fhir/StructureDefinition/structuredefinition-expression">
128             <valueString value="reference.startsWith('#').not() or
129 ($context.reference.substring(1).log('url') in $resource.contained.id.log('ids'))"/>
130           </extension>
131           <key value="ref-1"/>
132           <severity value="error"/>
133           <human value="SHALL have a local reference if the resource is provided inline"/>
134           <xpath value="not(starts-with(f:reference/@value, '#')) or exists(ancestor::*[self::f:entry or
135 self::f:parameter]/f:resource/f/*/f:contained/f:*[f:id/@value=substring-after(current()/f:reference/@value,
136 '#')]|/*/f:contained/f/*[f:id/@value=substring-after(current()/f:reference/@value, '#')]")"/>
137           </constraint>
138           <isSummary value="true"/>
139           <mapping>
140             <identity value="rim"/>
141             <map value="The target of a resource reference is a RIM entry point (Act, Role, or Entity)"/>
142           </mapping>
143         </element>
144       </DataElement>
145     </resource>
146   </entry>
```

147

148

1.3.3 Element Property example

```

149 <entry>
150   <fullUrl value="http://hl7.org/fhir/DataElement/Reference.display"/>
151   <resource>
152     <DataElement>
153       <id value="Reference.display"/>
154       <meta>
155         <lastUpdated value="2015-12-31T00:38:37.614+00:00"/>
156       </meta>
157       <url value="http://hl7.org/fhir/DataElement/Reference.display"/>
158       <status value="draft"/>
159       <experimental value="true"/>
160       <stringency value="fully-specified"/>
161       <element>
162         <path value="Reference.display"/>
163         <short value="Text alternative for the resource"/>
164         <definition value="Plain text narrative that identifies the resource in addition to the resource
165 reference."/>
166         <comments value="This is generally not the same as the Resource.text of the referenced resource. The
167 purpose is to identify what's being referenced, not to fully describe it."/>
168         <min value="0"/>
169         <max value="1"/>
170         <type>
171           <code value="string"/>
172         </type>
173         <isSummary value="true"/>
174         <mapping>
175           <identity value="rim"/>
176           <map value="N/A"/>
177         </mapping>
178       </element>
179     </DataElement>
180   </resource>
181 </entry>
```

182

1.3.4 Element Example “Reference” in OWL

```

183 ### http://hl7.org/fhir/Reference
184
185 fhir:Reference rdf:type owl:Class ;
186
187   rdfs:subClassOf fhir:Element ,
188     [ rdf:type owl:Restriction ;
189       owl:onProperty fhir:Reference.link ;
190       owl:allValuesFrom fhir:DomainResource
191     ] ,
192     [ rdf:type owl:Restriction ;
193       owl:onProperty fhir:Reference.display ;
194       owl:maxCardinality "1"^^xsd:nonNegativeInteger
195     ] ,
196     [ rdf:type owl:Restriction ;
197       owl:onProperty fhir:Reference.display ;
198       owl:allValuesFrom fhir:string
199     ] ,
200     [ rdf:type owl:Restriction ;
201       owl:onProperty fhir:Reference.reference ;
202       owl:allValuesFrom fhir:string
203     ] ,
204     [ rdf:type owl:Restriction ;
205       owl:onProperty fhir:Reference.reference ;
206       owl:maxCardinality "1"^^xsd:nonNegativeInteger
207     ] ,
208     [ rdf:type owl:Restriction ;
209       owl:onProperty fhir:Reference.link ;
210       owl:maxCardinality "1"^^xsd:nonNegativeInteger
211     ] ;
212   fhir:lastUpdated "2015-12-31T00:38:37.614+00:00"^^xsd:dateTime ;
213   fhir:isSummary "true"^^xsd:boolean ;
```

```
214     fhir:experimental "true"^^xsd:boolean ;
215     fhir:concept_definition "A reference from one resource to another" ;
216     fhir:status "draft" ;
217     fhir:stringency "fully-specified" ;
218     fhir:short "A reference from one resource to another" .
```

219

220 The object property restrictions are all defined in the containing element as opposed to FHIR Element
221 definitions.

222 [1.3.5 Element Property “Reference.display” example in OWL](#)

```
223 ### http://hl7.org/fhir/Reference.display
224
225 fhir:Reference.display rdf:type owl:ObjectProperty ;
226   rdfs:domain fhir:Reference ;
227   rdfs:subPropertyOf fhir:objectProperty ;
228   rdfs:range fhir:string .
```

229

1.3.6 Element Definition to OWL mapping

FHIR Element Definition	FHIR OWL Definitions
<[name] xmlns="http://hl7.org/fhir">	
<!-- from Element: extension -->	
<path value="[string]" /><!-- 1..1 The path of the element (see the Detailed Descriptions) -->	fhir:[string] rdf:type owl:Class ; fhir: "[string]" rdf:type owl:ObjectProperty ;
<representation value="[code]" /><!-- 0..* How this element is represented in instances -->	
<name value="[string]" /><!-- 0..1 Name for this particular element definition (reference target) -->	
<label value="[string]" /><!-- 0..1 Name for element to display with or prompt for element -->	rdfs:label
<code><!-- 0..* Coding Defining code --></code>	
<slicing> <!-- 0..1 This element is sliced - slices follow -->	
<discriminator value="[string]" /><!-- 0..* Element values that used to distinguish the slices -->	
<description value="[string]" /><!-- 0..1 Text description of how slicing works (or not) -->	
<ordered value="[boolean]" /><!-- 0..1 If elements must be in same order as slices -->	
<rules value="[code]" /><!-- 1..1 closed open openAtEnd -->	
</slicing>	
<short value="[string]" /><!-- 0..1 Concise definition for xml presentation -->	fhir:short "" .
<definition value="[markdown]" /><!-- 0..1 Full formal definition as narrative text -->	fhir:concept_definition "" ;
<comments value="[markdown]" /><!-- 0..1 Comments about the use of this element -->	
<requirements value="[markdown]" /><!-- 0..1 Why is this needed? -->	
<alias value="[string]" /><!-- 0..* Other names -->	
<min value="[integer]" /><!-- 0..1 Minimum Cardinality -->	[rdf:type owl:Restriction ; owl:onProperty fhir:"[property]" ; owl:minCardinality "[N]"^^xsd:nonNegativeInteger] ,
<max value="[string]" /><!-- 0..1 Maximum Cardinality (a number or *) -->	[rdf:type owl:Restriction ; owl:onProperty fhir:"[property]" ; owl:maxCardinality "[N]"^^xsd:nonNegativeInteger] ,
<base> <!-- 0..1 Base definition information for tools -->	owl:subClassOf owl:subPropertyOf
<path value="[string]" /><!-- 1..1 Path that identifies the base element -->	
<min value="[integer]" /><!-- 1..1 Min cardinality of the base element -->	
<max value="[string]" /><!-- 1..1 Max cardinality of the base element -->	
</base>	
<type> <!-- 0..* Data type and Profile for this element -->	rdf:type
<code value="[code]" /><!-- 1..1 Name of Data type or Resource -->	
<profile value="[uri]" /><!-- 0..* Profile (StructureDefinition) to apply (or IG) -->	
<aggregation value="[code]" /><!-- 0..* contained referenced bundled - how aggregated -->	
</type>	

```

<nameReference value="[string]" /><!-- 0..1 To
another element constraint (by element.name) -->
<defaultValue[x]><!-- 0..1 * Specified value it
missing from instance --></defaultValue[x]>
<meaningWhenMissing value="[markdown]" /><!-- 0..1
Implicit meaning when this element is missing -->
<fixed[x]><!-- 0..1 * Value must be exactly this --
</fixed[x]>
<pattern[x]><!-- 0..1 * Value must have at least
these property values --></pattern[x]>
<example[x]><!-- 0..1 * Example value: [as defined
for type] --></example[x]>
<minValue[x]><!-- 0..1 * Minimum Allowed Value (for
some types) --></minValue[x]>
<maxValue[x]><!-- 0..1 * Maximum Allowed Value (for
some types) --></maxValue[x]>
<maxLength value="[integer]" /><!-- 0..1 Max length
for strings -->
<condition value="[id]" /><!-- 0..* Reference to
invariant about presence -->
<constraint> <!-- 0..* Condition that must evaluate
to true -->
  <key value="[id]" /><!-- 1..1 Target of 'condition'
reference above -->
  <requirements value="[string]" /><!-- 0..1 Why this
constraint necessary or appropriate -->
  <severity value="[code]" /><!-- 1..1 error | warning
-->
  <human value="[string]" /><!-- 1..1 Human description
of constraint -->
  <xpath value="[string]" /><!-- 1..1 XPath expression
of constraint -->
</constraint>
<mustSupport value="[boolean]" /><!-- 0..1 If the
element must supported -->
<isModifier value="[boolean]" /><!-- 0..1 If this
modifies the meaning of other elements -->
<isSummary value="[boolean]" /><!-- 0..1 Include when
_summary = true? -->
<binding> <!-- 0..1 ValueSet details if this is
coded -->
  <strength value="[code]" /><!-- 1..1 required | extensible | preferred | example --> Only required and extensible are mapped to
extensible | preferred | example --> owl:restriction. Other are mapped to owl:annotation
  <description value="[string]" /><!-- 0..1 Human
explanation of the value set -->
  <valueSet[x]><!-- 0..1 uri|Reference(ValueSet)
Source of value set --></valueSet[x]> [ rdf:type owl:Restriction ; owl:onProperty
fhir:[property] ;owl:allValuesFrom '[value-set]' ] ,
</binding>
<mapping> <!-- 0..* Map element to another set of
definitions -->
  <identity value="[id]" /><!-- 1..1 Reference to
mapping declaration -->
  <language value="[code]" /><!-- 0..1 Computable
language of mapping ↗ -->
  <map value="[string]" /><!-- 1..1 Details of the
mapping -->
</mapping>
</[name]>

```

231 **2 Message and Resource identity**

232 **2.1 XML Identity**

233 **2.1.1 XML File identity**

234 The read RESTful interaction

235 `GET [base]/[type]/[id] {?_format=[mime-type]}`

236 Causes a return of the mime type file which has an identity of [base]/[type]/[id].[mime-type] These four parts
237 form the dereferenceable URI and the identity of that file.

238 **2.1.2 XML Resource identity**

239 The XML Root tag binds the root element to a Complex Type. In FHIR the tag and the Complex Type have the
240 same value however this is not always true in XML.

```
241 <AllergyIntolerance xmlns="http://hl7.org/fhir" >
242   <id value="1"/>
243   <text>
244     </text>
245   <!-- the date that this entry was recorded -->
246   <recordedDate value="2010-03-01"/>
247   <!-- the patient that actually has the risk of adverse reaction -->
248   <patient>
249     <reference value="http://record/Patient/PeterPatient"/>
250     <display value="Peter Patient"/>
251   </patient>
252   <!-- substance, coded from SNOMED CT-->
253   <substance>
254     <coding>
255       <system value="http://snomed.info/id/" />
256       <code value="90614001"/>
257       <display value="beta-Lactam antibiotic"/>
258     </coding>
259   </substance>
260   <status value="confirmed"/>
261   <criticality value="high"/>
262   <category value="medication"/>
263 </AllergyIntolerance>
```

264 The id value represents only a segment of the identifier. The type is taken from the root element and the base is
265 not included in the Resource so it is not clear in FHIR that the Resource can be clearly disambiguated.

266 **2.2 RDF/OWL identities**

```
267 @prefix owl: <http://www.w3.org/2002/07/owl#> .
268 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
269 @prefix xml: <http://www.w3.org/XML/1998/namespace> .
270 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
271 @prefix fhir: <http://hl7.org/fhir/> .
272 @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
273 <http://record/AllergyIntolerance/1> rdf:type owl:Ontology ; owl:imports <http://hl7.org/fhir> .
274
275 <http://record/AllergyIntolerance/1> rdf:type <http://PatientSafetyProfile/AllergyIntolerance> ,
276 owl:NamedIndividual ;
277   fhir:Resource.id [ rdf:type fhir:id ; fhir:value "1" ] ;
278   fhir:AllergyIntolerance.status [ rdf:type fhir:code ;
279     fhir:ConceptBase.coding [ fhir:CodingBase.code [ fhir:value "confirmed" ] ] ]
280   ] ;
281   fhir:AllergyIntolerance.patient [ rdf:type fhir:Reference ;
282     fhir:Reference.reference [ fhir:value "http://record/Patient/PeterPatient" ] ;
283     fhir:Reference.display [ fhir:value "Peter Patient" ] ;
284   ] ;
285   fhir:AllergyIntolerance.substance [ rdf:type fhir:CodeableConcept , <http://snomed.info/id/90614001>;
286     fhir:ConceptBase.coding [ rdf:type fhir:CodingBase ;
287       fhir:CodingBase.code [ rdf:type fhir:codeBase ; fhir:value "90614001" ] ;
288       fhir:CodingBase.system [ rdf:type fhir:uri ; fhir:value "http://snomed.info/sct" ] ;
289       fhir:CodingBase.display [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ] ]
290     ] ;
291     fhir:ConceptBase.text [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ]
292   ] .
```

293

294 **2.2.1 RDF File identity**

295 The identity of the RDF file is its file name (e.g. <http://record/AllergyIntolerance/1.ttl>)

296 The first three segment (without the mime-type) are the name of the Ontology.

```
297 <http://record/AllergyIntolerance/1> rdf:type owl:Ontology ;
```

298 The file is an ontology. This is required since there appears to be a restriction on import statements importing
299 the same ontology more than once. This is independent of prefixes of the elements.

300 **2.2.2 RDF Individual identity**

301 The name of the individual is derived from the URL identity of the resource. The class of the individual is
302 declared using rdf:type:

```
303 <http://record/AllergyIntolerance/1> rdf:type <http://PatientSafetyProfile/AllergyIntolerance>,
304 owl:NamedIndividual ;
```

305 In simple resources the identity of the message is mapped to the identity of the root element. However they
306 may have different types.

307 In this case the name of the individual is the same as the name of the ontology. This appears to work.

308 In Bundles the identity of the message (bundle) is different from the identities of contained resources.

309 Note that the type of the resource is qualified by the profile which is obtained from Meta.profile (see Profile
310 section later).

311 **2.2.3 Ontology triples**

312 The ontology identity is linked to the import predicate which links to the fhir ontology:

313 <[http://hl7.org/fhir](http://record>AllergyIntolerance/1> rdf:type owl:Ontology ; owl:imports < .

314 The import statement is required for Turtle files so that the loading can distinguish between Object Properties

315 and Annotation Properties.

316

317 3 Datatypes (section 1.18.0.1)

318 Difference in the treatment of datatypes code, string and uri as classes with primitive values as rdf:Datatypes.
319 Datatypes are transformed into OWL Classes where the value is expressed as a an OWL DataProperty with
320 restrictions (facets etc).

321 3.1 Id

322 3.1.1 Id instance

323 3.1.2 Id schema

```
324 fhir:id rdf:type owl:Class ;
325     rdfs:subClassOf fhir:Element ,
326         [ rdf:type owl:Restriction ;
327             owl:onProperty fhir:value ;
328             owl:allValuesFrom [ rdf:type rdfs:Datatype ;
329                 owl:onDatatype xsd:string ;
330                 owl:withRestrictions ( [ xsd:pattern "[A-Za-z0-9\\-\\.]{1,64}" ] )
331                     ]
332                 ],
333             [ rdf:type owl:Restriction ;
334                 owl:onProperty fhir:value ;
335                 owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
336                 owl:onDataRange xsd:string
337             ];
338             rdfs:comment "Any combination of letters, numerals, '-' and '.' with a length limit of 64 characters.
339 (This might be an integer, an unprefixed OID, UUID or any other identifier pattern that meets these constraints.)
340 Ids are case-insensitive." .
```

341 Note that since id is case insensitive but RDF is case sensitive, the id containing letters should be converted to
342 lower case.

343 3.2 Decimal

344 Decimal has an additional DataProperty fhir:fractionDigits which allows the explicit declaration of scale.

345 3.2.1 Decimal OWL instance

```
346 [ a fhir:decimal ; fhir:value 123.4 ; fhir:fractionDigits 3 ]
```

347 3.2.2 Decimal OWL Schema

```
348 fhir:decimal rdf:type owl:Class ;
349     rdfs:subClassOf fhir:Element ,
350         [ rdf:type owl:Restriction ;
351             owl:onProperty fhir:fractionDigits ;
352             owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
353             owl:onDataRange xsd:nonNegativeInteger
354         ],
355         [ rdf:type owl:Restriction ;
356             owl:onProperty fhir:fractionDigits ;
357             owl:allValuesFrom xsd:nonNegativeInteger
358         ],
359         [ rdf:type owl:Restriction ;
360             owl:onProperty fhir:value ;
361             owl:allValuesFrom xsd:decimal
362         ],
363         [ rdf:type owl:Restriction ;
364             owl:onProperty fhir:value ;
365             owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
366             owl:onDataRange xsd:decimal
367         ];
368         rdfs:comment "A rational number with implicit precision" .
```

370 **3.3 FHIR CodeableConcept and Coding Structure Definition**

371 **3.3.1 FHIR XML**

372 Codeable Concept example

```
373 <substance>
374   <coding>
375     <system value="http://snomed.info/sct"/>
376     <code value="90614001"/>
377     <display value=" beta-lactam (antibiotic)"/>
378   </coding>
379   <text value=" beta-lactam (antibiotic)"/>
380 </substance>
```

381 CodeableConcept Structural Definition

```
382 <[name] xmlns="http://hl7.org/fhir">
383   <!-- from Element: extension -->
384   <coding><!-- 0..* Coding Code defined by a terminology system --></coding>
385   <text value="[string]" /><!-- 0..1 Plain text representation of the concept -->
386 </[name]>
```

387

388 Coding Structural Definition

```
389 <[name] xmlns="http://hl7.org/fhir">
390   <!-- from Element: extension -->
391   <system value="[uri]" /><!-- 0..1 Identity of the terminology system -->
392   <version value="[string]" /><!-- 0..1 Version of the system - if relevant -->
393   <code value="[code]" /><!-- 0..1 Symbol in syntax defined by the system -->
394   <display value="[string]" /><!-- 0..1 Representation defined by the system -->
395   <primary value="[boolean]" /><!-- 0..1 If this code was chosen directly by the user -->
396 </[name]>
```

397

398 **3.3.2 RDF Data for Codeable Concept Instance**

399 The RDF variant for fhir:Code, fhir:Coding and fhir:CodeableConcept are not straight translations of the FHIR
400 representation. 3 new additional classes are introduced – codeBase, CodingBase and ConceptBase.

```
401   fhir:AllergyIntolerance.substance [ rdf:type fhir:CodeableConcept ;
402     fhir:ConceptBase.coding [ rdf:type fhir:CodingBase ;
403       fhir:CodingBase.code [ rdf:type fhir:codeBase ; fhir:value "90614001" ] ;
404       fhir:CodingBase.system [ rdf:type fhir:uri ; fhir:value "http://snomed.info/sct" ] ;
405       fhir:CodingBase.display [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ]
406     ] ;
407     fhir:ConceptBase.text [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ]
408   ] .
```

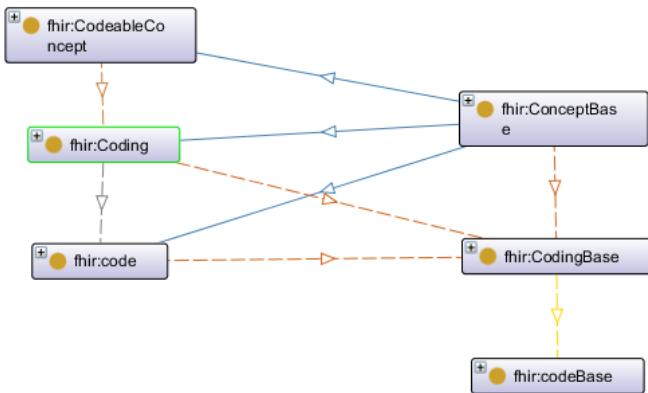
409

410 The fhir:CodeableConcept type assertion allows round trip back to the original XML type. The same approach
411 will be taken for fhir:Coding and fhir:code.

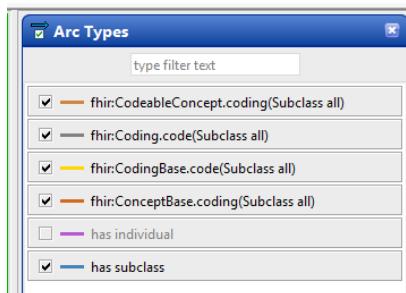
412 This approach will be implemented by creating ConceptBase, CodingBase and codeBase individuals as blank
413 nodes.

414 3.3.3 FHIR OWL Schema

415 ConceptBase has subclasses fhir:CodeableConcept, fhir:Coding and fhir:code.



416



417

```

418 [ rdf:type owl:AllDisjointClasses ;
419   owl:members ( fhir:CodingBase
420                 fhir:ConceptBase
421                 fhir:codeBase
422               )
423 ] .
  
```

424

```

425 #####
426 # Classes
427 #####
428
429 ### http://hl7.org/fhir/ConceptBase
430
431 fhir:ConceptBase rdf:type owl:Class ;
432   rdfs:subClassOf fhir:Datatype ,
433   [ rdf:type owl:Restriction ;
434     owl:onProperty fhir:ConceptBase.coding ;
435     owl:allValuesFrom fhir:CodingBase
436   ] ,
437   [ rdf:type owl:Restriction ;
438     owl:onProperty fhir:ConceptBase.text ;
439     owl:maxCardinality "1"^^xsd:nonNegativeInteger
440   ] ,
441   [ rdf:type owl:Restriction ;
442     owl:onProperty fhir:ConceptBase.text ;
443     owl:allValuesFrom fhir:string
444   ]
  
```

```
447     ### http://hl7.org/fhir/CodingBase
448     fhir:CodingBase rdf:type owl:Class ;
449         rdfs:subClassOf fhir:Element ,
450             [ rdf:type owl:Restriction ;
451                 owl:onProperty fhir:CodingBase.system ;
452                 owl:allValuesFrom fhir:uri
453             ] ,
454             [ rdf:type owl:Restriction ;
455                 owl:onProperty fhir:CodingBase.system ;
456                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
457             ] ,
458             [ rdf:type owl:Restriction ;
459                 owl:onProperty fhir:CodingBase.version ;
460                 owl:allValuesFrom fhir:string
461             ] ,
462             [ rdf:type owl:Restriction ;
463                 owl:onProperty fhir:CodingBase.version ;
464                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
465             ] ,
466             [ rdf:type owl:Restriction ;
467                 owl:onProperty fhir:CodingBase.code ;
468                 owl:allValuesFrom fhir:codeBase
469             ] ,
470             [ rdf:type owl:Restriction ;
471                 owl:onProperty fhir:CodingBase.code ;
472                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
473             ] ,
474             [ rdf:type owl:Restriction ;
475                 owl:onProperty fhir:CodingBase.display ;
476                 owl:allValuesFrom fhir:string
477             ] ,
478             [ rdf:type owl:Restriction ;
479                 owl:onProperty fhir:CodingBase.display ;
480                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
481             ] ,
482             [ rdf:type owl:Restriction ;
483                 owl:onProperty fhir:CodingBase.primary ;
484                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
485             ] ,
486             [ rdf:type owl:Restriction ;
487                 owl:onProperty fhir:CodingBase.primary ;
488                 owl:allValuesFrom fhir:boolean
489             ] .
490
```

```
491
492     fhir:codeBase rdf:type owl:Class ;
493         rdfs:subClassOf fhir:Element ,
494             [ rdf:type owl:Restriction ;
495                 owl:onProperty fhir:value ;
496                 owl:allValuesFrom xsd:token
497             ] ,
498             [ rdf:type owl:Restriction ;
499                 owl:onProperty fhir:value ;
500                 owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
501                 owl:onDataRange xsd:token
502             ] .
```

503 The concrete subclasses of ConceptBase apply the additional restrictions:

```
504     ### http://hl7.org/fhir/CodeableConcept
505     fhir:CodeableConcept rdf:type owl:Class ;
506         rdfs:subClassOf fhir:ConceptBase ;
507         rdfs:comment "The set of possible coded values this coding was chosen from or constrained by." .
508
```

```
509     ### http://hl7.org/fhir/Coding
510     fhir:Coding rdf:type owl:Class ;
511         rdfs:subClassOf fhir:ConceptBase ,
512             [ rdf:type owl:Restriction ;
513                 owl:onProperty fhir:ConceptBase.text ;
514                 owl:maxCardinality "0"^^xsd:nonNegativeInteger
515             ] ,
516             [ rdf:type owl:Restriction ;
517                 owl:onProperty fhir:ConceptBase.coding ;
518                 owl:cardinality "1"^^xsd:nonNegativeInteger
519             ] .
```

```
520
521     fhir:code rdf:type owl:Class ;
522         rdfs:subClassOf fhir:ConceptBase , [ rdf:type owl:Restriction ;
523             owl:onProperty fhir:ConceptBase.coding ;
524             owl:allValuesFrom [ rdf:type owl:Class ;
525                 owl:intersectionOf ( fhir:CodingBase
526                     [ rdf:type owl:Restriction ;
527                         owl:onProperty fhir:CodingBase.code ;
528                         owl:cardinality "1"^^xsd:nonNegativeInteger
529                     ] [
530                     rdf:type owl:Restriction ;
531                         owl:onProperty fhir:CodingBase.display ;
532                         owl:maxCardinality "0"^^xsd:nonNegativeInteger
533                     ] [
534                     rdf:type owl:Restriction ;
535                         owl:onProperty fhir:CodingBase.primary ;
536                         owl:maxCardinality "0"^^xsd:nonNegativeInteger
537                     ] [
538                     rdf:type owl:Restriction ;
539                         owl:onProperty fhir:CodingBase.system ;
540                         owl:maxCardinality "1"^^xsd:nonNegativeInteger
541                     ] [
542                     rdf:type owl:Restriction ;
543                         owl:onProperty fhir:CodingBase.version ;
544                         owl:maxCardinality "1"^^xsd:nonNegativeInteger
545                     ]
546                 )
547             ]
548         ] ,
549         [ rdf:type owl:Restriction ;
550             owl:onProperty fhir:ConceptBase.coding ;
551             owl:cardinality "1"^^xsd:nonNegativeInteger
552         ] .
```

553

554 **4 Terminology**

555 **4.1 Code system**

556 A code system is a namespace which makes its codes unique. A Code system may contain Concepts. You can
557 have many concept hierarchies in the same code system (e.g. SNOMED) or you can have one concept hierarchy
558 in a code system (e.g. HL7 internal codes).

559 **4.1.1 HL7 FHIR Internal Code System XML example**

560 A definition of a code system, inlined into the value set instance (as a packaging convenience).

```
561 <codeSystem>
562   <extension url="http://hl7.org/fhir/StructureDefinition/valueset-oid">
563     <valueUri value="urn:oid:2.16.840.1.113883.4.642.1.50"/>
564   </extension>
565   <system value="http://hl7.org/fhir/allergy-intolerance-status"/>
566   <version value="1.0.0"/>
567   <caseSensitive value="true"/>
568   <concept>
569     <code value="active"/>
570     <display value="Active"/>
571     <definition value="An active record of a reaction to the identified Substance."/>
572     <concept>
573       <code value="confirmed"/>
574       <display value="Confirmed"/>
575       <definition value="A high level of certainty about the propensity for a reaction to the identified Substance,
576         which may include clinical evidence by testing or rechallenge."/>
577     </concept>
578   </concept>
579 </codeSystem>
```

580

581 **4.1.2 RDF CodeSystemURI declaration**

582 A code system will have one named individual representing the code system. This is a member of class:
583 fhir:CodeSystemURI.

584 CodeSystemURI is a subclass of fhir:uri and allows named individuals to represent the URI. The properties are
585 added to it as annotation properties.

586 Thus the reference to a system in CodingBase.system can have a value e.g. <<http://snomed.info/sct>> and not
587 have to declare a further anonymous individual.

588 **4.1.2.1 HL7 Internal Code system URI example**

```
589 ### http://hl7.org/fhir/cs/allergy-intolerance-status
590
591 fhircs:allergy-intolerance-status rdf:type fhir:CodeSystemURI , owl:NamedIndividual ;
592   fhir:caseSensitive "true"^^xsd:boolean ;
593   fhir:valueset-oid "urn:oid:2.16.840.1.113883.4.642.1.50" ;
594   fhir:value "http://hl7.org/fhir/cs/allergy-intolerance-status" ;
595   fhir:prefix "http://hl7.org/fhir/allergy-intolerance-status#" ;
596   fhir:version "1.0.2" .
```

597 Note that since this acts as a namespace it has the case sensitivity indicator and a prefix (not in HL7 FHIR) to
598 prepend the concepts to make them unique.

599 **4.1.2.2 SNOMED RDF Code System URI example**

```
600    ##### http://snomed.info/sct  
601  
602 <http://snomed.info/sct> rdf:type fhir:CodeSystemURI , owl:NamedIndividual ;  
603   fhir:value "http://snomed.info/sct"^^xsd:anyURI .  
604   fhir:caseSensitive "false"^^xsd:boolean ;  
605   fhir:prefix "http://snomed.info/id/"^^xsd:string ;  
606   fhir:valueset-oid "2.16.840.1.113883.6.96" ;  
607   fhir:version "US1000124_20140301" .
```

608 Code systems are published at <http://hl7-fhir.github.io/terminologies-systems.html> and the URI
609 identifier is used for FHIR/RDF rather than the OID.

610 **4.1.2.3 Code System Version**

611 Version of code system as part of the name is TBD.

612 **4.2 Bridging Ontologies**

613 Both external and HL7 internal terminologies use bridging ontologies to map between the Concepts and Codes.

614 If the terminology has an RDF representation then the bridging ontology binds from a common representation
615 of Concept, Code and Value Set to that terminology.

616 In the case that there is not and RDF representation then the bridging ontology provides the complete
617 representation and is constructed by transformation of the non-RDF representation.

618 **4.3 Concept**

619 **4.3.1 RDF Concept Definition**

620 A Concept in RDF/OWL is a named Class which has a restriction for CodingBase individuals associated with that
621 concept. A specific Concept is a named subclass of the fhir:Concepts class or it is a subclass of another Concept.
622 Where the restrictions are defined on the Concept they are the intersection of the restriction on
623 ConceptBase.coding and CodingBase.code and CodingBase.system.

624 Concepts may have one or more CodingBase restrictions. The FHIR valueset resource structure definition only
625 allows one but the RDF equivalent will relax that cardinality. A Concept which has multiple Codes associated
626 with it, have a union of multiple CodingBase.code restrictions.

627 **4.3.2 HL7 Bridging Ontology**

628 **4.3.2.1 HL7 FHIR XML Concept**

629 The following fragment from Allergy Intolerance Status found at <http://hl7-fhir.github.io/valueset-allergy-intolerance-status.html>

631 In FHIR, Code System contains ValueSet.codeSystem.concept elements.

632 ValueSet.codeSystem.concept have code, abstract, display, definition, designation and nested
633 Valueset.Concepts.

```

634 <codeSystem>
635   <extension url="http://hl7.org/fhir/StructureDefinition/valueset-oid">
636     <valueUri value="urn:oid:2.16.840.1.113883.4.642.1.50"/>
637   </extension>
638   <system value="http://hl7.org/fhir/allergy-intolerance-status"/>
639   <version value="1.0.0"/>
640   <caseSensitive value="true"/>
641   <concept>
642     <code value="active"/>
643     <display value="Active"/>
644     <definition value="An active record of a reaction to the identified Substance."/>
645     <concept>
646       <code value="confirmed"/>
647       <display value="Confirmed"/>
648       <definition value="A high level of certainty about the propensity for a reaction to the identified Substance,
649         which may include clinical evidence by testing or rechallenge."/>
650     </concept>
651   </concept>
652 </codeSystem>
653 </ValueSet>

```

654 The nesting of <concept> represents general to specific concepts although the structure does not indicate that
 655 semantic but rather a containment.

4.3.2.2 FHIR internal XML Concept mapping

656 The RDF Concept is a named Class which maps to the components of the ValueSet.codeSystem.concept element
 657 in FHIR Valueset Resource.

- 659 • System maps to the restriction on CodingBase.system
- 660 • Code maps to the restriction on CodingBase.code
- 661 • Display maps to rdfs:label
- 662 • Definition maps to fhir:concept_definition annotation
- 663 • Nesting maps to subclass assertions (as a default)
- 664 • An abstract Concept (ValueSetConcept.abstract = "true") has no restriction on CodingBase.code just a
 665 position in the class hierarchy.
- 666 • Designation will probably transform into annotation language (e.g. @en) or type.

667 4.3.2.3 *HL7 Internal Concept RDF Example*

```
668    #### http://hl7.org/fhir/allergy-intolerance-status#Concept
669
670    allergy-intolerance-status:Concept rdf:type owl:Class ;
671     rdfs:label "Allergy Intolerance Status Concept" ;
672     rdfs:subClassOf fhir:Concepts ;
673     fhir:concept_definition "Assertion about certainty associated with a propensity, or potential risk, of a reaction to the
674     identified Substance." .
675
676    #### http://hl7.org/fhir/allergy-intolerance-status#active
677
678    allergy-intolerance-status:active rdf:type owl:Class ;
679     rdfs:label "Active" ;
680     rdfs:subClassOf allergy-intolerance-status:Concept ;
681     fhir:concept_definition "An active record of a reaction to the identified Substance" .
682
683 [ rdf:type owl:Restriction ;
684     rdfs:subClassOf allergy-intolerance-status:active ; owl:onProperty fhir:ConceptBase.coding ;
685     owl:someValuesFrom [ rdf:type owl:Class ;
686         owl:intersectionOf ( [ rdf:type owl:Restriction ;
687             owl:onProperty fhir:CodingBase.code ;
688             owl:allValuesFrom [ rdf:type owl:Restriction ;
689                 owl:onProperty fhir:value ;
690                 owl:hasValue "active"
691             ]
692             ]
693             [ rdf:type owl:Restriction ;
694             owl:onProperty fhir:CodingBase.system ;
695             owl:hasValue fhircs:allergy-intolerance-status
696             ]
697         )
698     ]
699 ]
700
701 #### http://hl7.org/fhir/allergy-intolerance-status#confirmed
702
703 allergy-intolerance-status:confirmed rdf:type owl:Class ;
704     rdfs:label "Confirmed@en" ;
705     rdfs:subClassOf allergy-intolerance-status:active ;
706     fhir:concept_definition "A high level of certainty about the propensity for a reaction to the identified Substance, which may
707     include clinical evidence by testing or rechallenge." .
708
709 [ rdf:type owl:Restriction ;
710     rdfs:subClassOf allergy-intolerance-status:confirmed ; owl:onProperty fhir:ConceptBase.coding ;
711     owl:someValuesFrom [ rdf:type owl:Class ;
712         owl:intersectionOf ( [ rdf:type owl:Restriction ;
713             owl:onProperty fhir:CodingBase.code ;
714             owl:allValuesFrom [ rdf:type owl:Restriction ;
715                 owl:onProperty fhir:value ;
716                 owl:hasValue "confirmed"
717             ]
718             ]
719             [ rdf:type owl:Restriction ;
720             owl:onProperty fhir:CodingBase.system ;
721             owl:hasValue fhircs:allergy-intolerance-status
722             ]
723         )
724     ]
725 ]
726
727
```

728 **4.3.2.4 External Concept RDF Example**
729 An external terminology is treated differently in that it is assumed that the ontology provided by the external
730 organization cannot be changed. A bridging ontology is therefore provided which allows the expressions to be
731 added to bind to the FHIR CodingBase instances.
732 The bridging ontology is constructed to add the expressions to categorize FHIR CodingBase individuals. This
733 binding occurs at both code/system and concepts. Direct use of the declared SNOMED concept identifier is
734 shown here but it is also possible to make an equivalent class if needed.

735 **4.3.2.4.1 External SNOMED Ontology**

736 The following example from the SNOMED OWL extraction shows the two top Concepts referenced in the
737 valueset substance-code:

```
738     ### http://snomed.info/id/105590001
739
740 <http://snomed.info/id/105590001> rdf:type owl:Class ;
741   rdfs:label "Substance (substance)" ;
742   rdfs:subClassOf <http://snomed.info/id/138875005> .
743
744     ### http://snomed.info/id/373873005
745
746 <http://snomed.info/id/373873005> rdf:type owl:Class ;
747   rdfs:label "Pharmaceutical / biologic product (product)" ;
748   rdfs:subClassOf <http://snomed.info/id/138875005> .
```

749 Notice there is no description and the display value is in rdfs:label. Concept 138875005 is the top level SNOMED
750 CT concept.

751 The extensions of the value set beyond substance-code are defined in SNOMED:

```
752     ### http://snomed.info/id/160244002
753
754 <http://snomed.info/id/160244002> rdf:type owl:Class ;
755   rdfs:label "No Known Allergies" ;
756   rdfs:subClassOf <http://snomed.info/id/138875005> .
757
758     ### http://snomed.info/id/409137002
759
760 <http://snomed.info/id/409137002> rdf:type owl:Class ;
761   rdfs:label "No Known Drug Allergies" ;
762   rdfs:subClassOf <http://snomed.info/id/138875005> .
763
764     ### http://snomed.info/id/428607008
765
766 <http://snomed.info/id/428607008> rdf:type owl:Class ;
767   rdfs:label "No Known Environmental Allergy" ;
768   rdfs:subClassOf <http://snomed.info/id/138875005> .
769
770     ### http://snomed.info/id/429625007
771
772 <http://snomed.info/id/429625007> rdf:type owl:Class ;
773   rdfs:label "No Known Food Allergies" ;
774   rdfs:subClassOf <http://snomed.info/id/138875005> .
```

775 These are shown as subclasses of the top concept which is incorrect.

776 **4.3.2.4.2 Bridging Ontology**

777 The FHIR SCTBridge ontology imports both fhir and snomed ontologies so it can see both:

```
778 <http://hl7.org/fhirSCTBridge> rdf:type owl:Ontology ;
779   owl:imports <http://hl7.org/fhir> ,
780   <http://snomed.info/id> .
```

781 The SNOMED ontology is named <http://snomed.info/id> which makes the concept URI construction natural.

782 The restrictions on the Concepts to CodingBase individuals are made through general class axioms in the same
783 way as internal code systems:

```
784 [ rdf:type owl:Restriction ;
785   rdfs:subClassOf <http://snomed.info/id/90614001> ;
786   owl:onProperty fhir:ConceptBase.coding ;
787   owl:someValuesFrom [ rdf:type owl:Class ;
788     owl:intersectionOf ( [ rdf:type owl:Restriction ;
789       owl:onProperty fhir:CodingBase.code ;
790       owl:allValuesFrom [ rdf:type owl:Restriction ;
791         owl:onProperty fhir:value ;
792         owl:hasValue "90614001"
793       ]
794     ]
795     [ rdf:type owl:Restriction ;
796       owl:onProperty fhir:CodingBase.system ;
797       owl:hasValue <http://snomed.info/sct>
798     ]
799   )
800 ]
801 ] .
```

802 This example shows that the Concept “Beta lactam antibiotic” is inferred when the ConceptBase.coding has a
803 CodingBase where CodingBase.code has a code of 90614001 and CodingBase.system has value
804 <<http://snomed.info/sct>>.

805 **4.3.3 Relationship of Concept to Code SystemURI**

806 The concept defines its CodeSystemURI through ConceptBase.system restriction.

807 The CodeSystemURI being an individual has no relationship to the Concepts in the Code system which are
808 Classes.

809

810 **4.4 ValueSets**

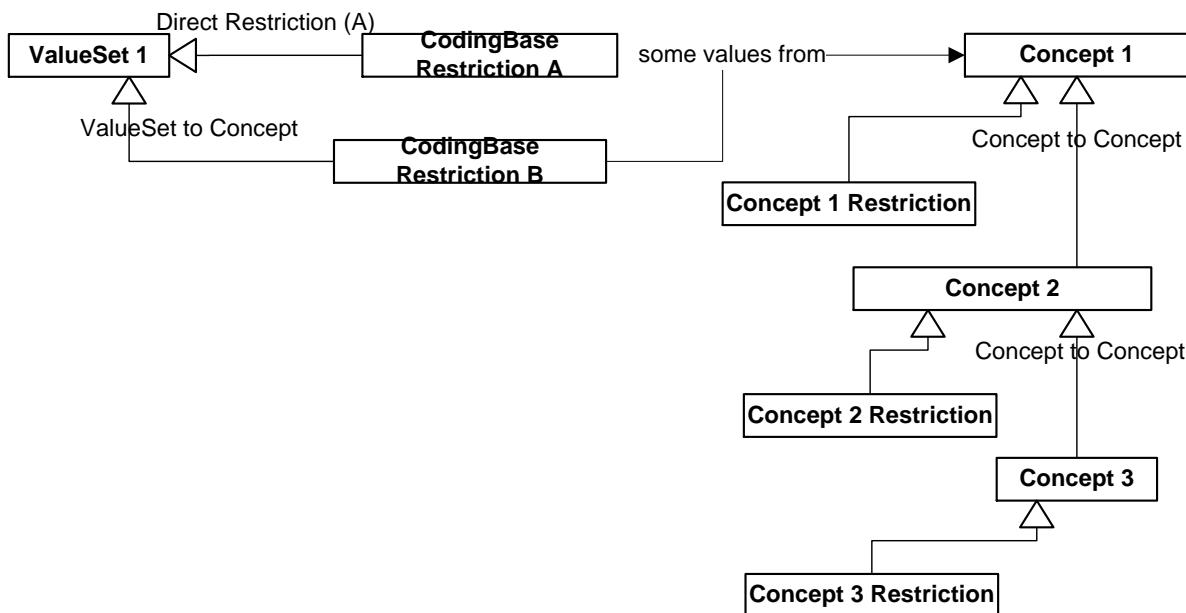
811 A ValueSet in RDF is a specific Class which defines the CodingBase individuals which are members of it.

812 There are two ways of declaring the ValueSet in RDF –

- 813 • ValueSets are named Classes with direct restrictions on CodingBase individuals (system + code)
- 814 • ValueSets are named Classes representing sets of CodingBase restrictions via Concept restrictions.

815 See the later section for more detailed consideration of the flexibility of ValueSet definitions. These definitions
816 will be mapped into the two ways above.

817 The following diagram shows the subclass relationships between the classes:



818

819 A valueset defines a subset of CodingBase individuals which meet the constraints of that ValueSet.

820 Two cases are explored A & B are the direct and indirect (via concepts) restrictions:

- 821 A. ValueSet direct restriction on CodingBase
- 822 B. ValueSet indirect restriction via Concepts

823 4.4.1 Coding Binding to external terminology (section 1.17.3.3.5)

824 4.4.1.1 FHIR XML

```
825 <AllergyIntolerance xmlns="http://hl7.org/fhir" >
826   <id value="1"/>
827   <text>
828     </text>
829   <!-- the date that this entry was recorded -->
830   <recordedDate value="2010-03-01"/>
831   <!-- the patient that actually has the risk of adverse reaction -->
832   <patient>
833     <reference value="http://record/Patient/PeterPatient"/>
834     <display value="Peter Patient"/>
835   </patient>
836   <!-- substance, coded from SNOMED CT-->
837   <substance>
838     <coding>
839       <system value="http://snomed.info/id"/>
840       <code value="90614001"/>
841       <display value="beta-Lactam antibiotic"/>
842     </coding>
843   </substance>
844   <status value="confirmed"/>
845   <criticality value="high"/>
846   <category value="medication"/>
847 </AllergyIntolerance>
```

848 4.4.1.2 RDF Instance Example

849 This is the raw instance before processing and after in green for inference and red for specific processing

```
850 @prefix : <http://record/AllergyIntolerance/> .
851 @prefix owl: <http://www.w3.org/2002/07/owl#> .
852 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
853 @prefix sct: <http://snomed.info/id/> .
854 @prefix xml: <http://www.w3.org/XML/1998/namespace> .
855 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
856 @prefix fhir: <http://hl7.org/fhir/> .
857 @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
858 @prefix profile: <http://PatientSafetyProfile/> .
859 @base <http://record/AllergyIntolerance/1> .
860
861 <http://record/AllergyIntolerance/> rdf:type owl:Ontology ;
862   owl:imports <http://PatientSafetyProfile> .
863
864 ### http://record/AllergyIntolerance/1
865
866 <http://record/AllergyIntolerance/1> rdf:type profile:DomainResource, owl:NamedIndividual ;
867   fhir:Resource.id [ rdf:type fhir:id ; fhir:value "1" ] ;
868   fhir:AllergyIntolerance.status [ rdf:type fhir:code , <http://hl7.org/fhir/allergyIntoleranceStatus#confirmed> ;
869     fhir:ConceptBase.coding [ fhir:CodingBase.code [ fhir:value "confirmed" ] ]
870   ] ;
871   fhir:AllergyIntolerance.patient [ rdf:type fhir:Reference ;
872     fhir:Reference.reference [ fhir:value "http://record/Patient/PeterPatient" ] ;
873     fhir:Reference.display [ fhir:value "Peter Patient" ] ;
874     fhir:Reference.link <http://record/Patient/PeterPatient> ;
875   ] ;
876   fhir:AllergyIntolerance.substance [ rdf:type fhir:CodeableConcept , <http://snomed.info/id/90614001> ;
877     rdfs:label "beta-lactam (antibiotic)" ;
878     fhir:ConceptBase.coding [ rdf:type fhir:CodingBase ;
879       fhir:CodingBase.code [ rdf:type fhir:codeBase ; fhir:value "90614001" ] ;
880       fhir:CodingBase.system [ rdf:type fhir:string ; fhir:value "http://snomed.info/sct" ] ;
881       fhir:CodingBase.display [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ]
882     ] ;
883     fhir:ConceptBase.text [ rdf:type fhir:string ; fhir:value "beta-lactam (antibiotic)" ]
884   ] .
```

885

886 Note the use of a profile binding through the type “profile:AllergyIntolerance” which then restricts the types of
887 CodingBase instances.

888 **4.4.2 OWL Record binding Definition**

889 **4.4.2.1 Allergy Intolerance Class**

890 The OWL schema fragment for the class and object properties is shown here:

```
891     ### http://hl7.org/fhir/AllergyIntolerance
892
893     fhir:AllergyIntolerance rdf:type owl:Class ;
894
895         rdfs:subClassOf fhir:DomainResource ,
896             [ rdf:type owl:Restriction ;
897                 owl:onProperty fhir:AllergyIntolerance.status ;
898                 owl:allValuesFrom fhirvs:allergy-intolerance-statusA
899             ] ,
900             [ rdf:type owl:Restriction ;
901                 owl:onProperty fhir:AllergyIntolerance.status ;
902                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
903             ] ,
904             [ rdf:type owl:Restriction ;
905                 owl:onProperty fhir:AllergyIntolerance.patient ;
906                 owl:allValuesFrom fhir:Reference
907             ] ,
908             [ rdf:type owl:Restriction ;
909                 owl:onProperty fhir:AllergyIntolerance.patient ;
910                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
911             ] ,
912             [ rdf:type owl:Restriction ;
913                 owl:onProperty fhir:AllergyIntolerance.substance ;
914                 owl:allValuesFrom fhir:CodeableConcept
915             ] ,
916             [ rdf:type owl:Restriction ;
917                 owl:onProperty fhir:AllergyIntolerance.substance ;
918                 owl:maxCardinality "1"^^xsd:nonNegativeInteger
919             ] ,
920
921         .....
922
```

923 It shows that:

- 924

925 - AllergyIntolerance.status is restricted to the set defined by fhirvs:allergy-intolerance-statusA because
the binding strength is “required”.
926 - AllergyIntolerance.substance is not restricted to the set defined by
fhirvs:allergyintolerance-substance-code but purely to the CodeableConcept since the binding strength
is “example”.

929

4.4.3 FHIR XML value set definition

930

4.4.3.1 Allergy Intolerance Status Structural Definition

931

```

<element>
  <path value="AllergyIntolerance.status"/>
  <short value="active | unconfirmed | confirmed | inactive | resolved | refuted | entered-in-error"/>
  <definition value="Assertion about certainty associated with the propensity, or potential risk, of a reaction
    to the identified Substance."/>
  <comments value="Decision support would typically raise alerts for 'Unconfirmed', 'Confirmed', and 'Resolved'
    and ignore a 'Refuted' reaction. In particular, 'Refuted' may be useful for reconciliation of the Adverse Reaction
    List. Some implementations may choose to make this field mandatory."/>
  <alias value="State"/>
  <min value="0"/>
  <max value="1"/>
  <type>
    <code value="code"/>
  </type>
  <isModifier value="true"/>
  <isSummary value="true"/>
  <binding>
    <strength value="required"/>
    <description value="Assertion about certainty associated with a propensity, or potential risk, of a reaction
      to the identified Substance."/>
    <valueSetReference>
      <reference value="http://hl7.org/fhir/ValueSet/allergy-intolerance-status"/>
    </valueSetReference>
  </binding>
  <mapping>
    <identity value="v2"/>
    <map value="IAM-17"/>
  </mapping>
  <mapping>
    <identity value="w5"/>
    <map value="status"/>
  </mapping>
</element>
```

964

4.4.3.2 AllergyIntolerance.substance Structural Definition

965

```

<element>
  <path value="AllergyIntolerance.substance"/>
  <short value="Substance, (or class) considered to be responsible for risk"/>
  <definition value="Identification of a substance, or a class of substances, that is considered to be responsible
    for the adverse reaction risk."/>
  <comments value="It is strongly recommended that the substance be coded with a terminology, where possible.
    For example, some terminologies used include RxNorm, SNOMED CT, DM+D, NDFRT, ICD-9, IDC-10,
    UNI, ATC and CPT. Plain text should only be used if there is no appropriate terminology
    available. Additional details about a substance can be specified in the text."/>
  <alias value="Agent"/>
  <min value="1"/>
  <max value="1"/>
  <type>
    <code value="CodeableConcept"/>
  </type>
  <isSummary value="true"/>
  <binding>
    <strength value="example"/>
    <description value="Type of the substance and Negation codes for reporting no known allergies."/>
    <valueSetReference>
      <reference value="http://hl7.org/fhir/ValueSet/allergyintolerance-substance-code"/>
    </valueSetReference>
  </binding>
  <mapping>
    <identity value="v2"/>
    <map value="AL1-3 / IAM-3"/>
  </mapping>
  <mapping>
    <identity value="w5"/>
    <map value="what"/>
  </mapping>
</element>
```

997

998

4.4.3.3 AllergyIntolerance.status Object Property definition

```

999  #### http://hl7.org/fhir/AllergyIntolerance.status
1000
1001 fhir:AllergyIntolerance.status rdf:type owl:ObjectProperty ;
1002   fhir:binding.valueSetReference "http://hl7.org/fhir/ValueSet/allergy-intolerance-status"^^xsd:anyURI ;
1003   fhir:isModifier "true"^^xsd:boolean ;
1004   fhir:isSummary "true"^^xsd:boolean ;
1005   rdfs:comment "Decision support would typically raise alerts for 'Unconfirmed', 'Confirmed', and 'Resolved' and ignore a
1006 'Refuted' reaction. In particular, 'Refuted' may be useful for reconciliation of the Adverse Reaction List. Some implementations
1007 may choose to make this field mandatory." ;
1008   fhir:short "active | unconfirmed | confirmed | inactive | resolved | refuted | entered-in-error" ;
1009   fhir:binding.description "Assertion about certainty associated with a propensity, or potential risk, of a reaction to the
1010 identified Substance." ;
1011   fhir:concept_definition "Assertion about certainty associated with the propensity, or potential risk, of a reaction to the
1012 identified Substance." ;
1013   fhir:binding.strength "required" ;
1014   rdfs:domain fhir:AllergyIntolerance ;
1015   rdfs:range fhir:code ;
1016   rdfs:subPropertyOf fhir:objectProperty .

```

1017

1018

4.4.3.4 AllergyIntolerance.substance Object Property

```

1019 #### http://hl7.org/fhir/AllergyIntolerance.substance
1020
1021 fhir:AllergyIntolerance.substance rdf:type owl:ObjectProperty ;
1022   fhir:isSummary "true"^^xsd:boolean ;
1023   fhir:binding.valueSetReference "http://hl7.org/fhir/ValueSet/allergyintolerance-substance-code" ;
1024   fhir:short "Substance, (or class) considered to be responsible for risk" ;
1025   fhir:concept_definition "Identification of a substance, or a class of substances, that is considered to be responsible for the
1026 adverse reaction risk." ;
1027   fhir:binding.strength "example" ;
1028   rdfs:comment "It is strongly recommended that the substance be coded with a terminology, where possible. For example, some
1029 terminologies used include RxNorm, SNOMED CT, DM+D, NDFRT, ICD-9, IDC-10, UNI, ATC and CPT. Plain text should only be used if
1030 there is no appropriate terminology available. Additional details about a substance can be specified in the text." ;
1031   fhir:binding.description "Type of the substance and Negation codes for reporting no known allergies." ;
1032   rdfs:domain fhir:AllergyIntolerance ;
1033   rdfs:range fhir:CodeableConcept ;
1034   rdfs:subPropertyOf fhir:objectProperty .

```

1035

1036

4.4.4 Approach to Conformance

1037 Binding strength to a ValueSet determines the conformance of the CodingBase.

1038 Almost all of the elements that have a coded data type are bound to a value set. The bindings are associated
1039 with various degrees of flexibility as to how closely the value set should be followed:

Required	To be conformant, instances of this element SHALL include a code from the specified value set
extensible	To be conformant, instances of this element must include a code from the specified value set if any of the codes within the value set can apply to the concept being communicated. If the valueset does not cover the concept (based on human review), alternate codings (from different code systems, including local ones) or (data type allowing) text) may be included instead.
Preferred	Instances are encouraged, to draw from the specified codes for interoperability purposes but are not required to do so to be considered conformant
Example	Instances are not expected or even encouraged to draw from the specified value set. The value set merely provides examples of the types of concepts intended to be included

1040 The classes that the CodingBase individual belong to, are inferred and the individual must belong to the
1041 ValueSet class declared in the schema if its binding strength is “required”.

1042 In the example above, the individual ConceptBase has a CodingBase which is a member of **fhirvs:allergy-**
1043 **intolerance-statusA** so the ConceptBase individual is conformant to the schema.

1044 This implies that a reasoner will work from the values in the CodingBase.system and CodingBase.code to infer
1045 the classes. The ValueSet Class must be equivalent or a superclass of the restriction for this to work.

1046 Being a member of the Target ValueSet meets the “required” binding strength. Being a member of another
1047 ValueSet meets the “extensible” binding strength.

1048 Note that the binding strength for AllergyIntolerance.substance is “example”. It is expected that a Profile would
1049 strengthen this to “required”.

1050 In ORIM, the subclassing of restrictions approach (as a general Class axiom) is taken which avoids complications
1051 from propagation. This subclass approach for restrictions and the superclass approach for Concepts will be taken
1052 in FHIR/RDF.

1053 The testing of the conformance is outside the scope of this paper but is expected to be performed with rules or
1054 query languages.

1055 4.4.5 HL7 Internal Concept RDF Example

1056 4.4.5.1 CodeSystem and Concept XML

```
1057 <ValueSet xmlns="http://hl7.org/fhir">
1058   <id value="allergy-intolerance-status"/>
1059   <meta>
1060     <lastUpdated value="2015-10-27T02:58:28.599+00:00"/>
1061     <profile value="http://hl7.org/fhir/StructureDefinition/valueset-shareable-definition"/>
1062   </meta>
1063   <text>
1064     </text>
1065   <extension url="http://hl7.org/fhir/StructureDefinition/valueset-oid">
1066     <valueUri value="urn:oid:2.16.840.1.113883.4.642.2.50"/>
1067   </extension>
1068   <url value="http://hl7.org/fhir/ValueSet/allergy-intolerance-status"/>
1069   <version value="1.0.2"/>
1070   <name value="AllergyIntoleranceStatus"/>
1071   <status value="draft"/>
1072   <experimental value="false"/>
1073   <publisher value="HL7 (FHIR Project)"/>
1074   <contact>
1075     <telecom>
1076       <system value="other"/>
1077       <value value="http://hl7.org/fhir"/>
1078     </telecom>
1079     <telecom>
1080       <system value="email"/>
1081       <value value="fhir@lists.hl7.org"/>
1082     </telecom>
1083   </contact>
1084   <date value="2015-10-27T02:58:28+00:00"/>
1085   <description value="Assertion about certainty associated with a propensity, or potential risk, of a reaction to the identified Substance."/>
1086   <codeSystem>
1087     <extension url="http://hl7.org/fhir/StructureDefinition/valueset-oid">
1088       <valueUri value="urn:oid:2.16.840.1.113883.4.642.1.50"/>
1089     </extension>
1090     <system value="http://hl7.org/fhir/allergy-intolerance-status"/>
1091     <version value="1.0.2"/>
1092     <caseSensitive value="true"/>
1093     <concept>
1094       <code value="active"/>
1095       <display value="Active"/>
1096       <definition value="An active record of a reaction to the identified Substance."/>
1097     <concept>
1098       <code value="unconfirmed"/>
1099       <display value="Unconfirmed"/>
1100       <definition value="A low level of certainty about the propensity for a reaction to the identified Substance."/>
1101     </concept>
1102     <concept>
1103       <code value="confirmed"/>
1104       <display value="Confirmed"/>
1105       <definition value="A high level of certainty about the propensity for a reaction to the identified Substance, which may include clinical evidence by testing or rechallenge."/>
1106     </concept>
1107     <concept>
1108       <code value="inactive"/>
1109       <display value="Inactive"/>
1110       <definition value="An inactive record of a reaction to the identified Substance."/>
1111     <concept>
1112       <code value="resolved"/>
1113       <display value="Resolved"/>
1114       <definition value="A reaction to the identified Substance has been clinically reassessed by testing or rechallenge and considered to be resolved."/>
1115     </concept>
1116     <concept>
1117       <code value="refuted"/>
1118       <display value="Refuted"/>
1119       <definition value="A propensity for a reaction to the identified Substance has been disproven with a high level of clinical certainty, which may include testing or rechallenge, and is refuted."/>
1120     </concept>
1121     <concept>
1122       <code value="entered-in-error"/>
1123       <display value="Entered In Error"/>
1124       <definition value="The statement was entered in error and is not valid."/>
1125     </concept>
1126     <concept>
1127       <code value="entered-in-error"/>
1128       <display value="Entered In Error"/>
1129       <definition value="The statement was entered in error and is not valid."/>
1130     </concept>
```

```
1131 </concept>
1132 </concept>
1133 </codeSystem>
1134 </ValueSet>
```

4.4.5.2 RDF Direct Restriction

The first option for value set is where the valueset entry defines the direct restriction on code and system itself without referencing a named concept and when the ValueSet is aligned (all codes from) with the CodingSystem the declaration is simple.

Valueset allergy-intolerance-statusA is defined using general class axiom restriction on CodingBase.system

```
1140 ### http://hl7.org/fhir/ValueSet/allergy-intolerance-statusA
1141
1142 fhirvs:allergy-intolerance-statusA rdf:type owl:Class ;
1143   rdfs:subClassOf fhir:Valuesets .
1144
1145 [ rdf:type owl:Restriction ;
1146   rdfs:subClassOf fhirvs:allergy-intolerance-statusA ;
1147   owl:onProperty fhir:CodingBase.system ;
1148   owl:hasValue fhircs:allergy-intolerance-status
1149 ]
1150
```

However, this mechanism does not validate that the coding is actually a member of the Code System which cannot be done without doing an indirect restriction (see B).

4.4.5.3 RDF Aligned ValueSet of CodingBase to Concept (B)

Since we can use the set expressions of OWL on classes (Concepts) there is a simplification to the expression of Valuesets subclasses as shown in allergy-intolerance-statusC.

The concepts are named classes as shown earlier. The Valuesets subclass can now refer to these named classes avoiding repetitive declaration of anonymous classes.

When the valueset is aligned with the code system the ValueSet is a superclass of all the CodingBase individuals which have a type Concept of the top concept (inferred).

```
1161 ### http://hl7.org/fhir/ValueSet/allergy-intolerance-statusC
1162
1163 fhirvs:allergy-intolerance-statusC rdf:type owl:Class ;
1164   rdfs:label "Allergy Int Status C" ;
1165   rdfs:subClassOf fhir:Valuesets .
1166
1167 [ rdf:type owl:Restriction ;
1168   rdfs:subClassOf fhirvs:allergy-intolerance-statusC ;
1169   owl:onProperty fhir:CodingBase.concept ;
1170   owl:someValuesFrom allergy-intolerance-status:Concept
1171 ] .
```

This is entered as a general class axiom as in the other examples.

Note the Object Property CodingBase.concept which is the inverse of ConceptBase.coding:

```
1174 ### http://hl7.org/fhir/CodingBase.concept
1175
1176 fhir:CodingBase.concept rdf:type owl:ObjectProperty ;
1177   owl:inverseOf fhir:ConceptBase.coding ;
1178   rdfs:subPropertyOf fhir:objectProperty .
```

The object property is then used in the restriction to say that the CodingBase individual belongs to the Concept as defined in the Concept restriction (in section 4.2.3).

1181 4.4.6 External terminology ValueSets

1182 4.4.6.1 All codes from

1183 No examples are given where the Valueset is all codes from an external code system since this is generally too
1184 broad. If this is required the same process as internal terminologies can be used.

1185 4.4.6.2 ValueSet Resource example in XML

1186 The valueset "allergyintolerance-substance-code" includes the valueset "substance-code" but adds some
1187 additional codes:

```
1188 <ValueSet xmlns="http://hl7.org/fhir">  
1189   <id value="substance-code"/>  
1190  
1191   <description value="This value set contains concept codes for specific substances"/>  
1192   <copyright value="This value set includes content from SNOMED CT, which is copyright © 2002+ International  
1193     Health Terminology Standards Development Organisation (IHTSDO), and distributed by agreement  
1194     between IHTSDO and HL7. Implementer use of SNOMED CT is not covered by this agreement"/>  
1195   <compose>  
1196     <include>  
1197       <system value="http://snomed.info/sct"/>  
1198       <filter>  
1199         <property value="concept"/>  
1200         <op value="is-a"/>  
1201         <value value="105590001"/>  
1202       </filter>  
1203     </include>  
1204     <include>  
1205       <system value="http://snomed.info/sct"/>  
1206       <filter>  
1207         <property value="concept"/>  
1208         <op value="is-a"/>  
1209         <value value="373873005"/>  
1210       </filter>  
1211     </include>  
1212   </compose>  
1213 </ValueSet>
```

1214

```
1215 <ValueSet xmlns="http://hl7.org/fhir">  
1216   <id value="allergyintolerance-substance-code"/>  
1217  
1218   <description value="This value set includes concept codes for specific substances and negation codes to specify  
1219     the absence of specific types of allergies." />  
1220   <copyright value="This value set includes content from SNOMED CT, which is copyright © 2002+ International  
1221     Health Terminology Standards Development Organisation (IHTSDO), and distributed by agreement  
1222     between IHTSDO and HL7. Implementer use of SNOMED CT is not covered by this agreement"/>  
1223   <compose>  
1224     <import value="http://hl7.org/fhir/ValueSet/substance-code"/>  
1225     <include>  
1226       <system value="http://snomed.info/sct"/>  
1227       <concept>  
1228         <code value="160244002"/>  
1229         <display value="No Known Allergies"/>  
1230       </concept>  
1231       <concept>  
1232         <code value="429625007"/>  
1233         <display value="No Known Food Allergies"/>  
1234       </concept>  
1235       <concept>  
1236         <code value="409137002"/>  
1237         <display value="No Known Drug Allergies"/>  
1238       </concept>  
1239       <concept>  
1240         <code value="428607008"/>  
1241         <display value="No Known Environmental Allergy"/>  
1242       </concept>  
1243     </include>  
1244   </compose>  
1245 </ValueSet>
```

1246 Notice that allergyintolerance-substance-code extends substance-code with 4 concepts with their code
1247 restrictions and the system restriction at the beginning.

1248 **4.4.6.3 RDF CodingBase Direct Restriction (A)**

1249 The Valueset substance-codeB is declared in the FHIR ontology with no restrictions:

```
1250    ##### http://hl7.org/fhir/ValueSet/substance-codeA  
1251    fhirvs:substance-codeB rdf:type owl:Class ;  
1252      rdfs:label "Substance Code" ;  
1253      rdfs:subClassOf fhir:Valuesets.  
1254  
1255
```

1256

1257 In the Bridging Ontology, substance-codeA is declared against CodingBase.system and CodingBase.code
1258 restrictions.

```
1259    [ rdf:type owl:Class ;  
1260      rdfs:subClassOf <http://hl7.org/fhir/ValueSet/substance-codeA> ;  
1261      owl:intersectionOf ( [ rdf:type owl:Restriction ; owl:onProperty fhir:CodingBase.code ;  
1262        owl:allValuesFrom [ rdf:type owl:Class ;  
1263          owl:unionOf ( [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "105590001" ]  
1264          [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "373873005" ]  
1265         )  
1266        ]  
1267        [ rdf:type owl:Restriction ; owl:onProperty fhir:CodingBase.system ;  
1268          owl:hasValue <http://snomed.info/sct>  
1269        ]  
1270       )  
1271      ]  
1272     ]  
1273 ].
```

1274 This will only define the ValueSet as the top code and **does not** include all the subconcepts as codes. In order to
1275 do this an expansion must be made with a filter. See <http://hl7-fhir.github.io/valueset-allergyintolerance-substance-code.html>

1277 The operation <filter><op> declares “is-a” to mean transitive subclassing. However this is not understood by
1278 RDF/OWL. What is understood is the subclassing of the SNOMED Concept ontology itself.

1279 The only solution is to extract all the codes in the hierarchy and explicitly declare them in the Bridging Ontology.
1280 The treatment of allergyintolerance-substance-code is to add the concepts to the enumerated list.

1281 **4.4.6.4 RDF ValueSet binding to Concepts(B)**

1282 The valueset substance-codeB is declared in FHIR as before:

```
1283    ### http://hl7.org/fhir/ValueSet/substance-codeB  
1284    fhirvs:substance-codeB rdf:type owl:Class ;  
1285         rdfs:label "Substance Codes B" ;  
1286         rdfs:subClassOf fhir:Valuesets .
```

1288

1289 The allergyintolerance-substance-code valueset is also declared in FHIR

```
1290    ### http://hl7.org/fhir/ValueSet/allergyintolerance-substance-code  
1291    <http://hl7.org/fhir//ValueSet/allergyintolerance-substance-code> rdf:type owl:Class ;  
1292         rdfs:label "AllergyIntolerance Substance and Negation Codes" ;  
1293         rdfs:subClassOf fhir:CodingBase_in_Valuesets .
```

1295

1296 The bridging ontology declares a general Class axiom which shows the mapping to the Concepts:

```
1297    [ rdf:type owl:Restriction ;  
1298         rdfs:subClassOf <http://hl7.org/fhir/ValueSet/substance-codeB> ;  
1299         owl:onProperty fhir:CodingBase.concept ; owl:someValuesFrom [ rdf:type owl:Class ;  
1300                 owl:unionOf ( <http://snomed.info/id/105590001>  
1301                         <http://snomed.info/id/373873005>  
1302                         )  
1303                         ]  
1304         ].
```

1305

```
1306    [ rdf:type owl:Class ;  
1307         rdfs:subClassOf <http://hl7.org/fhir/ValueSet/allergyintolerance-substance-code> ;  
1308         owl:unionOf ( <http://hl7.org/fhir/ValueSet/substance-codeD>  
1309                 [ rdf:type owl:Restriction ;  
1310                         owl:onProperty fhir:CodingBase.concept ; owl:someValuesFrom [ rdf:type owl:Class ;  
1311                                 owl:unionOf ( <http://snomed.info/id/160244002>  
1312                                         <http://snomed.info/id/409137002>  
1313                                         <http://snomed.info/id/428607008>  
1314                                         <http://snomed.info/id/429625007>  
1315                                 )  
1316                         ]  
1317                 )  
1318         ].
```

1319 CodingBase.concept defines the restriction on concepts for the Codingbase.

1320 The display values are redundant and since closure is achieved with these classes, their display as rdfs:label can
1321 be shown at any time in an OWL tool.

1323 **4.4.6.5 FHIR Allergy Intolerance OWL Schema**

1324 The schema is abridged to show the topics of interest:

```
1325    ### http://hl7.org/fhir/AllergyIntolerance  
1326  
1327    fhir:AllergyIntolerance rdf:type owl:Class ;  
1328  
1329         rdfs:subClassOf fhir:DomainResource ,  
1330                 [ rdf:type owl:Restriction ;  
1331                         owl:onProperty fhir:AllergyIntolerance.substance ;  
1332                         owl:maxCardinality "1"^^xsd:nonNegativeInteger  
1333                 ] ,  
1334                 [ rdf:type owl:Restriction ;  
1335                         owl:onProperty fhir:AllergyIntolerance.substance ;  
1336                         owl:allValuesFrom fhir:CodeableConcept  
1337                 ] ,  
1338         Etc..  
1339         .
```

1340 The substance Object Property has no valueset type yet only the restriction that it is a CodeableConcept type.

1341 The valueset gets applied through the structural definition or profile binding.

1342 **4.4.7 Definitions of Code System, Concept**

1343 This section is needed to ground the definitions of Coding System, and Concept when defined in RDF/OWL.

1344 **4.4.7.1 Code System**

1345 The *system* ensures that codes can be unambiguously traced back to their original definition, and that logical
1346 comparisons, matching and inferences can be performed consistently by different systems.

1347 In RDF/OWL a code system is a namespace in which the code is unique. Since a code forms a fragment of a URI,
1348 the code-system forms a prefix to that fragment making it unique. The code system identity and the prefix may
1349 not be the same but are related using a property of the code system.

URI	Source	OID
http://snomed.info/sct	SNOMED CT (IHTSDO)	2.16.840.1.113883.6.96

1350 The prefix for snomed is http://snomed.info.id/

1351

```
1352    ### http://snomed.info/sct  
1353  
1354    <http://snomed.info/sct> rdf:type fhir:CodeSystemURI ,  
1355                 owl:NamedIndividual ;  
1356  
1357                 fhir:value "http://snomed.info/sct" .
```

1358 A specific CodeSystem may be declared as a class which is a set of all the CodingBase individuals restricted
1359 by the CodingBase.system property.

```

1360
1361     ### http://snomed.info/sct
1362     <http://snomed.info/sct> rdf:type owl:Class ;
1363
1364         rdfs:subClassOf fhir:CodingBase_in_Systems .

```

1365 **4.4.8 Concept**

1366 A concept may be a single Class in RDF which may in turn be a union of multiple classes based on subclass
1367 relationships.

1368 **4.4.8.1 ValueSet**

1369 Example is substance-code used in AllergyIntolerance

1370 **4.4.8.1.1 Summary**

Defining URL:	
Name:	Substance Code
Definition:	This value set contains concept codes for specific substances
OID:	2.16.840.1.113883.4.642.2.57 (for OID based terminology systems)
Copyright:	This value set includes content from SNOMED CT, which is copyright © 2002+ International Health Terminology Standards Development Organisation (IHTSDO), and distributed by agreement between IHTSDO and HL7. Implementer use of SNOMED CT is not covered by this agreement
Source Resource	XML / JSON

1371

1372 **4.4.8.1.2 Content Logical Definition**

1373 This value set includes codes from the following code systems:

1374• Include codes from <http://snomed.info/sct> where concept is-a 105590001

1375• Include codes from <http://snomed.info/sct> where concept is-a 373873005

1376 **4.4.8.1.3 RDF Definition**

1377 Since these concepts in snomed are hierarchical, classes the valueset is by definition a union of concept classes.

1378 A named Valueset as a class is a union of named concept classes (not a superclass). If an instance of CodingBase
1379 is typed to a Valueset then it probably means that the codeBase is unknown or to be selected.

1380 The FHIR “include” gets stranslated to a union expression:

1381

1382 4.4.8.1.4 Examples

1383 4.4.8.1.4.1 *ValueSet schema in FHIR*

1384 A ValueSet individual will have define, compose and expansion object properties to applicable objects. The
1385 following RDF samples show a direct translation of the metamodel viewpoint.

```
1386   ### http://hl7.org/fhir/ValueSet
1387 fhir:ValueSet rdf:type owl:Class ;
1388     rdfs:subClassOf fhir:DomainResource ,
1389         [ rdf:type owl:Restriction ;
1390             owl:onProperty fhir:ValueSet.define ;
1391             owl:allValuesFrom fhir:ValueSet.Define
1392         ] ,
1393         [ rdf:type owl:Restriction ;
1394             owl:onProperty fhir:ValueSet.define ;
1395             owl:maxCardinality "1"^^xsd:nonNegativeInteger
1396         ] ,
1397         [ rdf:type owl:Restriction ;
1398             owl:onProperty fhir:ValueSet.compose ;
1399             owl:allValuesFrom fhir:ValueSet.Compose
1400         ] ,
1401         [ rdf:type owl:Restriction ;
1402             owl:onProperty fhir:ValueSet.expansion ;
1403             owl:maxCardinality "1"^^xsd:nonNegativeInteger
1404         ] ,
1405         [ rdf:type owl:Restriction ;
1406             owl:onProperty fhir:ValueSet.expansion ;
1407             owl:allValuesFrom fhir:ValueSet.Expansion
1408         ] ,
1409         [ rdf:type owl:Restriction ;
1410             owl:onProperty fhir:ValueSet.compose ;
1411             owl:maxCardinality "1"^^xsd:nonNegativeInteger
1412         ] .
1413
1414   ### http://hl7.org/fhir/ValueSet.Compose
1415 fhir:ValueSet.Compose rdf:type owl:Class ;
1416     rdfs:subClassOf fhir:BackboneElement .
```

1417

```
1418
1419  ### http://hl7.org/fhir/ValueSet.Concept
1420  fhir:ValueSet.Concept rdf:type owl:Class ;
1421      rdfs:subClassOf fhir:BackboneElement ,
1422          [ rdf:type owl:Restriction ;
1423              owl:onProperty fhir:ValueSet.Concept.display ;
1424              owl:allValuesFrom fhir:string
1425          ] ,
1426          [ rdf:type owl:Restriction ;
1427              owl:onProperty fhir:ValueSet.Concept.code ;
1428              owl:cardinality "1"^^xsd:nonNegativeInteger
1429          ] ,
1430          [ rdf:type owl:Restriction ;
1431              owl:onProperty fhir:ValueSet.Concept.code ;
1432              owl:allValuesFrom fhir:code
1433          ] ,
1434          [ rdf:type owl:Restriction ;
1435              owl:onProperty fhir:ValueSet.Concept.definition ;
1436              owl:maxCardinality "1"^^xsd:nonNegativeInteger
1437          ] ,
1438          [ rdf:type owl:Restriction ;
1439              owl:onProperty fhir:ValueSet.Concept.display ;
1440              owl:maxCardinality "1"^^xsd:nonNegativeInteger
1441          ] ,
1442          [ rdf:type owl:Restriction ;
1443              owl:onProperty fhir:ValueSet.Concept.definition ;
1444              owl:allValuesFrom fhir:string
1445          ] .
```

1445

```
1446
1447  ### http://hl7.org/fhir/ValueSet.Define
1448  fhir:ValueSet.Define rdf:type owl:Class ;
1449      rdfs:subClassOf fhir:BackboneElement ,
1450          [ rdf:type owl:Restriction ;
1451              owl:onProperty fhir:ValueSet.Define.system ;
1452              owl:allValuesFrom fhir:uri
1453          ] ,
1454          [ rdf:type owl:Restriction ;
1455              owl:onProperty fhir:ValueSet.Define.system ;
1456              owl:cardinality "1"^^xsd:nonNegativeInteger
1457          ] ,
1458          [ rdf:type owl:Restriction ;
1459              owl:onProperty fhir:ValueSet.Define.concept ;
1460              owl:allValuesFrom fhir:ValueSet.Concept
1461          ] .
1462
1463  ### http://hl7.org/fhir/ValueSet.Expansion
1464  fhir:ValueSet.Expansion rdf:type owl:Class ;
1465      rdfs:subClassOf fhir:BackboneElement .
```

1465

1466

1467

1468 **4.4.8.2 FHIR internal System and Coding bindings (OWL Schema)**

1469 The system is inclusive of all the terms within it and all the instances of those terms.

```
1470 @prefix allergy-intolerance-status: <http://hl7.org/fhir/allergy-intolerance-status#> .  
1471  
1472   ### http://hl7.org/fhir/allergy-intolerance-status  
1473  
1474   fhir:allergy-intolerance-status rdf:type owl:Class ;  
1475     rdfs:subClassOf fhir:valueset-system ,  
1476       [ rdf:type owl:Class ;  
1477         owl:unionOf (  
1478           allergy-intolerance-status:confirmed  
1479           allergy-intolerance-status:entered-in-error  
1480           allergy-intolerance-status:refuted  
1481           allergy-intolerance-status:resolved  
1482           allergy-intolerance-status:unconfirmed  
1483         )  
1484       ]  
1485       [ rdf:type owl:Restriction ;  
1486         owl:onProperty fhir:CodingBase.system ;  
1487         owl:allValuesFrom [ rdf:type owl:Restriction ;  
1488           owl:onProperty fhir:value ; owl:hasValue "http://hl7.org/fhir/allergy-intolerance-status"  
1489         ]  
1490       ]  
1491       fhir:prefix "http://hl7.org/fhir/allergy-intolerance-status#" .  
1492  
1493   ### http://hl7.org/fhir/allergy-intolerance-status#confirmed  
1494  
1495   allergy-intolerance-status:confirmed rdf:type owl:Class ;  
1496     rdfs:label "Confirmed" ;  
1497     rdfs:subClassOf fhir:allergy-intolerance-status ,  
1498       [ rdf:type owl:Restriction ;  
1499         owl:onProperty fhir:CodingBase.code ;  
1500         owl:allValuesFrom [ rdf:type owl:Restriction ;  
1501           owl:onProperty fhir:value ; owl:hasValue "confirmed"  
1502         ]  
1503       ]  
1504       rdfs:comment "A high level of certainty about the propensity for a reaction to the identified Substance, which  
1505       may include clinical evidence by testing or rechallenge." .  
1506  
1507   ### http://hl7.org/fhir/allergy-intolerance-status#entered-in-error  
1508  
1509   allergy-intolerance-status:entered-in-error rdf:type owl:Class ;  
1510     rdfs:label "Entered In Error" ;  
1511     rdfs:subClassOf fhir:allergy-intolerance-status ,  
1512       [ rdf:type owl:Restriction ;  
1513         owl:onProperty fhir:CodingBase.code ;  
1514         owl:allValuesFrom [ rdf:type owl:Restriction ;  
1515           owl:onProperty fhir:value ; owl:hasValue "entered-in-error"  
1516         ]  
1517       ]  
1518       rdfs:comment "The statement was entered in error and is not valid" .
```

1519

1520 The system Class definition shows it is a subclass of the abstract valueset-system and restricts its members to
1521 the CodingBase.system.

1522 There is also an annotation property fhir:prefix which defines the structure of the URI prefix when naming the
1523 members of the system. It causes the @prefix declaration.

1524 Two members are shown “confirmed” and “entered-in-error”. They are subclasses of allergy-intolerance-status
1525 and have the restrictions of that class so they do not have to declare CodingBase.system restrictions.

1526 **4.4.8.3 System and codings external RDF representation**

1527 From the SNOMED RDF:

```
1528 <http://snomed.info/id/138875005> rdf:type owl:Class ;
1529   rdfs:label "SNOMED CT Concept" .
1530
1531 <http://snomed.info/id/105590001> rdf:type owl:Class ;
1532   rdfs:label "Substance (substance)" ;
1533   rdfs:subClassOf <http://snomed.info/id/138875005> .
1534
1535 <http://snomed.info/id/373873005> rdf:type owl:Class ;
1536   rdfs:label "Pharmaceutical / biologic product (product)" ;
1537   rdfs:subClassOf <http://snomed.info/id/138875005> .
1538
1539 <http://snomed.info/id/346325008> rdf:type owl:Class ;
1540   rdfs:label "Antibacterial drugs (product)" ;
1541   rdfs:subClassOf <http://snomed.info/id/373873005> .
1542
1543 <http://snomed.info/id/90614001> rdf:type owl:Class ;
1544   rdfs:label "beta-Lactam antibiotic" ;
1545   rdfs:subClassOf <http://snomed.info/id/346325008> .
```

1546 The system is defined further in the FHIR ontology

```
1547 @prefix sct: <http://snomed.info/id/> .
1548
1549 ### http://snomed.info/sct
1550
1551 <http://snomed.info/sct> rdf:type owl:Class ;
1552   rdfs:subClassOf fhir:valueset-system ;
1553   fhir:prefix "http://snomed.info/id/" .
```

1554

1555

1556 **4.4.8.4 Valueset Definition**

1557 A ValueSet is somewhat similar to a value-set-system in that it applies constraints to the members but they can
1558 be from different systems.

1559 The specific ValueSet is a Class which is a union of Concept classes from one or more coding-systems. It is
1560 expected that this representation can be computed from the FHIR representation.

1561 **4.4.8.4.1.1 Anonymous codings**

1562 Here is the definition of the specific ValueSet as a Class with restrictions on values not types:

```
1563 <http://hl7.org/fhir/vs/allergy-intolerance-status> rdf:type owl:Class ;  
1564   rdfs:label "Allergy Intolerance Status Value Set" ;  
1565   rdfs:subClassOf fhir:valueset ,  
1566     [ rdf:type owl:Class ;  
1567       owl:intersectionOf (  
1568         [ rdf:type owl:Restriction ;  
1569           owl:onProperty fhir:CodingBase.code ;  
1570           owl:someValuesFrom [ rdf:type owl:Class ;  
1571             owl:unionOf (  
1572               [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "confirmed" ]  
1573               [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "entered-in-error" ]  
1574               [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "refuted" ]  
1575               [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "resolved" ]  
1576               [ rdf:type owl:Restriction ; owl:onProperty fhir:value ; owl:hasValue "unconfirmed" ]  
1577             )  
1578           ]  
1579         ]  
1580         [ rdf:type owl:Restriction ;  
1581           owl:onProperty fhir:CodingBase.system ;  
1582           owl:allValuesFrom [ rdf:type owl:Restriction ; owl:onProperty fhir:value ;  
1583             owl:hasValue "http://fhir/allergy-intolerance-status"  
1584           ]  
1585         ]  
1586       )  
1587     ].
```

1588 If the valueset needs to identify CodingBase restrictions from other systems then the restriction will have a
1589 slightly different structure. The example here shows the optimization for a single system (Define).

1590 **4.4.8.4.2 Named codings**

1591 If named codings are used then the expression can be greatly simplified since the restrictions are in the named
1592 class.

```
1593 <http://hl7.org/fhir/vs/allergy-intolerance-status> rdf:type owl:Class ;  
1594   rdfs:label "Allergy Intolerance Status Value Set" ;  
1595   rdfs:subClassOf fhir:valueset ,  
1596     [ rdf:type owl:Class ;  
1597       owl:unionOf ( allergy-intolerance-status:confirmed  
1598                     allergy-intolerance-status:entered-in-error  
1599                     allergy-intolerance-status:refuted  
1600                     allergy-intolerance-status:resolved  
1601                     allergy-intolerance-status:unconfirmed  
1602       )  
1603     ].
```

1604

1605

1606 ***4.4.8.5 ValueSet schema in the metamodel***

1607 A metamodel is introduced when Classes in the Model are instances of MetaClasses which are subclasses of
1608 owl:Class. In general the Element Definition (1.23.0) is a metamodel.

1609 In the metamodel viewpoint, an instance of ValueSet will have object property assertions to

1610 a) instances of ValueSet.Define if all the codes are taken from a single system

1611 b) instances of ValueSet.Compose if the codes come from multiple systems and allow inclusion and
1612 exclusion

1613 c) instances of ValueSet.Expansion if the valueset is converted into an enumerated list

1614 A ValueSet individual will have define, compose and expansion object properties to applicable objects. However,
1615 these object property semantics are not understood by RDF or OWL. They are translated in the Model to
1616 subclass, intersection and union relationships between classes.

1617

1618 **4.4.8.6 Restriction equivalents to Compose Elements**

1619 The Compose element has subelements – import, include, exclude.

1620 **4.4.8.6.1 Import**

1621 Import has a value of a ValueSet URI that is to be imported (see earlier Valueset example – 7.2.1)

```
1622 owl:unionOf ( <http://hl7.org/fhir/ValueSet/substance-codeD>
1623     [ rdf:type owl:Restriction ;
1624       Etc. ]
1625   )
```

1626 The import equivalent is the unionOf with the named Class representing the Valueset (here shown as
1627 <<http://hl7.org/fhir/ValueSet/substance-codeD>>).

1628 **4.4.8.6.2 CodeSystem – Concepts**

1629 The extensional definition of a Code system includes its concepts as subclasses of the top concept. This is
1630 translated into a CodeSystemURI individual with the annotation properties of the CodeSystem and the
1631 associated Concept Classes.

1632 However, there is no direct ontology relationship between the CodeSystemURI and the top concept. Some
1633 thoughts about a pun relationship might be useful.

1634 See - HL7 Internal Concept RDF Example.

1635 **4.4.8.6.3 Filter**

1636 The Filter element selects concepts by specify a matching criteria based on the properties (including
1637 relationships) defined by the system. If multiple filters are specified, they SHALL all be true.

1638 The Filter Operator value set has an inline code system <http://hl7.org/fhir/filter-operator>, which defines the
1639 following codes:

Code	Display	Definition
=	Equals	The specified property of the code equals the provided value.
is-a	Is A (by subsumption)	Includes all concept ids that have a transitive is-a relationship with the concept Id provided as the value, including the provided concept itself.
is-not-a	Not (Is A) (by subsumption)	The specified property of the code does not have an is-a relationship with the provided value.
regex	Regular Expression	The specified property of the code matches the regex specified in the provided value.
in	In Set	The specified property of the code is in the set of codes or concepts specified in the provided value (comma separated list).
not-in	Not in Set	The specified property of the code is not in the set of codes or concepts

		specified in the provided value (comma separated list).
--	--	---

1640 4.4.8.6.4 Is-a – by subsumption

1641 4.4.8.6.4.1 *XML example*

```

1642 <include>
1643   <system value="http://snomed.info/sct"/>
1644   <filter>
1645     <property value="concept"/>
1646     <op value="is-a"/>
1647     <value value="105590001"/>
1648   </filter>
1649 </include>
1650 <include>
1651   <system value="http://snomed.info/sct"/>
1652   <filter>
1653     <property value="concept"/>
1654     <op value="is-a"/>
1655     <value value="373873005"/>
1656   </filter>
1657 </include>
```

1658

1659 The difficulty with this filter is that while it appears to apply to the concept class which can have is-a
1660 subsumption, the value is the CodingBase.code value which restricts it to the concept class without
1661 subsumption. CodingBase is a single class and the instances are not subsumable.

1662 4.4.8.6.4.2 *Compose Include is-a Concept*

1663 The approach is that the value must be translated into the Concept Class Name which would be
1664 <<http://snomed.info/id/373873005>> and would be used in the restriction.

1665 <<http://snomed.info/sct>> fhir:prefix "<http://snomed.info/id/>"^^xsd:string .

1666 An annotation property on the CodeSystem individual can be used to construct the concept name where a
1667 simple prefix is used with the codeBase value.

1668 This may also be articulated by the ValueSet fragment class which has the system and filter annotation
1669 properties and could be translated into the final RDF form.

1670 The include element in conjunction with filtering on is-a concept is transformed into a union of the named
1671 concept:

```

1672 owl:someValuesFrom [ rdf:type owl:Class ;
1673   owl:unionOf ( <http://snomed.info/id/105590001>
1674     <http://snomed.info/id/373873005>
```

1675 4.4.8.6.5 Exclude

1676 4.4.8.6.5.1 *XML Example*

```

1677 <exclude>
1678   <system value="http://snomed.info/sct"/>
1679   <filter>
1680     <property value="concept"/>
1681     <op value="is-a"/>
1682     <value value="410942007"/>
1683   </filter>
1684 </exclude>
```

1685

1686 4.4.8.6.5.2 Compose Exclude is-a Concept

```
[ rdf:type owl:Class ;
  rdfs:subClassOf <http://hl7.org/fhir/ValueSet/allergyintolerance-substance-code> ;
  owl:unionOf ( <http://hl7.org/fhir/ValueSet/substance-codeD>
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:CodingBase.concept ;
      owl:someValuesFrom [ rdf:type owl:Class ;
        owl:intersectionOf ( [ rdf:type owl:Class ;
          owl:unionOf ( <http://snomed.info/id/160244002>
            <http://snomed.info/id/409137002>
            <http://snomed.info/id/428607008>
            <http://snomed.info/id/429625007>
          )
        ]
      ]
    )
  )
] .
```

1708

1709 In this case the concept <http://snomed.info/id/410942007> is in the intersection as a complementOf so as to
1710 be excluded.

1711 4.4.8.6.6 Equals and In

1712 4.4.8.6.6.1 XML Example

```
<description value="All RxNorm codes that have TTY = IN,PIN,MIN,BN, but TTY != OCD."/>
<compose>
  <include>
    <system value="http://www.nlm.nih.gov/research/umls/rxnorm"/>
    <filter>
      <property value="TTY"/>
      <op value="in"/>
      <value value="IN,PIN,MIN,BN"/>
    </filter>
  </include>
  <exclude>
    <system value="http://www.nlm.nih.gov/research/umls/rxnorm"/>
    <filter>
      <property value="TTY"/>
      <op value="="/>
      <value value="OCD"/>
    </filter>
  </exclude>
</compose>
```

1735 These properties are specific to the code systems illustrated and would be expressed in the bridging ontology for
1736 that system.

1737 4.4.8.6.6.2 Filter RDF Expression

1738 Each filter is defined as a class. In the RDF example these will be named to assist testing and visibility.

1739 A filter class will declare the set meeting the filter properties which are annotation properties. The set are
1740 CodingBase individuals and the filter is therefore a fragment of a ValueSet.

```

1741 #### http://hl7.org/fhir/SomeBridge/fragmentA
1742
1743 <http://hl7.org/fhir/SomeBridge/fragmentA> rdf:type owl:Class ;
1744   rdfs:subClassOf fhir:Valuesets ;
1745   fhir:filter.property "TTY" ;
1746   fhir:filter.op "in" ;
1747   fhir:filter.system "http://www.nlm.nih.gov/research/umls/rxnorm" ;
1748   fhir:filter.value "IN,PIN,MIN,BN" .
1749
1750 #### http://hl7.org/fhir/SomeBridge/fragmentB
1751
1752 <http://hl7.org/fhir/SomeBridge/fragmentB> rdf:type owl:Class ;
1753   rdfs:subClassOf fhir:Valuesets ;
1754   fhir:filter.property "TTY" ;
1755   fhir:filter.op "=" ;
1756   fhir:filter.system "http://www.nlm.nih.gov/research/umls/rxnorm" ;
1757   fhir:filter.value "OCD" .

```

1758

1759 The definition may not be interpreted by OWL but can be through other mechanisms.

1760 Further exploration needs to be done on SPARQL and SWRL expressions to define the fragment membership of
1761 CodingBase individuals there thereby the membership of the ValueSet.

1762 4.4.8.6.6.3 *The RDF ValueSet*

1763 The fragments are combined together based on include and exclude elements:

```

1764 #### http://hl7.org/fhir/ValueSet/substance-rxnorm
1765
1766 <http://hl7.org/fhir/ValueSet/substance-rxnorm> rdf:type owl:Class ;
1767   rdfs:label "DAF Substance RxNorm Codes" ;
1768   rdfs:subClassOf fhir:Valuesets ;
1769   fhir:telecom.other "http://hl7.org/fhir" ;
1770   fhir:lastUpdated "2015-10-15T03:44:57.526+00:00" ;
1771   fhir:publisher "FHIR Project team" ;
1772   fhir:status "draft" ;
1773   fhir:concept_definition "All RxNorm codes that have TTY = IN,PIN,MIN,BN, but TTY != OCD." ;
1774   fhir:valueset-oid "urn:oid:2.16.840.1.113762.1.4.1010.7" .
1775
1776 [ rdf:type owl:Class ;
1777   rdfs:subClassOf <http://hl7.org/fhir/ValueSet/substance-rxnorm> ;
1778   owl:intersectionOf ( <http://hl7.org/fhir/SomeBridge/fragmentA>
1779     [ rdf:type owl:Class ;
1780       owl:complementOf <http://hl7.org/fhir/SomeBridge/fragmentB>
1781     ]
1782   )
1783 ]
1784

```

1785

1786

1787 **5 Resource References**

1788 **5.1 FHIR XML**

```
1789 <AllergyIntolerance xmlns="http://hl7.org/fhir">
1790   <id value="1"/>
1791   <text>
1792     </text>
1793   <!-- the date that this entry was recorded -->
1794   <recordedDate value="2010-03-01"/>
1795   <!-- the patient that actually has the risk of adverse reaction -->
1796   <patient>
1797     <reference value="http://record/Patient/PeterPatient"/>
1798     <display value="Peter Patient"/>
1799   </patient>
1800 
1801 </AllergyIntolerance>
```

1802 **5.2 RDF Data After processing (acquiring the resource and importing)**

```
1803 fhir:AllergyIntolerance.patient [ fhir:Reference.display [ fhir:value "Peter Patient" ] ;
1804   fhir:Reference.reference [ fhir:value "http://record/Patient/PeterPatient" ] ;
1805   fhir:Reference.link <http://record/Patient/PeterPatient>
1806   ] ;
```

1807 Note that Reference object has been supplemented by the URI of the Reference.link.

1808 AllergyIntolerance.patient.link can represent the property chain as shown earlier. A reverse property of the
1809 property chain can get the resources for a particular patient.

```
1810 ### http://hl7.org/fhir/AllergyForPatient
1811 fhir:AllergyForPatient rdf:type owl:ObjectProperty ;
1812   owl:inverseOf fhir:AllergyIntolerance.patient.link .
1813 ### http://hl7.org/fhir/AllergyIntolerance.patient.link
1814 fhir:AllergyIntolerance.patient.link rdf:type owl:ObjectProperty ;
1815   owl:propertyChainAxiom ( fhir:AllergyIntolerance.patient fhir:Reference.link ) .
```

1816 The Reference.link is declared when the resource has been imported and closure has been achieved. This allows
1817 the consumer to determine whether the import has happened or not and can trigger that function. If the
1818 Reference.link is pre-established there will be no indication in the import and the Resource instance will be
1819 empty.

1820

5.3 FHIR OWL Schema

1821

```
### http://hl7.org/fhir/Reference

fhir:Reference rdf:type owl:Class ;
  rdfs:subClassOf fhir:Element ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.reference ;
      owl:allValuesFrom fhir:string
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.reference ;
      owl:maxCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.display ;
      owl:allValuesFrom fhir:string
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.display ;
      owl:maxCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.link ;
      owl:allValuesFrom fhir:DomainResource
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Reference.link ;
      owl:maxCardinality "1"^^xsd:nonNegativeInteger
    ] .
```

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1850 6 Containment

1851 Containment is where a resource or container contains other resources.

1852 It applies to Bundle, Contained and Parameters.

1853 6.1 Bundle

1854 One common operation performed with resources is to gather a collection of resources into a single instance
1855 with containing context. In FHIR this is referred to as "bundling" the resources together. These resource bundles
1856 are useful for a variety of different reasons, including:

- 1857 • Returning a set of resources that meet some criteria as part of a server operation (see [RESTful](#)
1858 [Search](#))
- 1859 • Returning a set of versions of resources as part of the history operation on a server (see [History](#))
- 1860 • Sending a set of resources as part of a message exchange (see [Messaging](#))
- 1861 • Grouping a self-contained set of resources to act as an exchangeable and persistable collection with
1862 clinical integrity - e.g. a clinical document (see [Documents](#))
- 1863 • Creating/updating/deleting a set of resources on a server as a single operation (including doing so as
1864 a single atomic transaction) (see [Transactions](#))
- 1865 • Storing a collection of resources

1866

6.1.1 Bundle XML instance

```

1867 <Bundle xmlns="http://hl7.org/fhir">
1868   <id value="bundle-example"/><!-- this example bundle is a search set -->
1869   <meta>
1870     <lastUpdated value="2014-08-18T01:43:30Z"/>
1871   </meta><!-- when the search was executed -->
1872   <type value="searchset"/><!-- the base URL of the server is responding to the search -->
1873   <base value="http://example.com/base"/><!-- the total number of matches. This is a stupid example - there's a
1874 grand total of 3 matches, and we're only going to return the first 1, with a next link, in order to demonstrate
1875 what a page link looks like -->
1876   <total value="3"/>
1877   <link>
1878     <relation value="self"/>
1879     <url
1880       value="https://example.com/base/MedicationPrescription?patient=347&_include=MedicationPrescription.medication"
1881     />
1882     </link><!-- now, the link to the next set of results.
1883 Note that a big set of results will include prev, first, last links as well as next -->
1884   <link>
1885     <relation value="next"/>
1886     <url value="https://example.com/base/MedicationPrescription?patient=347&searchId=ff15fd40-ff71-4b48-b366-
1887 09c706bed9d0&page=2"/>
1888   </link><!-- now, the actual entries -->
1889   <entry>
1890     <resource>
1891       <MedicationPrescription><!-- the matching resource -->
1892         <id value="3123"/>
1893         <text>
1894           Omitted
1895         </text>
1896         <patient>
1897           <reference value="Patient/347"/>
1898         </patient>
1899         <medication>
1900           <reference value="Medication/example"/>
1901         </medication>
1902       </MedicationPrescription>
1903     </resource>
1904     <search><!-- this resource included as a match to the search criteria. Servers are not required to populate
1905 this, but should, because there are a few cases where it might be ambiguous whether a resource is added because
1906 it's a match or an include -->
1907       <mode value="match"/><!-- score. For matches where the criteria are not determinate,
1908       e.g. text search on narrative, the server can include a score to indicate
1909       how well the resource matches the conditions. Since this search is by patient
1910       identifier, there's nothing fuzzy about it, but for example purposes: -->
1911       <score value="1"/>
1912     </search>
1913   </entry>
1914   <entry>
1915     <resource>
1916       <Medication>
1917         <id value="example"/>
1918         <text>
1919           </text>
1920       </Medication>
1921     </resource><!-- snip -->
1922     <search><!-- added because the client asked to include the medications -->
1923       <mode value="include"/>
1924     </search>
1925   </entry>
1926 </Bundle>
```

1927

1928

6.1.2 Bundle XML content description

```

1929 <Bundle xmlns="http://hl7.org/fhir">
1930   <!-- from Resource: id, meta, implicitRules, and language -->
1931   <type value="[code]"/><!-- 1..1 document | message | transaction | transaction-response | batch | batch-response
1932   | history | searchset | collection -->
1933   <total value="[unsignedInt]" /><!-- 0..1 If search, the total number of matches -->
1934   <link> <!-- 0..* Links related to this Bundle -->
1935   <relation value="[string]" /><!-- 1..1 http://www.iana.org/assignments/link-relations/link-relations.xhtml -->
1936   <url value="[uri]" /><!-- 1..1 Reference details for the link -->
1937 </link>
1938   <entry> <!-- 0..* Entry in the bundle - will have a resource, or information -->
1939     <link><!-- 0..* Content as for Bundle.link Links related to this entry --></link>
1940     <fullUrl value="[uri]" /><!-- 0..1 Absolute URL for resource (server address, or UUID/OID) -->
1941     <resource><!-- 0..1 Resource A resource in the bundle --></resource>
1942     <search> <!-- 0..1 Search related information -->
1943       <mode value="[code]" /><!-- 0..1 match | include | outcome - why this is in the result set -->
1944       <score value="[decimal]" /><!-- 0..1 Search ranking (between 0 and 1) -->
1945     </search>
1946     <request> <!-- 0..1 Transaction Related Information -->
1947       <method value="[code]" /><!-- 1..1 GET | POST | PUT | DELETE -->
1948       <url value="[uri]" /><!-- 1..1 URL for HTTP equivalent of this entry -->
1949       <ifNoneMatch value="[string]" /><!-- 0..1 For managing cache currency -->
1950       <ifModifiedSince value="[instant]" /><!-- 0..1 For managing update contention -->
1951       <ifMatch value="[string]" /><!-- 0..1 For managing update contention -->
1952       <ifNoneExist value="[string]" /><!-- 0..1 For conditional creates -->
1953     </request>
1954     <response> <!-- 0..1 Transaction Related Information -->
1955       <status value="[string]" /><!-- 1..1 Status return code for entry -->
1956       <location value="[uri]" /><!-- 0..1 The location, if the operation returns a location -->
1957       <etag value="[string]" /><!-- 0..1 The etag for the resource (if relevant) -->
1958       <lastModified value="[instant]" /><!-- 0..1 Server's date time modified -->
1959     </response>
1960   </entry>
1961   <signature><!-- 0..1 Signature Digital Signature --></signature>
1962 </Bundle>

```

1963

1964 **6.1.3 Bundle RDF Content**

```
1965 <http://record/medpres1> rdf:type owl:Ontology ; owl:imports <http://hl7.org/fhir> .  
1966  
1967 ##### http://record/medpres1/bundle1  
1968  
1969 <http://record/medpres1/bundle1> rdf:type fhir:Bundle , owl:NamedIndividual ;  
1970   fhir:Bundle.entry [ rdf:type fhir:Bundle.Entry ;  
1971     fhir:Bundle.Entry.resource <http://record/MedicationPrescription/1>  
1972   ] ;  
1973   fhir:Bundle.type [ fhir:value "searchset"];  
1974   fhir:Bundle.link [ rdf:type fhir:uri ; fhir:value "self"] ;  
1975   fhir:Bundle.total [ rdf:type fhir:unsignedInt ; fhir:value 3 ];  
1976   fhir:Resource.meta [ rdf:type fhir:Meta ; fhir:Meta.lastUpdated  
1977     [ rdf:type fhir:instant ; fhir:value "2015-08-02T00:00:00"^^xsd:dateTime]  
1978   ] .  
1979  
1980 ##### http://record/MedicationPrescription/1  
1981  
1982 <http://record/MedicationPrescription/1> rdf:type profile:MedicationPrescription , owl:NamedIndividual ;  
1983   fhir:MedicationOrder.medicationReference [ rdf:type fhir:Reference ;  
1984     fhir:Reference.link <http://record/Medication/1> ;  
1985     fhir:Reference.reference [ fhir:value http://record/Medication/1 ] ;  
1986     fhir:Reference.display [ fhir:value "Amoxicillin (product)" ]  
1987   ] ;  
1988   fhir:MedicationOrder.patient [ rdf:type fhir:Reference ;  
1989     fhir:Reference.link <http://record/Patient/PeterPatient> ;  
1990     fhir:Reference.display [ fhir:value "Peter Patient" ] ;  
1991     fhir:Reference.reference [ fhir:value "http://record/Patient/PeterPatient"  
1992   ]  
1993 ] .  
1994
```

1995
1996 A Bundle may or may not have an Id (inherited from Resource) therefore it can be referenced as an Ontology
1997 e.g. record/Bundle/123. It may therefore be a named or anonymous individual.

1998

6.1.4 Bundle RDF Schema

1999

```
### http://hl7.org/fhir/Bundle

fhir:Bundle rdf:type owl:Class ;
  rdfs:subClassOf fhir:Resource ,
    [ rdf:type owl:Restriction ; owl:onProperty fhir:Bundle.total ;
      owl:onClass fhir:unsignedInt ;
        owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.entry ;
      owl:allValuesFrom fhir:Bundle.Entry
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.signature ;
      owl:onClass fhir:Signature ;
      owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.type ;
      owl:onClass fhir:code ;
      owl:qualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.link ;
      owl:allValuesFrom fhir:Bundle.Link
    ] .

### http://hl7.org/fhir/Bundle.Entry

fhir:Bundle.Entry rdf:type owl:Class ;
  rdfs:subClassOf fhir:BackboneElement ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.Entry.search ;
      owl:onClass fhir:Bundle.Search ;
      owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.Entry.link ;
      owl:onClass fhir:Bundle.Link ;
      owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.Entry.resource ;
      owl:onClass fhir:Resource ;
      owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] ,
    [ rdf:type owl:Restriction ;
      owl:onProperty fhir:Bundle.Entry.fullURI ;
      owl:onClass fhir:uri ;
      owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger
    ] .
```

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2051 **7 Ordering**

2052 **7.1 Github example**

2053 No example

2054 **7.2 RDF individual ordering example**

2055 Simple integer DataProperty fhir:index can be applied to individuals of subclasses of fhir:Element

2056

```
2057 ##### http://hl7.org/fhir/index
2058 fhir:index rdf:type owl:DatatypeProperty ;
2059     rdfs:range fhir:index-primitive .
2060
2061 ##### http://hl7.org/fhir/index-primitive
2062 fhir:index-primitive rdf:type rdfs:Datatype ;
2063     owl:equivalentClass [ rdf:type rdfs:Datatype ;
2064         owl:onDatatype xsd:integer ;
2065         owl:withRestrictions ( [ xsd:minInclusive 1 ] )
2066     ] .
2067 ##### http://hl7.org/fhir/Element
2068 fhir:Element rdf:type owl:Class ;
2069     rdfs:label "Element" ;
2070     rdfs:subClassOf [ rdf:type owl:Restriction ;
2071         owl:onProperty fhir:Element.extension ;
2072         owl:someValuesFrom fhir:Extension
2073     ] ,
2074     [ rdf:type owl:Restriction ;
2075         owl:onProperty fhir:Element.id ;
2076         owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
2077         owl:onDataRange fhir:id-primitive
2078     ] ,
2079     [ rdf:type owl:Restriction ;
2080         owl:onProperty fhir:index ;
2081         owl:maxQualifiedCardinality "1"^^xsd:nonNegativeInteger ;
2082         owl:onDataRange fhir:index-primitive
2083     ] ;
2084     rdfs:comment "The base element used for all FHIR elements and resources - allows for them to be
2085 extended with extensions" .
2086 .
```

2087 In general fhir:value and fhir:Element.id are converted to an attribute in XML. fhir:index dictates the sequence
2088 only.

2089 **7.3 RDF Object Property Ordering example**

2090 Where object properties need to be ordered to construct the sequence of properties in XML, the fhir:index is
2091 defined as an annotation property on the Object Property. The example of ordered properties inside CodingBase
2092 is shown:

```
2093 ##### http://hl7.org/fhir/index
2094
2095 fhir:index rdf:type owl:AnnotationProperty .
```

2096

```
2097
2098  ### http://hl7.org/fhir/CodingBase.system
2099  fhir:CodingBase.system rdf:type owl:ObjectProperty ;
2100      fhir:index 1 ;
2101
2102  ### http://hl7.org/fhir/CodingBase.version
2103  fhir:CodingBase.version rdf:type owl:ObjectProperty ;
2104      fhir:index 2 .
2105
2106  ### http://hl7.org/fhir/CodingBase.code
2107  fhir:CodingBase.code rdf:type owl:ObjectProperty ;
2108      fhir:index 3 .
2109
2110  ### http://hl7.org/fhir/CodingBase.display
2111  fhir:CodingBase.display rdf:type owl:ObjectProperty ;
2112      fhir:index 4 ;
2113
2114  ### http://hl7.org/fhir/CodingBase.primary
2115  fhir:CodingBase.primary rdf:type owl:ObjectProperty ;
      fhir:index 5 ;
2116
2117
2118
```

2119 8 Profiles

2120 The example shows a ‘profile’ ontology restricting the Valueset of Substance:

2121 The AllergyIntolerance Resource is declared again inside the Profile ontology.

```
2122 <http://record/AllergyIntolerance/1> rdf:type <http://PatientSafetyProfile/AllergyIntolerance>,
2123 owl:NamedIndividual ;
```

2125 profile:AllergyIntolerance.substance is defines a restriction to be applied to the valueset for substance

```
2126 @prefix profile: <http://PatientSafetyProfile/> .
2127 ### http://PatientSafetyProfile/AllergyIntolerance
2128
2129 profile:AllergyIntolerance rdf:type owl:Class ;
2130     rdfs:subClassOf fhir:AllergyIntolerance , [ rdf:type owl:Restriction ;
2131         owl:onProperty <http://hl7.org/fhir/AllergyIntolerance/AllergyIntolerance.substance> ;
2132         owl:allValuesFrom profile:substance-type
2133     ] .
```

2134

2135 The valueset definition applies:

```
2136
2137 #### http://PatientSafetyProfile/substance-type
2138 <http://PatientSafetyProfile/substance-type> rdf:type owl:Class ;
2139     rdfs:subClassOf fhir:ValueSets ,
2140     [ rdf:type owl:Class ;
2141         owl:unionOf (
2142             <http://snomed.info/id/105590001>
2143             <http://snomed.info/id/373873005>
2144         )
2145     ] .
```

2147

- 2150 **11 Extensions**
- 2151 **11.1 Extension Definition**
- 2152 **11.2 Extension Structural Definition**