

# **FHIR, RDF and the Semantic Web**


**Semantic Representation of Clinical Care and Research in HL7 FHIR**



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**November 14, 2019**


**(Slides derived from 2018 SWAT4LS Tutorial)**

# FHIR is defined using FHIR

 **FHIR Release 3 (STU)**



HomeGetting StartedDocumentationResourcesProfilesExtensionsOperationsTerminologies

 Conformance > **StructureDefinition**

ContentExamplesDetailed DescriptionsMappingsProfiles & ExtensionsOperationsR2 Conversions

## 5.3 Resource StructureDefinition - Content

<a href="#">FHIR Infrastructure</a>  Work Group	Maturity Level: 5	Trial Use	Compartments: Not linked to any defined compartments
--	-------------------	-----------	--

A definition of a FHIR structure. This resource is used to describe the underlying resources, data types defined in FHIR, and also for describing extensions and constraints on resources and data types.

### 5.3.1 Scope and Usage

The StructureDefinition resource describes a structure - a set of data element definitions, and their associated rules of usage. These structure definitions are used to describe both the content defined in the FHIR specification itself - Resources, data types, the underlying infrastructural types, and also are used to describe how these structures are used in implementations. This allows the definitions of the structures to be shared and published through repositories of structure definitions, compared with each other, and used as the basis for code, report and UI generation.

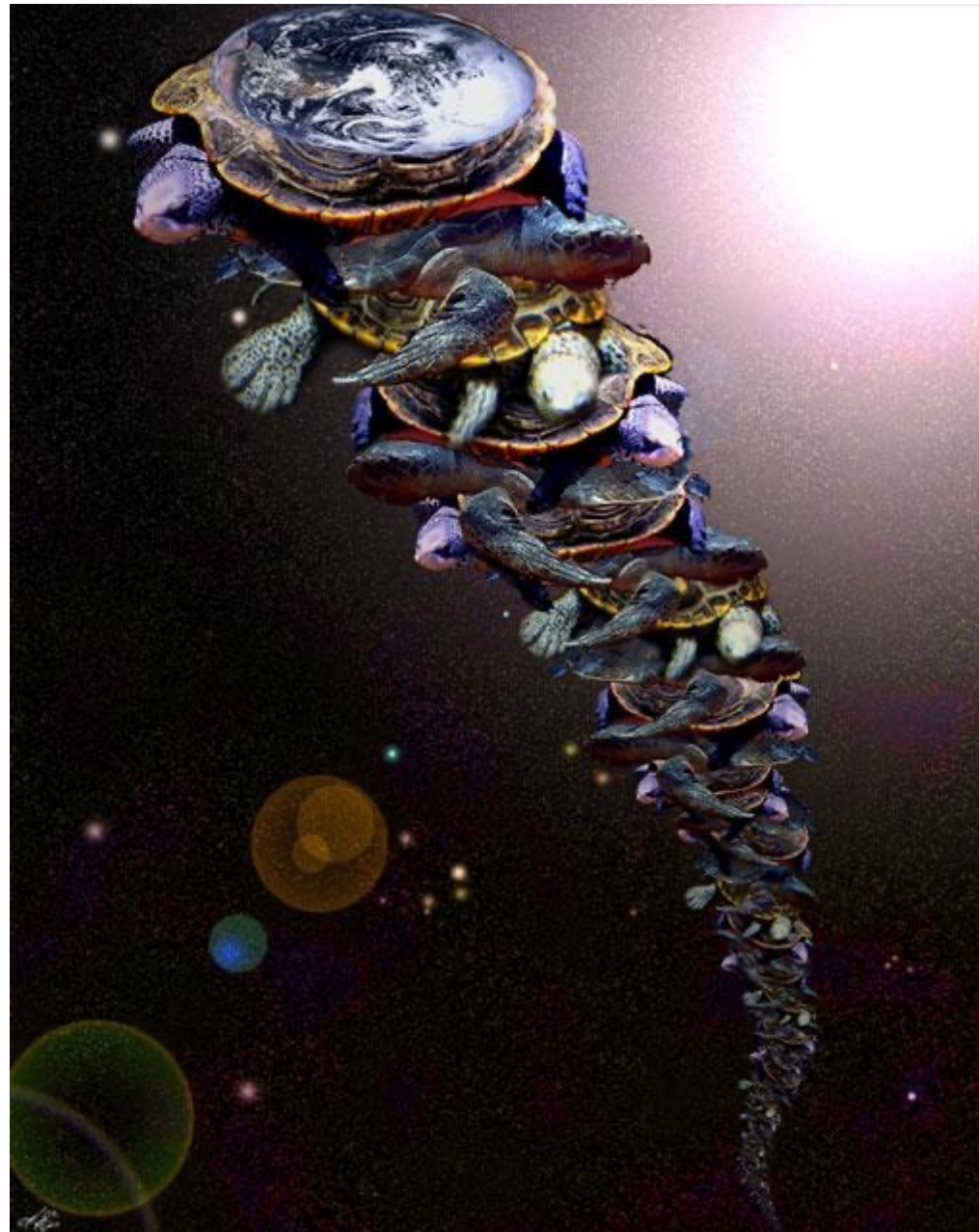
Note that as part of the specification itself, a [full set of structure definitions](#) for all resources and data types is published.

### 5.3.2 Boundaries and Relationships

- StructureDefinitions are used by [CapabilityStatement](#) instances for specifying how resources are used
- StructureDefinitions use [Value Sets](#) to specify the content of coded elements

<http://www.hl7.org/FHIR/structuredefinition.html>  
[www.hl7.org/FHIR/StructureDefinition/patient/](http://www.hl7.org/FHIR/StructureDefinition/patient/)  
<http://hl7.org/fhir/StructureDefinition/structuredefinition/>

# Turtles all the way down....



<http://prosperouswaydown.com/wp-content/uploads/2013/11/Fig2.jpg>



... but not all turtles are created equal



<http://www.pxleyes.com/images/users/a/anatole/298/fullsize/4a51dc3b8760b.jpg>



# FHIR “turtles” - ~~five~~ **six** different languages

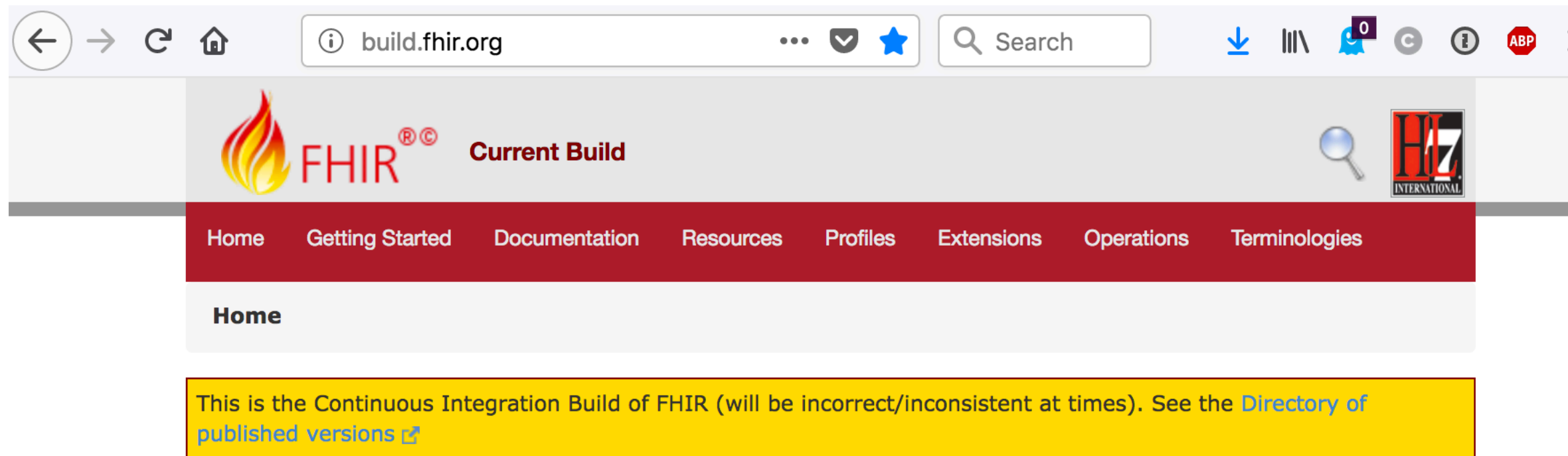
- StructureDefinition & friends — core model
- Extension — tag/value
- Constraint — FhirPath
- “Slicing” —
- Value Sets
- Terminology Property Language

# Some things that FHIR isn't

- A solution to healthcare interoperability
- A standard (yet)
- Resource Oriented Architecture (ROA)
- A tool for representing / standardizing clinical *semantics* (CIMI in particular)



# FHIR is not a standard (yet)



## 0 Welcome to FHIR®

FHIR is a standard for health care data exchange, published by HL7®. Note: The continuous build is getting ready for the first normative ballot. See [the ballot introduction](#) for details.

# FHIR Normative Ballot

Categorized					Alphabetical					R2 Layout					By Maturity					By Ballot Status					By Committee				
Foundation	<b>Conformance</b> <ul style="list-style-type: none"><li>• CapabilityStatement 3 <b>N</b></li><li>• StructureDefinition 5 <b>N</b></li><li>• ImplementationGuide 1</li><li>• SearchParameter 3</li><li>• MessageDefinition 1</li><li>• OperationDefinition 4 <b>N</b></li><li>• CompartmentDefinition 1</li><li>• StructureMap 2</li><li>• GraphDefinition 0</li><li>• ExampleScenario 0</li></ul>					<b>Terminology</b> <ul style="list-style-type: none"><li>• CodeSystem 5 <b>N</b></li><li>• ValueSet 5 <b>N</b></li><li>• ConceptMap 3 <b>N</b></li><li>• ExpansionProfile 2</li><li>• NamingSystem 1</li><li>• TerminologyCapabilities 0</li></ul>					<b>Security</b> <ul style="list-style-type: none"><li>• Provenance 3</li><li>• AuditEvent 3</li><li>• Consent 1</li></ul>					<b>Documents</b> <ul style="list-style-type: none"><li>• Composition 2</li><li>• DocumentManifest 2</li><li>• DocumentReference 3</li><li>• EntryDefinition 0</li></ul>					<b>Other</b> <ul style="list-style-type: none"><li>• Basic 1</li><li>• Binary 5 <b>N</b></li><li>• Bundle 5 <b>N</b></li><li>• Linkage 0</li><li>• MessageHeader 4</li><li>• OperationOutcome 5 <b>N</b></li><li>• Parameters 5 <b>N</b></li><li>• Subscription 3</li><li>• UserSession 0</li></ul>								
	Base	<b>Individuals</b> <ul style="list-style-type: none"><li>• Patient 5 <b>N</b></li><li>• Practitioner 3</li><li>• PractitionerRole 2</li><li>• RelatedPerson 2</li><li>• Person 2</li><li>• Group 1</li></ul>					<b>Entities</b> <ul style="list-style-type: none"><li>• Organization 3</li><li>• OrganizationRole 0</li><li>• HealthcareService 2</li><li>• Endpoint 2</li><li>• Location 3</li><li>• Substance 2</li><li>• BiologicallyDerivedProduct 0</li><li>• Device 2</li><li>• DeviceComponent 1</li><li>• DeviceMetric 1</li></ul>					<b>Workflow</b> <ul style="list-style-type: none"><li>• Task 2</li><li>• Appointment 3</li><li>• AppointmentResponse 3</li><li>• Schedule 3</li><li>• Slot 3</li><li>• ProcessRequest 2</li><li>• ProcessResponse 2</li></ul>					<b>Management</b> <ul style="list-style-type: none"><li>• Encounter 2</li><li>• EpisodeOfCare 2</li><li>• Flag 1</li><li>• List 1</li><li>• Library 2</li></ul>												
<b>Summary</b> <ul style="list-style-type: none"><li>• AllergyIntolerance 3</li></ul>					<b>Diagnostics</b> <ul style="list-style-type: none"><li>• Observation 5 <b>N</b></li></ul>					<b>Medications</b> <ul style="list-style-type: none"><li>• MedicationRequest 3</li></ul>					<b>Care Provision</b> <ul style="list-style-type: none"><li>• CarePlan 2</li></ul>					<b>Request &amp; Response</b> <ul style="list-style-type: none"><li>• Communication 2</li></ul>									

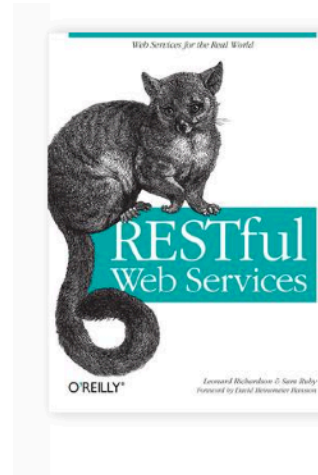


# FHIR is not Resource-Oriented Architecture

## That's the Resource-Oriented Architecture. It's just four

### concepts:

- 1. Resources
- 1. Their names (URIs)
- 1. Their representations
- 1. The links between them



### RESTful Web Services

★★★★★ 26 reviews

by Sam Ruby, Leonard Richardson

Publisher: O'Reilly Media, Inc.

Release Date: May 2007

ISBN: 9780596529260

Topics: **Java**

[View table of contents](#)

### and four properties:

- 1. Addressability
- 2. Statelessness
- 3. Connectedness
- 4. A uniform interface



**“A web service is connected to the extent that you can put the service in different states just by following links and filling out forms”**

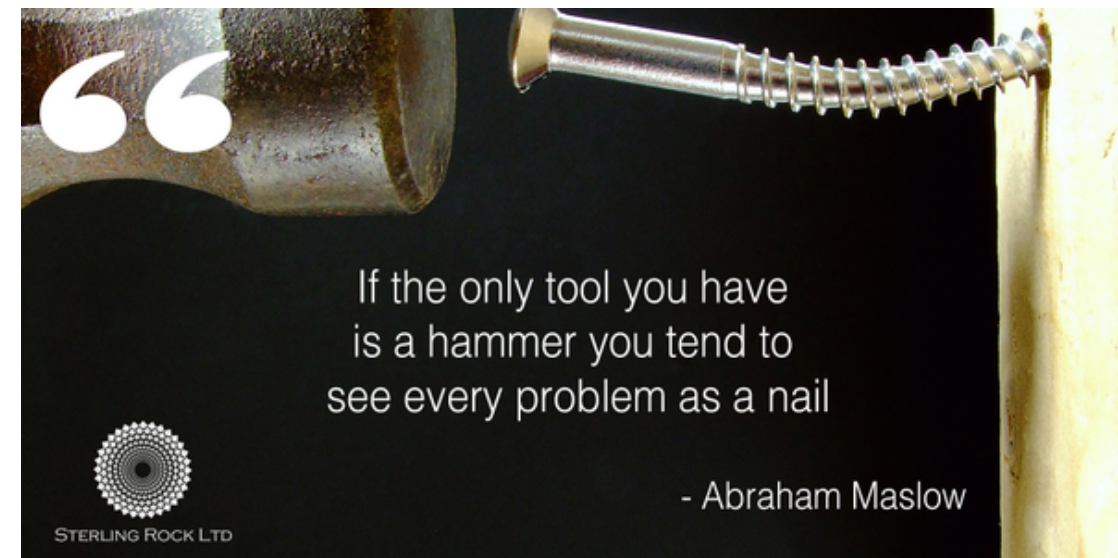
<http://my.safaribooksonline.com/9780596529260/restclients>

# FHIR is *not* the solution to clinical semantics

## 2.15.1 Why FHIR is better

FHIR offers many improvements over existing standards:

- A strong focus on implementation – fast and easy to implement (multiple developers have had simple interfaces working in a single day)
- Multiple implementation libraries, many examples available to kick-start development
- Specification is free for use with no restrictions
- Interoperability out-of-the-box– base resources can be used as is, but can also be adapted for local requirements
- Evolutionary development path from HL7 Version 2 and CDA – standards can co-exist and leverage each other
- Strong foundation in Web standards– XML, JSON, HTTP, OAuth, etc.
- Support for RESTful architectures, seamless exchange of information using messages or documents, and service based architectures
- Concise and easily understood specifications
- A human-readable serialization format for ease of use by developers
- Solid ontology-based analysis with a rigorous formal mapping for correctness



**FHIR is focused in *implementors*.**

- **Communities can use FHIR to develop specifications for *how* clinical information is represented.**
- **FHIR does not provide tooling for representing the *meaning* of said information**
- **FHIR's target audience is NOT clinicians (!)**



# Part 2

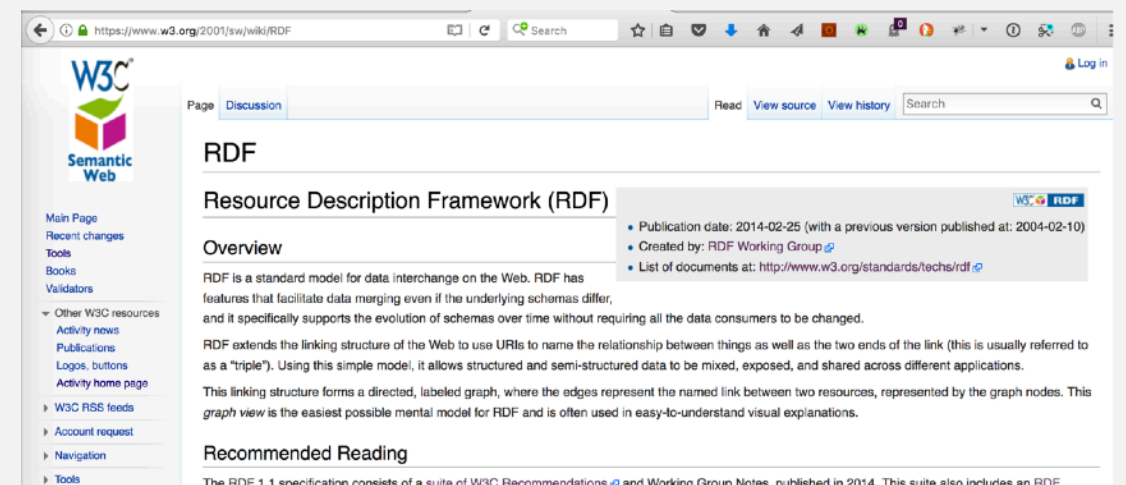
## The Resource Description Framework (RDF)

- **Triples, URI's and BNodes**
- RDF Catalogs



# Resource Description Framework (RDF)

- “Standard model for data interchange on the Web.”
- “Facilitates data merging even if the underlying schemas differ.”
- URI based linking structure in the form of a directed, labeled graph.

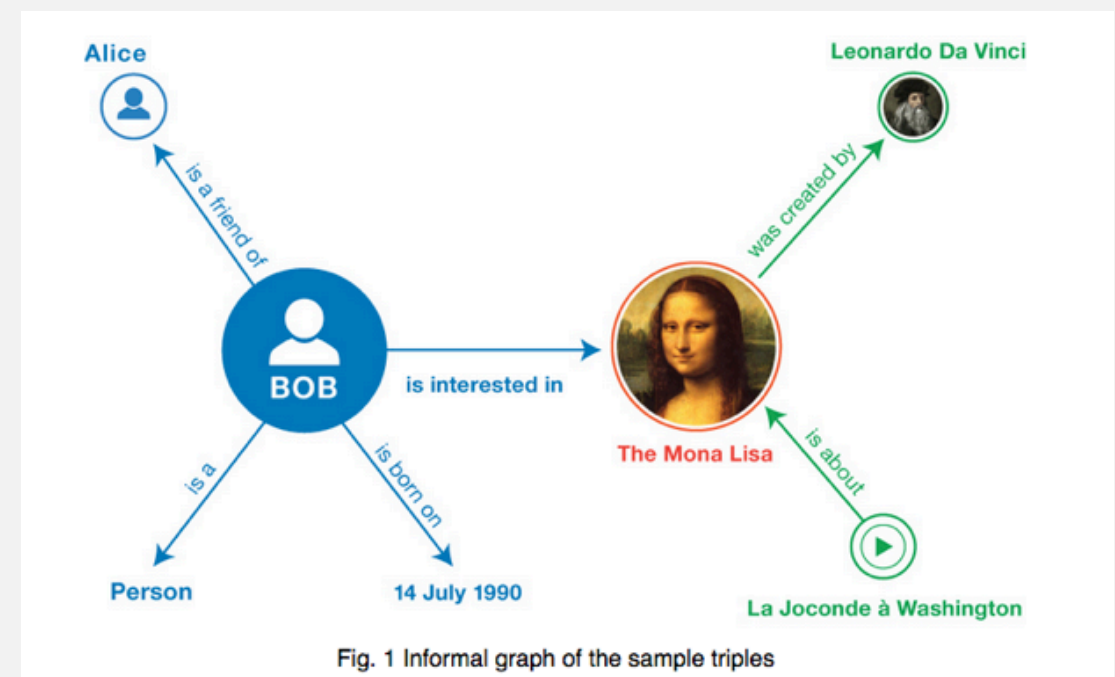


<https://www.w3.org/2001/sw/wiki/RDF>

# RDF – Informal Graph Model

```
<Bob> <is a> <person>.  
<Bob> <is a friend of> <Alice>.  
<Bob> <is born on> <the 4th of July 1990>.  
<Bob> <is interested in> <the Mona Lisa>.
```

```
<Leonardo da Vinci> <is the creator of> <the Mona Lisa>.  
<The video 'La Joconde à Washington'> <is about> <the Mona Lisa>
```



<https://www.w3.org/TR/rdf11-primer/>



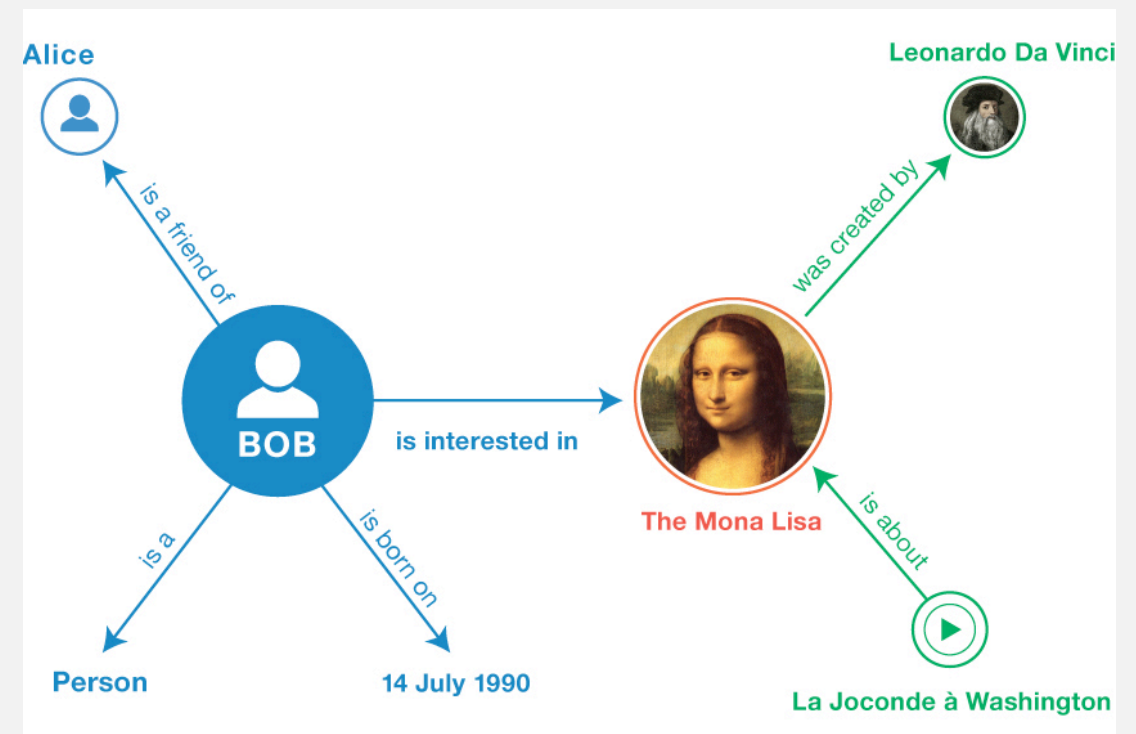
# RDF Components

## URI (IRI)

- <Bob>: <http://corporation.org/employee#BobGleeson>
- <is a>: <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
- <is born on>: <http://schema.org/birthDate>
- <Person>: <http://xmlns.com/foaf/1.0/Person>

## Literal

- String - “Bob”
- String + Language - “avalanche”@en
- Typed String - “1990-07-14”^^xsd:date  
“42”^^xsd:integer



# RDF Triples

Subject Predicate Object

- **Subject:** URI or Blank Node
- **Predicate:** URI
- **Object:** URI or Literal or Blank Node

**Subject (URI):**

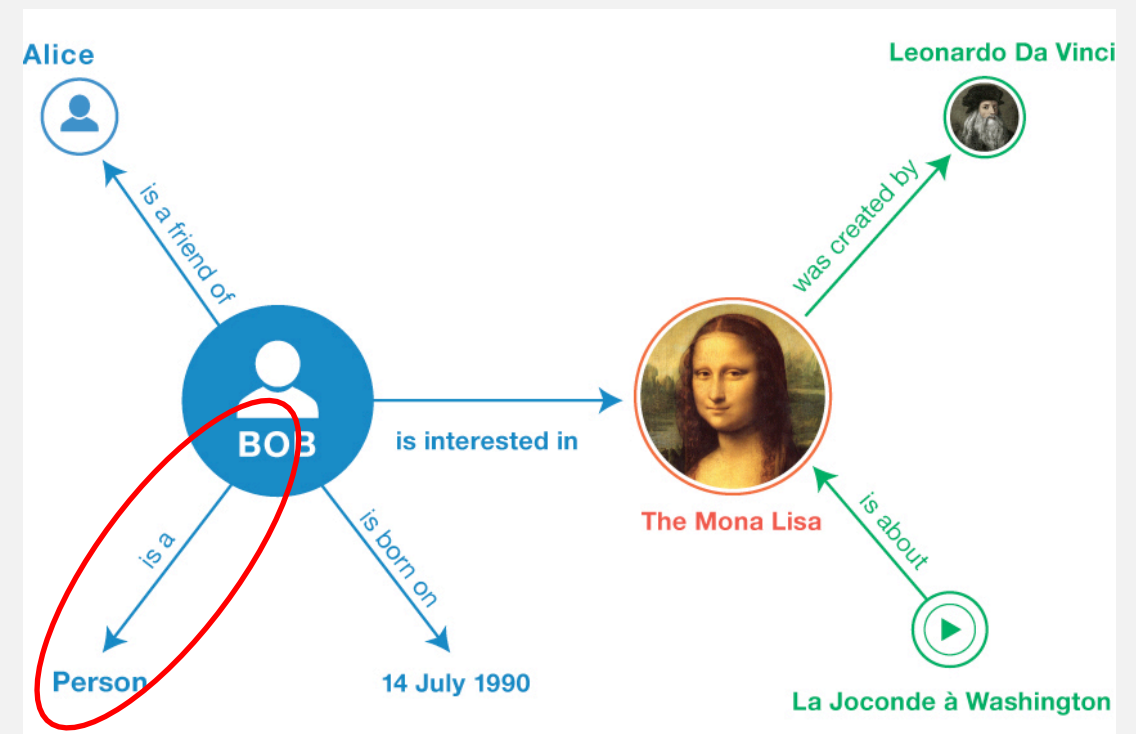
<http://corporation.org/employee#BobGleeson>

**Predicate (URI):**

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

**Object (URI):**

<http://xmlns.com/foaf/1.0/Person>



# RDF Triples

Subject Predicate Object

**Subject (URI):**

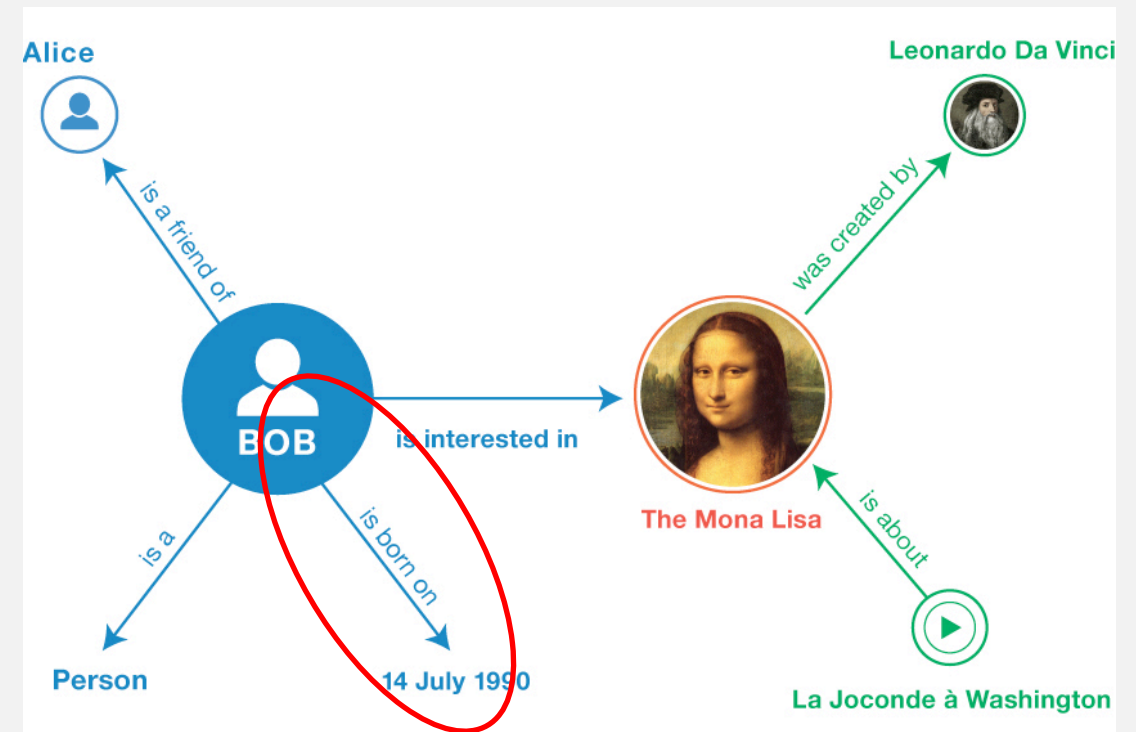
<http://corporation.org/employee#BobGleeson>

**Predicate (URI):**

<http://schema.org/birthDate>

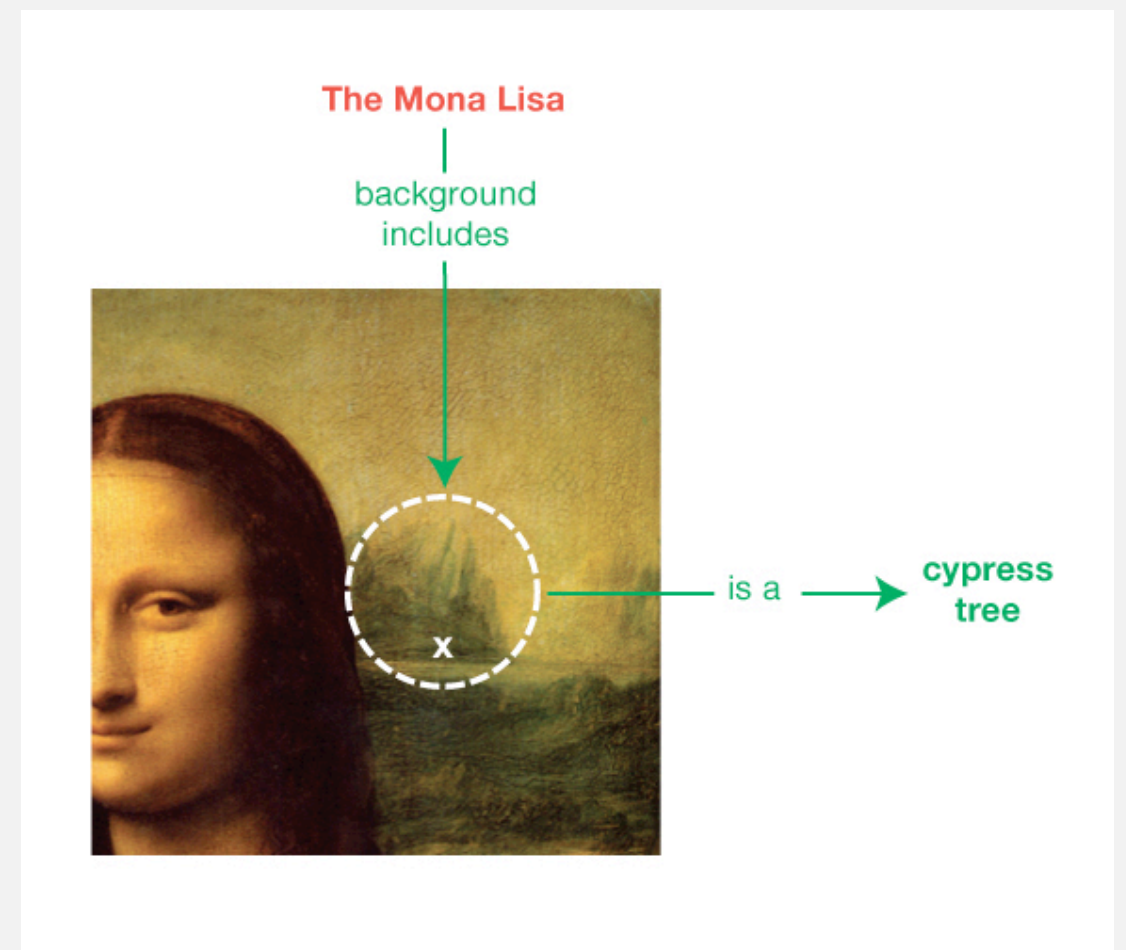
**Object (Literal):**

"1990-07-04"^^<<http://www.w3.org/2001/XMLSchema#date>>



# RDF Triples – Blank Nodes (BNodes)

- Blank – unnamed
- NOT a URI
- “The last house on the hill”
- “The person who hit me”
- “An item in the background of the painting, ‘The Mona Lisa’”





# RDF Triples – Blank Nodes (BNodes)

Subject (URI):

[http://dbpedia.org/resource/Mona\\_Lisa](http://dbpedia.org/resource/Mona_Lisa)

Predicate (URI):

<http://purl.org/net/lio#shows>

Object (BNode):

**\_:abc17**

Subject (BNode):

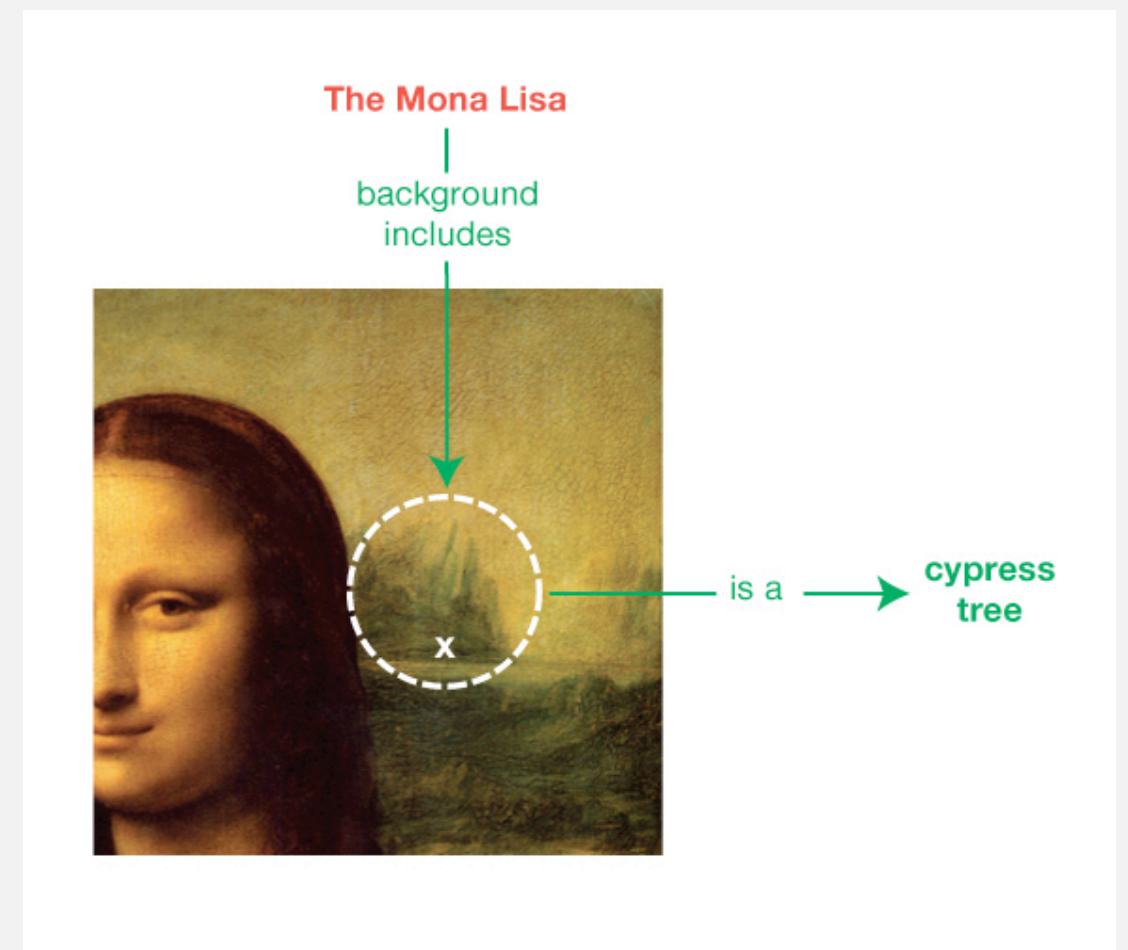
**\_:abc17**

Predicate (URI):

<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>

Object (URI):

<http://dbpedia.org/resource/Cypress>



# RDF Turtle Notation

- Terse RDF Triple Language”
- One of *several* possible formats for representing RDF
- Others include:
  - RDF XML
  - RDF Ntriples
  - JSON-LD
  - ...

## NTriples

```
<http://corporation.org/employee>  
<http://schema.org/birthDate>  
"1990-07-04"^^<http://www.w3.org/2001/XMLSchema#date> .
```

## RDF XML

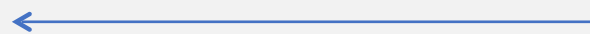
```
<?xml version="1.0" encoding="UTF-8"?>  
<rdf:RDF  
  xmlns:ns1="http://schema.org/"  
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"  
>  
  <rdf:Description rdf:about="http://corporation.org/employee">  
    <ns1:birthDate rdf:datatype="http://www.w3.org/2001/XMLSchema#date">1990-07-04  
  </ns1:birthDate>  
  </rdf:Description>  
</rdf:RDF>
```

## JSON-LD

```
[  
  {  
    "@id": "http://corporation.org/employee",  
    "http://schema.org/birthDate": [  
      {  
        "@type": "http://www.w3.org/2001/XMLSchema#date",  
        "@value": "1990-07-04"  
      }  
    ]  
  }  
]
```

# RDF Turtle Notation

subject predicate object .



subject predicate1 object1 ;

predicate1 object2 ;

...

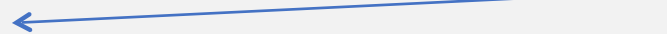
predicateN objectN .

subject predicate object1 ,

object2 ,

...

objectN .



## Equivalent

subject predicate object .

subject predicate1 object1 .

subject predicate2 object2 .

...

subject predicateN objectN .

subject predicate object1 .

subject predicate object2 .

...

subject predicate objectN .

# RDF Turtle Notation - Prefixes

@prefix ex: <<http://example.org/some/really/long/path#>> .

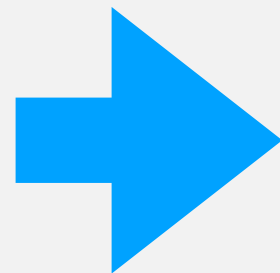
@prefix fhir: <<http://hl7.org/fhir/>> .

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .

@prefix : <<http://example.org/some/really/long/path#>> .

ex:Jim rdf:type fhir:Patient .

:Jim a fhir:Patient .



<http://example.org/some/really/long/path#Jim>  
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>  
<http://hl7.org/fhir/Patient> .



## RDF Turtle Notation – Blank Nodes

```
subject predicate1 [  
    predicate2 object2 ;  
    predicate3 object 3  
].
```

```
subject predicate4 [  
    predicate5 “abc” ].
```

```
subject predicate1 _:a1 .  
_:a1 predicate2 object2 ;  
    predicate3 object3 .
```

```
Subject prediate4 _:b1 .  
_:b1 predicate5 “abc” .
```

# RDF – The Good News

## Minimal Structure

- No rules
- Anyone can say anything anywhere (AAA)

## 2 ½ Data Types

- IRI
- Literal
  - More like a “data type” – second language embedded within
  - “text”^^<URI for type>.
  - “text”@<language> .
- Blank Node
  - NO Identity (!)

# RDF – The Bad News

## Minimal Structure

- No rules
- Anyone can say Anything Anywhere

## URI's

- Anyone can create them
- RDF is strictly a *syntax* until agreement can be reached on the use and meaning of IRI's

# Outline (continued)

## **The Resource Description Framework (RDF)**

- Triples, URI's and BNodes
- **RDF Catalogs**



# (some) RDF Catalogs

- Resource Description Format – `rdf:type`, `rdf:Resource`
- RDF Schema – `rdfs:domain`, `rdfs:range`, `rdfs:subClassOf`
- Web Object Language (OWL) –
- `owl:Restriction`, `owl:someValueFrom`
- Dublin Core (`dc`, `dcterms`)
- Simple Knowledge Organization System (`skos`)
- Friend of a Friend (`foaf`)
- `dbPedia`
- ...
- [schema.org](http://schema.org)



# How do it know?

Google mens watches

About 383,000,000 results (0.44 seconds)

**The Official Cartier Website | Shop Cartier Men's Watches | cartier.com**  
Ad [www.cartier.com/Watches/Men](http://www.cartier.com/Watches/Men)  
★★★★★ Rating for cartier.com: 4.8  
Sophisticated Designs & Innovation. Shop Cartier **Men's Watches** at Cartier.com. Shop Online. Complimentary Shipping. Contact Us. Locate a Boutique. Types: Bracelets, Rings, Necklaces, **Watches**, Leather Goods, Fragrances.





**Men's MVMT™ Watches | Free Shipping & Returns | mvmtwatches.com**  
Ad [www.mvmtwatches.com/official-site/mens-watches](http://www.mvmtwatches.com/official-site/mens-watches)  
Shop Our Best **Men's Watches** Starting at \$95. Free Shipping & Returns Worldwide! Join the MVMT. Men's Watches · Shop MVMT Watches Online · Shop MVMT Program · MVMT E-Gift Card · Chrono Series

**FOSSIL® Men's Watches | Check Out the New Design | fossil.com**  
Ad [www.fossil.com/Men/Watches](http://www.fossil.com/Men/Watches)  
★★★★★ Rating for fossil.com: 4.5 - 8,220 reviews  
Create an Exquisite Style with Timeless & Elegant **Men's Watches**. Order Today. Timeless Design.

**Shinola® Detroit Men's Watches | Shinola.com**  
Ad [www.shinola.com/Mens/Watches](http://www.shinola.com/Mens/Watches)  
Quality Timepieces Hand Assembled In Detroit. Shop Shinola Today! All **Watches** Ship Free. Detroit Built. Swiss & Imported Parts. Types: The Runwell, The Runwell Sport Chrono, The Canfield. Men's Leather · Shop Father's Day Gifts · Men's Watch Collection · The Shinola Guarantee

**Mens Watches - Macy's**  
<https://www.macys.com/shop/jewelry-watches/mens-watches?id=57386>

**Shop on Google** Sponsored ⓘ

 Jaeger-LeCoultre... - Geophysic ... <b>\$15,700.00</b> mrporter.com Free shipping	 All Wood Watch Zebrawood ... <b>\$139.00</b> Tree Hut Design ★★★★★ (1k+)
 Citizen Men's Chronograph ... <b>\$103.99</b> Macy's Special offer	 MVMT Men's Watches   ... <b>\$135.00</b> MVMT ★★★★★ (2k+)

# What you see...



SHIPPING TO  
UNITED STATES

## MR PORTER

Search



SALE

WHAT'S NEW

DESIGNERS

CLOTHING

SHOES

ACCESSORIES

WATCHES

SPORT

GROOMING

EDITORIAL



## JAEGER-LECOULTRE

Geophysic Universal Time 41mm Stainless Steel Watch

\$15,700

### EDITORS' NOTES

Swiss-engineered with a True Second® system and Gyrolab® balance wheel developed in Jaeger-LeCoultre's Le Sentier workshop, this 'Geophysic® Universal Time' watch is calibrated for accuracy and reliability across all 24 timezones. Housed in sleek polished stainless steel, the lacquered sunray dial depicts an intricate map of the world encircled with the names of major cities. It'll prove a thoughtful gift for globetrotters and business travellers alike.

We offer a five-year warranty for all working parts and manufacturing faults for luxury watches. Call our Customer Care team for more information.

Need more advice? Read the [Luxury Watch Guide](#).

### SIZE & FIT



# What the search engine sees

```
</nav>
```

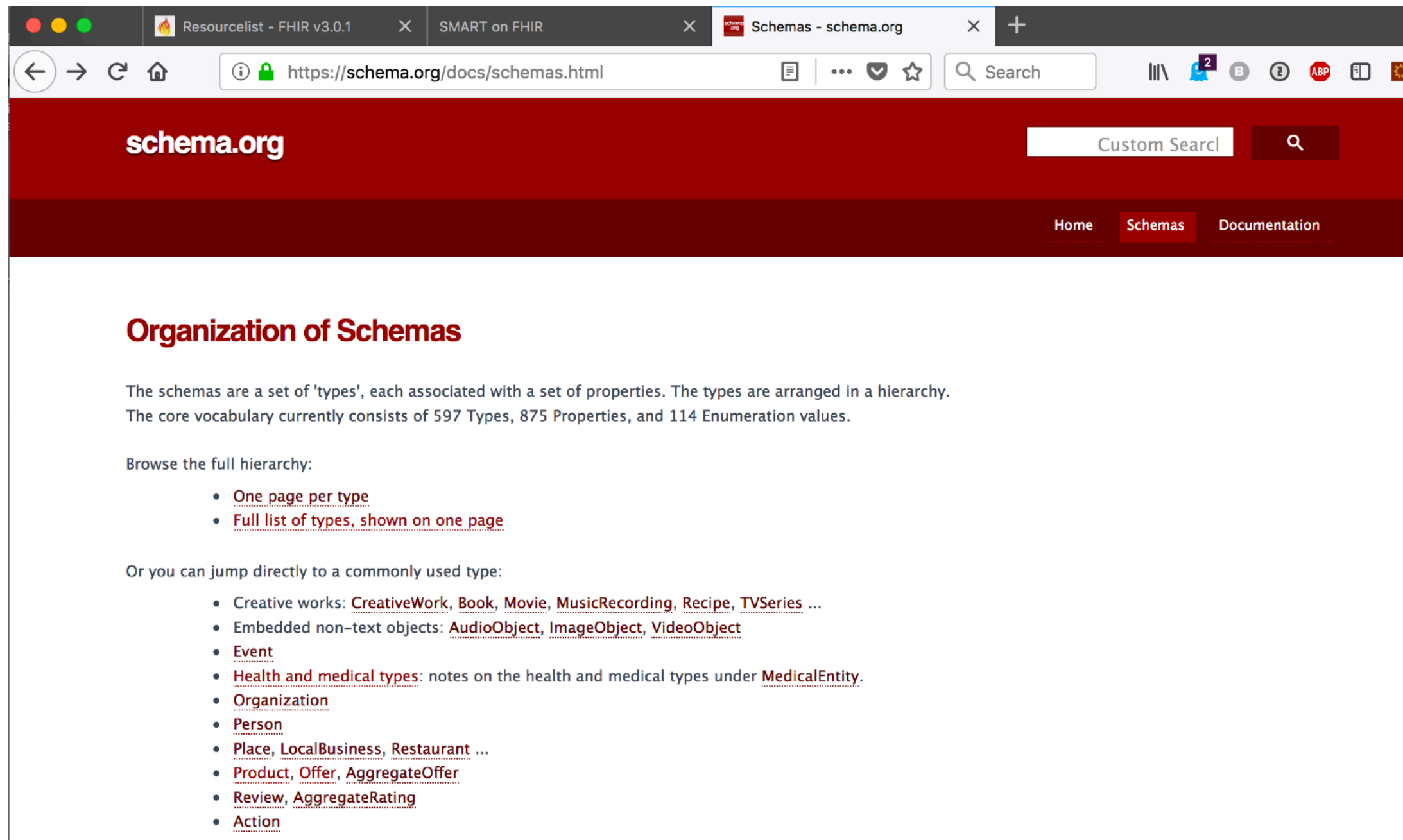
```
<div id="wrap-content">
```

```
  <main id="main">
```

```
    <div id="content" class="clearfix"><div id="product-page"><div><section
class="product-page"><noscript></noscript><section class="product-details js-product-details"
itemtype="//schema.org/Product"><span class="product-details__badge"></span><h1><a href="/en-us/mens/
designers/Jaeger-LeCoultre" class="product-details__designer--link" title="View all Jaeger-LeCoultre"><span
class="product-details__designer" itemprop="brand"><span>Jaeger-LeCoultre</span></span></a><span
class="product-details__name" itemprop="name"><span>Geophysic Universal Time 41mm Stainless Steel
Watch</span></span></h1><span class="product-details-price undefined" itemprop="offers"
itemtype="//schema.org/Offer"><noscript></noscript><span class="product-details__price price-sale"
itemprop="priceSpecification" itemscope itemtype="http://schema.org/PriceSpecification"><span
class="price-sale" itemprop="priceCurrency" content="USD"></span><span class="product-details__price--value
price-sale" itemprop="price"
content="15700">$15,700</span><noscript></noscript><noscript></noscript></span></span></section><section
class="product-gallery"><div class="product-fullscreen"><div class="product-fullscreen__carousel"><div
```

# schema.org

# RDF Catalog



The screenshot shows a web browser window with the URL <https://schema.org/docs/schemas.html>. The page has a dark red header with the **schema.org** logo on the left and a search bar on the right. Below the header, there are navigation links for [Home](#), [Schemas](#) (which is highlighted), and [Documentation](#).

## Organization of Schemas

The schemas are a set of 'types', each associated with a set of properties. The types are arranged in a hierarchy. The core vocabulary currently consists of 597 Types, 875 Properties, and 114 Enumeration values.

Browse the full hierarchy:

- [One page per type](#)
- [Full list of types, shown on one page](#)

Or you can jump directly to a commonly used type:

- Creative works: [CreativeWork](#), [Book](#), [Movie](#), [MusicRecording](#), [Recipe](#), [TVSeries](#) ...
- Embedded non-text objects: [AudioObject](#), [ImageObject](#), [VideoObject](#)
- [Event](#)
- [Health and medical types](#): notes on the health and medical types under [MedicalEntity](#).
- [Organization](#)
- [Person](#)
- [Place](#), [LocalBusiness](#), [Restaurant](#) ...
- [Product](#), [Offer](#), [AggregateOffer](#)
- [Review](#), [AggregateRating](#)
- [Action](#)



# How do it know?

The image is a screenshot of a Google search results page for the query "asthma symptoms". At the top, the Google logo is on the left, the search bar contains "asthma symptoms", and on the right are icons for a grid, notifications, and a profile. Below the search bar are tabs for "All", "Images", "Videos", "News", "Books", "More", "Settings", and "Tools". The "All" tab is selected. The results show "About 94,800,000 results (3.08 seconds)".

The first result is an advertisement from [www.asthma.com/](http://www.asthma.com/) titled "Asthma Signs & Symptoms - Living With Asthma". It includes sub-links for "Asthma Symptoms" and "ASTHMA CONTROL TEST™".

The second result is another advertisement from a "Prescription treatment website" titled "What Is Asthma? - Discover Signs And Symptoms". It includes sub-links for "Asthma Control Test", "Asthma & FAQs", "How To Use", and "Talk To Your Doctor".

The third result is from WebMD, titled "Asthma Attack Symptoms & Early Signs of Asthma - WebMD", with the URL <https://www.webmd.com/asthma/guide/asthma-symptoms>. A large green arrow points from this result towards the right-hand summary box.

At the bottom left, there is a "People also ask" section with the question "What are the early symptoms of asthma?".

On the right side of the page, there is a teal summary box titled "Asthma" with the subtitle "Also called: bronchial asthma". It has tabs for "ABOUT", "SYMPTOMS" (which is active), and "TREATMENTS". The "SYMPTOMS" tab contains the following information:

- Requires a medical diagnosis**  
Asthma may cause difficulty breathing, chest pain, cough, and wheezing. The symptoms may sometimes flare-up.
- People may experience:**
  - Cough:** can occur at night, during exercise, can be chronic, dry, with phlegm, mild, or severe
  - Respiratory:** difficulty breathing, wheezing, breathing through the mouth, fast breathing, frequent respiratory infections, rapid breathing, or shortness of breath at night
  - Also common:** chest pressure, flare, anxiety, early awakening, fast heart rate, or throat irritation
- Consult a doctor for medical advice
- Sources:** Mayo Clinic and others. Learn more





# What the search engine sees

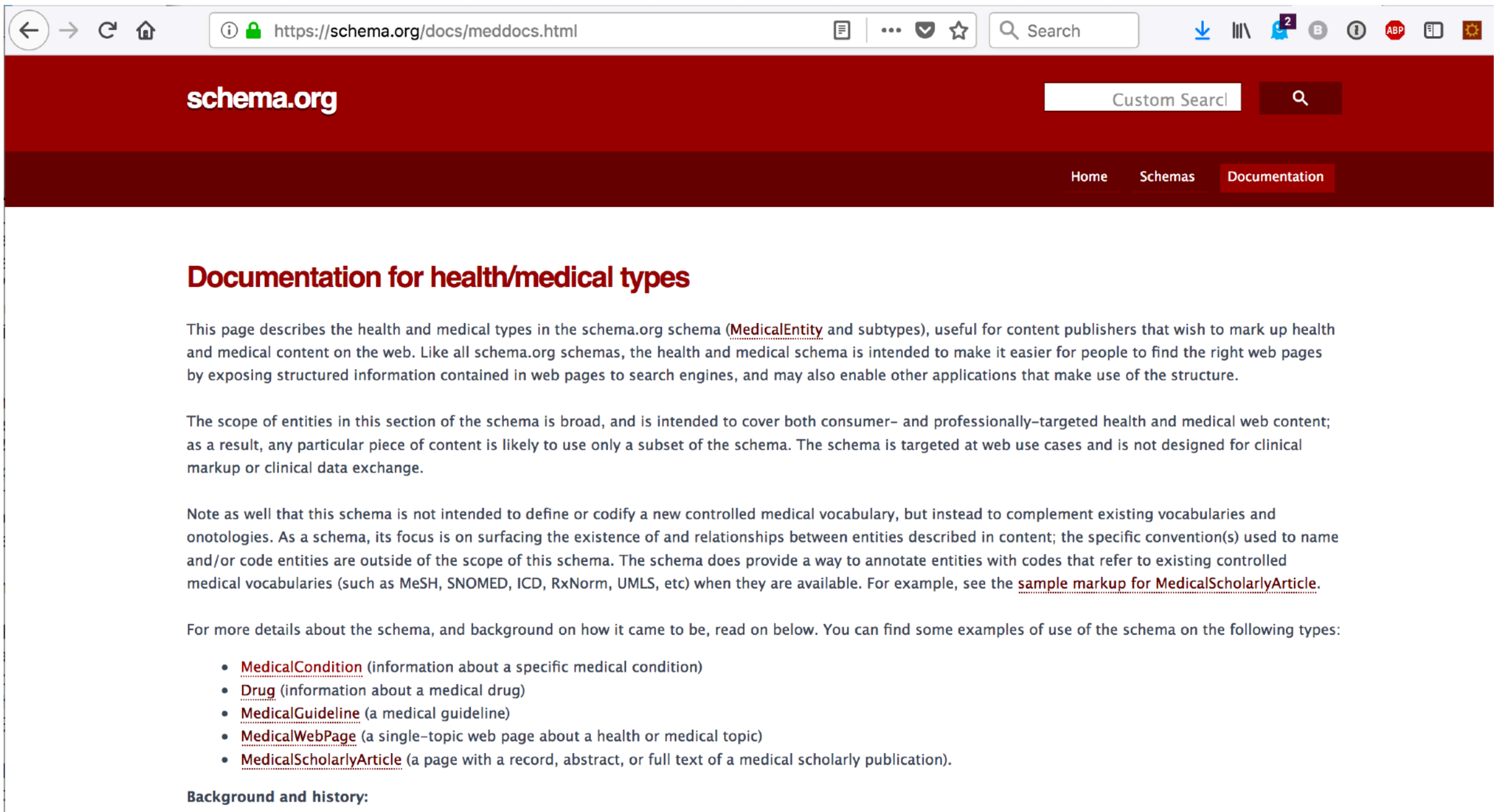
```
<meta property="og:image" content="http://www.mayoclinic.org/-/media/web/GBS/Shared/Images/SocialMedia-Metadata/MC_OpenGraph_600x315.jpg" />

<link rel="alternate" href="https://www.mayoclinic.org/diseases-conditions/asthma/symptoms-causes/syc-20369653" hreflang="en"/>
<link rel="alternate" href="https://www.mayoclinic.org/es-es/diseases-conditions/asthma/symptoms-causes/syc-20369653" hreflang="es"/>
<link rel="alternate" href="https://www.mayoclinic.org/ar/diseases-conditions/asthma/symptoms-causes/syc-20369653" hreflang="ar"/>
<link rel="canonical" href="https://www.mayoclinic.org/diseases-conditions/asthma/symptoms-causes/syc-20369653"/>
<meta name="PublishDate" content="2018-03-09" />
<script type="application/ld+json">{"@context": "http://schema.org", "@type": "WebPage", "name": "Asthma - Symptoms and causes - Mayo Clinic", "datePublished": "2018-03-09", "url": "https://www.mayoclinic.org/diseases-conditions/asthma/symptoms-causes/syc-20369653"}</script>

<!--[if lt IE 9]>
|   <script src="//html5shim.googlecode.com/svn/trunk/html5.js"></script>
<![endif]-->

<link rel="stylesheet" type="text/css" href="/styles/css/gbs/mayocombined_7CFF73F48D4FC75429B89D07C70FF404.css" />
```

# Healthcare and schema.org



The screenshot shows a web browser window with the address bar displaying `https://schema.org/docs/meddocs.html`. The page has a dark red header with the **schema.org** logo on the left and a search bar labeled 'Custom Search' on the right. Below the header is a navigation bar with links for 'Home', 'Schemas', and 'Documentation' (which is highlighted). The main content area is titled 'Documentation for health/medical types' in a dark red font. The text explains that this page describes health and medical types in the schema.org schema, specifically [MedicalEntity](#) and its subtypes. It notes that the schema is intended to make it easier for people to find web pages by exposing structured information to search engines. The scope is broad, covering both consumer- and professionally-targeted health and medical web content, but it is not designed for clinical markup or data exchange. A note states that the schema is not intended to define a new controlled medical vocabulary but to complement existing ones. It mentions that the schema provides a way to annotate entities with codes from existing vocabularies like MeSH, SNOMED, ICD, RxNorm, and UMLS, with a reference to [sample markup for MedicalScholarlyArticle](#). A paragraph follows stating that more details about the schema and its background can be found below, and that examples of use can be found on the following types:

- [MedicalCondition](#) (information about a specific medical condition)
- [Drug](#) (information about a medical drug)
- [MedicalGuideline](#) (a medical guideline)
- [MedicalWebPage](#) (a single-topic web page about a health or medical topic)
- [MedicalScholarlyArticle](#) (a page with a record, abstract, or full text of a medical scholarly publication).

The page concludes with the heading 'Background and history:' followed by a horizontal line.

# Part 3

## **FHIR, RDF and the Semantic Web**

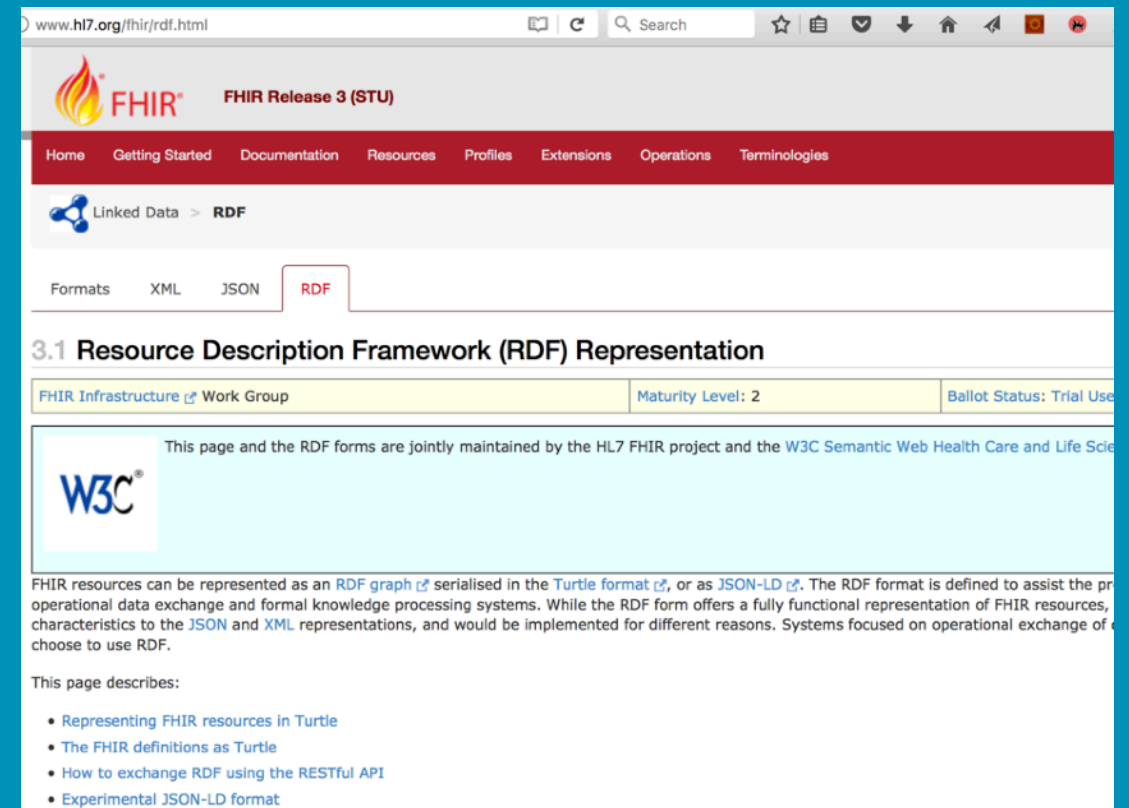
- **The FHIR RDF Specification**



- Why RDF and FHIR

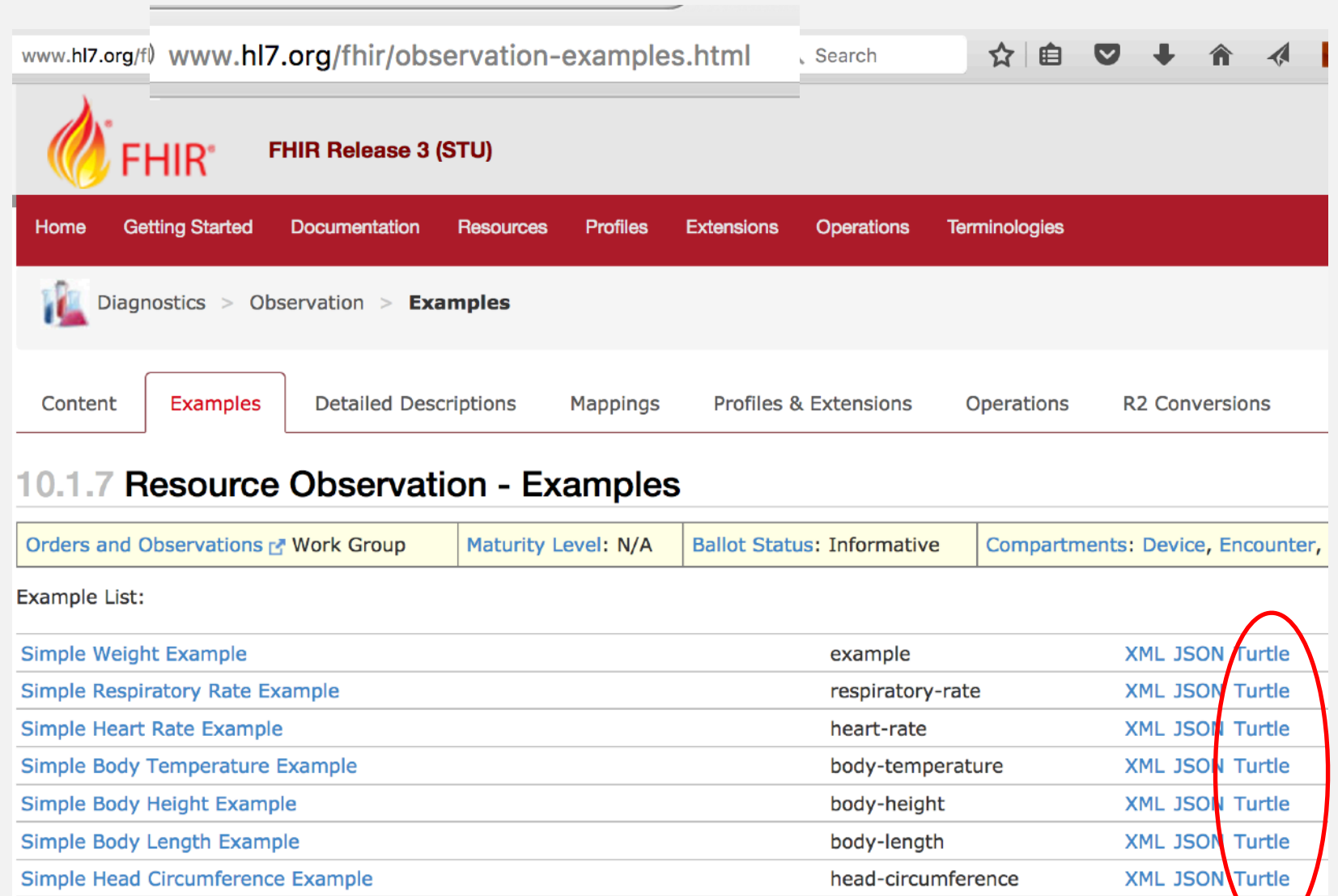
# FHIR and RDF

- First released in STU3
- Maturity Level: 2
- Ballot status: Trial Use
- Components
  - FHIR → RDF RDF→FHIR
  - StructureDefinition → Shape Expressions (ShEx)
  - StructureDefinition → FHIR Resource Catalog



# RDF in FHIR

## R4 Examples Available in RDF Turtle



The screenshot shows the FHIR website (www.hl7.org/fhir) with the URL www.hl7.org/fhir/observation-examples.html. The page is titled "10.1.7 Resource Observation - Examples". It features a navigation bar with links: Home, Getting Started, Documentation, Resources, Profiles, Extensions, Operations, and Terminologies. Below the navigation bar, there is a breadcrumb trail: Diagnostics > Observation > Examples. The page content includes a table with columns for "Orders and Observations", "Work Group", "Maturity Level", "Ballot Status", and "Compartments". The table lists several examples, including "Simple Weight Example", "Simple Respiratory Rate Example", "Simple Heart Rate Example", "Simple Body Temperature Example", "Simple Body Height Example", "Simple Body Length Example", and "Simple Head Circumference Example". Each example has a corresponding "example" ID and a list of available formats: XML, JSON, and Turtle. The "Turtle" format is highlighted in red in the original image.

Orders and Observations	Work Group	Maturity Level	Ballot Status	Compartments
Simple Weight Example	example	N/A	Informative	Device, Encounter,
Simple Respiratory Rate Example	respiratory-rate			
Simple Heart Rate Example	heart-rate			
Simple Body Temperature Example	body-temperature			
Simple Body Height Example	body-height			
Simple Body Length Example	body-length			
Simple Head Circumference Example	head-circumference			



# Comparison JSON and RDF

## JSON

```
{
  "resourceType": "Observation",
  "id": "example",
  "text": {
    "status": "generated",
    "div": "<div xmlns='http://www.w3.org/1999/xhtml'><p><b>Generated Narrative with Details</b></p><p><b>id</b>: example</p><p><b>status</b>: final</p><p><b>category</b>: Vital Signs <span>(Details : {http://hl7.org/fhir/observation-category code 'vital-signs' = 'Vital Signs', given as 'Vital Signs'})</span></p><p><b>code</b>: Body Weight <span>(Details : {LOINC code '29463-7' = 'Body weight', given as 'Body Weight'; {LOINC code '3141-9' = 'Body weight Measured', given as 'Body weight Measured'; {SNOMED CT code '27113001' = 'Body weight', given as 'Body weight'; {http://acme.org/devices/clinical-codes code 'body-weight' = 'body-weight', given as 'Body Weight'}}</span></p><p><b>subject</b>: <a>Patient/example</a></p><p><b>context</b>: <a>Encounter/example</a></p><p><b>effective</b>: 28/03/2016</p><p><b>value</b>: 185 lbs<span> (Details: UCUM code [lb_av] = 'lb_av')</span></p></div>"
  },
  "status": "final",
  "category": [
    {
      "coding": [
        {
          "system": "http://hl7.org/fhir/observation-category",
          "code": "vital-signs",
          "display": "Vital Signs"
        }
      ]
    }
  ],
  "code": {
    "coding": [
      {
        "system": "http://loinc.org",
        "code": "29463-7",
        "display": "Body Weight"
      }
    ]
  }
}
```

## RDF

### Simple Weight Example

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

# - resource -----

<http://hl7.org/fhir/Observation/example> a fhir:Observation;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "example"];
  fhir:DomainResource.text [
    fhir:Narrative.status [ fhir:value "generated" ];
    fhir:Narrative.div "<div xmlns='http://www.w3.org/1999/xhtml'><p><b>Generated Narrative with Details</b></p><p><b>id</b>: example</p><p><b>status</b>: final</p><p><b>category</b>: Vital Signs <span>(Details : {http://hl7.org/fhir/observation-category code 'vital-signs' = 'Vital Signs', given as 'Vital Signs'})</span></p><p><b>code</b>: Body Weight <span>(Details : {LOINC code '29463-7' = 'Body weight', given as 'Body Weight'; {LOINC code '3141-9' = 'Body weight Measured', given as 'Body weight Measured'; {SNOMED CT code '27113001' = 'Body weight', given as 'Body weight'; {http://acme.org/devices/clinical-codes code 'body-weight' = 'body-weight', given as 'Body Weight'}}</span></p><p><b>subject</b>: <a>Patient/example</a></p><p><b>context</b>: <a>Encounter/example</a></p><p><b>effective</b>: 28/03/2016</p><p><b>value</b>: 185 lbs<span> (Details: UCUM code [lb_av] = 'lb_av')</span></p></div>"
  ];
  fhir:Observation.status [ fhir:value "final"];
  fhir:Observation.category [
    fhir:index 0;
    fhir:CodeableConcept.coding [
      fhir:index 0;
      fhir:Coding.system [ fhir:value "http://hl7.org/fhir/observation-category" ];
      fhir:Coding.code [ fhir:value "vital-signs" ];
      fhir:Coding.display [ fhir:value "Vital Signs" ]
    ]
  ];
  fhir:Observation.code [
    fhir:CodeableConcept.coding [
      fhir:index 0;
      a loinc:29463-7;
      fhir:Coding.system [ fhir:value "http://loinc.org" ];
      fhir:Coding.code [ fhir:value "29463-7" ];
      fhir:Coding.display [ fhir:value "Body Weight" ]
    ]
  ]
}
```

# FHIR Data Types

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

FHIR SD —> FHIR RDF —> FHIR SD

Which is why:

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

instead of:

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

# Preserving Extensibility

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

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

and:

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

should be the same.

# RDF “Round Trippability”

## JSON

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

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

Identify Document Root

Preserve List Order

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

# RDF Rendering Extensions – Concept URIs

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

**RDF**

[<http://snomed.info/id/394914008>](http://snomed.info/id/394914008)

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

**JSON**

# RDF Rendering Extensions – Resource Types

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

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

Resource Type

Construct the actual URI



# Ontology Header

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

## Requirement: import FHIR URI Catalog

- No 'import in RDF' – have to use OWL
- owl:imports requires owl:Ontology
- 'f201.ttl' vs. 'f201' – reasoners don't cope well with something that is *both* a fhir:DiagnosticReport *and* an owl:Ontology (ontology *describes* report, not *IS* the report)

## Stay tuned:

- Looking at <http://hl7.org/fhir/DiagnosticReport/owl/f201> as an alternative

# Accessing FHIR RDF

- Mime Types
  - 'text/turtle'
  - (Discussing others)
- Format
  - \_format=
    - ttl
    - turtle
    - text/
    - text/turtle

# Accessing FHIR RDF

## Supporting servers

- STU3 (<http://hl7.org/fhir/>)
  - Doesn't recognize format or mime types – have to access physical file
  - <http://hl7.org/fhir/Patient/f201> ← NO
  - <http://hl7.org/fhir/patient-example-f201-roel.ttl>
- Latest Build (<http://build.fhir.org/>)
  - Same as STU3
- FHIR Test Server (<http://test.fhir.org/Patient>)
  - <http://test.fhir.org/r3/Patient/f201?format=text/turtle>
  - Accept: text/turtle;q=0.9, ...

```
> curl http://test.fhir.org/r3/Patient/204?_format=text/turtle
```

```
@prefix fhir: <http://hl7.org/fhir/> .
```

```
@prefix owl: <http://www.w3.org/2002/07/owl#> .
```

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
```

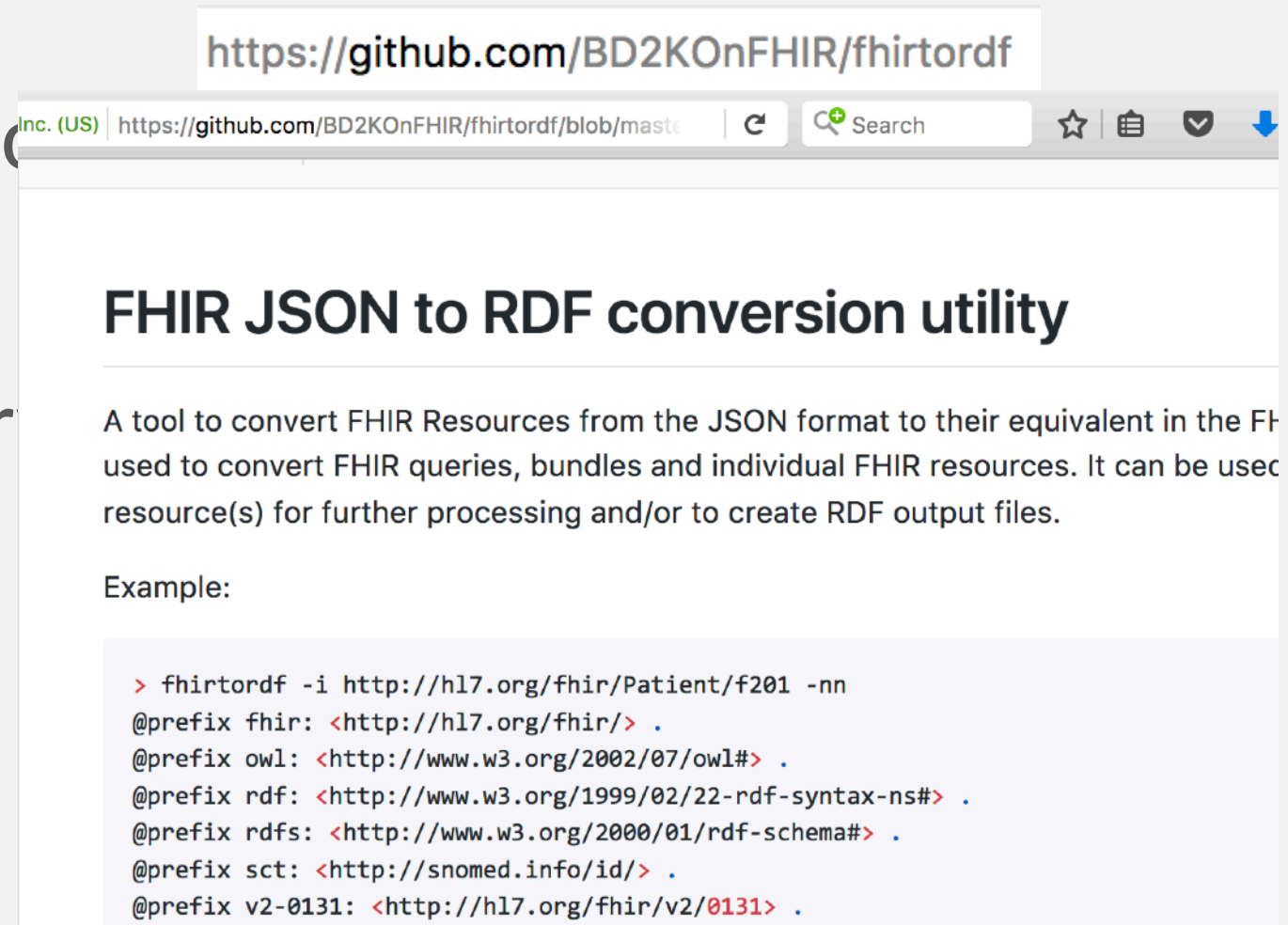
```
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
```

```
<http://test.fhir.org/r3/Patient/204> a fhir:Patient ;  
  fhir:nodeRole fhir:treeRoot ;  
  fhir:Resource.id [ fhir:value "204"^^xsd:string ] ;  
  fhir:Resource.meta [  
    fhir:Meta.versionId [ fhir:value "1"^^xsd:string ] ;  
    fhir:Meta.lastUpdated [ fhir:value  
      "2017-09-26T21:59:49Z"^^xsd:dateTime ]  
  ] ;  
  fhir:DomainResource.text [
```

# Accessing FHIR RDF – JSON to RDF

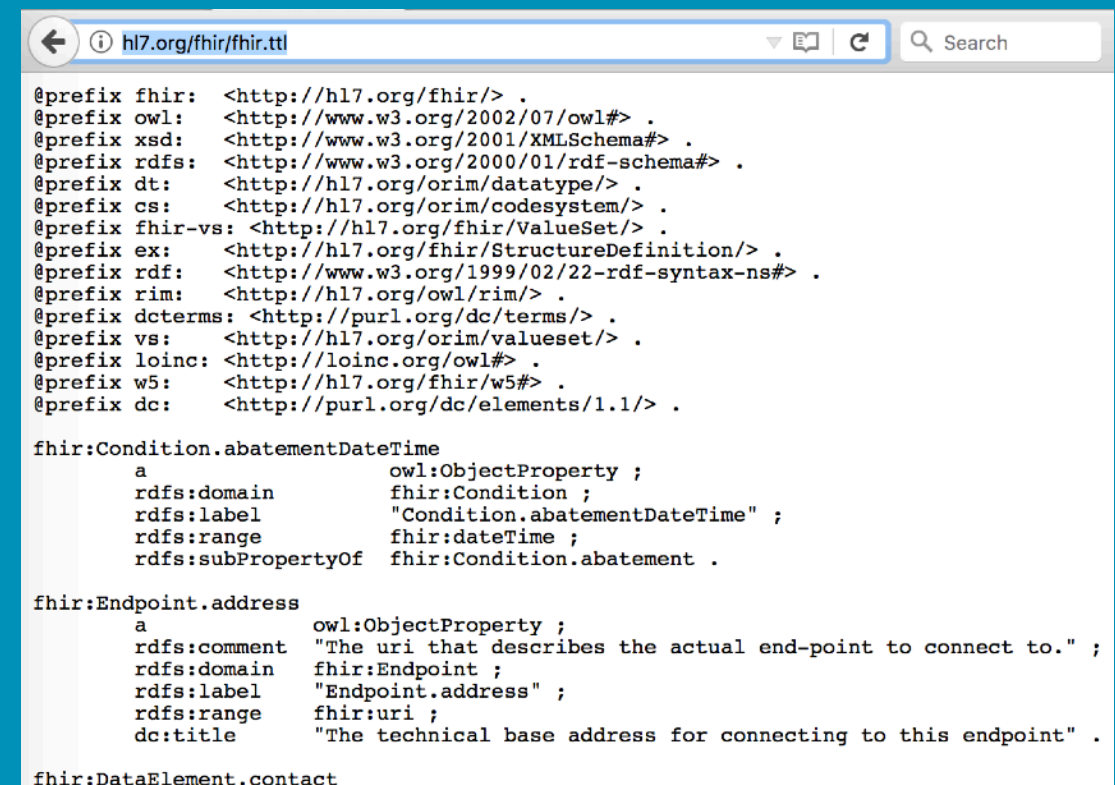
## FHIR JSON to RDF Converter

- Python3
- Command line and library
- Used in i2FHIRb2



# FHIR Structure Vocabulary

- Sometimes referred to as the “FHIR Ontology”...
- <http://hl7.org/fhir/fhir.ttl>
- Direct representation of FHIR StructureDefinition information
  - (Very) proper subset
- Purpose is (or includes):
  - Define the classes and predicates used in the FHIR RDF representation



```
@prefix fhir: <http://hl7.org/fhir/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dt: <http://hl7.org/orim/datatype/> .
@prefix cs: <http://hl7.org/orim/codesystem/> .
@prefix fhir-vs: <http://hl7.org/fhir/ValueSet/> .
@prefix ex: <http://hl7.org/fhir/StructureDefinition/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rim: <http://hl7.org/owl/rim/> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix vs: <http://hl7.org/orim/valueset/> .
@prefix loinc: <http://loinc.org/owl#> .
@prefix w5: <http://hl7.org/fhir/w5#> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .

fhir:Condition.abatementDateTime
  a owl:ObjectProperty ;
  rdfs:domain fhir:Condition ;
  rdfs:label "Condition.abatementDateTime" ;
  rdfs:range fhir:dateTime ;
  rdfs:subPropertyOf fhir:Condition.abatement .

fhir:Endpoint.address
  a owl:ObjectProperty ;
  rdfs:comment "The uri that describes the actual end-point to connect to." ;
  rdfs:domain fhir:Endpoint ;
  rdfs:label "Endpoint.address" ;
  rdfs:range fhir:uri ;
  dc:title "The technical base address for connecting to this endpoint" .

fhir:DataElement.contact
```

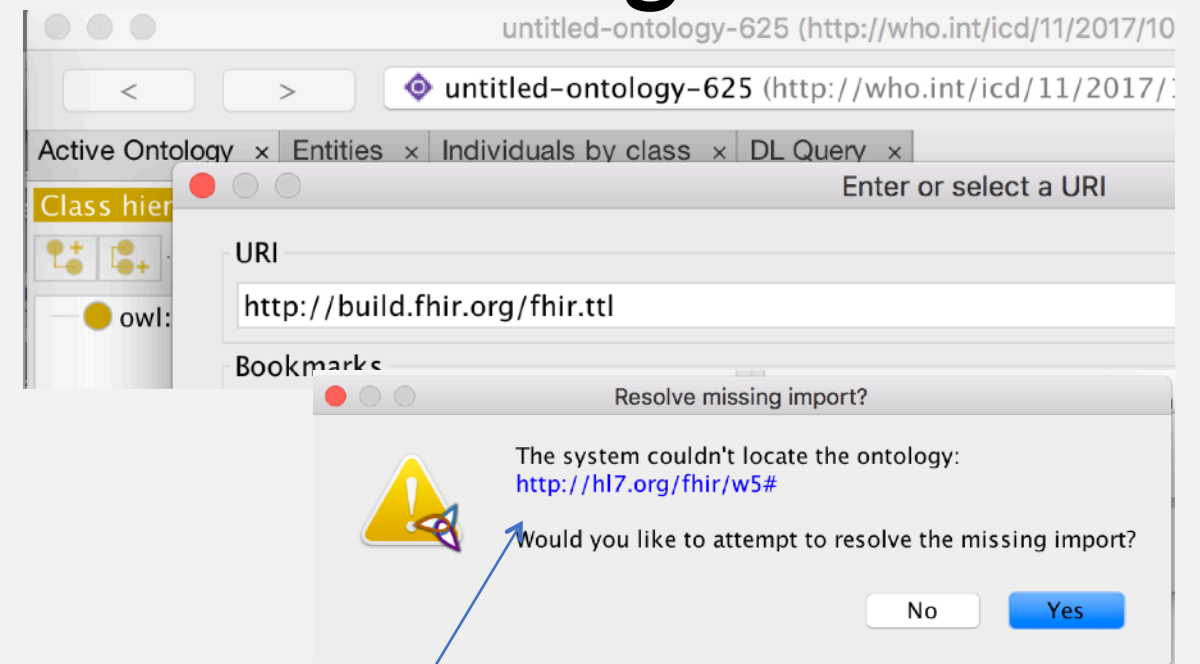
# FHIR Structure Vocabulary

```
fhir:Observation a owl:Class ;  
  rdfs:comment "Measurements and simple assertions made about a patient" ;  
  rdfs:label "Observation" ;  
  rdfs:subClassOf fhir:DomainResource , w5:clinical.diagnostics ;  
  rdfs:subClassOf [ a owl:Restriction ;  
    owl:allValuesFrom fhir:ObservationRelatedComponent ;  
    owl:onProperty fhir:Observation.related  
  ] ;
```

```
rdfs:subClassOf [ a owl:Restriction ;  
  owl:cardinality 1 ;  
  owl:onProperty fhir:Observation.status ;  
  owl:someValuesFrom fhir:code  
] ;  
rdfs:subClassOf [ a owl:Restriction ;
```

```
fhir:Observation.status  
  a owl:ObjectProperty ;  
  rdfs:comment "The status of the result value." ;  
  rdfs:domain fhir:Observation ;  
  rdfs:label "Observation.status" ;  
  rdfs:range fhir:code ;  
  rdfs:subPropertyOf w5:status ;  
  dc:title "registered | preliminary | final | amended +" .
```

## Protégé



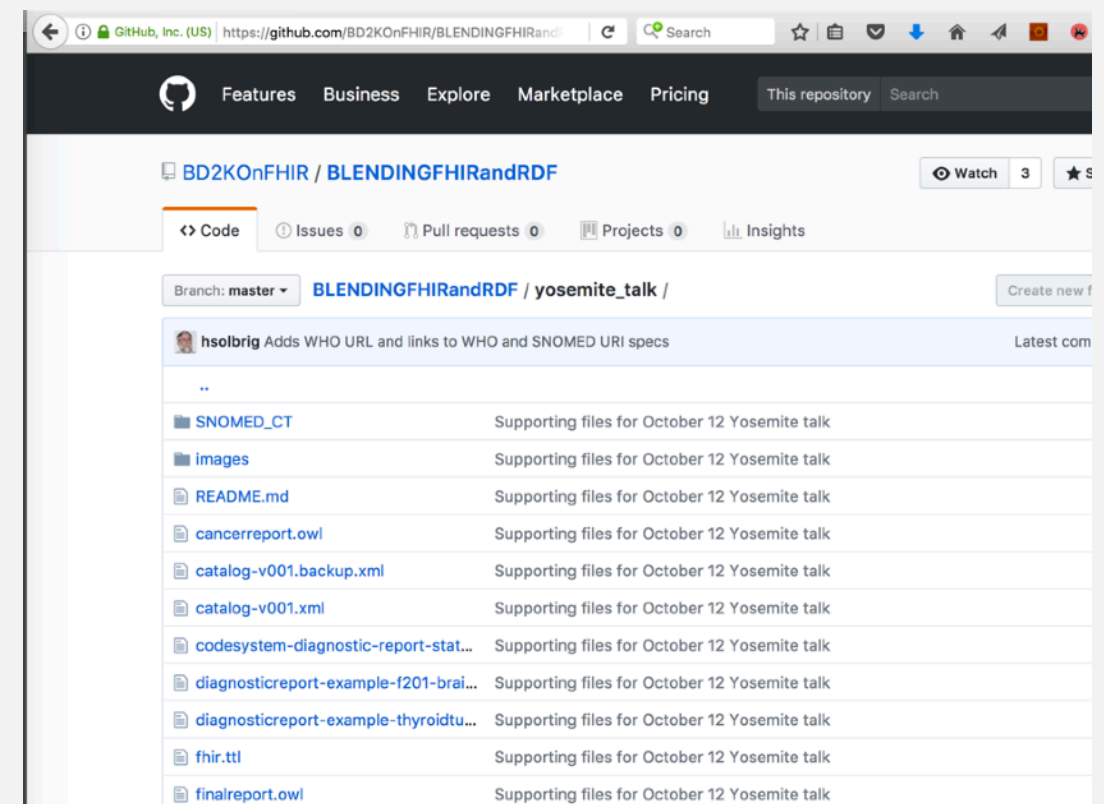
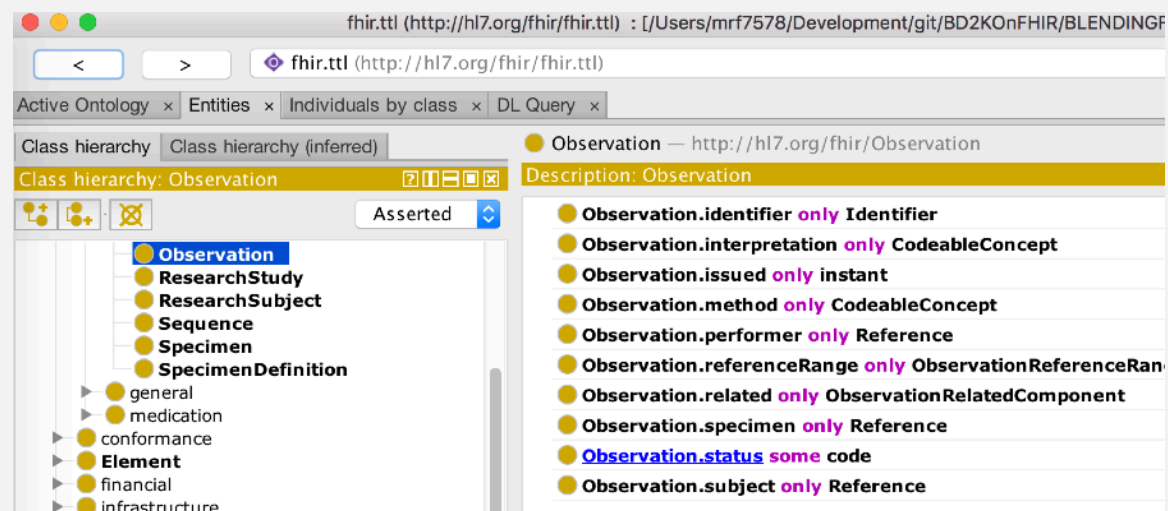
## ISSUE

Short term solution:

Keep a local copy of <http://hl7.org/fhir/w5.ttl>



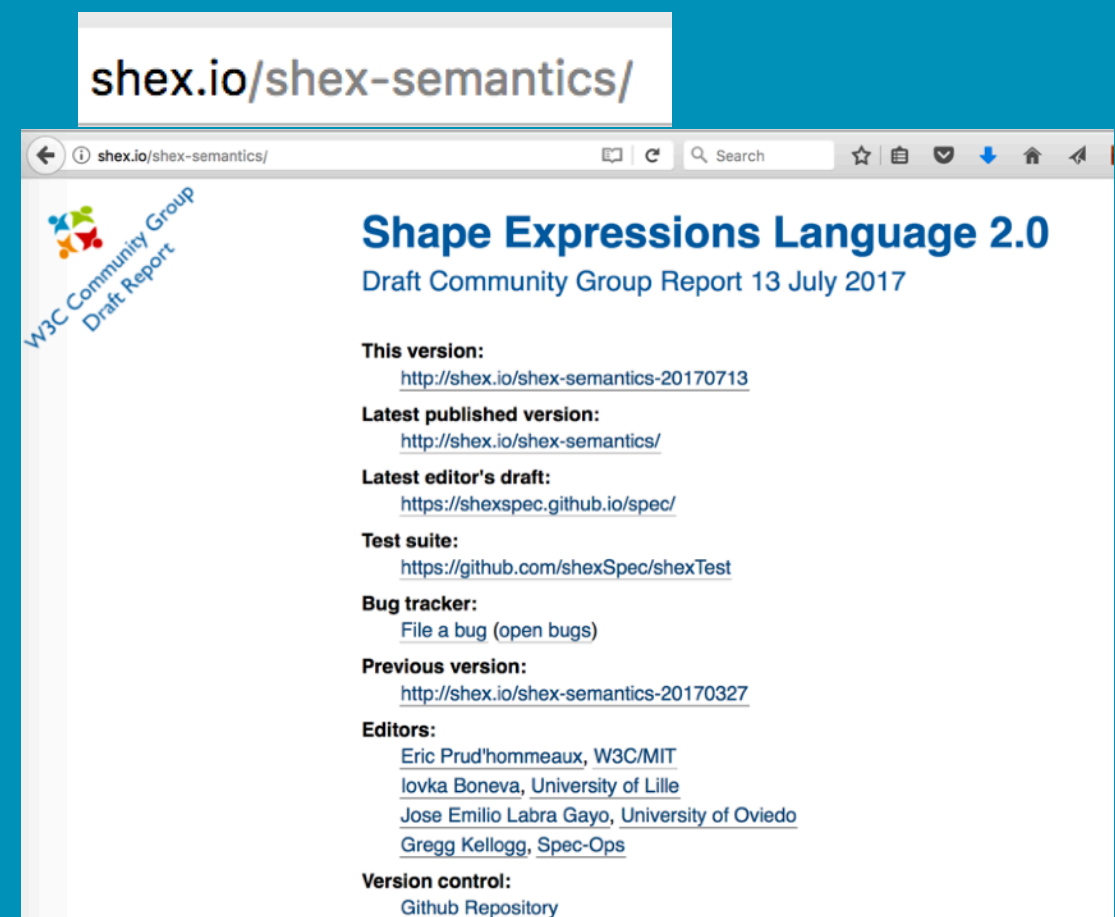
# FHIR Structure Vocabulary in Protégé



[https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/tree/master/yosemite\\_talk](https://github.com/BD2KOnFHIR/BLENDINGFHIRandRDF/tree/master/yosemite_talk)

# Shape Expressions (ShEx) - RDF “Schema”

- “Schema” because “RDF Schema” is also used for something else
- Called Shape Expressions (ShEx)
  - Good for almost as many puns as “FHIR” ...
  - ... but you have to be very careful



# ShEx Schemas available for all R4 resources

The screenshot shows the HL7 FHIR Observation resource page. On the left, a tree view lists the components of the Observation resource: valueRatio, valueSampledData, valueAttachment, valueTime, valueDateTime, valuePeriod, dataAbsentReason, interpretation, and referenceRange. Each component is linked to its corresponding ShEx schema. Below the tree, there is a link for 'Documentation for this format'. At the bottom, a note states: 'Alternate definitions: Master Definition (XML, JSON), XML Schema/Schematron (for ) + JSON Schema, ShEx (for Turtle)'.

Component	ShEx Schema
valueRatio	Ratio
valueSampledData	SampledData
valueAttachment	Attachment
valueTime	time
valueDateTime	dateTime
valuePeriod	Period
dataAbsentReason	CodeableConcept
interpretation	CodeableConcept
referenceRange	see referenceRange

Documentation for this format

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

Schema, ShEx (for Turtle)

The screenshot shows the HL7 FHIR Observation ShEx schema page. The title is 'ShEx statement for observation'. The schema is written in ShEx notation and includes the following prefixes: PREFIX fhir: <http://hl7.org/fhir/>, PREFIX fhirvs: <http://hl7.org/fhir/ValueSet/>, PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>, and BASE <http://hl7.org/fhir/shape/>. The schema starts with 'start=@<Observation> AND {fhir:nodeRole [fhir:treeRoot]]'. It then defines the structure of the Observation resource, including the 'Observation' element, its children, and the 'basedOn' element. The schema is written in ShEx notation and includes the following prefixes: PREFIX fhir: <http://hl7.org/fhir/>, PREFIX fhirvs: <http://hl7.org/fhir/ValueSet/>, PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>, and BASE <http://hl7.org/fhir/shape/>. The schema starts with 'start=@<Observation> AND {fhir:nodeRole [fhir:treeRoot]]'. It then defines the structure of the Observation resource, including the 'Observation' element, its children, and the 'basedOn' element.

```
ShEx statement for observation

PREFIX fhir: <http://hl7.org/fhir/>
PREFIX fhirvs: <http://hl7.org/fhir/ValueSet/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
BASE <http://hl7.org/fhir/shape/>

start=@<Observation> AND {fhir:nodeRole [fhir:treeRoot]]

# Measurements and simple assertions
<Observation> CLOSED {
  a [fhir:Observation];
  fhir:nodeRole [fhir:treeRoot]?;
  fhir:Resource.id @<id>?; # Logical id of this artifact
  fhir:Resource.meta @<Meta>?; # Metadata about the resource
  fhir:Resource.implicitRules @<uri>?; # A set of rules under which this
  # content was created
  fhir:Resource.language @<code>?; # Language of the resource content
  fhir:DomainResource.text @<Narrative>?; # Text summary of the resource, for
  # human interpretation
  fhir:DomainResource.contained @<Resource>*; # Contained, inline Resources
  fhir:DomainResource.extension @<Extension>*; # Additional Content defined by
  # implementations
  fhir:DomainResource.modifierExtension @<Extension>*; # Extensions that cannot be ig
  nored
  fhir:Observation.identifier @<Identifier>*; # Business Identifier for observation
  fhir:Observation.basedOn # Fulfills plan, proposal or order
  ( @<CarePlanReference> OR
    @<DeviceRequestReference> OR
    @<ImmunizationRecommendationReference> OR
    @<MedicationRequestReference> OR
    @<NutritionOrderReference> OR
    @<ProcedureRequestReference> OR
    @<ReferralRequestReference>
  )
}
```

# ShEx Conformance checking

The screenshot shows the ShEx2 Simple Online Validator interface. The left pane displays a ShEx query map for an FHIR Observation resource, and the right pane shows the corresponding RDFS graph. The status bar at the bottom indicates the query is passing.

**ShEx2 — Simple Online Validator** controls ▾

**Left Pane (ShEx Query Map):**

```
PREFIX fhir: <http://hl7.org/fhir/>
PREFIX fhirvs: <http://hl7.org/fhir/ValueSet/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
BASE <http://hl7.org/fhir/shape/>

start=@<Observation> AND {fhir:nodeRole [fhir:treeRoot]}

# Measurements and simple assertions
<Observation> CLOSED {
  a [fhir:Observation];
  fhir:nodeRole [fhir:treeRoot]?;
  fhir:Resource.id @<id>;           # Logical id of this artifact
  fhir:Resource.meta @<Meta>;      # Metadata about the resource
  fhir:Resource.implicitRules @<uri>; # A set of rules under which
  this
  fhir:Resource.language @<code>;   # content was created
  # Language of the resource
  content
  fhir:DomainResource.text @<Narrative>; # Text summary of the
  resource, for
  fhir:DomainResource.contained @<Resource>*; # human interpretation
  # Contained, inline
  Resources
  fhir:DomainResource.extension @<Extension>*; # Additional Content
  defined by
}
```

**Right Pane (RDFS Graph):**

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

# - resource
-----
<http://hl7.org/fhir/Observation/f001> a fhir:Observation;
  fhir:nodeRole fhir:treeRoot;
  fhir:Resource.id [ fhir:value "f001"];
  fhir:DomainResource.text [
    fhir:Narrative.status [ fhir:value "generated" ];
    fhir:Narrative.div "<div xmlns='http://www.w3.org/1999/xhtml'><p>
      <b>Generated Narrative with Details</b></p><p><b>id</b>: f001</p>
      <p><b>identifier</b>: 6323 (OFFICIAL)</p><p><b>status</b>: final</p>
      <p><b>code</b>: Glucose [Moles/volume] in Blood <span>(Details : {LOINC
      code '15074-8' = 'Glucose [Moles/volume] in Blood', given as 'Glucose
      [Moles/volume] in Blood'})</span></p><p><b>subject</b>: <a>P. van de
      Heuvel</a></p><p><b>effective</b>: Apr 2, 2013 9:30:10 AM --&gt;
      (ongoing)</p><p><b>issued</b>: Apr 3, 2013 3:30:10 PM</p>
      <p><b>performer</b>: <a>A. Langeveld</a></p><p><b>value</b>: 6.3
      mmol/L<span> (Details: UCUM code mmol/L = 'mmol/L')</span></p><p>
      <b>interpretation</b>: High <span>(Details : {http://hl7.org/fhir/v2/0078
      code 'H' = 'High', given as 'High'})</span></p><h3>ReferenceRanges</h3>
    ]
  ]
}
```

**Examples:**

- FHIR Observation R3
- FHIR Observation R4

**Query Map** | Query Map Editor | Fixed Map

`<http://hl7.org/fhir/Observation/f001>@<Observation>`

**Passing:**

- sample glucose observation

validate (ctl-enter)

✓ `<http://hl7.org/fhir/Observation/f001>@<http://hl7.org/fhir/shape/Observation>`

[http://shaclex.herokuapp.com/validate?examples=https://raw.githubusercontent.com/BD2KOnFHIR/FHIRDevDays2017/master/shex\\_examples.json](http://shaclex.herokuapp.com/validate?examples=https://raw.githubusercontent.com/BD2KOnFHIR/FHIRDevDays2017/master/shex_examples.json)

[http://rawgit.com/shexSpec/shex.js/master/doc/shex-simple.html?examples=https://raw.githubusercontent.com/BD2KOnFHIR/FHIRDevDays2017/master/shex\\_examples.json](http://rawgit.com/shexSpec/shex.js/master/doc/shex-simple.html?examples=https://raw.githubusercontent.com/BD2KOnFHIR/FHIRDevDays2017/master/shex_examples.json)

# FHIR and RDF -- Summary

- FHIR R4 specification includes RDF representational format
  - RDF is available on some FHIR servers
  - Python JSON to RDF conversion tool is available
- FHIR RDF specification includes FHIR Structure Vocabulary
  - A public, standard catalog of URI's for FHIR resources
  - Potentially the “Dublin Core” for healthcare?
- Shape Expression (ShEx) schemas are available for FHIR Resources
  - Today: basic RDF validation
  - Near future: will include slicing, constraints and other enhancements

# Part 3

## **FHIR, RDF and the Semantic Web**

- The FHIR RDF Specification
- **Why RDF and FHIR**





# FHIR RDF ~~is not~~ Resource-Oriented Architecture

**That's the Resource-Oriented Architecture. It's just four concepts:**

- 1. Resources
- 1. Their names (URIs)
- 1. Their representations
- 1. The links between them



## RESTful Web Services

★★★★☆ 26 reviews

by Sam Ruby, Leonard Richardson

Publisher: O'Reilly Media, Inc.

Release Date: May 2007

ISBN: 9780596529260

Topics: **Java**

[View table of contents](#)

**and four properties:**

- 1. Addressability
- 2. Statelessness
- 3. Connectedness
- 4. A uniform interface



**“A web service is connected to the extent that you can put the service in different states just by following links and filling out forms”**

<http://my.safaribooksonline.com/9780596529260/restclients>

# FHIR “turtles” - ~~five~~ **six** different languages

- StructureDefinition & friends — core model
- Extension — tag/value
- Constraint — FhirPath
- “Slicing” —
- Value Sets
- Terminology Properties

**RDF + ShEx (can) reduce these to a *single* idiom**

# FHIR Structure Vocabulary (fhir.ttl)



## Welcome to fhir.schema.org

### Introduction

The FHIR® – Fast Healthcare Interoperability Resources are built from a set of modular components called "Resources". These resources could potentially be viewed as a loose set of "semantics" that could be used as markup for HTML, XML, JSON, etc.

While we aren't certain whether the FHIR resource constructs make sense in the context of the schema.org ecosystem, this question might be to propose a way of representing FHIR in the schema.org environment and use it to demonstrate the use of FHIR in schema.org.

To accomplish this, we have created two schema.org extensions:

1. The [FHIR WS "ontology"](#) – this provides a upper level classification of FHIR resources, as well as providing predicates
2. The FHIR resource definitions themselves – this is the set of resources and their attributes as defined in the [FHIR WS](#)

It would also be possible (and even sensible) to extend this core ontology with appropriate FHIR [Profiles](#)

### Relationship to other schema.org schemas

At the moment, there is almost no overlap between the FHIR schema elements and the components of the [core schema.org ontology \(WS\)](#) is currently a direct subclass of [THING](#). All other classes in the WS and FHIR schemas subclass WS structure is also preserved.

Assuming that the FHIR schema.org resource can be proven to be potentially useful, an obvious next step would be to

- The proposed [Health and medical types](#)
- The [Bioschemas proposal](#)
- Schema.org root classes themselves

[Thing](#) > [Resource](#) > [DomainResource](#) > [Observation](#)  
[clinical.diagnostics](#) > [Observation](#)

Base StructureDefinition for Observation Resource

Usage: Fewer than 10 domains

[more.]

Property	Expected Type	Description
<b>Properties from <a href="#">Observation</a></b>		
<a href="#">Observation.bodySite</a>	<a href="#">body-site</a>	Indicates the site on the subject's body where the observation was made (i.e. the target site).
<a href="#">Observation.category</a>	<a href="#">observation-category</a>	A code that classifies the general type of observation being made. This is used for searching, sorting and display purposes.
<a href="#">Observation.code</a>	<a href="#">observation-codes</a> or <a href="#">Icd10-codes</a>	LDL Cholesterol –measured or calculated per code.
<a href="#">Observation.comments</a>	<a href="#">Text</a>	May include statements about significant, unexpected or unreliable values, or information about the source of the value where this may be relevant to the interpretation of the result.
<a href="#">Observation.component</a>	<a href="#">BackboneElement</a>	Some observations have multiple component observations. These component observations are expressed as separate code value pairs that share the same attributes. Examples include systolic and diastolic component observations for blood pressure measurement and multiple component observations for genetics observations.
<a href="#">Observation.component.code</a>	<a href="#">observation-codes</a>	Describes what was observed. Sometimes this is called the observation "code".
<a href="#">Observation.component.dataAbsentReason</a>	<a href="#">observation-valueabsentreason</a>	Provides a reason why the expected value in the element Observation.value[x] is missing.
<a href="#">Observation.component.valueAttachment</a>	<a href="#">Attachment</a>	The information determined as a result of making the observation, if the information has a simple value.
<a href="#">Observation.component.valueCodeableConcept</a>	<a href="#">CodeableConcept</a>	The information determined as a result of making the observation, if the information has a simple value.
<a href="#">Observation.component.valuePeriod</a>	<a href="#">Period</a>	The information determined as a result of making the observation, if the information has a simple value.
<a href="#">Observation.component.valueQuantity</a>	<a href="#">Quantity</a>	The information determined as a result of making the observation, if the information has a simple value.

## Observation

Defined in the [fhir.schema.org](#) extension.

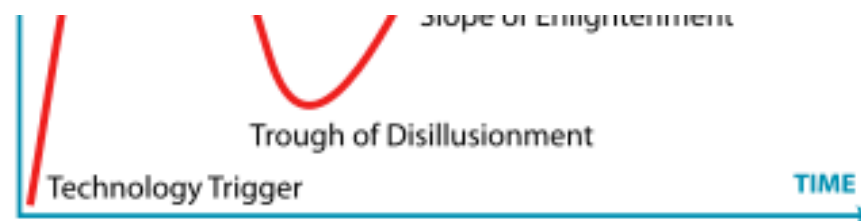
Canonical URL: <http://schema.org/Observation>

# FHIR Structure Vocabulary (fhir.ttl)

## Potential Use Cases

- Provenance for FHIR Narrative Text
- HTML FHIR Interchange Format
- Markup for personal device measurements
- Mapping for HL& Continuity of Care (CCD) and other data formats
- Markup for blogs and other Personal Health Records (PHR)
- Linking Medical Knowledge / Data / Products

# WHY FHIR RDF



Where are we on that curve, people want to know? Well, my answer is that as far as I can tell, the rate of

HL7 is an IT standardisation Organization. We have severely limited ability to standardise the practice of healthcare or medicine. We just have to accept them as they are. So we can't provide prescriptive information models. We can't force vendors or institutions to do things the same way. We can't force them to share particular kinds of information at particular times. All we can do is describe a common way to do it, if people want to do it.

So what things do I see that I think are hype? Well there are many symptoms, but one fundamental cause: there's an apparently widely held view that "FHIR will solve interoperability".

It's not going to.

FHIR is 2 things: a technology, and a culture. I'm proud of both of those things. I think both of those will make a huge contribution towards solving the problems of interoperability in healthcare. But people who think that problem will be solved anytime soon don't understand the constraints we work under.

HL7 is an IT standardisation Organization. We have severely limited ability to standardise the practice of



<http://www.healthintersections.com.au/?p=2514>



# FHIR Structure Vocabulary (FSV) in i2b2

i2b2 Query & Analysis Tool

Project: i2b2 Demo

User: i2b2 User

Find Patients | Analysis Tools

Navigate Terms

Find

FHIR Resources

administrative

clinical

careprovision

diagnostics

BodyStructure

DiagnosticReport

ImagingStudy

Observation

Observation basedOn

Observation bodySite

Observation category

Observation code

text

Observation code coding

code

Symbol in syntax defined by the system

system

userSelected

version

Observation comment

Observation component

Observation context

Observation dataAbsentReason

Observation derivedFrom

Observation device

Observation effectiveDateTime

Query Tool

Query Name:

Temporal Constraint:

Treat all groups

Group 1			Group 2		
Dates	Occurs > 0x	Exclude	Dates	Occurs > 0x	Exclude
Treat Independently			Treat Independently		
<div>drop a term on here</div>					

Run Query

Clear

0 Groups

Show Query Status

Graph Results

Query Report



# I2b2 Client Query with Literal Model

Query Tool

Query Name: It140Triglycerides1

Temporal Constraint: Items Instance will be the same

Group 1

DatesOccurs > 0xExclude

Items Instance will be the same

Observation code coding [code [Exact: 2571-8]]

one or more of these

AND

Group 2

DatesOccurs > 0xExclude

Items Instance will be the same

Observation code coding [system [Exact: http://loinc.org]]

one or more of these

AND

Group 3

DatesOccurs > 0xExclude

Occurs in Same Encounter

Observation valueQuantity [value < 140]

one or more of these

Run Query

Clear

3 Groups

Previous

Previous

New Group

Next

Next

Show Query Status

Graph Results

Query Report

Number of patients

82

For Query "It140Triglycerides1"

# Result

The screenshot shows a web browser window with the address bar displaying 'finalpatientcancerreport (http://example.org/swat4ls/finalpatientcancerreport)'. The browser has tabs for 'Active Ontology', 'Entities', 'Individuals by class', and 'DL Query'. The 'Active Ontology' tab is selected, showing a class hierarchy on the left and details for 'FinalPatientReportWithCancerDiagnosis' on the right.

**Class hierarchy (inferred):**

- owl:Thing
  - administrative
  - clinical
  - conformance
  - DxStatus
  - Element
  - FinalStatus
  - financial
  - infrastructure
  - Narrative.div
  - PatientReport
    - FinalPatientReportWithCancerDiagnosis**
  - Primitive
  - ReportWithCancerDiagnosis
    - FinalPatientReportWithCancerDiagnosis**
  - Resource
  - 'SNOMED CT Concept (SNOMED RT+CTV3)'
  - treeRoot
  - workflow
  - xhtml

**Description: FinalPatientReportWithCancerDiagnosis**

Equivalent To +

- ReportWithCancerDiagnosis and FinalReport and PatientReport**

SubClass Of +

- FinalReport
- PatientReport
- ReportWithCancerDiagnosis

General class axioms +

SubClass Of (Anonymous Ancestor)

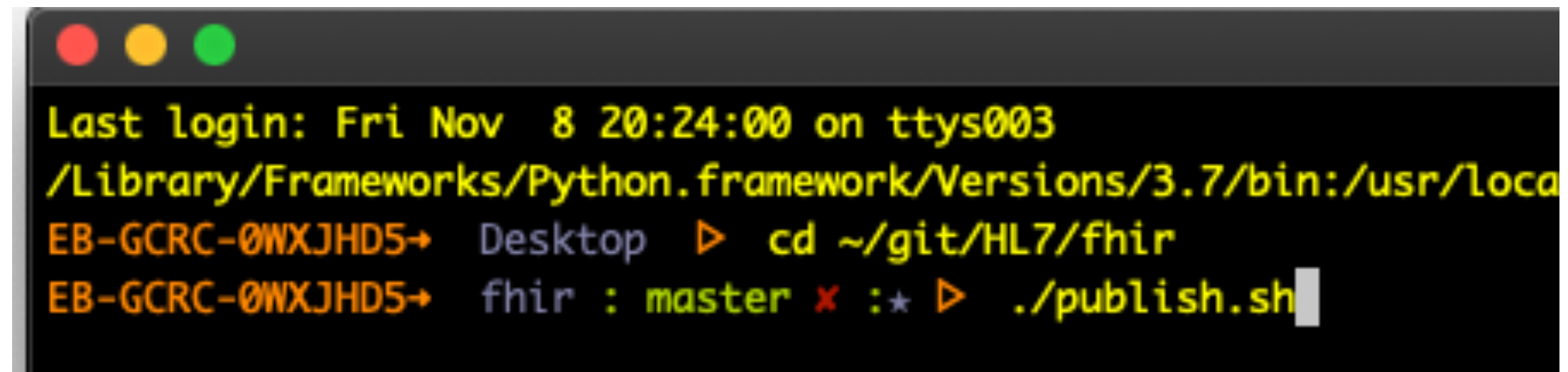
- DiagnosticReport.subject.link **some** Patient
- DiagnosticReport.codedDiagnosis.coding **some** 'Malignant neoplastic disease (disorder)'
- DiagnosticReport.status **some** FinalStatus

Instances +

- f201**

# HOW FHIR RDF is generated today

- Clone <https://github.com/HL7/fhir>
- `cd fhir`

A terminal window with a dark background and yellow text. The window has three colored window control buttons (red, yellow, green) in the top-left corner. The text inside the terminal shows a login session on 'ttys003' with a prompt indicating the current directory is '/usr/local/Library/Frameworks/Python.framework/Versions/3.7/bin'. The user enters 'cd ~/git/HL7/fhir' and then './publish.sh'.

```
Last login: Fri Nov  8 20:24:00 on ttys003
/Library/Frameworks/Python.framework/Versions/3.7/bin:/usr/local
EB-GCRC-0WXJHD5→ Desktop ▷ cd ~/git/HL7/fhir
EB-GCRC-0WXJHD5→ fhir : master x :★ ▷ ./publish.sh
```

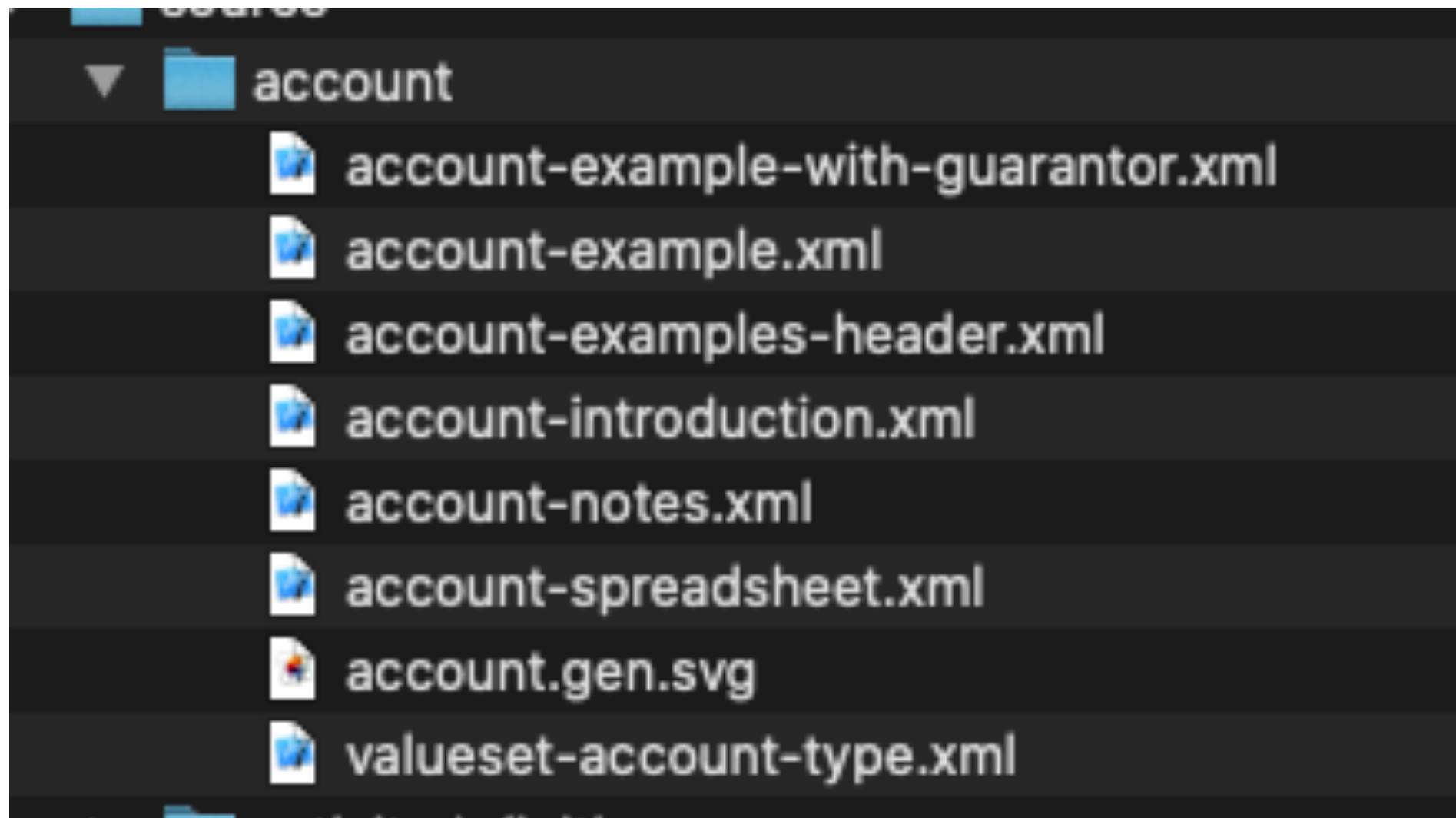
... time elapses ...

# How HL7 FHIR is Generated

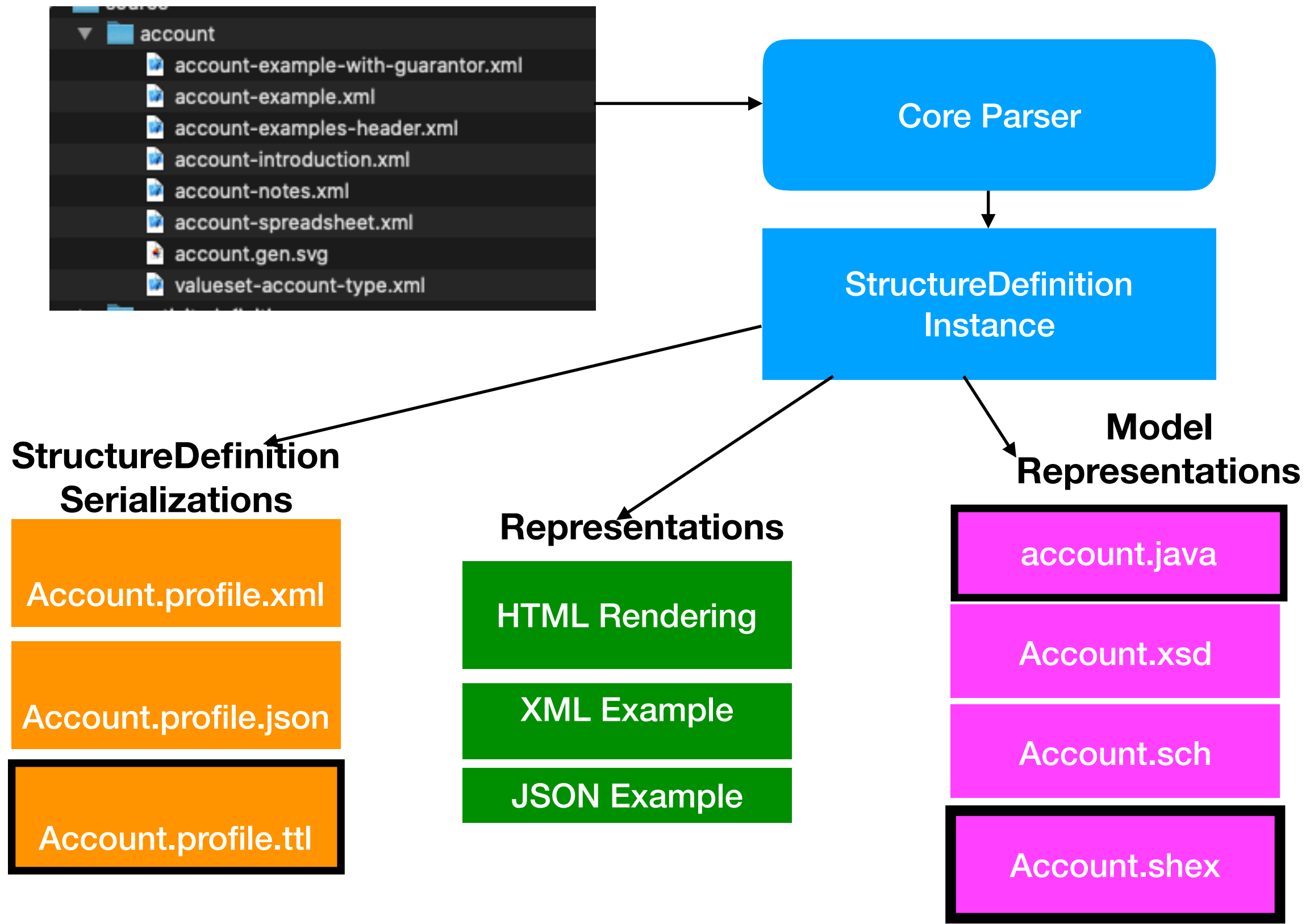
```
[java] ...resource Resource 3.554 266sec 1307MB
[java] ...resource Account 0.893 267sec 1845MB
[java] ...resource ActivityDefinition 1.785 268sec 3349MB
[java] ...resource AdministrableProductDefinition 6.672 275sec 1778MB
[java] ...resource AdverseEvent 3.68 279sec 3696MB
[java] ...resource AllergyIntolerance 2.893 282sec 1368MB
[java] ...resource Appointment 2.29 284sec 3356MB
[java] ...resource AppointmentResponse 3.622 288sec 1339MB
```

# What is happening

**fhir/source/account:**

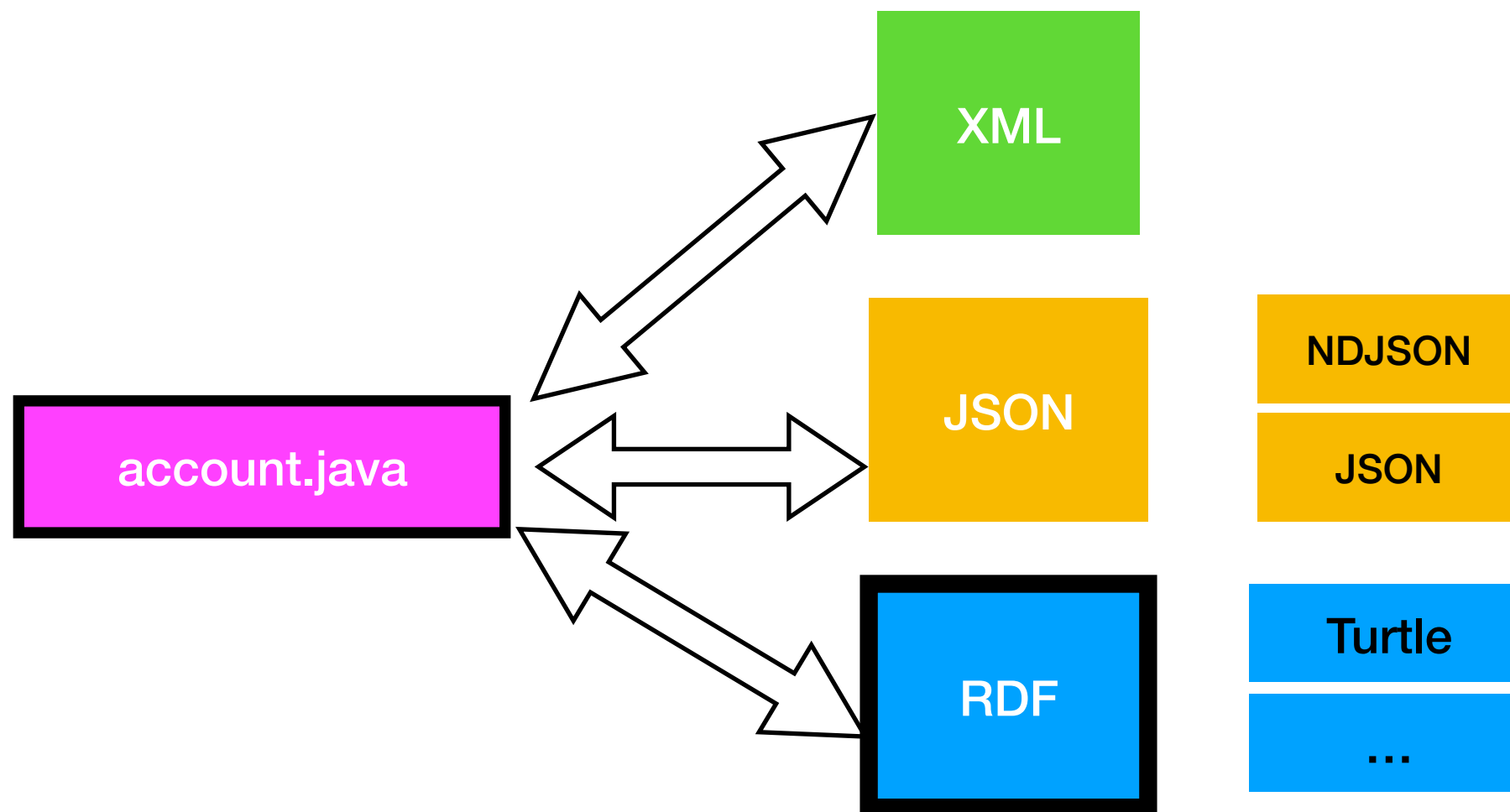


# What is happening





# FHIR Representation Formats



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