JSON-LD 1.1 and FHIR RDF

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OUTLINE

- FHIR RDF ITS Status as of Today
- FHIR RDF ITS Proposed Revisions
- Brief introduction to JSON-LD
- Conversion Tools
- Realizing Goals (next slide)

Goals

- Convert FHIR JSON to FHIR R4 RDF
- Convert FHIR R4 RDF to FHIR JSON
- Validate FHIR R4 RDF using ShEx
- Extract FHIR R4 resource from triple-store using ShEx
- Create FHIR R4 Resource from RDFa Markup

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FHIR RDF ITS
Status as of today

FHIR RDF ITS

Formats | XML | JSON | ND-JSON | RDF

2.6.4 Resource Description Framework (RDF) Representation

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

Some scattered use — i2b2 imports, NCATS Translator imports, …

Issues:

1. Not yet implemented in HAPI or other major servers
2. Current standard has some “speed bumps” that make it difficult to use.
    - e.g. “boolean”: True —> “boolean”: {“value”: True}

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FHIR RDF ITS
New Developments

JSON-LD 1.0 specification was not rich enough to support FHIR use case - only allowed one URI per JSON key, meaning that “name” in one context could not be differentiated from a second context.

Current FHIR RDF ITS requires manual implementation as a result

JSON-LD 1.1 specification released in December, 2019 now supports path based URI maps … and several other good things.

FHIR RDF ITS
New Developments

FHIR RDF working group is now working on the following development path:

1) Specify JSON-LD 1.1 contexts for all FHIR model elements.

2) Identify all changes that need to be made to vanilla FHIR JSON to support automated JSON —> FHIR RDF transformations.

3) Prove that the existing FHIR RDF ITS specification can be fully realized via 1) and 2)

3) Determine which changes from 2) are not strictly necessary and propose a R5 version of the RDF spec to support them.

FHIR RDF Generation Today

FHIR Resource Definitions
e.g. http://hl7.org/fhir/observation.html

FHIR Resource Examples
e.g. http://hl7.org/fhir/observation-example-f001-glucose.json

FHIR Build Process

RDF Turtle Resource Templates

ShEx Schema Definitions

FHIR URI Catalog (fhir.ttl)

FHIR Resource Examples in RDF (*.ttl)

http://hl7.org/fhir/observation.shex.html

http://hl7.org/fhir/observation-example-f001-glucose.ttl.html

10.1.3 Resource Content

Structure | UML | XML | JSON | Turtle | R3 Diff | All

Turtle Template

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


[ a fhir:Observation;
  fhir:nodeRole fhir:treeRoot; # if this is the parser root

  # from Resource: .id, .meta, .implicitRules, and .language
  # from DomainResource: .text, .contained, .extension, and .modifierExtension
```

http://build.fhir.org/fhir.ttl *

* missing in R4 build (?)

Proposed Additions

FHIR Resource Definitions

e.g. http://hl7.org/fhir/observation.html

FHIR Build Process

RDF Turtle Resource Templates

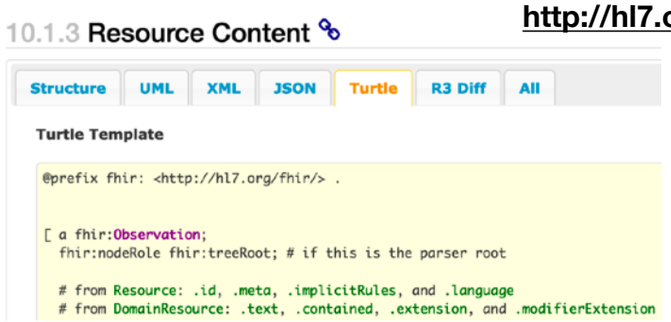
ShEx Schema Definitions

FHIR URI Catalog (fhir.ttl)

JSON-LD Contexts

JSON-LD Frames

http://hl7.org/fhir/observation.shex.html



https://fhircat.org/fhir/contexts/r5/patient.context.jsonld

(still under development)

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RDF Triples

RDF Triples (NTriples)

<http://example.org/Sam> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://example.org/Sam> <http://example.org/name> _:b1 .
<http://example.org/Sam> <http://xmlns.com/foaf/0.1/knows> _:b2 .
_:b1 <http://xmlns.com/foaf/0.1/givenName> "Sam" .
_:b1 <http://xmlns.com/foaf/0.1/familyName> "Smith" .

_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Melissa> .
_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> _:b3 .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Dazhi> .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> <http://www.w3.org/1999/02/22-rdf-syntax-ns#nil> .

<http://example.org/Melissa> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://example.org/Melissa> <http://example.org/name> _:b3 .
_:b3 <http://xmlns.com/foaf/0.1/givenName> "Johnson" .

<http://example.org/Dazhi> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .

<http://example.org/Dazhi> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .

Sam (as defined in http://example.org) is a Person (as defined by FOAF)
Sam's first name is "Sam" (using FOAF's definition of "givenName")
Sam's last name is "Smith" (using FOAF's definition of "familyName")
Sam knows (FOAF's definition of knows) Melissa
Melissa is a Person
Melissa's last name is "Johnson"
Sam knows Dazhi
Dazhi is a Person

RDF Formats

RDF Triples (NTriples)

```
<http://example.org/Sam> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://example.org/Sam> <http://example.org/name> _:b1 .
<http://example.org/Sam> <http://xmlns.com/foaf/0.1/knows> _:b2 .
_:b1 <http://xmlns.com/foaf/0.1/givenName> "Sam" .
_:b1 <http://xmlns.com/foaf/0.1/familyName> "Smith" .

_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Melissa> .
_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> _:b3 .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Dazhi> .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> <http://www.w3.org/1999/02/22-rdf-syntax-ns#nil> .

<http://example.org/Melissa> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://example.org/Melissa> <http://example.org/name> _:b3 .
_:b3 <http://xmlns.com/foaf/0.1/givenName> "Johnson" .

<http://example.org/Dazhi> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
```

Equivalent to:

RDF Turtle

```
@prefix : <http://example.org/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

:Sam a foaf:Person ;
   :name [ foaf:familyName "Smith" ;
           foaf:givenName "Sam" ] ;
   foaf:knows ( :Melissa :Dazhi ) .

:Melissa a foaf:Person ;
   :name [ foaf:givenName "Johnson" ] .
```

RDF Formats

RDF Triples (NTriples)

```
<http://example.org/Sam> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person>
<http://example.org/Sam> <http://example.org/name> _:b1 .
<http://example.org/Sam> <http://xmlns.com/foaf/0.1/knows> _:b2 .
_:b1 <http://xmlns.com/foaf/0.1/givenName> "Sam" .
_:b1 <http://xmlns.com/foaf/0.1/familyName> "Smith" .

_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Melissa> .
_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> _:b3 .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Dazhi> .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> <http://www.w3.org/1999/02/22-rdf-syntax-ns#nil> .

<http://example.org/Melissa> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person>
<http://example.org/Melissa> <http://example.org/name> _:b3 .
_:b3 <http://xmlns.com/foaf/0.1/givenName> "Johnson" .

<http://example.org/Dazhi> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person>
```

RDF XML

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
  xmlns="http://example.org/"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>
  <foaf:Person rdf:about="http://example.org/Sam">
   <foaf:knows rdf:parseType="Collection">
    <rdf:Description rdf:about="http://example.org/Melissa"/>
    <rdf:Description rdf:about="http://example.org/Dazhi"/>
   </foaf:knows>
   <name>
    <rdf:Description rdf:nodeID="ub2bL4C11">
     <foaf:givenName>Sam</foaf:givenName>
     <foaf:familyName>Smith</foaf:familyName>
    </rdf:Description>
   </name>
  </foaf:Person>
  <foaf:Person rdf:about="http://example.org/Melissa">
   <name>
    <rdf:Description rdf:nodeID="ub2bL9C11">
     <foaf:givenName>Johnson</foaf:givenName>
    </rdf:Description>
   </name>
  </foaf:Person>
  <foaf:Person rdf:about="http://example.org/Dazhi"/>
</rdf:RDF>
```

Equivalent to:

RDF Turtle

```
@prefix : <http://example.org/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

:Sam a foaf:Person ;
    :name [ foaf:familyName "Smith" ;
            foaf:givenName "Sam" ] ;
    foaf:knows ( :Melissa :Dazhi ) .

:Melissa a foaf:Person ;
    :name [ foaf:givenName "Johnson" ] .
```

RDF Formats

RDF Turtle

```
@prefix : <http://example.org/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

:Sam a foaf:Person ;
    :name [ foaf:familyName "Smith" ;
            foaf:givenName "Sam" ] ;
    foaf:knows ( :Melissa :Dazhi ) .

:Melissa a foaf:Person ;
    :name [ foaf:givenName "Johnson" ] .
```

RDF XML

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
  xmlns="http://example.org/"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
>
  <foaf:Person rdf:about="http://example.org/Sam">
    <foaf:knows rdf:parseType="Collection">
      <rdf:Description rdf:about="http://example.org/Melissa"/>
        <rdf:Description rdf:about="http://example.org/Dazhi"/
```

Different representations of *exactly* the same information

RDF Triples (NTriples)

```
<http://example.org/Sam> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/
foaf/0.1/Person> .
<http://example.org/Sam> <http://example.org/name> _:b1 .
<http://example.org/Sam> <http://xmlns.com/foaf/0.1/knows> _:b2 .
_:b1 <http://xmlns.com/foaf/0.1/givenName> "Sam" .
_:b1 <http://xmlns.com/foaf/0.1/familyName> "Smith" .

_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Melissa> .
_:b2 <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> _:b3 .
_:b3 <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> <http://example.org/Dazhi> .
```

JSON-LD
is just another syntax (!)

RDF Turtle

```
@prefix : <http://example.org/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

:Sam a foaf:Person ;
   :name [ foaf:familyName "Smith" ;
           foaf:givenName "Sam" ] ;
   foaf:knows ( :Melissa :Dazhi ) .

:Melissa a foaf:Person ;
   :name [ foaf:givenName "Johnson" ] .
```

Different representations of *exactly* the same information

JSON-LD

```
{
 "@context": {
  "foaf": “http://xmlns.com/foaf/0.1/"
 },
 "@graph": [
  { "@id": "http://example.org/Melissa",
    "@type": "foaf:Person",
    "http://example.org/name": {"@id": "_:c1"}
  },
  { "@id": "_:c1",
    "foaf:givenName": "Johnson"
  },
  { "@id": "http://example.org/Dazhi",
    "@type": "foaf:Person"
  },
  { "@id": "http://example.org/Sam",
    "@type": "foaf:Person",
    "foaf:knows": {
      "@list": [
        { "@id": "http://example.org/Melissa" },
        { "@id": "http://example.org/Dazhi" }
      ]
    },
    "http://example.org/name": { "@id": "_:c2"}
  },
  { "@id": "_:c2",
    "foaf:familyName": "Smith",
    "foaf:givenName": "Sam"
  }
 ]
}
```

Just another RDF Syntax…

Just another RDF Syntax…
… why should I care?

JSON *plus* JSON-LD context gives you the best of both worlds:

1. The “plain ol” JSON you’ve grown to know and love… for services, applications, GUI’s, IoT devices, FHIR Resources, etc.

2. The formal semantics and identifiers of RDF to combining, transforming and aggregating data *across* domains.

JSON-LD Context

The “secret sauce”

Plain ‘ol JSON

```
{
  “name": “BigCocoInc",
  "type": "Company",
  "people": {
     "Sam": {
        "name": {
         first": "Sam",
        "last": "Smith"
      },
     "employees": ["Melissa", "Dazhi"]
   },
   "Melissa": {
      "name": {
        "last": "Johnson"
      }
   },
   "Dazhi": {
  }
}
```

Context

```
{
  "@context": {
    "sdo": "http://schema.org/",
    "foaf": "http://xmlns.com/foaf/0.1/",
    "co": "http://companies.com/",
    "@base": "http://companies.com",
    "type": "@type",
    "name": "@id",
    "people": {
      "@id": "sdo:employee",
      "@container": "@id",
      "@context": {
           "name": "sdo:name",
        "first": "foaf:givenName",
        "last": "foaf:familyName",
        "employees": {
          "@reverse": "co:reports_to",
          "@type": "@id"
        }
      }
    }
```

RDF

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix co: <http://companies.com/> .
@prefix sdo: <http://schema.org/> .

co:BigCocoInc a co:Company ;
    sdo:employee co:Dazhi,
        co:Melissa,
        co:Sam .

co:Dazhi co:reports_to co:Sam .

co:Melissa co:reports_to co:Sam ;
    sdo:name [ foaf:familyName "Johnson" ] .

co:Sam sdo:name [ foaf:familyName "Smith" ;
            foaf:givenName "Sam" ] .
```

http://tinyurl.com/tbmkhzp

JSON-LD Context

- A mapping between:
  - json names and URI’s
  - json values and types + representation
- Context and JSON can be *completely* separate
  - Either add in an “@context” or can applied completely separately
  - Contexts can be URL’s (!!)

https://raw.githubusercontent.com/fhircat/fhir_rdf_validator/master/tutorial/company.context.jsonld

JSON-LD Context

The “secret sauce”

Slightly Edited JSON

```
{
  "@context": "https://raw.githubusercontent.com/fhircat/
fhir_rdf_validator/master/tutorial/company.context.jsonld",
  "name": "BigCocoInc",
  "type": "Company",
  "people": {
    "Sam": {
      "name": {
        "first": "Sam",
        "last": "Smith"
      },
      "employees": [
        "Melissa",
        "Dazhi"
      ]
    },
    "Melissa": {
      "name": {
        "last": "Johnson"
      }
    },
    "Dazhi": {}
  }
}
```

RDF

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix co: <http://companies.com/> .
@prefix sdo: <http://schema.org/> .

co:BigCocoInc a co:Company ;
    sdo:employee co:Dazhi,
        co:Melissa,
        co:Sam .

co:Dazhi co:reports_to co:Sam .

co:Melissa co:reports_to co:Sam ;
    sdo:name [ foaf:familyName "Johnson" ] .

co:Sam sdo:name [ foaf:familyName "Smith" ;
            foaf:givenName "Sam" ] .
```

http://tinyurl.com/whgprn2

JSON-LD Framing

Makes it bidirectional (!)

Plain ‘ol JSON

```
{
 ,
  "name": "BigCocoInc",
  "type": "Company",
  "people": {
    "Sam": {
      "name": {
        "first": "Sam",
        "last": "Smith"
      },
      "employees": [
        "Melissa",
        "Dazhi"
      ]
    },
    "Melissa": {
      "name": {
        "last": "Johnson"
      }
    },
    "Dazhi": {}
  }
}
```

http://tinyurl.com/tgxu78k

RDF

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix co: <http://companies.com/> .
@prefix sdo: <http://schema.org/> .

co:BigCocoInc a co:Company ;
    sdo:employee co:Dazhi,
        co:Melissa,
        co:Sam .

co:Dazhi co:reports_to co:Sam .

co:Melissa co:reports_to co:Sam ;
    sdo:name [ foaf:familyName "Johnson" ] .

co:Sam sdo:name [ foaf:familyName "Smith" ;
            foaf:givenName "Sam" ] .
```

Frame

```
{ "@context": [
  "https://raw.githubusercontent.com/fhircat/fhir_rdf_validator/master/tutorial/
company.context.jsonld",
   {
     "@vocab": "http://company.com/",
     "@base": "http://company.com/"
   }
 ],
 "@type": "co:Company"
}
```

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The FHIRCat JSON-LD Playground

https://fhircat.org/jsonld/playground/

Most Visited | Getting Started | raw.githubusercont...

NOTE: The playground uses jsonld.js which conforms to JSON-LD 1.0 syntax, API, framing, and errata, the W3C Community Group JSON-LD 1.1 syntax, API, and framing drafts, and partial support of the W3C Working Group JSON-LD 1.1 syntax, API, and framing drafts. Also see the classic JSON-LD 1.0 playground and the RDF Distiller.

Examples: | Patient | Observation | CodeSystem | Medication | AllergyIntolerance | Copy ↑ | Permalink | Gist | Shortcuts

JSON-LD Input | Options | Document URL

```
{
  "resourceType": "Patient",
  "id": "pat1",
  "text": {
    "status": "generated",
    "div": "<div xmlns=\"http://www.w3.org/1999/xhtml\">\n      \n      <p>Patient Donald DUCK @ Acme Healthcare, Inc. MR =
654321</p>\n    \n    </div>"
  },
  "identifier": [
    {
      "use": "usual",
      "type": {
        "coding": [
          {
```

Expanded | Compacted | Flattened | Framed | N-Quads | Normalized | Table | Visualized | JSON-LD R4 | JSON-LD R5

```
[]
```

FHIR RDF toolkit

Python tools

Assumes Python > 3.7 and pipenv/pip installed on machine (instructions are for Mac)

```
> mkdir connectathon
> cd connectathon
> pipenv install PyShEx
Installing PyShEx…
Adding PyShEx to Pipfile's [packages]…
✔ Installation Succeeded
Pipfile.lock not found, creating…
Locking [dev-packages] dependencies…
Locking [packages] dependencies…
✔ Success!
Updated Pipfile.lock (20777b)!
Installing dependencies from Pipfile.lock (20777b)…
🐍  ████████████████████████████████████████ 19/19 — 00:00:02
> pipenv shell
(connectathon) >
```

FHIR RDF toolkit
Python tools (cont.)

(connectathon) >
(connectathon) > pip install -e git+https://github.com/fhircat/fhir_rdf_validator.git#egg=fhir_rdf_validator
...
> convertrdf -h

```
usage: convertrdf [-h] [-i [INFILE [INFILE ...]]] [-id INDIR]
                  [-o [OUTFILE [OUTFILE ...]]] [-od OUTDIR] [-f] [-s]
                  [-if {html,hturtle,json-ld,mdata,microdata,n3,nquads,nt,nt11,ntriples,rdfa,rdfa1.0,rdfa1.1,trig,trix,ttl,turtle,xml}]
                  [-of {json-ld,n3,nquads,nt,nt11,ntriples,pretty-xml,trig,trix,ttl,turtle,xml}]

RDF Format Converter

optional arguments:
  -h, --help            show this help message and exit
  -i [INFILE [INFILE ...]], --infile [INFILE [INFILE ...]]
                        Input file(s)
  -id INDIR, --indir INDIR
                        Input directory
  -o [OUTFILE [OUTFILE ...]], --outfile [OUTFILE [OUTFILE ...]]
                        Output file(s)
  -od OUTDIR, --outdir OUTDIR
                        Output directory
  -f, --flatten         Flatten output directory
  -s, --stoponerror     Stop on processing error
  -if {html,hturtle,json-ld,mdata,microdata,n3,nquads,nt,nt11,ntriples,rdfa,rdfa1.0,rdfa1.1,trig,trix,ttl,turtle,xml}, --informat {html,hturtle,json-ld,mdata,microdata,n3,nqu
ads,nt,nt11,ntriples,rdfa,rdfa1.0,rdfa1.1,trig,trix,ttl,turtle,xml}
                        Input RDF format and file suffix
  -of {json-ld,n3,nquads,nt,nt11,ntriples,pretty-xml,trig,trix,ttl,turtle,xml}, --outformat {json-ld,n3,nquads,nt,nt11,ntriples,pretty-xml,trig,trix,ttl,turtle,xml}
                        Output RDF format and file suffix
```

Tools:

- **shexeval — validate RDF using ShEx schemas**
- **convertrdf — convert RDF formats**
- **validate — validate RDF directories w/ ShEx**
- **comparerdf — compare RDF files**
- **tofhirr4 — "tweak" vanilla FHIR for R4 conversioon**

FHIR RDF toolkit
Javascript Tools

```
> cd connectathon
> git clone git@github.com:fhircat/fhir_to_jsonld_context.git
Cloning into 'fhir_to_jsonld_context'...
remote: Enumerating objects: 3157, done.
remote: Counting objects: 100% (3157/3157), done.
remote: Compressing objects: 100% (143/143), done.
remote: Total 3157 (delta 3037), reused 3093 (delta 2976), pack-reused 0
Receiving objects: 100% (3157/3157), 1.14 MiB | 655.00 KiB/s, done.
Resolving deltas: 100% (3037/3037), done.
>  cd fhir_to_jsonld_context
>  yarn clean
yarn run v1.21.1
$ rm -fr logs/* jsonldc/contexts/r5/*
✨  Done in 0.18s.
>  yarn install
yarn install v1.21.1
[1/4] 🔍  Resolving packages...
[2/4] 🚚  Fetching packages...
[3/4] 🔗  Linking dependencies...
[4/4] 🔨  Building fresh packages...
✨  Done in 37.92s.
>
```

https://github.com/fhircat/fhir_to_jsonld_context

Converting NQuads to TTL

Expanded | Compacted | Flattened | Framed | N-Quads | Normalized | Table | Visualized | JSON-LD R4 | JSON-LD R5

```
<http://hl7.org/fhir/example> <http://example.com/UNKNOWN#_birthDate> _:b0 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/DomainResource.text> _:b2 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.active> "true"^^<http://www.w3.org/2001/XMLSchema#boolean> .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.address> _:b3 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.birthDate> "1974-12-25" .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.contact> _:b5 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.deceasedBoolean> "false"^^<http://www.w3.org/2001/XMLSchema#boolean> .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.gender> "male" .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.identifier> _:b15 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.managingOrganization> _:b20 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.name> _:b21 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.name> _:b22 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.name> _:b23 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.telecom> _:b25 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.telecom> _:b26 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.telecom> _:b27 .
<http://hl7.org/fhir/example> <http://hl7.org/fhir/Patient.telecom> _:b28 .
<http://hl7.org/fhir/example> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://example.com/UNKNOWN#Patient> .
_:b0 <http://hl7.org/fhir/DomainResource.extension> _:b1 .
_:b1 <http://hl7.org/fhir/Extension.url> "http://hl7.org/fhir/StructureDefinition/patient-birthTime" .
_:b1 <http://hl7.org/fhir/Extension.valueDateTime> "1974-12-25T14:35:45-05:00" .
```

Copy and paste into a file… w/ “.nt” suffix
Then run converter:
> convertrdf -i file.nt -o file.ttl

```
(connectathon) EB-GCRC-0WXJHD5→  samples  ▷  convertrdf -i fhir1.nt -o fhir1.ttl
Total=1 Successful=1
```

OUTLINE

- FHIR RDF ITS Status as of Today
- FHIR RDF ITS Proposed Revisions
- Brief introduction to JSON-LD
- Conversion Tools
- **Realizing Goals (next slide)**

Goals

- Convert FHIR JSON to FHIR R4 RDF
- Convert FHIR R4 RDF to FHIR JSON
- Validate FHIR R4 RDF using ShEx
- Extract FHIR R4 resource from triple-store using ShEx
- Create FHIR R4 Resource from RDFa Markup

Task 1: Convert FHIR JSON to FHIR R4 RDF

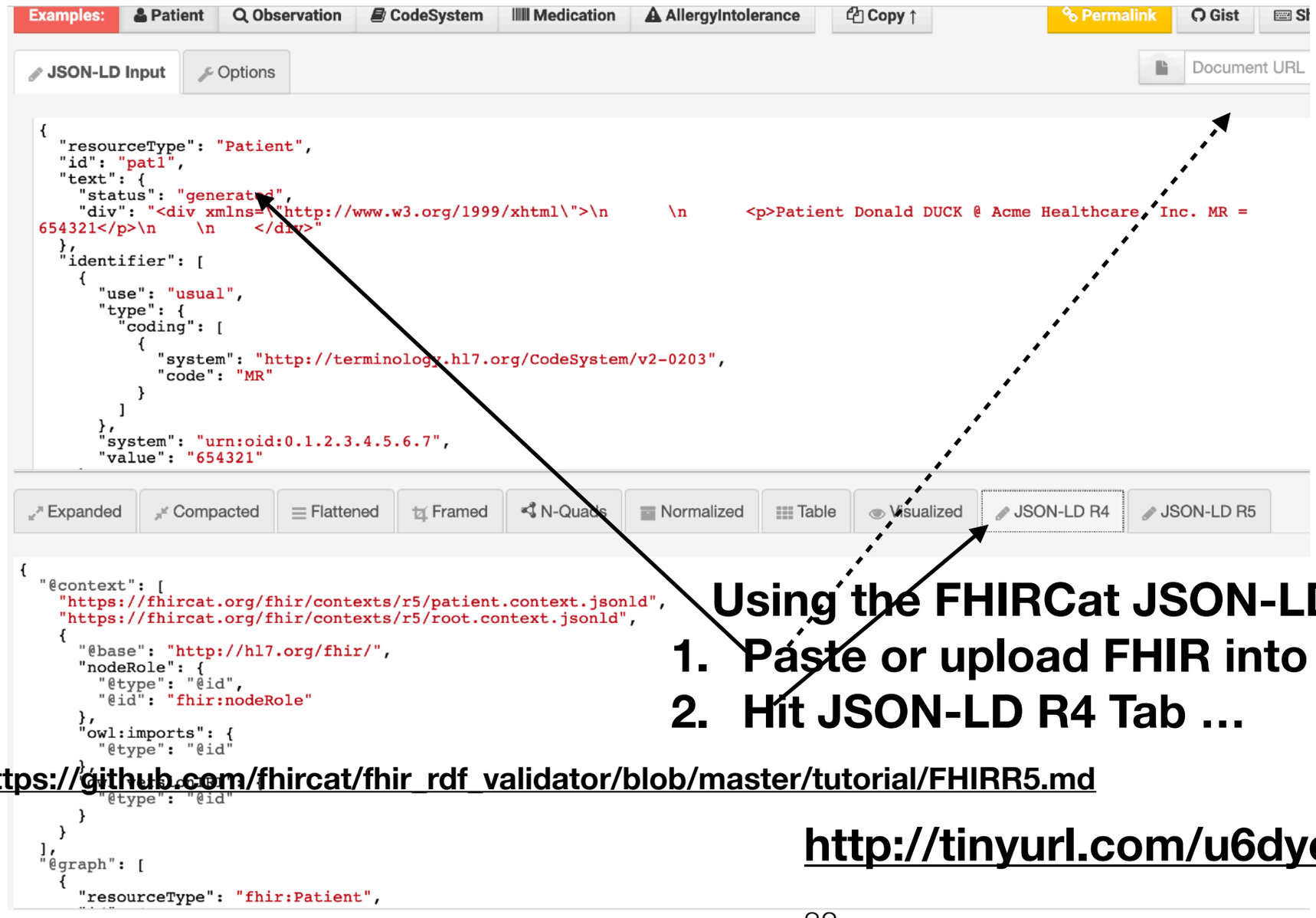
1. Edit FHIR JSON to produce FHIR R4 JSON-LD

2. Use JSON-LD 1.1 processor to convert JSON-LD to expanded form

3. Use any RDF tool to convert to the target format

Task 1: Convert FHIR JSON to FHIR R4 RDF

1. Edit FHIR JSON to produce FHIR R4 JSON-LD …



Using the FHIRCat JSON-LD Playground:

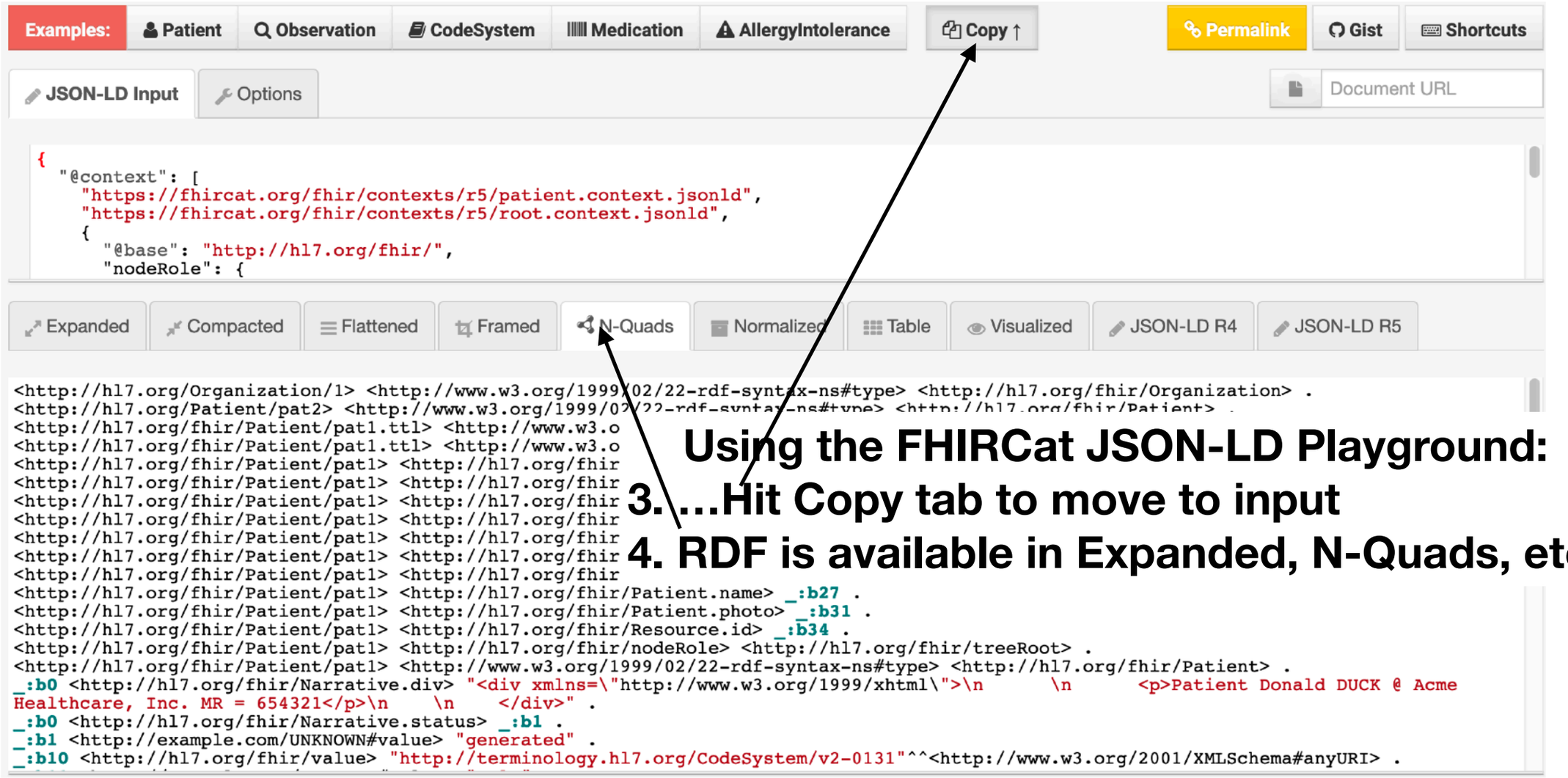
1. **Paste or upload FHIR into JSON-LD Input**
2. **Hit JSON-LD R4 Tab …**

https://github.com/fhircat/fhir_rdf_validator/blob/master/tutorial/FHIRR5.md

http://tinyurl.com/u6dyea4

Task 1: Convert FHIR JSON to FHIR R4 RDF

2. … Edit FHIR JSON to produce FHIR R4 JSON-LD



Using the FHIRCat JSON-LD Playground:

3. …Hit Copy tab to move to input

4. RDF is available in Expanded, N-Quads, etc.

http://tinyurl.com/v9xgwmw

Task 1: Convert FHIR JSON to FHIR R4 RDF (alt.)

1. Run conversion script

> tofhirr4 -c -fs http://hl7.org/fhir/ -i http://build.fhir.org/patient-example-d.json -o patient-example-d-edited.json
Total=1 Successful=1
> less patient-example-d-edited.json


```
{
   "@graph": [
      {
         "resourceType": "fhir:Patient",
         "id": {
            "value": "pat4"
         },
         "text": {
            "status": {
               "value": "generated"
            },
            "div": "<div xmlns=\"http://www.w3.org/1999/xhtml\">\n\t\t\t<p>Patient Sandy Notsowell @ Acme Healthcare, Inc. MR = 123458, D
ECEASED</p>\n\t\t</div>"
         },
         "identifier": [
            {
               "use": {
                  "value": "usual"
               },
               "type": {
                  "coding": [
                     {
                        "system": {
                           "value": "http://terminology.hl7.org/CodeSystem/v2-0203"
```

Task 1: Convert FHIR JSON to FHIR R4 RDF (alt.)

2. Convert to expanded form

> yarn jsonld -c expand -i ../samples/patient-example-d-edited.json

See: https://github.com/fhircat/fhir_to_jsonld_context for details

http://tinyurl.com/u6dyea4

Task 2: Convert FHIR R4 RDF to FHIR JSON

1. Convert R4 RDF to JSON-LD Expanded form

2. Use JSON-LD framing processor to convert to JSON compacted form

3. Remove the JSON-LD specific artifacts

Task 2: Convert FHIR R4 RDF to FHIR JSON-LD

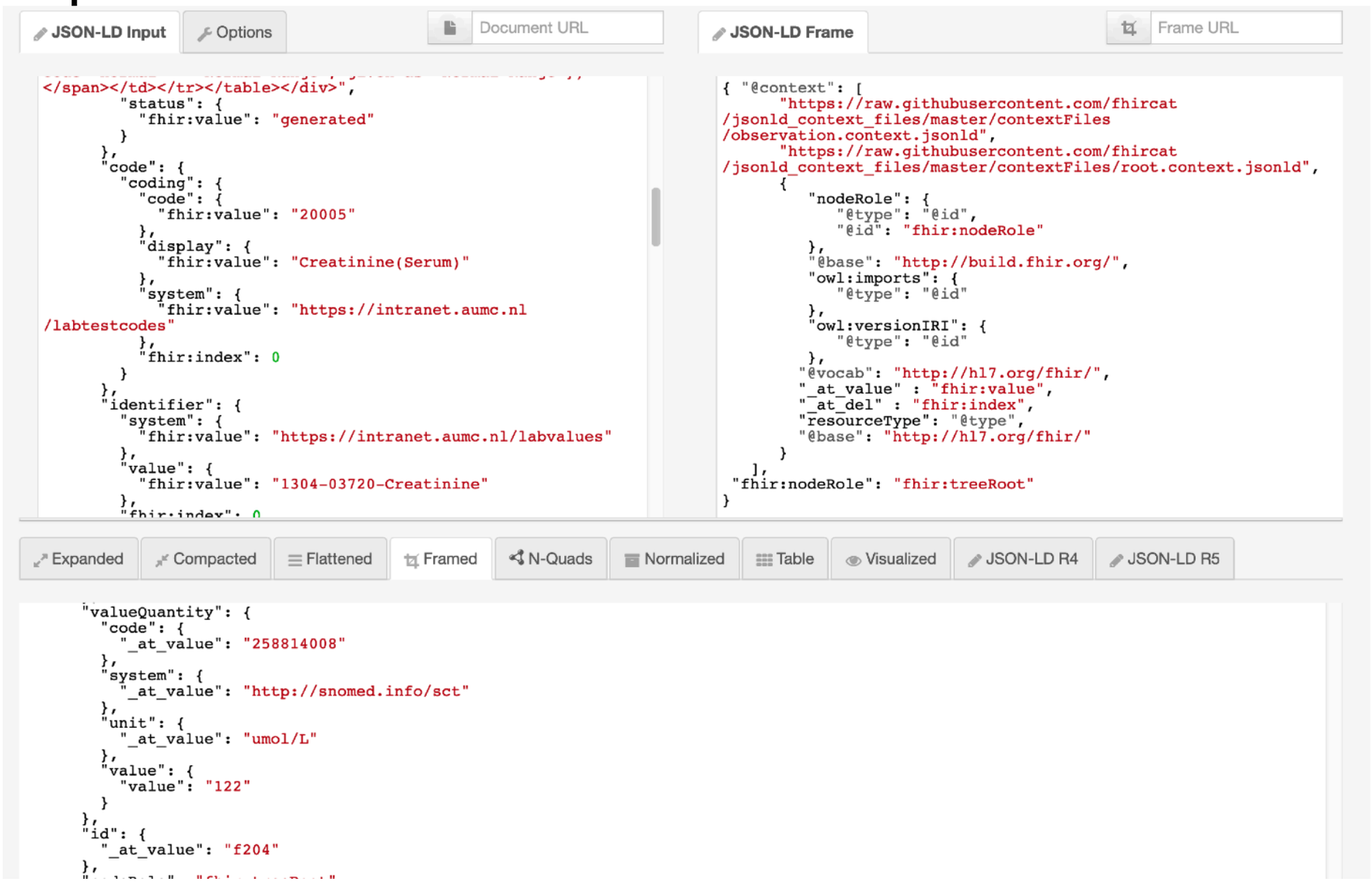
1. Convert R4 RDF to JSON-LD Expanded form…

> convertrdf -i http://build.fhir.org/observation-example-f204-creatinine.ttl -o f204.json-ld
Total=1 Successful=1
> less f204.json-ld


```
{
  "@context": {
    "fhir": "http://hl7.org/fhir/",
    "owl": "http://www.w3.org/2002/07/owl#",
    "rdf": "http://www.w3.org/1999/02/22-rdf-syntax-ns#",
    "rdfs": "http://www.w3.org/2000/01/rdf-schema#",
    "sct": "http://snomed.info/id/",
    "xsd": "http://www.w3.org/2001/XMLSchema#"
  },
  "@graph": [
    {
      "@id": "http://hl7.org/fhir/Patient/f201",
      "@type": "fhir:Patient"
    },
    {
      "@id": "http://hl7.org/fhir/Observation/f204.ttl",
      "@type": "owl:Ontology",
      "owl:imports": {
        "@id": "fhir:fhir.ttl"
      },
      "owl:versionIRI": {
        "@id": "http://build.fhir.org/Observation/f204.ttl"
      }
    },
    {
      "@id": "http://hl7.org/fhir/Observation/f204",
```

Task 2: Convert FHIR R4 RDF to FHIR JSON

2. … use JSON-LD framing processor to convert to JSON compacted form



Task 2: Convert FHIR R4 RDF to FHIR JSON

2. … Remove the JSON-LD specific artifacts

Task 3: Validate FHIR RDF using ShEx

> shexeval -f json-ld obs.json-ld http://build.fhir.org/observation.shex -fn http://hl7.org/fhir/Observation/f001

Evalute obs.json-ld using

http://build.fhir.org/observation.shex

Rooted with subject http://hl7.org/fhir/Observation/f001 (aka. focus node)

Task 3: Evaluation Results

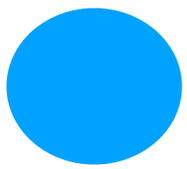
```
(connectathon) EB-GCRC-0WXJHD5→  samples  ▷  shexeval -f json-ld obs.json-ld http://build.fhir.org/observation.shex -fn http://hl7.org/fhir/Observat
ion/f001
ANTLR runtime and generated code versions disagree: 4.8!=4.7.1
ANTLR runtime and generated code versions disagree: 4.8!=4.7.1
Errors:
  Focus: http://hl7.org/fhir/Observation/f001
  Start: _:start
  Reason:   Testing <http://hl7.org/fhir/Observation/f001> against shape http://hl7.org/fhir/shape/Observation
    Testing _:b1 against shape http://hl7.org/fhir/shape/Narrative
    _:b1 context:
      <http://hl7.org/fhir/Observation/f001> fhir:DomainResource.text _:b1 .
         _:b1 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 '1507
4-8' = '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://terminolog
y.hl7.org/CodeSystem/v3-ObservationInterpretation code 'H' = 'High', given as 'High'})</span></p><h3>ReferenceRanges</h3><table><tr><td>-</td><td><b
>Low</b></td><td><b>High</b></td></tr><tr><td>*</td><td>3.1 mmol/l<span> (Details: UCUM code mmol/L = 'mmol/L')</span></td><td>6.2 mmol/l<span> (Det
ails: UCUM code mmol/L = 'mmol/L')</span></td></tr></table></div>" .
         _:b1 fhir:Narrative.status _:b2 .
           _:b2 <http://example.com/UNKNOWN#value> "generated" .

      Testing _:b2 against shape http://hl7.org/fhir/shape/code
      _:b2 context:
        _:b1 fhir:Narrative.status _:b2 .
           _:b2 <http://example.com/UNKNOWN#value> "generated" .

        Unmatched triples in CLOSED shape:
        <N740cb203062c4d18bb0e0d10334927d1> <http://example.com/UNKNOWN#value> generated .
```

Task 4: Extract FHIR R4 resource from triple-store using ShEx

The issue: you have a triple store that links *everything* together in one huge graph:



Task 5: Create a FHIR Resource from RDFa Markup