Semantic Representations of Clinical Care Data Leveraging HL7 FHIR

SWAT4LS 2016
Harold Solbrig & Eric Prud’hommeaux
Credits

• Portions of this presentation are derived from a variety of resources, the majority of which can be found at: http://gforge.hl7.org/svn/fhir/trunk/presentations (anonymous login)

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Note on SVN

http://gforge.hl7.org/svn/fhir/trunk looks really uninteresting in a browser …

… you need to use the SVN interface:

http://gforge.hl7.org/gf/project/fhir/scmsvn/?action=browse&path=%2Ftrunk%2F
What you should see...
Introductions

Eric Prud’hommeaux - W3C/MIT staff contact for the Semantic Web in Health Care and Life Sciences Interest Group

Harold Solbrig - Mayo Clinic
Outline

Part 1- HL7 and FHIR

1. Short history of HL7 information and related terminology standards

2. Introduction to FHIR — history, purpose and state

3. Navigating FHIR documentation and infrastructure (Hands On)

4. FHIR profiles and conformance resources — why and how

5. Create a simple FHIR profile (Demonstration)

6. Validate a simple FHIR data instance (Demonstration)

—— Break ——
Outline

Part 2 — Semantic Web and

7. RDF Data Shapes - introduction to ShEx and SHACL

8. ShEx and FHIR - documenting RDF constraints using ShEx

9. Validating FHIR RDF instance using ShEx (Hands On)

10. Ontology and FHIR — terminologies, value sets and meaning bindings

11. Use Protege reasoner to query FHIR data records matching subsumptive queries (Hands On)
Outline

Part 1- HL7 and FHIR

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—- Break —-
Health Level Seven (HL7)

More Info: http://hl7.org
Health Level Seven (HL7)

ANSI-accredited standards developing organization

Developing a framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services
HL7 History
Early HL7

Formed in 1987 to address the problem of communication between healthcare *systems*

- Scope: mostly single institution
- ADT system patient —> lab system
- Order system orders —> lab system / scheduling
- Lab system results —> reporting system
- ...

HL7 History
First Mission Statement

What is HL7?
Health Level Seven is one of several ANSI-accredited Standards Developing Organizations (SDOs) operating in the healthcare arena. Most SDOs produce standards (sometimes called specifications or protocols) for a particular healthcare domain such as pharmacy, medical devices, imaging or insurance (claims processing) transactions. Health Level Seven’s domain is clinical and administrative data. Our mission is to: "To provide standards for the exchange, management and integration of data that support clinical patient care and the management, delivery and evaluation of healthcare services. Specifically, to create flexible, cost effective approaches, standards, guidelines, methodologies, and related services for interoperability between healthcare information systems."
HL7 Version 1

• Proof of concept

• First draft produced October, 1987

• Coverage
  • Admit, Discharge and Transfer (ADT)
  • Order Entry
  • Queries for reporting and display

• No real impact
HL7 Version 2 (V2.x)

- HL7 V2.0 Messaging Standard — 1989 - present

- “Level 7” was an ideal, but V2.x had a lot of emphasis on lower levels as well

- Segment / Pipe / Hat formatting:

```
MSH|~\&|MegaReg|XYZHospC|SuperOE|XYZImgCtr|20060529090131-0500||.
EVB|200605290901||200605290900
PID|56782445~^UAR&PI|KLEINSAMPLE^BARRY^Q^JR|19620910|M|20
PV1|I^389^1^UBH^3^3|12345^MORGAN^REX^J^MD^0010^UAMC^L|
OBX|1^NM^Body Height|1.80^m^Meter^ISO+||F
OBX|2^NM^Body Weight|79^kg^Kilogram^ISO+||F
AL1|1|^ASPIRIN
DGL|1|786.50^CHEST PAIN, UNSPECIFIED^I9||A
```
HL7 Version 2 (V2.x)

• Widespread adoption and uptake

• XML implementation now available

• Still the major standard for healthcare systems communication in use today

• 95% of US healthcare organizations use HL7 V2.x

• Implemented in 35+ countries

HL7 Version 2

Good News and Bad News

• Good News — easy to claim compliance
• Bad News — easy to claim compliance
• Good News — easy to adapt to local systems
• Bad News — local adaptations do not interoperate
• Good News — easily extended (‘Z’ segments)
• Bad News — ‘Z’ segments don’t interoperate
• Good News — widespread vendor support
• Bad News — $50k to $250k to customize system to individual site
HL7 Version 3
1995 - 2015

• Focus on the “bad news” aspect of V2.x
• “Optionality is a four letter word”
• Separation of model and implementation
• Standardized codes
• Based on HL7 specific tooling
  • See: HL7 timeline slide
• Healthcare community contributed to other specs
HL7 Version 3
1995-present

Limited uptake

- Main channel of adoption was via the Clinical Document Architecture (CDA) suite of standards
- US - CCD / EU - EPSOS

Few “pure V3” implementations

- Difficult to implement
- High training costs

“HL7 v3 has failed” http://www.healthintersections.com.au/?p=476
(Some) Version 3 Issues

Tooling and dissemination — HL7 was always “ahead of the curve”

• Parts of many of the standards we know today (XML, RDF, SOAP, UML, OWL, …) can be traced back to healthcare and HL7 use cases

Intellectual property restrictions

• No way to “kick the tires”

Unintended consequences of scope changes
HL7 IP

Pre 2013:

• Open participation in development of standards
• HL7 Membership required for actual use
• ... worked well for *system to system* standards
• ... not so much for other environments

2013 - today:

• Registration but no cost for existing standards
• Members get 3 months head start on new standards ...
• ... training, support, discounts on other standards
The mission of HL7 is:

To provide a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services. Specifically, to create flexible, cost effective standards, guidelines, and methodologies to enable healthcare information system interoperability and sharing of electronic health records.

Sharing, and retrieval of electronic health information to enable healthcare information system interoperability and sharing of electronic health records.
HL7 Mission (today)

November 2016

HL7's Mission:
HL7 provides standards for interoperability that improve care delivery, optimize workflow, reduce ambiguity and enhance knowledge transfer among all of our stakeholders, including healthcare providers, government agencies, the vendor community, fellow SDOs and patients. In all of our processes we exhibit timeliness, scientific rigor and technical expertise without compromising transparency, accountability, practicality, or our willingness to put the needs of our stakeholders first.

“Healthcare system” is no longer mentioned…
Unintended Consequences

TUESDAY, JUNE 18, 2013

HL7 V3 Makes Great Strides in Providing a Clear Representation of Body Weight

BodyWeight has Device
Device is a coded description
Clothing is a coded description
BodyWeight has Clothing
BodyWeight is a physical quantity
BodyWeight has BodyWeight

From:
V3_DCM Models_R1_I1_2010Sep-BodyWeight-v1.08.pdf

What could go wrong?

POSTED BY BARRY SMITH AT TUESDAY, JUNE 18, 2013 1 COMMENT:
LINKS TO THIS POST

http://hl7-watch.blogspot.com
HL7
Clinical Document Architecture (CDA)

A new approach based on XML

• Level 1 - Structured Header + unspecified Body

• Level 2 - Level 1 + Narrative Blocks in Body identified by codes

• Level 3 - Level 2 + Structured blocks in Body based on RIM and LOINC, SNOMED, etc.
HL7 CDA

• Concept first presented to HL7 V3 group ~2002

• HL7 rejected the approach

• Proponents went to ASTM and developed the Continuity of Care Record (CCR)

• CCR began getting major traction…

• HL7 rethought rejection, adopted Clinical Document Architecture (CDA) and, after much legal wrangling, CDA (2005) and follow on Continuity of Care Document (CCD) (2007) became a significant part of HL7
HL7 CCD Snippet
HL7
Summary

• HL7 is an ANSI Standards organization

• HL7 Version 2.0 is widely used today
  • Both hat bar format and (later) XML format

• HL7 Version 3.0 laid a foundation but was never widely adopted
  • CCD and CDA constitute the majority of the use today
Clinical Terminology
Terminology
Filling the slots

• On July 17, 2015, Mr. Grunt P Snooter presented with a simple fracture of the right proximal tibia

• On examination, there was no indication of osteomyelitis

• Leukocyte count test was normal

• Prescribed Ibuprofen Tablets 400 mg every 4 to 6 hours as needed

• Billing code: Simple Fracture of Tibia
“Terminology”

- **Classification System** — describes a (typically) disjoint, complete set of codes for classifying a specific event.

- **Lexicon** — a stock of terms used by a particular profession

- **Dictionary (Ontology)** — “[A book] listing words or other linguistic items in a particular category or subject with specialized information about them”

- **Nomenclature** — a system of names used in an art or science

- **Thesaurus** — groups of words (codes) according to similarity of meaning

- **Knowledge Base** — a collection of facts or rules
HL7/FHIR Terminology

ICD-10

International Classification of Diseases Version 10 (ICD-10)

• A *classification system* for diseases and disorders

• Published by World Health Organization

• Extended/modified for specific purposes by various countries / organizations

  • ICD-10-CM, ICD-10-PCS, ICD-10-AM

• Used for reimbursement and statistics reporting
ICD-10

International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) Version for 2010

Chapter IV
Endocrine, nutritional and metabolic diseases
(E00-E90)

Diabetes mellitus
(E10-E14)

Use additional external cause code (Chapter XX), if desired, to identify drug, if drug-induced.

The following fourth-character subdivisions are for use with categories E10-E14:

.0 With coma
  Diabetic:
  • coma with or without ketoacidosis
  • hyperosmolar coma
  • hypoglycaemic coma
  Hyperglycaemic coma NOS

.1 With ketoacidosis
  Diabetic:
  • acidosis
  • ketoacidosis
  without mention of coma

.2+ With renal complications
  Diabetic nephropathy (N08.3*)
  Intracapillary glomerulonephrosis (N08.3*)
  Kimmelstiel-Wilson syndrome (N08.3*)

.3+ With ophthalmic complications
  Diabetic:
  • cataract (H28.0*)
  • retinopathy (H36.0*)

E10 Insulin-dependent diabetes mellitus
[See before E10 for subdivisions]

Incl.: diabetes (mellitus):
  • brittle
  • juvenile-onset
  • ketosis-prone
  • type I

Excl.: diabetes mellitus (in):
  • malnutrition-related (E12-)
  • neonatal (P70.2)
  • pregnancy, childbirth and the puerperium (O24-)
  glycosuria:
    • NOS (R81)
    • renal (E74.8)
  impaired glucose tolerance (R73.0)
  postsurgical hypoinsulinaemia (E89.1)

http://apps.who.int/classifications/icd10/browse/2010/en#/E10-E14
ICD-10

Proximal Tibia Fracture

Fracture of lower leg, including ankle

*Incl.*: malleolus

*Excl.*: fracture of foot, except ankle (S92.-)

The following subdivisions are provided for optional use in a supplementary character position where it is not possible or not desired to use multiple coding to identify fracture and open wound; a fracture not indicated as closed or open should be classified as closed.

0 closed
1 open

S82.0 Fracture of patella

Knee cap

S82.1 Fracture of upper end of tibia

Tibial:
- condyles
- head
- proximal end
- tuberosity

with or without mention of fracture of fibula

[http://apps.who.int/classifications/icd10/browse/2010/en#/S82.1](http://apps.who.int/classifications/icd10/browse/2010/en#/S82.1)
HL7/FHIR Terminology
LOINC

Logical Observation Identifiers Names and Codes (LOINC)

- A *nomenclature* (identifiers, names, codes) for clinical laboratory tests and observations

- Published by Regenstrief Institute

- Sparse array approach — mapping multiple axes into a code (Property / Time / System / Scale / Method)

- Used for laboratory tests and other observations
# LOINC White Cell Count

## 26464-8 Leukocytes [#/volume] in Blood

### NAME

<table>
<thead>
<tr>
<th>Fully-Specified Name:</th>
<th>Component</th>
<th>Property</th>
<th>Time</th>
<th>System</th>
<th>Scale</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukocytes</td>
<td></td>
<td>NCnc</td>
<td>Pt</td>
<td>Bld</td>
<td>Qn</td>
<td></td>
</tr>
</tbody>
</table>

### PART DEFINITION/DESCRIPTION(S)

**Part: Leukocytes**

White blood cells are intrinsic components of the blood. They are produced in the bone marrow and help to defend against infectious agents and foreign materials. As part of the immune system, they also help fight against malignant and aberrant cells.

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**Source:** Wikipedia, URL: Leukocytes (Wikipedia)

**Part: Leukocytes**

A population of white blood cells, generated in the bone marrow, that include granular cells (basophils, eosinophils, neutrophils) as well as non-granular leukocytes (lymphocytes, monocytes).

**Source:** National Library of Medicine, MedSH 2006

### MAPPING GUIDANCE

**Description:** Most leukocyte counts will be done by an automated counter and will be reported under [LOINC: 6690-2]. This term should be used only rarely.

**Source:** Regenstrief Help, URL: Mapper's Guide for the Top 2000 plus LOINC Laboratory Observations

### BASIC ATTRIBUTES

<table>
<thead>
<tr>
<th>Class/Type:</th>
<th>HEM/BC/Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDISC Lab Text:</td>
<td>Y</td>
</tr>
<tr>
<td>Common Lab Results Rank:</td>
<td>#33</td>
</tr>
<tr>
<td>Common SI Lab Results Rank:</td>
<td>#33</td>
</tr>
<tr>
<td>Created On:</td>
<td>2000/09/08</td>
</tr>
<tr>
<td>Last Updated in Version:</td>
<td>2.52</td>
</tr>
<tr>
<td>Order vs. Obs.:</td>
<td>Both</td>
</tr>
<tr>
<td>Status:</td>
<td>Active</td>
</tr>
<tr>
<td>Change Reason:</td>
<td>Changed Order_Obs from 'Observation Only' to fit the current order use cases.</td>
</tr>
</tbody>
</table>

### EXAMPLE UNITS

<table>
<thead>
<tr>
<th>Unit</th>
<th>Source Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>#/mm3</td>
<td>REGENSTRIEF</td>
</tr>
<tr>
<td>10^3/μL</td>
<td>EXAMPLE UCUM UNITS</td>
</tr>
<tr>
<td>k/cumm</td>
<td>REGENSTRIEF</td>
</tr>
</tbody>
</table>

### UNITS AND RANGE

<table>
<thead>
<tr>
<th>Range</th>
<th>Units Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^9</td>
<td>/L[4.4,11.3]</td>
</tr>
</tbody>
</table>
HL7/FHIR Terminology

RxNorm

RxNorm

- A *nomenclature* (identifiers, names, codes) for clinical drugs

- A *knowledge base* that includes:
  - Links to identifiers used in common pharmacy management and drug interaction systems
  - Information about active ingredients, dose forms, packaging, brand names, etc.

- US-Centric. ATC equivalent in EU…
RxNorm
(via RxNav)

https://mor.nlm.nih.gov/RxNav/search?searchBy=String&searchTerm=Ibuprofen
HL7/FHIR Terminology
SNOMED-CT

Systemized Nomenclature of Medicine - Clinical Terms (SNOMED-CT)

- (Primarily) An ontology of clinical healthcare
- International maintenance organization
  - International Healthcare Terminology Standards Development Organization (IHTSDO) to end of year
  - SNOMED International starting Jan 1, 2017
- Not free for use
  - Licensed for use in 28 countries
  - Netherlands - yes. Germany/France - no.
- Starting to realize actual use
SNOMED-CT

SNOMED CT

- Provides direct information in clinical records
- Provides definitions for the axes of LOINC
- (Could) provide definitions for classifications (ICD-11/SNOMED project…)
- (Could) provide definitions for clinical record components (more later)…
Terminology
Filling the slots

• On July 17, 2015, Mr. Grunt P Snooter presented with a **simple fracture** of the **right proximal tibia**
  
  **SCT:**706886007  
  **SCT:**(38624006 + 272741003 = 24028007)

• On examination, there was no indication of **osteomyelitis**
  
  **SCT:**60168000

• **Leukocyte count test** was **normal**
  
  **LOINC:**26464-8  
  **HL7/v2/0078:**N

• Prescribed **Ibuprofen Tablets 400 mg** every 4 to 6 hours as needed
  
  **RxNorm:**317388

• Billing code: **Simple Fracture of Tibia**  
  **ICD-10:**S82.101A
“Terminology”

There is unfortunately no cure for terminology; you can only hope to manage it. (Kelly Washbourne)
Terminology Summary

• Terminology “fills the slots” in clinical information records

• The term, *terminology*, covers a broad spectrum of uses:
  
  • Classification Systems, Dictionary/Ontology, Lexicon, Nomenclature, Thesaurus, Knowledge Base
  
  • Each has a different scope and purpose
  
• ICD-10 / LOINC / RxNorm / SNOMED-CT are the major terminologies used in HL7 (and FHIR) records
Outline

Part 1- FHIR

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—— Break ——
HL7 v3 has failed.

Now, a few readers are going to stop reading at this point and rush off and go quoting me saying "v3 is broken" or "you shouldn't use v3" or "national program XXX shouldn't have used v3", but I haven't said any of those things — v3 can be made to work if you provide enough skills and resources, and for some things, it's the best solution (CDA, for instance). But overall, v3 has failed to achieve the goals that HL7 has (being the general best solution to everything), and is not a vehicle that can take the organization forward from here.

That's a sad and painful admission for an organization that has invested *so* much work into an idea that seems to have so much promise. And HL7 really has worked hard on v3. But where we've ended up hasn't been where we expected to end up.
Fast Healthcare Interoperable Resource (FHIR)

- First began to form in 2012 time frame
- “Baby Bear” of standards?
  - HL7 V2 — easy but underspecified
  - HL7 V3 — tightly specified but too difficult
  - HL7 CDA — easier but still based on V3
- FHIR — easy … postpone tightness
FHIR

• A cool acronym: **Fast Healthcare Interoperable Resources**

• A technology stack (!)

• A community

• And …

… a *platform for a* healthcare interoperability standard.
Introduction to FHIR

HL7 Working Group Meeting
Baltimore, MD September, 2016
Brett Marquard
This presentation

- Can be downloaded here:
    - Use “anonymous” and email address to logon
- Is licensed for use under the Creative Commons, specifically:
  - [Creative Commons Attribution 3.0 Unported License](http://creativecommons.org/licenses/by/3.0)
  - (Do with it as you wish, so long as you give credit)
Genesis of FHIR

- HL7 undertook a “Fresh look”
  - What would healthcare exchange look like if we started from scratch using modern approaches?

- Web search for success markers led to RESTful based APIs

- Drafted a healthcare exchange API based on this approach
Timeline: Where does FHIR fit?

- V2: 1987
- Start V3: 1995
- V3 CDA: 2005
- Fresh FHIR Look: 2011
- DSTU 2: 2016

V2

The Goals of FHIR

- Implementer Focus
- Target the 80% (common stuff)
- Use today’s web technologies
- Support human readability
- Paradigm & architecturally agnostic
- Open Source
Implementer Focus

- Specification is written for one target audience… **Implementers**
  - Rationale, modeling approaches, etc. kept elsewhere
  - Make the resources **simple** and easy to understand and use
  - Multiple Implementation tools to help get you started from day 1
    - Publicly available test servers
    - Starter APIs published with spec
      - C#, Java, Pascal, ObjectiveC, Javascript
  - Lots and lots of examples (and they’re valid too)
Support the 80%

- Focus on scenarios that the implementers ask for
- Decision to include content into the core specification:
  - “We only include data elements if we are confident that most normal implementations using that resource will make use of the element” (80% rule)
- Other content is included through creation of Profiles and extensions
In FHIR, every resource should have a human-readable expression

- Can be direct rendering or human entered

(Just like C-CDA)
Paradigm Agnostic

The Content is the same despite the interoperability paradigm

Receive a lab result in a message…

Lab System

FHIR Message

FHIR Repository

FHIR Document

National Exchange

…Package it in a discharge summary document

..Update a patient record
Open Source

- Unencumbered – free for use, no membership required
- http://hl7.org/fhir

FHIR License

FHIR plain English license:

- FHIR is © HL7. The right to maintain FHIR remains vested in HL7
- You can redistribute FHIR
- You can create derivative specifications or implementation-related products and services
- Derivative Specifications cannot redefine what conformance to FHIR means
- You can’t claim that HL7 or any of its members endorses your derived [thing] because it uses content from this specification
- Neither HL7 nor any of the contributors to this specification accept any liability for your use of FHIR
Resources: What are they?

- The Content model
- The Thing that is exchanged
  - Via REST (FHIR Restful API), Messages, Documents
- Informed by much past work inside & outside of HL7
  - HL7: version 2, version 3 (RIM), CDA
  - Other SDO: openEHR, CIMI, ISO 13606, IHE, DICOM
What does a FHIR Resource represent?

- Clinical Perspective: The resource content defines a small amount of focused clinical and administrative information
- Implementor Perspective: Additional Infrastructural stuff too.
Connecting Resources

- Resources are independent – don’t need other resources to correctly interpret a resource
- But a single resource doesn't say very much, but a collection of Resources taken together creates a useful clinical record.
Connecting Resources

FHIR resource

“container” of information that represent something in the real world

Link between resources
Taking a tour of a FHIR Resource

- Scope and Usage Notes
- Resource Content (UML and XML)
- Terminology Bindings
- Constraints
- Implementation Issues
- Search Parameters
- Examples, Profiles, Formal Definitions
- Mappings to RIM, CDA, v2, etc
Anatomy of a Resource

1.7.3 Example Resource: Patient

This simple example shows the important parts of a resource: a local extension, the human readable HTML presentation, and the standard defined data content.

```xml
<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+11:00"/>
  </meta>
  <text>
    <status value="generated"/>
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
      <p>MRN: 123456. Male, 24-Sept 1932</p>
    </div>
  </text>
  <extension url="http://example.org/StructureDefinition/trials">
    <valueCode value="renal"/>
  </extension>
  <identifier>
    <use value="usual"/>
    <type>
      <coding>
        <system value="http://hl7.org/fhir/v2/0203"/>
        <code value="MRN"/>
      </coding>
    </type>
    <system value="http://www.goodhealth.org/identifiers/mrn"/>
    <value value="123456"/>
  </identifier>
  <active value="true"/>
  <name>
    <family value="Levin"/>
  </name>
</Patient>
```

- **Resource Identity & Metadata**
- **Human Readable Summary**
- **Extension with URL to definition**
- **Standard Data:**
  - MRN
  - Name
  - Gender
  - Birth Date
  - Provider
Resource Element

- Each Resource is composed of about 20-40 resource “elements”
- Each resource element is defined by:
  - Name
  - Cardinality
  - Type (Data type or structural resource)
  - Description
  - Terminology Binding
  - Other stuff (Comments, Constraints, Summary Flags, mappings, etc)
Data types: Primitive

- Based on w3c schema and ISO data types
- Stick to the “80% rule” – only expose what most will use
  - Simplified
Complex
Polymorphic Properties

- Where a property can have different datatypes
- Can use a profile to restrict to specific type
  - To come!
Constraints & Notes

- **Inv-1**: On Patient.contact: Must at least contain a contact's details or a reference to an organization (xpath on f:Patient/f:contact: f:name or f:telecom or f:address or f:organization)

Notes:

- `multipleBirth` can be either expressed as a boolean (just indicating whether the patient is part of a multiple birth) or as an integer, indicating the actual birth order.
- Patient records may only be in one of two statuses: in use (active=true) and not in use (active=false). A normal record is active, i.e. it is in use. Active is set to 'false' when a record is created as a duplicate or in error. A record does not need to be linked to be inactivated.
- The `link` element is used to assert that two or more Patient resources are both about the same actual person. See below for further discussion.
- There should be only one preferred language (Language.preference = true) per mode of expression.
- The Contact for a Patient has an element `organization`, this is for use with guardians or business related contacts where just the organization is relevant.
Resource Identifiers

- 2 different ‘sorts’ of identity
  - ID identifies a resource on a server
    - Is Metadata
    - Will change between servers
  - Identifier
    - Business identifier
    - Is an element in the resource
A Resource’s ID Example

Nutritionorder-example-diabeticdiet.json

```
{
  "resourceType": "NutritionOrder",
  "id": "diabeticdiet",
  "text": {
    "fhireComments": ["This is an example resource"]
  }
}
```

Resource Identifier

```
"resourceType": "NutritionOrder",
"id": "diabeticdiet"
```

Business Identifier

```
"identifier": [
  {
    "system": "http://goodhealthhospital.org/nutrition-orders",
    "value": "123"
  }
]
```

Resource can be found at:

A Resource’s ID

➢ http://server.org/fhir/Patient/1

resource type

endpoint

id

Note: This URL resolves to the current version of a resource
It’s also specific to a server
In addition, each resource carries a human-readable text representation using html as a fallback display option for clinical safety. This is particularly important for complex clinical information where many systems take a simple textual/document based approach.

1.7.3 Example Resource: Patient

This simple example shows the important parts of a resource: a local extension, the human readable HTML presentation, and the standard defined data content.

```xml
<Patient xmlns="http://hl7.org/fhir">
  <id value="42-536016"/>
  <meta lastUpdated value="2014-11-13T11:41:00+11:00"/>
  <text status value="generated">
    <div xmlns="http://www.w3.org/1999/xhtml">
      <p>Henry Levin the 7th</p>
      <p>MRN: 123456. Male, 24-Sep 1932</p>
    </div>
  </text>
  <extension url="http://example.org/StructureDefinition/trials">
    <valueCode value="renal"/>
  </extension>
  <identifier use="usual">
    <type>
      <coding>
        <system value="http://hl7.org/fhir/v2/0203"/>
        <code value="MRN"/>
      </coding>
    </type>
    <system value="http://www.goodhealth.org/identifiers/mrn"/>
    <value value="123456"/>
  </identifier>
  <active value="true"/>
  <name>
    <family value="Levin"/>
  </name>
</Patient>
```
Narrative example
Terminology
Examples of Coded Data in FHIR

- **Code Datatype**
  - e.g. Patient gender = “male”

- **CodeableConcept Datatype**
  - e.g. Observation code for a Blood Glucose measurement: LOINC = “2339-0” (Glucose [Mass/volume] in Blood)
    Displayed as Glucose, Blood

- **Quantity Datatype**
  - Units of measure for the Blood Glucose measurement:
    80 UCUM units = mg/dL
CodeableConcept: Example

A simple code for headache initially coded in SNOMED CT and then translated to ICD-10:

```xml
<concept>
  <coding>
    <system value="http://hl7.org/fhir/sid/icd-10" />
    <code value="R51" />
  </coding>
  <coding>
    <system value="http://snomed.info/sct" />
    <code value="25064002" />
    <display value="Headache" />
    <userSelected value="true" />
  </coding>
  <text value="general headache" />
</concept>
```

A concept represented in an institution’s local coding systems for unit for which CodeableConcept is defined.
Examples

- **Code**: "status" : "confirmed"
- **Coding**: {
  "code": "C3214954",
  "display": "cashew nut allergenic extract Injectable"
}
- **CodeableConcept**: {
  "coding": [{
    "system": "http://snomed.info/sct",
    "code": "39579001",
    "display": "Anaphylactic reaction"
  }],
  "text": "Anaphylaxis"
}
Code Systems

- SNOMED CT / LOINC / RxNORM
- HGVS, ICPC, MIMS + 100s more
- ICD-X+
- ANZSCO, METEOR
- A drug formulary
- A config table in an application
- A list of enums in a java class
- Australian state codes

**Code System:** Defines a set of concepts with a coherent meaning

- Code
- Display
- Definition
Value Sets

Code System:
Defines a set of concepts with a coherent meaning

Code Display Definition

Value Set:
A selection of a set of codes for use in a particular context
Bindings

Code System: Defines a set of concepts with a coherent meaning

Value Set: A selection of a set of codes for use in a particular context

Binds

A FHIR Coded Element

Selects from one or more
Binding Strength

- How closely the options in the value set should be followed

Values
- Required (must come from set)
- Extensible (may use alternate if have to)
- Preferred (don’t have to, but should)
- Example (set isn’t specified)

Can use extension to vary
- (Make stronger not weaker)
Binding Strength and Validation

- “Required” is the only strength that can be formally validated
- Most “required” is code data type (at least in FHIR core)
- A couple of coding examples
- CodeableConcept means at least one entry
Versioning

- **Most recent version**
  - [http://server.org/fhir/Patient/1](http://server.org/fhir/Patient/1)
  - Returns single resource

- **All versions**
  - [http://server.org/fhir/Patient/1/_history](http://server.org/fhir/Patient/1/_history)
  - Returns bundle of versions

- **Specific version**
  - [http://server.org/fhir/Patient/1/_history/1](http://server.org/fhir/Patient/1/_history/1)
  - Returns single resource

- Version support is optional
Version history – and revival

/server.org/fhir/Patient/33/_history/13

/server.org/fhir/Patient/33/_history/14

/server.org/fhir/Patient/33/_history/15

/server.org/fhir/Patient/33/_history/16

/server.org/fhir/Patient/33/_history/17

/server.org/fhir/Patient/33
Tools to Visualize FHIR resources

- **TextEditor, XML editor, FHIR Notepad++ Plugin**
- (David Hay’s) **clinFHIR tool**
  - Educational tool
    - For non-techies (especially clinicians & BA)
    - Beta software!
  - Resource Builder
    - View Resources
    - Create Condition
- [http://clinfhir.com/](http://clinfhir.com/)
FHIR RESTful Interactions

2.1.0 RESTful API

| FHIR Infrastructure Work Group | Maturity Level: N/A | Ballot Status: DSTU 2 |

Each "resource type" has the same set of interactions defined that can be used to manage the resources in a highly granular fashion. Applications claiming conformance to this framework claim to be conformant to "RESTful FHIR" (see Conformance).

The following logical interactions are defined:

**Instance Level Interactions**
- read: Read the current state of the resource
- vread: Read the state of a specific version of the resource
- update: Update an existing resource by its id (or create it if it is new)
- delete: Delete a resource
- history: Retrieve the update history for a particular resource

**Type Level Interactions**
- create: Create a new resource with a server assigned id
- search: Search the resource type based on some filter criteria
- history: Retrieve the update history for a particular resource type

**Whole System Interactions**
- conformance: Get a conformance statement for the system
- batch/transaction: Update, create or delete a set of resources in a single interaction
- history: Retrieve the update history for all resources
- search: Search across all resource types based on some filter criteria

In addition to these interactions, there is an operations framework, which includes endpoints for validation, messaging and transactions.
REST in practice

- “Resources” with an explicit and stable URI
  - The name for what gets exchanged in REST
  - Defined behaviour and meaning
  - Known identity / location
  - Quite an abstract idea

- Formats: XML / JSON / RDF
- Exchange using HTTP
- Security: SSL / OAuth
- “REST” followed loosely, hence “RESTful”
FHIR RESTful - Syntax

- **Instance**
  - Read: GET [base]/Patient/100
  - Vread: GET [base]/Patient/100/{vid}
  - Update: PUT [base]/Patient/100
  - Delete: DELETE [base]/Patient/100
  - History: GET [base]/Patient/100/_history

- **Type**
  - Create: POST [base]/Patient
  - Search: GET [base]/Patient?name=eve
  - History: GET [base]/Patient/_history
  - Validate: POST [base]/Patient/100/_validate/{id}

- **System**
  - Conformance: GET [base]/metadata
  - Transaction: POST bundle to root
  - History: GET [base]/_history
  - Search: GET [base]/Patient?name=eve
# FHIR RESTful Search

### Summary Table

<table>
<thead>
<tr>
<th>Search Parameter</th>
<th>GET</th>
<th>Result Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>Date/DateTime</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>String</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>Token</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>URI</td>
<td>[base]/Patient/100</td>
<td></td>
</tr>
<tr>
<td>_tag</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_profile</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_security</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_text</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_content</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_list</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_query</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_sort</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_count</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_include</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_reinvoke</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_summary</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_elements</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_contained</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
<tr>
<td>_containedType</td>
<td>[base]/Observation?code=3141-9</td>
<td></td>
</tr>
</tbody>
</table>

Playing with FHIR

- Access public server using
  - Browser can be used for Read
  - Developer Tools to Create and Update
    - Curl – command line tool
    - Fiddler, Postman and other applications
    - ClinFHIR, NotePad++ Plugin

- Applications
  - Smart Clients
# FHIR Operations

## 2.2.0.2 FHIR defined Operations

This specification defines several operations:

### Base Operations (All resource types)

<table>
<thead>
<tr>
<th>Operation</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validate a resource</td>
<td>[base]/[Resource]$/validate</td>
</tr>
<tr>
<td>Add profiles, tags, and security labels to a resource</td>
<td>[base]/[Resource]/[id]$/meta-add</td>
</tr>
<tr>
<td>Delete profiles, tags, and security labels for a resource</td>
<td>[base]/[Resource]/[id]$/meta-delete</td>
</tr>
</tbody>
</table>

### Operations Defined by Resource Types

<table>
<thead>
<tr>
<th>Operation</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate a Document</td>
<td>[base]/Composition$/document</td>
</tr>
<tr>
<td>Concept Translation</td>
<td>[base]/ConceptMap$/translate</td>
</tr>
<tr>
<td>Closure Table Maintenance</td>
<td>[base]/$closure</td>
</tr>
<tr>
<td>Evaluate</td>
<td>[base]/DecisionSupportRule/[id]$/evaluate</td>
</tr>
<tr>
<td>Evaluate</td>
<td>[base]/DecisionSupportServiceModule/[id]$/evaluate</td>
</tr>
<tr>
<td>Fetch Encounter Record</td>
<td>[base]/Encounter/[id]$/everything</td>
</tr>
<tr>
<td>Find a functional list</td>
<td>[base]/List$/find</td>
</tr>
<tr>
<td>Process Message</td>
<td>[base]/$process-message</td>
</tr>
<tr>
<td>Fetch Patient Record</td>
<td>[base]/Patient$/everything</td>
</tr>
<tr>
<td>Populate Questionnaire</td>
<td>[base]/Questionnaire$/populate</td>
</tr>
<tr>
<td>Build Questionnaire</td>
<td>[base]/StructureDefinition$/questionnaire</td>
</tr>
<tr>
<td>Value Set Expansion</td>
<td>[base]/ValueSet$/expand</td>
</tr>
<tr>
<td>Concept Look Up</td>
<td>[base]/ValueSet$/lookup</td>
</tr>
<tr>
<td>Value Set based Validation</td>
<td>[base]/ValueSet$/validate-code</td>
</tr>
</tbody>
</table>

### Operations Defined by Implementation Guides
The need for Profiles

- Many different contexts in healthcare, but a single set of Resources
- Need to be able to describe restrictions based on use and context
- Allow for these usage statements to:
  - Authored in a structured manner
  - Published in a repository
  - Used as the basis for validation, code, report and UI generation.
- Note Profiling is going to be very important
  - ‘Message from the chair’
The need for Profiles

- Profiles can serve the same purpose as:
  - CDA templates & implementation guides
  - HL7 v2 “static” profiles
  - CIMI implementation guides
  - OpenEHR Archetypes & templates

- Profiles aren’t mandatory for interoperability, but they improve the degree of it.
- Profiles never change meaning of an instance
Profiling a resource. For example...

Require that the identifier uses the NHI – and is required

Limit names to just 1 (instead of 0..*)

Limit maritalStatus to another set of codes that extends the one from HL7 international

Add an extension to support “Iwi”

Constrain out animal element(card = 0..0)
Extensions

- FHIR has a standard framework for extensions
  - Built into wire format
- Every FHIR element can be extended
  - Including datatypes
- Every extension has:
  - Reference to a computable definition
  - Value – from a set of known types
- Every system can read, write, store and exchange all legal extensions
- All extensions are valid by schema etc.
Extension Example
FHIR
(Personal Observations)

Healthcare standards (data aggregation / exchange / sharing / …) have always been on or ahead of the “bleeding edge”

FHIR is MDA done right (or at least done better…)

• FHIR is built on FHIR both technically and philosophically
• FHIR is open community, open source, transparent management
• BDFL approach to governance

FHIR is Open Source community done right (…)

• Open tools
• Freely available training / documentation
• Wide and growing community eager to help (and learn)
From the BDFL

# FHIR and the Gartner Hype Cycle

As FHIR product director, I get plenty of comments about the hype associated with FHIR. And there is plenty of hype. Here’s the Gartner hype curve:

Where are we on that curve, people want to know? Well, my answer is that as far as I can tell, the rate of increase of hype is still increasing, so it seems as though we’re still in the initial rocket phase.

What’s the hype?

For me, hype is beyond enthusiasm – it’s when people make wildly inflated claims about what is possible, (wilfully) misunderstand the limitations of the technology, and evangelise the technology for all sorts of ill judged applications (about where block chain in healthcare is right now).

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 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.

FHIR is good for sharing information out of an EHR – but confirming to FHIR doesn’t prove anything; there’ll have to be serious engagement for governments to change anything. Getting them to adopt the FHIR culture – that will. But you cannot impose that.
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Outline

Part 1- FHIR

1. Short history of HL7 information and related terminology standards
2. Introduction to FHIR — history, purpose and state
3. Navigating FHIR documentation and infrastructure (Hands On)
4. FHIR profiles and conformance resources — why and how
5. Create a simple FHIR profile (Demonstration)
6. Validate a simple FHIR data instance (Demonstration)

—- Break —-
Navigation

http://www.hl7.org/FHIR/
Community

http://chat.fhir.org/
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—— Break ——
Editing in Forge
Publish to Simplifier
Simplifier

PROJECT

SWAT4LS

SWAT4LS Demo Project

Publications

Order By: Publication Name (A-Z)

Draft 12/4/2016

MyBodySite
Profile on BodySite
A StructureDefinition

Fhir Status

or not
POST
Validating Resources against Profiles

You can validate a resource against a profile in several different ways

  - find the profile on fhir.healthintersections.com.au server by searching through the profiles
  - if your profile isn't there, you can put it on the server - paste it into the edit box at the bottom of the page, check the operation is "transaction", and choose Upload
  - now, go back to fhir.healthintersections.com.au/open, paste your resource into the edit box at the bottom of the page, choose "validate" for the operation, and pick the relevant profile, and choose upload
  - get a list of errors
- You can use the [validation] interaction
  - use a RESTful client like [POSTman], or write code to do this in the background
  - post the resource as described by the validation operation, and tag it with the profile you wish it to be tested against (see below)
  - most servers require the profile to be hosted on the server itself
- You can use the validator package
  - This is a java jar that you can use to validate a resource
  - get the validator from the FHIR downloads page for the version of FHIR you are using- download the validation pack, and unzip it
  - [source] is a file name of the resource to validate, or a URL at which to find it
  - [validation.zip] is the file name of the file validation.zip included in the tool zip download from above
  - [url] - the file name or url of the profile to use when validating the resource. if this is not provided, the resource is validated against the base
- You can use the java classes directly
  - see the java package org.hl7.fhir.instance.validation in the [FHIR svn]
  - The fhir.healthintersections.com.au source is available at [2]
- this can used if desired
Meta model
Part 1 Summary

HL7 Standards have played a significant role in healthcare data exchange since 1989

- HL7 V2 is still in widespread use
- HL7 V3 got stuck between being a model of healthcare / healthcare data and data exchange
- HL7 Clinical Data Architecture (CDA) had moderate uptake

FHIR emerged from the V3 “Fresh Look”

- Targeted exclusively at implementors
- Agile, open, auto generation and validation
- FHIR resources — define what is common on an information exchange
- FHIR profiles — constrain and/or extend resources for specific use cases
FHIR

• Provides identification scheme and extensible(!) content model for a broad range of healthcare data

• Is slated to become the model for open healthcare data…

… and maybe clinical research, clinical trials, cancer studies, as well.

• Is representation agnostic - XML / JSON + Plain Old (Java/C#/Javascript/…) objects…

… and, as of STU3, RDF

• Positioned to be the (first) platform for Linked Open Healthcare Data (!!!)
FHIR (continued)

FHIR has (at least) 4 modeling paradigms:

- **StructureDefinition** — first class structured elements
- **Extension** — tag/value pairs (second class structured elements)
- **Slicing** — renaming of repeating groups
- **Constraints** — Rules about combinations and content

FHIR also defines:

- links to other FHIR (and non-FHIR!) resources
- terminological content
FHIR and RDF/ShEx

Part 2 describes how the combination of RDF and Shape Expressions (ShEx):

- Serve to unify the modeling paradigms under a single formalism
- Allow seamless integration between FHIR resource instances and:
  - Other FHIR resources
  - Non-FHIR resources (Linked Open Data)
  - Terminology