FHIR Introduction

Centre for Global eHealth Innovation
August 17, 2016
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» Acknowledgements: Grahame Grieve, Lloyd McKenzie, Ewout Kramer, David Hay, Josh Mandel, Eric Haas, Rik Smithies
Agenda

- EHR Standards
- The Data Model
- The RESTful API
- Open Source Tools
- FHIR Servers / Who’s using FHIR
- Profiling and Extensions
- Advanced Features
- Timelines and Process
- Hands On!
Show of Hands

- Worked with health data before?
- Worked with HL7 before?
- Developer? Languages?
What We Heard you Wanted

- Primary focus on what is FHIR, how do you use the resources, how can it be applied to CGM data
- How to create a smartphone app with a FHIR service
- Consent management
- Patient resource vs person resource
- Resource extensions
- New resource definition
- Review resources team came up with & validate it against FHIR
Structure for Today

- Ask questions any time!
- Lots of learning, then some time to play
- We can adjust based on what you find interesting
3 Laws of Healthcare Interoperability

- **Interoperability**: It’s all about the people
- **Complexity**: You can move it around, or externalize it, but you can’t make it go away
- **Healthcare Software**: Cheap, Flexible, Interoperable (pick 2)

(courtesy Grahame Grieve)
The Fascinating World of EHR Standards

- **Data Exchange** (how to move data around)
- **Vocabulary** (how do we codify things)
- **Imaging** (pictures)
- **Profiling** (constraining things for use)
Vocabulary Standards

- Lab value: “Hemoglobin count of 6.5 grams per deci-litre”
- X-Ray: “Humerus”
Vocabulary Standards

- Lab value: “Hemoglobin count of 6.5 grams per deci-litre”
- X-Ray: “Humerus”
LOINC (Logical Identifiers Names and Codes)

- LOINC codes represent the “Question” for a test/measurement
  - E.g. “4548-4” = “Hemoglobin A1c/Hemoglobin.total in Blood”
- Adoption is growing worldwide
- Free to access, free to use

[https://search.loinc.org/](https://search.loinc.org/)
SNOMED-CT (Systematized Nomenclature of Medicine--Clinical Terms)

- SNOMED-CT models almost everything in healthcare
  - Body parts, devices, conditions, symptoms, locations, services, etc etc etc etc etc
  - Multi-axial subtype hierarchy
SNOMED-CT (Systematized Nomenclature of Medicine--Clinical Terms)

- Bone structure of clavicle and/or scapula and/or humerus
- Structure of long bone
- Upper arm part
- Bone structure of distal humerus
- Bone structure of proximal humerus
- Structure of bone marrow of humerus

- http://browser.ihtsdotools.org
UCUM (Unified Codes of Units and Measures)

- Nomenclature for units
  - E.g. “kg”, “Cel”, “mm[Hg]”

- [http://unitsofmeasure.org/](http://unitsofmeasure.org/)
Imaging: DICOM (Digital Imaging and Communications in Medicine)

- DICOM is all things imaging
  - Storage data format
  - Transmission protocol
  - Query specification
Profiling Organizations

- A number of organizations are working on profiling existing standards for specific uses
  - IHE (Integrating the Healthcare Enterprise)
  - Continua Health Alliance
  - SMART (more on this later)
Data Exchange Standards: A Backgrounder

- HL7 Version 2 is the dominant standard today for transactional messaging
HL7 Version 2

- Messages are defined as “pipe-and-hat” delimited lines of text

- Format is archaic, but support in tools and applications is very good
HL7 Version 3

- HL7 Version 3 – The “modeller’s paradise”
<entry typeCode="DRIV">
  <observation classCode="OBS" moodCode="EVN">
    <code code="29308-4" codeSystem="2.16.840.113883.6.1"/>
    <statusCode code="completed"/>
    <effectiveTime> <low value="20090313"/> </effectiveTime>
    <value xsi:type="CD" code="A01.5" codeSystem="2.16.840.1.113883.6.236"
      codeSystemName="CCC" displayName="Physical Mobility Impairment">
      <originalText> <reference value="#diag-1"/> </originalText>
      <qualifier>
        <name code="8" codeSystem="2.16.840.1.113883.3.7.1"/>
        <value code="G" codeSystem="2.16.840.1.113883.3.7.1.8"
          displayName="confirmed diagnosis"/>
      </qualifier>
    </value>
  </observation>
</entry>
...
Healthcare Messaging Standards
The Sorry State in 2010

- HL7 v2 is everywhere - it’s old but it works
  - Exchanges within organizations
  - Exchanges between organizations
- HL7 v3 has seen limited uptake - not sustainable
  - Mostly large government sponsored projects
- Apps are becoming a new reality
  - No suitable standards exist
Fast Healthcare Interoperability Resources
The Name

F Fast (to model and to implement)

H Health (why we’re here)

I Interoperability (ditto)

R Resources (more on this to come)
What else is FHIR?

- A terrible source of puns
  - Spark
  - Sprinkler
  - WildFHIR
  - FHIRWorks
  - FHIRMen
  - etc.....

- Don’t try to think of new ones. You are too late.
Complexity Model

Semantic Depth

Complexity (Log)

Text

HTTP/HTML

XML

SOAP

HL7v2

CDA

openEHR

HL7v3

FHIR?
The FHIR Manifesto

- Focus on **Implementers**
- Target support for **common scenarios**
- Leverage cross-industry **web technologies**
- Support **human readability** as base level of interoperability
- Make content **freely available**
- Support multiple **paradigms & architectures**

Manifesto: Implementer Focus

- Specification is written for one target audience: Implementors (developers! developers! developers!)
- Every detail in the specification is tested at connectathons
**Manifesto: Common Scenarios**

- **Heavy emphasis on the 80:20 rule:**
  - Cover only things that 80% will need
  - Enable and encourage extensions for remainder
Manifesto: Be Open

- FHIR itself is licensed under the Creative Commons "No Rights Reserved" License (CC0)
- FHIR tutorial material is generally also CC0
- Samples are also CC0
- Software is generally MIT or Apache 2
Manifesto: Support Multiple Paradigms and Architectures

- FHIR can be a document format, and a point-to-point messaging architecture
- For most of this session, we’ll assume that it’s a REST repository
What is FHIR?

- FHIR is an attempt to define a free and open data API for health data, based on modern techniques.
- FHIR is essentially four things:
  - A robust **data model** for describing health and administrative data.
  - A **RESTful API** for interacting with that data using either JSON or XML.
  - A set of **open source tools** to implement and test FHIR applications.
  - A set of **FHIR Servers** that you can interact with (both public and private).
The Data Model
Representing Health Data in FHIR

The RESTful API
Open Source Tools
FHIR Servers
The Data Model

- FHIR defines a set of roughly 150 resources
- These are the building blocks of the specification, examples include:
  - **Patient** (the person who receives healthcare)
  - **Encounter** (a doctor’s appointment or hospital stay)
  - **Observation** (e.g. a device reading, or lab value)
  - **DiagnosticReport** (e.g. a whole lab or Xray report)
  - **MedicationPrescription** (Rx for meds)
What’s a Resource?

Examples

- **Administrative**
  - Patient, Practitioner, Location, Organization

- **Clinical**
  - Allergy, Observation, Order, Diagnostic Report

Non-examples

- **Gender**
  - too small

- **Electronic Health Record**
  - too big

- **Blood Pressure**
  - too specific

- **Intervention**
  - too broad
The Balance for Granularity

- Observation (basically a key-value pair) is a generic data model that can hold lots of things
  - Lab result - e.g. Hb 7.2 g/dL at 15:20
  - Step count - e.g. 1007 steps between 9:00 and 10:00
  - Blood Pressure - e.g. 120/77 mmHg taken on the left arm at rest at 11:05
The Web of Resources

A resource is a container of information which represents something in the real world.

- **Patient**
  - **DiagnosticReport**
    - Complete Blood Count for John Smith
- **Encounter**
  - **Subject**
    - **Observation**
      - Subject
      - Result
The Model

- FHIR’s model is available online

<table>
<thead>
<tr>
<th>Name</th>
<th>Flags</th>
<th>Card.</th>
<th>Type</th>
<th>Description &amp; Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td></td>
<td></td>
<td>DomainResource</td>
<td>Information about a person or animal receiving care</td>
</tr>
<tr>
<td>identifier</td>
<td>Σ</td>
<td>0..*</td>
<td>Identifier</td>
<td>An identifier for the person as this patient</td>
</tr>
<tr>
<td>name</td>
<td>Σ</td>
<td>0..*</td>
<td>HumanName</td>
<td>A name associated with the patient</td>
</tr>
<tr>
<td>telecom</td>
<td>Σ</td>
<td>0..*</td>
<td>ContactPoint</td>
<td>A contact detail for the individual</td>
</tr>
</tbody>
</table>
| gender        | Σ     | 0..1  | code                  | male | female | other | unknown
| birthDate     | Σ     | 0..1  | date                  | The date of birth for the individual                                                       |
| birthTime     | Σ     | 0..1  | time                  | The time of birth for the individual                                                       |
| deceased[]    | M Σ   |       | boolean               | Indicates if the individual is deceased or not                                             |
| deceasedBoolean|       | 0..1  | boolean               |                                                                                           |
| deceasedDateTime|       | 0..1  | dateTime              |                                                                                           |
| address       | Σ     | 0..*  | Address               | Addresses for the individual                                                               |
| maritalStatus | Σ     | 0..1  | CodeableConcept       | Marital (civil) status of a person                                                         |
| multipleBirth[] |       | Σ     | boolean               | Whether patient is part of a multiple birth                                                |
| multipleBirthBoolean|       | 0..1  | boolean               |                                                                                           |
| multipleBirthInteger|       | 0..1  | integer               |                                                                                           |
| photo         | 0..*  |       | Attachment            | Image of the person                                                                         |
| contact       | I     | 0..*  | Element               | A contact party (e.g. guardian, partner, friend)                                          |

Developer friendly documentation
Demo Time

- FHIR’s model is available online
- http://hl7.org/fhir/
Data Types: Primitives

- string: Patient is awake
- boolean: true
- date: 2016-02-19
- decimal: 12.347000
- integer: 500
- uri: http://snomed.info/sct
- base64: rwr39o9h=
- dateTime: 2015-01-26T15:33:13-05:00
- instant: 2015-01-26T15:33:13.000-05:00
- markdown: **woohoo**
Data Types: Primitives

ISO8601 - Timezone is mandatory

- **date** 2016-02-19
- **decimal** 12.347000
- **integer** 500
- **uri** http://snomed.info/sct

- **dateTime** 2015-01-26T15:33:13-05:00
- **instant** 2015-01-26T15:33:13.000-05:00

- **markdown** **woohoo**
Data Types: Primitives

Human Times, variable precision

- **date** 2016-02-19
- **integer** 500
- **uri** http://snomed.info/sct

System Times, fixed precision

- **dateTime** 2015-01-26T15:33:13-05:00
- **instant** 2015-01-26T15:33:13.000-05:00

**markdown**

**woohoo**
**Data Types: Primitives**

- **string**: "Patient is awake"
- **integer**: 500
- **uri**: "http://snomed.info/sct"
- **dateTime**: 2015-01-26T15:33:13-05:00
- **instant**: 2015-01-26T15:33:13-05:00
- **markdown**: **woohoo**

FHIR internally uses markdown to define itself... will the EHR do so too?
Data Types: Composites
## Data Types: Composites

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</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>Σ I</td>
<td>0..1</td>
<td>Element</td>
<td>A measured or measurable amount.</td>
</tr>
<tr>
<td>value</td>
<td>Σ</td>
<td>0..1</td>
<td>decimal</td>
<td>Numerical value (with implicit precision).</td>
</tr>
<tr>
<td>comparator</td>
<td>?! Σ</td>
<td>0..1</td>
<td>code</td>
<td>&lt;</td>
</tr>
<tr>
<td>unit</td>
<td>Σ</td>
<td>0..1</td>
<td>string</td>
<td>Unit representation</td>
</tr>
<tr>
<td>system</td>
<td>Σ I</td>
<td>0..1</td>
<td>uri</td>
<td>System that defines coded unit</td>
</tr>
<tr>
<td>code</td>
<td>Σ</td>
<td>0..1</td>
<td>code</td>
<td>Coded form of the unit</td>
</tr>
</tbody>
</table>
Other Model Concepts: Identifiers

- FHIR resources are scoped around identifiable things (Patients, Orders, Locations, etc.)
- Identifiers consist of a **System** and an **Identifier**
- For example:
  - **System**: http://uhn.ca/ns/mrn
  - **Identifier**: 7000135
- Other systems:
  - urn:oid:2.16.840.1.113883.4.3.1 (Alabama Driver’s License)
Other Model Concepts: Identifiers

- HL7 maintains a standard list of identifier systems (but it is very US-centric)

- It is very common for organizations to define their own identifier systems, e.g.
  - [http://uhn.ca/ns/mrn](http://uhn.ca/ns/mrn)
Other Model Concepts: Coded Values

- Many things are drawn from a set of allowable coded values
- A coded value consists of a **Code System** and a **Code**, and optionally a **Display Text**
- For example:
  - **System:** http://snomed.info/sct
  - **Code:** 267038008
  - **Display:** Edema (finding)
Other Model Concepts: Coded Values

- HL7 also maintains a list of standard code systems:
Parts of a Resource

- Resource
- Metadata
- Extensions
- Narrative
- Body
Parts of a Resource

- Resource
- Metadata
- Extensions
- Narrative
- Body

- Resource ID
- Resource Version
- Tags
- Profiles

*more on these things later*
Parts of a Resource

Resource

- Metadata
- Extensions
- Narrative

Body

Any information that didn’t fit in the 80%
Parts of a Resource

- Metadata
- Extensions
- Narrative
- Body

- Human-readable version of the content (optional but encouraged)
- CDA has taught us that this is very important
Parts of a Resource

- Resource
- Metadata
- Extensions
- Narrative
- Body

The actual data
FHIR Wire Format

- FHIR defines a wire format for serializing resources in both XML and JSON
- RDF is proposed as a 3rd wire format
Let's Make it Real in JSON

```json
{
  "resourceType": "Observation",
  "id": "287",
  "meta": {
    "versionId": "2"
  },
  "extension": [{
    "url": "http://uhn.ca/fhir/readings#context",
    "valueCode": "BREAKFAST"
  }],
  "text": {
    "div": "<div>Fasting glucose of <b>11.2 mg/dl</b></div>"
  },
  "status": "final",
  "code": {
    "coding": [{
      "system": "http://loinc.org",
      "code": "41604-0",
      "display": "Fasting glucose [Mass/volume] in Capillary blood by Glucometer"
    }]
  },
  "subject": {
    "reference": "Patient/1"
  },
  "effectiveDateTime": "2015-02-12T09:30:00-05:00",
  "valueQuantity": {
    "value": 11.2,
    "system": "http://unitsofmeasure.org",
    "code": "mg/dL"
  },
  "device": {
    "reference": "Device/23324"
  }
}
```
Let’s Make it Real in JSON

```json
{
  "resourceType": "Observation",
  "id": "287",
  "meta": {
    "versionId": "2"
  },
  "extension": [{
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  }],
  "text": {
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  },
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      "display": "Fasting glucose [Mass/volume] in Capillary blood by Glucometer"
    }]
  },
  "subject": {
    "reference": "Patient/1"
  },
  "effectiveDateTime": "2015-02-12T09:30:00-05:00",
  "valueQuantity": {
    "value": 11.2,
    "system": "http://unitsofmeasure.org",
    "code": "mg/dL"
  },
  "device": {
    "reference": "Device/23324"
  }
}
```
Let’s Make it Real in XML

```xml
<Observation xmlns="http://hl7.org/fhir">
  <id value="287"/>
  <meta>
    <versionId value="2"/>
  </meta>
  <text>
    <div xmlns="http://www.w3.org/1999/xhtml">Fasting glucose of
      <b>11.2 mg/dl</b>
    </div>
  </text>
  <extension url="http://uhn.ca/fhir/readings#context">
    <valueCode value="BREAKFAST"/>
  </extension>
  <status value="final"/>
  <code>
    <coding>
      <system value="http://loinc.org"/>
      <code value="41604-0"/>
      <display value="Fasting glucose [Mass/volume] in Capillary blood by Glucometer"/>
    </coding>
  </code>
  <subject>
    <reference value="Patient/1"/>
  </subject>
  <effectiveDateTime value="2015-02-12T09:30:00-05:00"/>
  <valueQuantity>
    <value value="11.2"/>
    <system value="http://unitsofmeasure.org"/>
    <code value="mg/dL"/>
  </valueQuantity>
  <device>
    <reference value="Device/23324"/>
  </device>
</Observation>
```
**Instantiating the Model: Primitive Types**

<table>
<thead>
<tr>
<th>Name</th>
<th>Flags</th>
<th>Cardinality</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>I</td>
<td></td>
<td>DomainResource</td>
<td></td>
</tr>
<tr>
<td>identifier</td>
<td></td>
<td>0..*</td>
<td>Identifier</td>
<td></td>
</tr>
<tr>
<td>status</td>
<td></td>
<td>?! 1..1</td>
<td>code</td>
<td></td>
</tr>
<tr>
<td>category</td>
<td></td>
<td>0..*</td>
<td>CodeableConcept</td>
<td></td>
</tr>
<tr>
<td>code</td>
<td></td>
<td>1..1</td>
<td>CodeableConcept</td>
<td></td>
</tr>
<tr>
<td>subject</td>
<td></td>
<td>0..1</td>
<td>Reference(Patient</td>
<td>Group</td>
</tr>
<tr>
<td>encounter</td>
<td></td>
<td>0..1</td>
<td>Reference(Encounter)</td>
<td></td>
</tr>
<tr>
<td>effective[x]</td>
<td></td>
<td>0..1</td>
<td>dateTime</td>
<td></td>
</tr>
<tr>
<td>effectiveDateTime</td>
<td></td>
<td>0..1</td>
<td>Period</td>
<td></td>
</tr>
<tr>
<td>issued</td>
<td></td>
<td>0..1</td>
<td>instant</td>
<td></td>
</tr>
</tbody>
</table>

```json
{
    "resourceType": "Observation",
    "id": "287",
    "meta": {
        "versionId": "2"
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    },
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    },
    "effectiveDateTime": "2015-02-12T09:30:00-05:00",
    "valueQuantity": {
        "value": 11.2,
        "system": "http://unitsofmeasure.org",
        "code": "mg/dL"
    },
    "device": {
        "reference": "Device/23324"
    }
}
```
Instantiating the Model: Composite Types

```
{  "resourceType":"Observation",  "id":"287",  "meta":{    "versionId":"2"  },  "extension":[[    "url":"http://uhn.ca/fhir/readings#context",    "valueCode":"BREAKFAST"  ]],  "text":{    "div":"<div>Fasting glucose of <b>11.2 mg/dl</b></div>"  },  "status":"final",  "code":{    "coding":[[      "system":"http://loinc.org",      "code":"41604-0",      "display":"Fasting glucose [Mass/volume] in Capillary blood by Glucometer"    ]]
  },  "subject":{    "reference":"Patient/1"  },
  "effectiveDateTime":"2015-02-12T09:30:00-05:00",
  "valueQuantity":{    "value":11.2,
    "system":"http://unitsofmeasure.org",
    "code":"mg/dL"
  },  "device":{    "reference":"Device/23324"  }
}
```
Instantiating the Model:

References

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<td>Card.</td>
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</tr>
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<td>0..*</td>
<td></td>
<td>Identifier</td>
</tr>
<tr>
<td>status</td>
<td>?! Σ</td>
<td>1..1</td>
<td>code</td>
</tr>
<tr>
<td>category</td>
<td>0..*</td>
<td></td>
<td>CodeableConcept</td>
</tr>
<tr>
<td>code</td>
<td>Σ</td>
<td>1..1</td>
<td>CodeableConcept</td>
</tr>
<tr>
<td>subject</td>
<td>Σ</td>
<td>0..1</td>
<td>Reference(Patient, Group, Device, Location)</td>
</tr>
<tr>
<td>encounter</td>
<td>0..1</td>
<td></td>
<td>Reference(Encounter)</td>
</tr>
<tr>
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<td>Σ</td>
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<td>instant</td>
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```
Instantiating the Model: Cardinalities

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<td>code</td>
<td>Σ</td>
<td>1..1</td>
<td>CodeableConcept</td>
</tr>
<tr>
<td>subject</td>
<td>Σ</td>
<td>0..1</td>
<td>Reference(Patient</td>
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<tr>
<td>encounter</td>
<td>0..1</td>
<td></td>
<td>Reference(Encounter)</td>
</tr>
<tr>
<td>effective[x]</td>
<td>Σ</td>
<td>0..1</td>
<td>dateTime</td>
</tr>
<tr>
<td>effectiveDateTime</td>
<td></td>
<td></td>
<td>valueQuantity</td>
</tr>
<tr>
<td>issued</td>
<td>Σ</td>
<td>0..1</td>
<td>instant</td>
</tr>
</tbody>
</table>
Instantiating the Model: Invariants

<table>
<thead>
<tr>
<th>Name</th>
<th>Flags</th>
<th>Card.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>I</td>
<td></td>
<td>DomainResource</td>
</tr>
<tr>
<td>identifier</td>
<td></td>
<td>0..*</td>
<td>Identifier</td>
</tr>
<tr>
<td>status</td>
<td>?! Σ</td>
<td>1..1</td>
<td>code</td>
</tr>
<tr>
<td>category</td>
<td></td>
<td>0..*</td>
<td>CodeableConcept</td>
</tr>
<tr>
<td>code</td>
<td>Σ</td>
<td>1..1</td>
<td>CodeableConcept</td>
</tr>
</tbody>
</table>

10.1.3.2 Constraints

- **obs-3**: On Observation.referenceRange: Must have at least a low or a high or text (expression on Observation.referenceRange: low.exists() or high.exists() or text.exists())
- **obs-6**: dataAbsentReason SHALL only be present if Observation.value[x] is not present (expression: dataAbsentReason.empty() or value.empty())
- **obs-7**: If code is the same as a component code then the value element associated with the code SHALL NOT be present (expression: value.empty() or code! = component.code)
The Data Model

The RESTful API
Exchanging Health Data in FHIR

Open Source Tools
FHIR Servers
FHIR Paradigms

- FHIR aims to support these four kinds of exchange

![Diagram showing FHIR paradigms: REST, Documents, Messages, Services. Our main interest today is indicated by an arrow pointing to the REST section.]
REST

- FHIR has a very powerful API for interacting with resources based on the principles of REST (Representational State Transfer)
- Make “Resources” URI addressable
- Use HTTP to do CRUD operations, and much more
- Interactions in FHIR are described in terms of two roles: **Client** and **Server**
REST for Diabetes Devices: Example Use Cases

- The Continua Model

- The Health Management App Model
Glucose Profile End-To-End Demo
Glucose Profile End-To-End Demo
Resource Identities

- Every FHIR resource has a unique identity, which is in fact a URL

http://fhirtest.uhn.ca/baseDstu2/Patient/1
CRUD: Create

POST http://fhirtest.uhn.ca/baseDstu2/Patient
Content-Type: application/json+fhir

{"resourceType":"Patient" ...... }
CRUD: Create

POST http://fhirtest.uhn.ca/baseDstu2/Patient
Content-Type: application/json+fhir

{"resourceType"":"Patient" …… }

201 Created
Content-Location: http://fhirtest.uhn.ca/baseDstu2/Patient/1841460/_history/1
Two URLs are implied here: versionless and version specific

The server maintains a complete version history (more in this in a minute)
CRUD: Read

GET http://fhirtest.uhn.ca/baseDstu2/Patient/1
CRUD: Create

- The server might also return a special OperationOutcome resource with status information

```
201 Created
Content-Location: http://fhirtest.uhn.ca/baseDstu2/Patient/1841460/_history/1
Content-Type: application/fhir+json; charset=utf-8

{
    "resourceType": "OperationOutcome",
    "issue": [
        {
            "severity": "error",
            "code": "code-invalid",
            "details": {
                "text": "The code \"W\" is not known and not legal in this context"
            }
        }
    ]
}
```
GET http://fhirtest.uhn.ca/baseDstu2/Patient/1

200 OK
Content-Type: application/json+fhir

{ “resourceType”: “Patient” .......... }
CRUD: Read

GET http://fhirtest.uhn.ca/baseDstu2/Patient/98188

- Demo time
CRUD: Read

GET http://fhirtest.uhn.ca/baseDstu2/Patient/1?_format=xml

200 ok
Content-Type: application/xml+fhir

<Patient ..........></Patient>
CRUD: Update

PUT http://fhirtest.uhn.ca/baseDstu2/Patient
Content-Type: application/json+fhir

{"resourceType":"Patient" ...... }
**CRUD: Update**

**PUT** `http://fhirtest.uhn.ca/baseDstu2/Patient/1`

**Content-Type:** application/json+fhir

```json
{"resourceType":"Patient"…… }
```
CRUD: Delete

DELETE http://fhirtest.uhn.ca/baseDstu2/Patient/1841460

200 OK
Try it Out

» Take a resource: https://goo.gl/LclVdM

» Upload it to: http://fhirtest.uhn.ca
The Web of Health Resources

- Reading one resource can reveal a resource with links to other resources

name: “Chest XRay”
status: “complete”
subject: “Patient/242”
author: “Practitioner/15”

http://acme.com/Patient/242
name: “Jim Tester”
birthDate: “1999-01-02”

http://acme.com/Practitioner/15
name: “Dr Fakie Faker”
address: “Better Health Clinic”
The Web of Health Resources

- Reading one resource can reveal a resource with links to other resources

name: “Chest XRay”
status: complete
subject: “Patient/242”
author: “Practitioner/15”

http://acme.com/Patient/242
name: “Jim Tester”
birthDate: “1999-01-02”

http://acme.com/Practitioner/15
name: “Dr Fakie Faker”
address: “Better Health Clinic”
The Web of Health Resources

- Resources can be distributed across servers too.
The Bundle Resource

- Sometimes we need to package multiple resources together
- We use a special container resource called “Bundle”
Resource History

- FHIR servers keep track of the complete history of a given resource instance
- This way, the client doesn’t need to keep track

Patient/1/_history/1
- family: "Agnew"
- given: "James"
- gender: "female"

Patient/1/_history/2
- family: "Agnew"
- given: "James"
- gender: "male"

Patient/1/_history/3
- family: "Agnew"
- given: "James"
- gender: "male"
- address: "342 Evergreen T."
The History Operation

http://fhirtest.uhn.ca/baseDstu2/Patient/1/_history

Patient/1/_history/1
family: "Agnew"
given: "Jamesss"
gender: "female"

Patient/1/_history/2
family: "Agnew"
given: "James"
gender: "male"

Patient/1/_history/3
family: "Agnew"
given: "James"
gender: "male"
address: "342 Evergreen T."

Bundle

Patient/1/_history/3
Patient/1/_history/2
Patient/1/_history/1
The History Operation: Paging

- What if there is lots of history?

http://fhirtest.uhn.ca/baseDstu2/Patient/1/_history
http://fhirtest.uhn.ca/baseDstu2/Patient/1/_history?_count=100
The History Operation: Modes

- There are 3 kinds of history

  - **Server** (all resources)
    - http://fhirtest.uhn.ca/baseDstu2/_history
  
  - **Type** (same type)
    - http://fhirtest.uhn.ca/baseDstu2/Patient/_history
  
  - **Instance** (same ID)
    - http://fhirtest.uhn.ca/baseDstu2/Patient/1/_history

- History can be used as a simple polling mechanism for subscription

  http://fhirtest.uhn.ca/baseDstu2/Patient/1/_history?
  _since=2011-02-23T15:00:01.0032-05:00
Searching for Resources

- Searching is one of the most powerful parts of the FHIR RESTful API
- Searches take the form:

  http://fhirtest.uhn.ca/baseDstu2/Patient?name=smith
Searching for Resources

- A basic search: find everything

GET $http://fhirtest.uhn.ca/baseDstu2/Patient$
Searching for Resources

- Every resource type defines a set of search parameters
- Let’s look at some search parameters:

Search by Name

```
GET http://fhirtest.uhn.ca/baseDstu2/Patient?name=smith
```

Search by Birth Date

```
GET http://fhirtest.uhn.ca/baseDstu2/Patient?birthdate=2008-03-15
```

Search by Gender

```
GET http://fhirtest.uhn.ca/baseDstu2/Patient?gender=male
```
Search Parameter Types

FHIR defines eight search parameter types: **String, Date, Number, Token, Quantity, URI, Reference, Composite**

- **String**
  
  - Example: `[base]/Patient?family=smith
  
  Left matches SMITH, smith, smithson, etc.

- **Exact String**
  
  - Example: `[base]/Patient?family:exact=Smith
  
  Matches Smith

- **Partial String**
  
  - Example: `[base]/Patient?family:contains=smith
  
  Matches Smith, Smithson, and Naismith
Search Parameter Types

FHIR defines eight search parameter types: **String**, Date, Number, Token, Quantity, URI, Reference, Composite

**OR**

```
[base]/Patient?name=smith,jones
```

Matches smith OR jones

**AND**

```
[base]/Patient?family=smith,jones&given=john
```

Matches “John Smith” or “John Jones”
Search Parameter Types

FHIR defines eight search parameter types: String, **Date**, Number, Token, Quantity, URI, Reference, Composite

- **Date**
  - [base]/Patient?birthdate=2013-02-12

- **Year**
  - [base]/Patient?birthdate=2013

- **Range**
  - [base]/Patient?birthdate=ge2013&birthdate=lt2016

Qualifiers: gt, ge, lt, le

Match both to form a range
Search Parameter Types

Parameters can be combined

[base]/Patient?family=smith,jones&birthdate=2013-02-12

Matches smith OR jones with birthdate Feb 12, 2013
Search Parameter Types

FHIR defines eight search parameter types:
String, Date, **Number**, Token, Quantity, URI, Reference, Composite

Number

[base]/Encounter?length=gt30

Matches encounters longer than 30 days
Search Parameter Types

FHIR defines eight search parameter types: String, Date, Number, **Token**, Quantity, URI, Reference, Composite

**Code**

```
[base]/Observation?code=http://loinc.org|41604-0
```

Matches blood glucose observations

**Code Hierarchy**

```
[base]/Observation?code:in=http://snomed.info/sct|65533
```

Matches any child types
Search Parameter Types

FHIR defines eight search parameter types: String, Date, Number, Token, **Quantity**, URI, Reference, Composite

- **With Units**
  - [base]/Observation?value-quantity = ge11|mg/dl|http://unitsofmeasure.org
  - Matches >= 11 mg/dl

- **Any Units**
  - [base]/Observation?value-quantity = ge11
  - Matches >= 11 (any units)
Search Parameter Types

FHIR defines eight search parameter types: String, Date, Number, Token, Quantity, URI, Reference, Composite

- URI and Composite are defined here:
  - http://hl7.org/fhir/search.html
Search Parameter Types

FHIR defines eight search parameter types:
String, Date, Number, Token, Quantity, URI, Reference, Composite

- **Code**
  - `[base]/Observation?subject=Patient/1`
  - Matches all observations for the given patient

- **Chained**
  - `[base]/Observation?subject.family=smith`
  - Matches any observations for a patient named smith
Other Search Features
These parameters apply to any resource

- **By Last Updated Time**
  - [base]/Observation?_lastUpdated=gt2016-02-22T15:22:00Z
  - Matches all observations updated after the date

- **Sorting results**
  - [base]/Observation?_sort:desc=birthdate
  - Sorts the results by birthdate

- **Include linked resources**
  - [base]/Observation?_include=Observation:subject
  - Also return patients

- **Count**
  - [base]/Observation?_count=100
  - Adjust page size
Taking Search for a Spin

» Search for Systolic Blood Pressure
  » http://fhirtest.uhn.ca/baseDstu2/Observation?
    code=http://loinc.org|8480-6
  » http://goo.gl/4TWIlp
Keep Spinning

» Search for Systolic Blood Pressure
The Data Model
The RESTful API

Open Source Tools
Where to get data and who is using FHIR

FHIR Servers
Open Source Tools

» UHN maintains a free Java Implementation for both clients and servers

🌐 http://jamesagnew.github.io/hapi-fhir/

» Libraries for C#, Swift, JavaScript, XML, Delphi are available under ‘code’

🌐 http://hl7-fhir.github.io/
The Data Model
The RESTful API
Open Source Tools

FHIR Servers
Where to get data and who is using FHIR
Publicly Available Test Servers

- Reading one resource can reveal a resource with links to other resources

  (HealthIntersections)

  http://fhirtest.uhn.ca/baseDstu2
  (UHN)

  http://spark.furore.com/fhir
  (Furore)
Demo Time

- http://fhirtest.uhn.ca
Host Your Own Copy

» HAPI’s Command Line Tool can give you a local version of the FHIR test server you can play with

Securing FHIR: The Basics

- TLS and HTTP Basic Auth is a simple but popular approach for system level authentication

GET https://fhirtest.uhn.ca/baseDstu/Patient/1
Authorization: 329fe89hfeiw38fs3fs4fg3s8oh4sg=
Securing FHIR: The Basics

- OAUTH2 is being explored for AuthZ/AuthN
Why OAUTH?

Stallons User Status is requesting permission to do the following:

- **Access my basic information**
  Includes name, profile picture, gender, networks, user ID, list of friends, and any other information I've shared with everyone.

- **Post to my Wall**
  Stallons User Status may post status messages, notes, photos, and videos to my Wall

- **Access posts in my News Feed**

- **Access my profile information**
  Birthday

Logged in as Jane Stallons (Not You?)

[Allow] [Don't Allow]
SMART Platforms / SMART-on-FHIR

- SMART is an industry-led project to combine OAUTH2 and FHIR
The App Store for Health

- Demo time:
- [https://gallery.smarthealthit.org](https://gallery.smarthealthit.org)
Project Argonaut

- Project Argonaut is a collaborative project to test/validate the FHIR data model and SMART auth standards
- Over 70 participating organizations
Project Argonaut

Argonaut Project Testing Community (as of July 23, 2015)

1. Accenture
2. AcutalMeds Corp.
3. AEGIS
4. Aetna
5. Akana
6. American Medical Association
7. Amida Technology Solutions
8. Apigee
9. Applied Informatics
10. athenahealth
11. Bespoke Systems
12. BIDMC
13. Care at Hand
14. Carebox
15. Carefluence
16. Carolinas HealthCare System
17. Cerner
18. CipherHealth
19. DoD/VA
20. Drajer LLC
21. Duke Medicine
22. EMR Direct
23. Epic
24. GE
25. Geisinger
26. Hackensack University Medical Center
27. Health Samurai
28. Infor
29. Intermountain Healthcare
30. InterSystems Corporation
31. Massachusetts eHealth Collaborative
32. Mana Health
33. Mayo Clinic
34. McKesson
35. Medfusion
36. MedicaSoft
37. MEDITECH
38. MITRE
39. MobileSmith
40. ModuleMD
41. NavHealth
42. Netsmart
43. NextGen
44. Office of National Coordinator
45. Optum (UnitedHealth Group)
46. Orion Health
47. OSIA Medical
48. Partners Healthcare
49. Pokitdok Inc.
50. Practice Fusion
51. Premier Inc
52. Qvera
53. Redox Engine
54. Reliant Medical Group
55. River Rock Associates
56. RxREVU
57. Surescripts
58. The Advisory Board Company
59. The Sequoia Project (formerly Health Level Seven International)
60. Trinity Health
61. UC Santa Cruz
62. UPMC
63. US Postal Service
64. Vetter Software
65. VigilLanz Corporation
66. VSee
67. xG Health Solutions
68. Xperterra
What Does The Future Hold?

- Several implementations of these standards are going live this year
- Vendors are expected to start selling compliant API modules this year
Profiling and Extensions
Adopting FHIR for a specific use
Curious Math

http://server.org/fhir/Patient/  406 hits
http://server.org/fhir/Patient?gender=M  234 hits
http://server.org/fhir/Patient?gender=F  167 hits

Total: 234 + 167 = 401
Curious Math

http://server.org/fhir/Patient/ 406 hits
http://server.org/fhir/Patient?gender=M 234 hits
http://server.org/fhir/Patient?gender=F 167 hits
http://server.org/fhir/Patient?gender:missing=true 5 hits

Total: 234 + 167 + 5 = 406

- This highlights an important point: very little is required in FHIR
Very Little is “Mandatory” in FHIR
Profiling and Extensions

» FHIR uses resources to profile itself
» FHIR defines 3 resources which can be used to profile resources for a specific use
  » **StructureDefinition**: This defines a resource’s structure (including extensions)
  » **ValueSet**: This defines a set of allowable codes
  » **NamingSystem**: This defines identifier namespaces
  » **ImplementationGuide**: Packages these together
StructureDefinition

» StructureDefinition is has two main purposes:
  » It defines **constraints** on a given resource
    » e.g. “Patient.gender has cardinality 1..1”
  » It defines **extensions** on a given resource
    » e.g. “Patient has eye colour extension”
ValueSet

- A ValueSet is a collection of codes allowed for a specific purpose
- Individual coded fields in FHIR’s model are “bound” to a ValueSet

**Code System**
(e.g. SNOMED CT, LOINC)

**Code**
(e.g. 12345 = Hb)

**ValueSet**
(e.g. Codes allowed in a haematology panel)

---

Other Codes

---

Defines

Composes

Composes
Value Set Bindings

• Specific fields in FHIR are “bound” to a ValueSet with a specific strength
  • **Required**: Use one of these codes
  • **Extensible**: Use one of these codes if one of them applies, otherwise use whatever
  • **Preferred**: Try to use one of these codes
  • **Example**: Here’s some codes you could use

• Demo time:
NamingSystem

» Defines an identifier scheme, e.g.

University Health Network MRNs could be defined as
http://uhn.ca/ns/mrn

» This URL could resolve to a definition
» In practice this is not used much.. yet…
A tool called Forge can be used to create a complete ImplementationGuide, including all required resources

http://fhir.furore.com/Forge
Profiling FHIR: Top-Down or Bottom-Up

Company

FHIR Specification

National Authority

FHIR Specification

Regional Authority

FHIR Specification
Profiling and Extensions

» If nothing in FHIR meets your needs, you are still allowed to create your own custom resource definitions

» This is discouraged because it is bad for interoperability! (but there are valid reasons for doing it)
Useful Resources
A guide to some models covered by FHIR
FHIR Data Models are Found Here

This page is provided to help find resources quickly. There is also a more detailed classification, on

<table>
<thead>
<tr>
<th>Categorized</th>
<th>Alphabetical</th>
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<td>General:</td>
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<td>- AllergyIntolerance 1</td>
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</tr>
<tr>
<td>- Condition (Problem) 2</td>
<td></td>
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<tr>
<td>- Procedure 1</td>
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<td>Medication &amp; Immunization:</td>
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<tr>
<td>- Medication 1</td>
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<tr>
<td>- MedicationOrder 1</td>
<td></td>
</tr>
<tr>
<td>- MedicationAdministration 1</td>
<td></td>
</tr>
</tbody>
</table>
Person vs. Patient

- Person is actually intended as a link between other resources, as opposed to a standalone thing.
Security & Consent Management

» Three resources are particularly interesting to the security domain:

» **Consent** - Tracking Privacy Consent Directives

» **Provenance** - Tracking the provenance of other resources

» **AuditEvent** - Tracking access/disclosure of data by a system user
Some Advanced Features

What’s Happening
Transactions

- Transactions use a bundle to package a number of FHIR operations into a single **atomic transaction** as a Bundle.
Tagging

- Resources have a set of tags which are maintained outside of the standard versioning scheme
- Often used for workflow

1. Create Resource
   - Add Tag: **Needs Review**

2. Find resources with Tag: **Needs Review**
   - Add Tag: **Signed Off**

3. Find resources with Tag: **Signed Off**
Contention Aware Updating

- ETAG (RFC7232) is used to prevent race conditions
Contestation Aware Updating

- ETAG (RFC7232) is used to prevent race conditions
FHIR Timelines
What’s Happening
The Past

- HL7 Version 2
- HL7 Version 3
- CDA
- FHIR
The Future

HL7 Version 2

2010  2015  2020  beyond?

FHIR Project Started
DSTU1 Released
DSTU2 Released
DSTU3 to be Released
First normative ballot

beyond?
Plans to go Normative

» FHIR will probably not have any normative content until 2019
» This does not mean it’s not ready for use!
» Lots of people are using FHIR today for production applications
FHIR Process

Where does FHIR come from?
FHIR Process

Work Groups

- Patient Administration
- Orders and Observations
- Financial Management
- FHIR Infrastructure
- Clinical Genomics
- etc.....
FHIR Process

Work Groups .. define resources

Patient Administration
Orders and Observations
Financial Management
FHIR Infrastructure
Clinical Genomics
etc.....

Resource Definitions
Resource Definitions
FHIR Process

Work Groups .. define resources .. which get tested

- Patient Administration
- Orders and Observations
- Financial Management
- FHIR Infrastructure
- Clinical Genomics
- etc.....

Resource Definitions

Connectathon

Ballot
FHIR Process

Work Groups .. define resources .. which get tested .. and ballotted
FHIR Process

Work Groups .. define resources .. which get tested .. and ballotted

- Patient Administration
- Orders and Observations
- Financial Management
- FHIR Infrastructure
- Clinical Genomics
- etc.....

Resource Definitions

Connectathon

Ballot
Questions?