FHIR Deep Dive

AMIA Symposium
Viet Nguyen, MD
November 4, 2017
Agenda

• The basics: resources and references
• Structured Data
• Profiling
• Paradigms of Exchange
• Ecosystem
Benefits to Clinicians

- Clinicians can get involved in system design
- Tooling available
- Improved access to more complete, higher quality patient information incl. genomics
- Greater choice and variety of applications and devices to support clinical workflow
- Increased IT development speed – solving business problems faster in innovative ways
- Improving Decision Support
  - E.g. Immunization protocol
- Saving time
Benefits to Consumers

• Prospect of improved patient engagement apps, enabled through FHIR APIs to clinical systems
  • Can engage more deeply
• Clinician has access to a more complete patient record and improved decision making tools, leading to:
  • Better decision making
  • More efficient diagnosis and treatment
  • Higher quality care
• Overall improved patient experience – reducing wasted time
Benefits to Health Care Organisations

• Most vendors are committed to FHIR
• Should lead to:
  • faster deployments
  • lower cost interoperability
  • reduced vendor lock in as FHIR is adopted by source systems
• Standards based APIs to support internal application development
• Capture data for
  • Analytics and Decision Support
  • Population Management
• Extending the functionality of the EHR
Benefits to Implementers and Vendors

• Familiar tooling and technologies
  • XML/JSON, HTTP, REST, SSL, OAuth
• Predefined resources and APIs
  • With built in extensibility
  • Allows implementer to focus on the core application functionality
• Extensive documentation, samples and reference server implementations
• Validation services
• Active and supportive community
• Open Source code libraries
  • HAPI (Java) and Furore (.Net)
• Mobile friendly
• Increases commercial viability of app development as FHIR compliant apps will work with different FHIR Servers (EMRs, HIEs)
BASICS OF FHIR
Overview of FHIR

- Fast Healthcare Interoperability Resources (FHIR)
- Consistent, simple to use content model (resources)
  - Controlled extensibility
- Supports all paradigms of exchange
  - Real-time APIs
  - Documents, Messages & Operations
- Designed with implementers in mind
- Freely available
- Detailed on-line, hyperlinked specification
- Freely available tooling, servers, libraries
- Strong endorsement and support from vendors, providers and regulatory community (e.g. NHS, INTEROpen, Project Argonaut)
- Massive supporting community
Related to other healthcare Standards

- HL7
  - Version 2
  - Version 3
  - CDA
- openEHR
- CIMI
- IHE
- DICOM
- Terminologies
  - SNOMED
  - ICD
The specification

http://hl7.org/fhir/index.html
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
## Resources

### General:
- AllergyIntolerance
- Condition (Problem)
- Procedure
- ClinicalImpression
- FamilyMemberHistory
- RiskAssessment
- DetectedIssue

### Care Provision:
- CarePlan
- CareTeam
- Goal
- ReferralRequest
- ProcedureRequest
- NutritionOrder
- VisionPrescription

### Medication & Immunization:
- Medication
- MedicationOrder
- MedicationAdministration
- MedicationDispense
- MedicationStatement
- Immunization
- ImmunizationRecommendation

### Diagnostics:
- Observation
- DiagnosticReport
- DiagnosticOrder
- Specimen
- BodySite
- ImagingStudy
- ImagingObjectSelection

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Name

Date of Birth

Gender

Patient Resource
Resource example

```
<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+00:00"/>
  </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/consent#trials">
    <valueCode value="tremel"/>
  </extension>

  <identifier>
    <use value="usual"/>
    <label value="MRN"/>
    <system value="http://www.goodhealth.org/identifiers/h" value="123456"/>
  </identifier>

  <name>
    <family value="Levin"/>
    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>

  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <careProvider>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </careProvider>

  <active value="true"/>
</Patient>
```

- **Resource Identity & Metadata**
- **Human Readable Summary**
- **Extension with URL to definition**

**Standard Data:**
- MRN
- Name
- Gender
- Birth Date
- Provider
References between resources

- **PATIENT**: Subject
- **PROCEDURE**: Related Item, Encounter, Performer
- **CONDITION**: Related Item
- **DIAGNOSTIC REPORT**: Report
- **ENCOUNTER**: Encounter
- **PRACTITIONER**: Performer
Representing narrative

12-year-old-boy

Initial Presentation
Complaining of pain in the right ear for 3 days with an elevated temperature. On examination, temperature 38°C and an inflamed right eardrum with no perforation. Diagnosis Otitis Media, and prescribed Amoxicillin 250mg 3 times per day for 7 days.

Follow up Visit
2 days later returned with an itchy skin rash. No breathing difficulties. On examination, urticarial rash on both arms. No evidence meningitis. Diagnosis of penicillin allergy. Antibiotics changes to Erythromycin 250mg 4 times per day for 10 days.
Encounter

- Pain right ear 3 days
- Elevated temperature
- Temperature 38°C
- Inflamed right drum
- Otitis media
- Amoxicillin 250mg
- Itchy skin rash
- No breathing difficulties
- Urticarial Rash
- Penicillin Allergy
- Erythromycin 250mg

Patient

Practitioner

As linked resources...
clinFHIR: Server roles

- Specific server roles (according to clinFHIR)
  - **Data/patient** – patient related (clinical) and ‘reference’ (Practitioner, Organization)
  - **Conformance** – profile, extensionDefinition (both StructureDefinition)
  - **Terminology** – ValueSet & Terminology operations
- Important to be STU consistent!
  - Hapi STU-3 for Data & Conformance, Grahame for Terminology
STRUCTURED AND CODED DATA
Why have structured / coded data

- Structured vs Coded
- Coded:
  - Improves UI possibilities
  - Improves exchange
  - ‘Secondary’ uses
    - Allows Decision Support
    - Population health
Resource example

Resource Identity & Metadata

Human Readable Summary

Extension with URL to definition

Standard Data:
- MRN
- Name
- Gender
- Birth Date
- Provider

XML code:

```xml
<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+11:00"/>
  </meta>
  <text>
    <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/consent#trials">
    <valueCode value="true"/>
  </extension>
  <identifier>
    <use value="usual"/>
    <label value="MRN"/>
    <system value="http://www.goodhealth.org/identifiers/mp">
      <value value="123456"/>
    </system>
  </identifier>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <careProvider>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </careProvider>
  <active value="true"/>
</Patient>
```
## Resource structure

<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><strong>Patient</strong></td>
<td></td>
<td></td>
<td>DomainResource</td>
<td>Information about an individual or animal receiving health care services</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Elements defined in Ancestors: id, meta, implicitRules, language, text, content</td>
</tr>
<tr>
<td>identifier</td>
<td>Σ</td>
<td>0..*</td>
<td>Identifier</td>
<td>An identifier for this patient</td>
</tr>
<tr>
<td>active</td>
<td>?! Σ</td>
<td>0..1</td>
<td>boolean</td>
<td>Whether this patient's record is in active use</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>
<tr>
<td>gender</td>
<td>Σ</td>
<td>0..1</td>
<td>code</td>
<td>male</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AdministrativeGender (Required)</td>
</tr>
<tr>
<td>birthDate</td>
<td>Σ</td>
<td>0..1</td>
<td>date</td>
<td>The date of birth for the individual</td>
</tr>
<tr>
<td>deceased[x]</td>
<td>Σ</td>
<td>0..1</td>
<td>date</td>
<td>Indicates if the individual is deceased or not</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>address</td>
<td>Σ</td>
<td>0..*</td>
<td>Address</td>
<td>Addresses for the individual</td>
</tr>
<tr>
<td>maritalStatus</td>
<td></td>
<td>0..1</td>
<td>CodeableConcept</td>
<td>Marital (civil) status of a patient</td>
</tr>
<tr>
<td>multipleBirth[x]</td>
<td></td>
<td>0..1</td>
<td>CodeableConcept</td>
<td>Whether patient is part of a multiple birth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>photo</td>
<td></td>
<td>0..*</td>
<td>Attachment</td>
<td>Image of the patient</td>
</tr>
<tr>
<td>contact</td>
<td></td>
<td>0..*</td>
<td>BackboneElement</td>
<td>A contact party (e.g. guardian, partner, friend) for the patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ SHALL at least contain a contact's details or a reference to an organization</td>
</tr>
<tr>
<td>relationship</td>
<td></td>
<td>0..*</td>
<td>CodeableConcept</td>
<td>The kind of relationship</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>v2 Contact Role (Extensible)</td>
</tr>
</tbody>
</table>
Data types: Primitive

Based on w3c schema and ISO data types

- Stick to the “80% rule” – only expose what most will use
  - Simplified
Data types: Complex
Datatypes

- Review datatypes in spec
  - Start from resource
- Datatypes in resource definition
  - Backbone element
  - ‘choice’ data types
- Identifiers
- Review coded data
  - ValueSet binding
Coded datatypes

- **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"
}
Terminology Sub-system

- SNOMED CT / LOINC / RxNORM
- ICPC, MIMS + 100s more
- ICD-X+
- A drug formulary
- Custom

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

Code
Display
Definition
Terminology Sub-system

- 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

Selects
Terminology Sub-system

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

Element
Definition: Type and Value set reference

Selects
Binds
Terminology Sub-system

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

Element Definition:
Type and Value set reference

Element:
code/Coding/CodeableConcept

Selects

Binds

Conforms

Refers to
ValueSet

- A context specific subset of one or more Code Systems
- Promotes consistency between applications
- Key component of Terminology
  - Also CodeSystem
- Target of a number of services
  - $expand

```json
{
    "resourceType": "ValueSet",
    "id": "condition-code",
    "url": "http://hl7.org/fhir/ValueSet/condition-code",
    "compose": {
        "include": [
            {
                "system": "http://snomed.info/sct",
                "filter": [
                    {
                        "property": "concept",
                        "op": "is-a",
                        "value": "404684003"
                    }
                ]
            },
            {
                "system": "http://snomed.info/sct",
                "concept": [
                    {
                        "code": "160245001",
                        "display": "No current problems or disability"
                    }
                ]
            }
        ]
    }
}
```
HL7.org/fhir

Value Set
Adapting FHIR to your needs: Profiling

- Many different contexts in healthcare, but want a single set of Resources
- Need to be able to describe ‘usage of FHIR’ based on context
- Allow for these usage statements to:
  - Authored in a structured manner
  - Published in a registry & Discoverable
  - Used as the basis for validation, code, report and UI generation.
- 3 main aspects:
  - Constraining a resource - remove element, change multiplicity fix values
  - Change coded element binding
  - Adding a new element (an extension)
- Profiling adapts FHIR for specific scenarios
For example...

- Limit names to just 1 (instead of 0..*)
- Change maritalStatus to another set of codes that extends the one from HL7 international
- Require that the identifier uses the NHS number – and is required
- Don’t support photo
- Add an extension to support ethnicity
- Note: Limited mandatory elements in the core spec
The ‘profile’

- Defined by StructureDefinition resource
  - Same as used for core resources
- Defines each element
  - Path, name, dataType, binding, multiplicity, mapping & much more
  - Including allowable extension points
- Can use Forge tooling to build
  - clinFHIR (and others) for learning/viewing
- US Core (was DAF)
Extension Definitions

- Also a StructureDefinition
  - Defines the content of a single extension
- Simple or Complex
- Definition:
  - Available on the web
  - Canonical Url
    - Resolvable or Registry
- In resource instance:
  - Reference to Url
  - Extension or ModifierExtension
Exchange Paradigms

- REST
- Documents
- Messages
- Services (Operations)
Bundles

- Container resource
- Types of Bundle
  - Searchset
  - Transaction
  - Document
  - Message
  - ...

Bundle Resource

- Observation Resource
- Device Resource
- List Resource
- Condition Resource
REST (API)

- “Representational State Transfer” – an architecture for how to connect systems in real time
- Uses HTTP/S
- Simple to use
- Very commonly used outside of healthcare – especially mobile
- For simple interactions
  - Create
  - Read (& Query)
  - Update
  - Delete
- A lot of tooling / experience available
Document paradigm

- Summary at a point in time
- Part of record
- Very common
- CDA
  - CDA on FHIR
Documents – are bundles

```xml
<Bundle>
  <entry>
    <Composition />
  </entry>
  <entry>
    <Observation />
  </entry>
  <entry>
    <Device />
  </entry>
  <entry>
    <List />
  </entry>
  <entry>
    <Condition />
  </entry>
</Bundle>
```
Messing paradigm

- Notification or instruction
- Not part of record
- HL7 v2
  - Good match with FHIR
    - Though implementations less common
- Work in progress
Messages – are bundles

```
<Bundle>
  <entry>
    <MessageHeader />
  </entry>
  <entry>
    <Observation />
  </entry>
  <entry>
    <Patient />
  </entry>
  <entry>
    <Device />
  </entry>
</Bundle>
```
Services / Operations

- For more complex server side logic
- Can be Real-time
- Key part of ecosystem
- E.g.
  - Prescribing with Decision Support
  - Terminology
  - Immunization protocols
FHIR Operations

• When more complex server logic required than simple CRUD
  • Midway between REST & SOAP
• Some defined in spec. e.g.:
  • Get all data for a patient
  • Expand/filter terminology
  • CDS services
• Can define custom services
  • Still using FHIR resources
  • Resources to define / inputs
Regardless of paradigm, the content is the same
THE ECOSYSTEM
An ecosystem

A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organisation, scalability and sustainability inspired from natural ecosystems.

Wikipedia
Components

- Terminology
- Decision Support
- Workflow
- Services Directory
- Provider/Patient Registry
- Conformance
- Repository
- Authorisation

FHIR API and Resources
Security

- FHIR is not a security standard
  - Leverages existing standards – for example
    - TLS
    - OAuth2
  - Support in the specification
    - Security tags (metadata)
    - Specialized resources
      - Provenance
      - AuditEvent
  - More detail
    - http://hl7.org/fhir/security.html
Supporting Standards

- SMART
- CDS-hooks
More information

From HL7
http://hl7.org/fhir/index.html
wiki.hl7.org/index.php?title=FHIR
http://www.fhir.org/

Community
https://chat.fhir.org/
List server (fhir@lists.hl7.org)
Stack Overflow (tag FHIR)

Blogs
https://fhirblog.com/
https://thefhirplace.com/
https://brianpos.com

Libraries
Java (http://hapifhir.io/)
C# (NuGet HL7.FHIR)

Tooling
Forge (http://fhir.furore.com/Forge)
http://clinfhir.com/

Test servers
https://fhirblog.com/2016/10/19/setting-up-your-own-fhir-server-for-profiling/
QUESTIONS?