HL7 Seminar: Introduction to HL7® FHIR®

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The Acronym

Fast
Relative – No tech

Health
That’s why we’re here

Interoperability

Resources
Building blocks – more on these to follow
HL7 v2.0
HL7 v3
Flexibility vs. useability

Generic vs. Specific

Re-useable vs. Single purpose

- HL7v2
- openEHR RM
- HL7 CDA
- HL7v3 RIM
- HL7v3 CMETS
- openEHR Archetypes
- openEHR Templates
- IHE PDQ
- C-CCD
- FHIR Profiles

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Focus on **implementers**
Keep **common scenarios** simple
Leverage **existing technologies**
Make content **freely available**

Invoke the **community**
Focus on implementers..

If your neighbour 's son can’t hack an app with <your technology X> in a weekend…..

you won’t get adopted
Background

THE RISE OF THE API
What I want from my healthcare app

Your “Mobile” device becomes the Big Aggregator and Coordinator of data and functionality
The API economy

Where companies expose their (internal) digital business assets or services in the form of (web) APIs to third parties with the goal of unlocking additional business value through the creation of new assets
3rd-party becomes the norm

1. Give the same functionality to third parties.
2. Means that third parties can build apps around data you provide
3. Mobile applications can use your API to create a better user experience
The Rise of the API

2012

2016
So what about HL7 & FHIR?

- With FHIR, HL7 joins the ranks of the API troopers.

- But other than Twitter, Facebook etc. HL7 has no “services” or “functionality” to offer

- FHIR is just a set of *flexible* standardized models and best-practices that *others* can use to create healthcare API’s

- 3rd-party (app/software) developers can then seamlessly connect to your FHIR API.
WHY (UNIVERSAL) STANDARDIZATION IS HARD
1st: Ego’s

**How Standards Proliferate:**
(See: A/C chargers, character encodings, instant messaging, etc)

**Situation:** There are 14 competing standards.

14?! Ridiculous! We need to develop one universal standard that covers everyone’s use cases. Yeah!

**Soon:**

**Situation:** There are 15 competing standards.
2nd: Cost

“Communicate first, standardize later”
“I need to be ready next month”

“Standardize first, communicate later”
“This needs to be done right, takes time”

“Chaos?”

“He who ships code, wins”
3rd: Different communities and timelines

- Other regions – trying the same thing
- Regional collaborations – share prescriptions
- GP System – Uses Prescriptions
- Cancer Center – Uses Prescriptions
In-Depth

COMPONENTS OF FHIR
A FHIR ‘Resource’

Divide health care data in discrete “building blocks”

- Cover “the 80%”
- Unit of exchange
- Maintained & documented independently
- Have a textual description
## Resources - example

### Identification
**Individuals:**
- Patient 5
- Practitioner 3
- RelatedPerson 0

**Groups:**
- Organization 4
- HealthcareService 0
- Group 0

**Entities:**
- Location 1
- Substance 0
- Person 1

**Devices:**
- Device 0
- DeviceComponent 0
- DeviceMetric 0

### Clinical
#### General:
- AllergyIntolerance 0
- Condition (Problem) 0
- Procedure 0
- ClinicalImpression 0
- FamilyMemberHistory 0
- RiskAssessment 0
- DetectedIssue 1

#### Care Provision:
- CarePlan 0
- Goal 0
- ReferralRequest 0
- ProcedureRequest 0
- NutritionOrder 0
- VisionPrescription 0

#### Medication & Immunization:
- Medication 0
- MedicationOrder 0
- MedicationAdministration 0
- MedicationDispense 0
- MedicationStatement 0
- Immunization 1
- ImmunizationRecommendation 1

#### Diagnostics:
- Observation 4
- DiagnosticReport 3
- DiagnosticOrder 1
- Specimen 1
- BodySite 0
- ImagingStudy 0
- ImagingObjectSelection 0
Example – Patient Resource

Patient (Resource)

- identifier : Identifier 0..*
- name : HumanName 0..*
- telecom : Contact 0..*
- gender : CodeableConcept 0..1 <<AdministrativeGender>>
- birthDate : dateTime 0..1
- deceased[x] : boolean|dateTime 0..1
- address : Address 0..*
- maritalStatus : CodeableConcept 0..1 <<MaritalStatus>>
- multipleBirth[x] : boolean|integer 0..1
- photo : Attachment 0..*
- communication : CodeableConcept 0..* <<Language>>
- careProvider : Resource(Organization|Practitioner) 0..*
- managingOrganization : Resource(Organization) 0..1
- active : boolean 0..1

Animal

- species : CodeableConcept 1..1 <<AnimalSpecies>>
- breed : CodeableConcept 0..1 <<AnimalBreed>>
- genderStatus : CodeableConcept 0..1 <<AnimalGenderStatus>>

Link

- other : Resource(Patient) 1..1
- type : code 1..1 <<LinkType>>

Contact

- relationship : CodeableConcept 0..* <<ContactRelationship>>
- name : HumanName 0..1
- telecom : Contact 0..*
- address : Address 0..1
- gender : CodeableConcept 0..1 <<AdministrativeGender>>
- organization : Resource(Organization) 0..1

References to other Resources
Extending Patient

Yes, but where are:

- citizenship
- mothersmaidenname,
- us-core-race

Don’t worry, you can add extensions: your own elements – FHIR even defines a few favorite ones!
Everyone needs extensions...

Simple choice – design for absolutely everything or allow extensions
Everyone needs extensions, everyone hates them!
References between resources

A web of resources that can tell any story
Clinical Scenario

First consultation
- Complaining of pain in the right ear for 3 days with an elevated temperature. On examination, temperature 38.5 degrees and an inflamed right ear drum with no perforation. Diagnosis: Otitis Media, and prescribed Amoxil 250mg TDS for 5 days.

Follow up consultation
- 5 days later returned with an itchy skin rash. No breathing difficulties. On examination, urticarial rash on both arms. No evidence of meningitis. Diagnosis of penicillin allergy. Antibiotics changed to erythromycin and advised not to take penicillin in the future.

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In REST: Possibly distributed...

FHIR server @ pat.registry.org
Patient/223
Patient

FHIR server @ lab.hospitalA.org
DiagnosticReport/4445
Diagnostic Report
Observation/3ff27
Observation

FHIR server @ hospitalA.org
Organization/1
Organization
Practitioner/87
Practitioner

subject
result
performer
REST: “Repository” model of healthcare

Hospital System

Lab System

Create Record

Create Encounter

Query Lab orders

Post Lab result

Update Patient data

Notify new Lab results

Patient

Order

Diagnostic Report

Observation

FHIR server
RESTful FHIR Examples

GET http://myfhirserver.com/Patient/123

GET http://myfhirserver.com/Encounter/904?_include=patient

PUT http://myfhirserver.com/Encounter/904 {XML or JSON Resource expression}

Bundle: FHIR Document

- **Discharge Summary**
  - Composition
- **Chief Complaint**
  - section
- **Physical**
  - section
- **Medications**
  - section

**Author**: Dr. Bernard  
**Practitioner**: Dr. Bernard

**Patient**: Patient John

**Condition**: Kidney Stones

**Observation**: Pulse
  - BP

**Prescription**: Dyclofenac
  - Tamsulosin

**List**: Vital Signs
- entry

**List**: Discharge Meds
- entry

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Regardless of **paradigm**, the content is the same.
Questions?
Adapting FHIR

FHIR PROFILING
The need for profiling

Need to be able to describe adaptations based on use and context

- Which resources and elements are used?
- Which API features are used?
- Which terminologies are used?
- How to map these to local requirements/implementations?
Layered profiles

- Country adapts a national profile
- Regions or specialties may develop specialized versions of national profile
- Profile with use-case specific constraints
Constraining a resource

Demand that the identifier uses your national patient identifier

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 “RaceCode”

Note: hardly any mandatory elements in the core spec!
In v3 CDA…“text-based”

<table>
<thead>
<tr>
<th>Table</th>
<th>Heading</th>
<th>Description</th>
<th>cardinality</th>
<th>SHALL/SHOULD/MAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>indicate Medication Started</td>
<td>low</td>
<td>1..1</td>
<td>SHALL</td>
<td></td>
</tr>
<tr>
<td>indicate Medication Stopped</td>
<td>high</td>
<td>1..1</td>
<td>SHALL</td>
<td></td>
</tr>
<tr>
<td>administrationTiming</td>
<td>effectiveTime</td>
<td>0..1</td>
<td>SHOULD</td>
<td></td>
</tr>
<tr>
<td>@operator</td>
<td>1..1</td>
<td>SHALL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>repeatNumber</td>
<td>0..1</td>
<td>MAY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>route</td>
<td>routeCode</td>
<td>0..1</td>
<td>MAY</td>
<td></td>
</tr>
<tr>
<td>site</td>
<td>approachSiteCode</td>
<td>0..1</td>
<td>MAY</td>
<td></td>
</tr>
<tr>
<td>dose</td>
<td>doseQuantity</td>
<td>0..1</td>
<td>SHOULD</td>
<td></td>
</tr>
</tbody>
</table>

Medications Section With Coded Entries Required
[section: templateId 2.16.840.1.113883.10.20.22.2.1.1(open)]

The following constraints apply to a Medications section in which entries are required.

1. Conforms to Medications Section (entries optional) template (2.16.840.1.113883.10.20.22.2.1).
2. SHALL contain exactly one [1..1] templateId (CONF:7568) such that it
   a. SHALL contain exactly one [1..1] @root="2.16.840.1.113883.10.20.22.2.1.1" (CONF:10433).
3. SHALL contain exactly one [1..1] @code="10160-0" History of medication use (CodeSystem: LOINC 2.16.840.1.113883.6.1 (CONF:7569)).
4. SHALL contain exactly one [1..1] title="Medications" (CONF:7570).
5. SHALL contain exactly one [1..1] text (CONF:7571).
6. SHALL contain at least one [1..*] entry (CONF:7572) such that it
   a. SHALL contain exactly one [1..1] Medication Activity (2.16.840.1.113883.10.20.22.4.16) (CONF:7573).
   b. If medication use is unknown, the appropriate nullFlavor MAY be present (see unknown information in Section 1) (CONF:10077).
openEHR ADL
FHIRE: StructureDefinition

Computable expression: as a Resource, just like Patient!
Adapting the API

- Read
- Update
- Search

FHIR REST

FHIR Server

- Validate
- Complex Operations
- Check Drug Interaction
- Merge Patient
- Expand ValueSet
Conformance Resources

“Implementation Guide”

- Implementation Guide
- Structure Definition
- ValueSet
- Concept Map
- SearchParam Definition
- NamingSystem
- Operation Definition

Forge
Excel
Conformance
TestScript
Implementation Guide

Pour in your Conformance resources and add human narrative:

- Functional Requirement and Use case(s)
- Data definitions
- Actors and Interactions
- Examples
- Technical Implementation Guidance
- Security
- Help
- Contact Information
Use Case

As a part of the restructuring of integrations in Helse Nord, we are working towards a loosely coupled and single data from our master systems. The goal is to remove all point-to-point integrations and move systems from the view, to start consuming a web service for this information.

Prescriber service

Several systems in Helse Nord has the need for updated information about Prescribers in their internal work definition a role given to a hospital unit, physician, nurse etc. A prescriber has the ability to order lab tests, other services provided by the hospital. Information about the prescriber is stored in our EPR as a part of the EP3.

Structure of Prescriber information

The Interface for Prescriber Information in Helse Nord, is an Oracle View called [https://example.com/](https://example.com/). This is from several parts of the Dips information model. Data is extracted using standard SQL Queries.

Userstories

Through a series of workshops with consumers, we have established the following user stories.

1. Find prescriber by name
2. Find prescriber by code
3. Retrieve all changes by date range

We need to be able to extend the functionality of the interface, as new stories and needs are uncovered.

Designing and implementing a FHIR based Web Service for Prescriber information

<table>
<thead>
<tr>
<th>Resource/Type</th>
<th>Structure(s)</th>
<th>Unknown Extensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practitioner</td>
<td>moPractitioner (SHALL)</td>
<td>MAY</td>
</tr>
<tr>
<td>Organization</td>
<td>moOrganization (SHALL)</td>
<td>MAY</td>
</tr>
<tr>
<td>HealthcareService</td>
<td>moHealthcareService</td>
<td>MAY</td>
</tr>
</tbody>
</table>

System-level interactions

<table>
<thead>
<tr>
<th>Name</th>
<th>Level</th>
<th>Unknown Extensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>conformance</td>
<td>SHALL</td>
<td></td>
</tr>
<tr>
<td>transaction</td>
<td>MAY</td>
<td></td>
</tr>
</tbody>
</table>
Publish!

Author & Store

Publish

http://simplifier.net
http://registry.fhir.org

Test & Validate

Guide

Implement

Certificate of Compliance
FHIR Registry
FUTURE PLANS
<table>
<thead>
<tr>
<th>Scheduling</th>
<th>Workflow / PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appointment, Schedule, Slot</td>
<td>CarePlan, Goal, Episode, Alert, Communication, ReferralRequest, DiagnosticOrder</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DICOM</th>
<th>IHE PCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ImagingStudy, ImagingObjectSelection, AuditEvent (ATNA)</td>
<td>DeviceComponent, DeviceMetric</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IHE XDS (MHD)</th>
<th>W3C</th>
<th>Conformance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DocumentReference</td>
<td>Provenance</td>
<td>ValueSet, Conformance, StructureDefinition, OperationDefinition</td>
</tr>
<tr>
<td>DocumentManifest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> 1,000 requests for changes processed
number of resources more or less doubled to just over 100
October 2016 – STU3

New resources & support around:

- Clinical Decision Support
- Care coordination
- Workflow management
- Genomic data
- eClaims
- Provider directories
- CCDA profiles
- Consent management

250 requests for changes processed (so far)
STU?

- Standard for TRIAL Use

“Regardless of the degree of prior implementation, all aspects of the FHIR specification are potentially subject to change.”
Level 0: “Draft”, Just added to the spec for first review

Level 1: Ready for test implementation by pilots
Level 2: Pilots exist and have interoperated with in realistic scenarios
Level 3: Meets quality guidelines, formal ballot resulting in changes
Level 4: Tested, verified and stable. Backw. compatibility becomes a prio.

Level 5: Widely implemented across scope and jurisdictions. Frozen.
Going normative

- Iterative process

- First FMM level 4/5 in 2018

- From 2018 updates every 18-24 months

- More and more parts become level 4/5
Background

THE FHIR COMMUNITY
Focus on the community
Where in the world?
2015 HAPI FHIR Test Server statistics
New products every day

Hackensack University follows FHIR-enabled route to data exchange
Innovations with emerging standards are helping the facility share medical alerts and information across disparate IT systems and devices, says Shafiq Rab, MD, its CIO.

SMART on FHIR gets a testing ground for data exchange
Developers can share apps that can enable exchanges between EHRs, says Cerner’s Bob Robke.

Healthcare connectivity set to take off with value-based care
Progress being made on several fronts, including secure messaging, e-prescribing and the exchange of continuity-of-care documents, but leaders such as Micki Tripathi of the Massachusetts E-Health Collaborative say there’s still work to be done.
US Co-operations

HSPC

SMART (on FHIR)

Profiles, OIDC/OAuth

FHIR

Services

Argonaut

C-CDA 1.1 FHIR Profiles (MU3)

Intermountain Healthcare, Veterans Affiars, IBM, Epic, Cerner, Mayo, Kaiser, …
At your service
FHIR foundation

Home of the community (not the SDO):

- Implementers chats
- Calendar of events, webcasts
- Repository of Extensions and profiles
- Showcases, repo of FHIR projects
- Best-practices & patterns
- Open-source initiatives

Located at [http://fhir.org](http://fhir.org)
Integrating in the EMR

SMART ON FHIR
Objective In early 2010, Harvard Medical School and Boston Children’s Hospital began an interoperability project with the distinctive goal of developing a platform to enable medical applications to be written once and run unmodified across different healthcare IT systems. The project was called Substitutable Medical Applications and Reusable Technologies (SMART).
Motivation....

- Turn bright ideas into real apps
- Take away the technology burdens
Why?

- App choice (substitutability) for users
- Low barriers to entry for developers
- Apps can run in systems by different vendors
- Apps can run in different contexts (e.g. EHR and Patient Portal)
App Gallery

Featured Apps
- Recently Updated
- Clinical Care
- Patient Education
- Genomics
  - Open Source
- iPhone and iPad

BP Centiles
Cardiac Risk
Diabetes Monograph
Disease Monograph
Growth Chart
MPR Monitor

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Growth analyzer

Kimberly Revis is **obese at 44.9 kg** (98 lb). Compared to her last weight assessment, she is more obese.

The healthy weight for her age and height is 22.8 kg — 37.9 kg (50th; 68th — 85th: 4oz).
Levemir Flexpen

How to Take the Medicine

Use the medicine once a day.

Use 30 units each time.

Morning

Afternoon

Evening

Night

Recommended Dose

50 Units

Important Information

Please refer to the instructions for use for additional information.

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SMART = FHIR + ...

<table>
<thead>
<tr>
<th>SMART on FHIR</th>
<th>FHIR DSTU1 Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorization</td>
<td>OAuth2</td>
</tr>
<tr>
<td>Authentication</td>
<td>OpenID Connect</td>
</tr>
<tr>
<td>Data Models</td>
<td>(From FHIR)</td>
</tr>
<tr>
<td>Profiles</td>
<td>SMART profiles (~10 use cases)</td>
</tr>
<tr>
<td>Data Access</td>
<td>(From FHIR)</td>
</tr>
<tr>
<td>Data Format</td>
<td>(From FHIR)</td>
</tr>
<tr>
<td>EHR UI</td>
<td>SMART launch specification including EHR context and UI embedding for Web apps</td>
</tr>
<tr>
<td>Integration</td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td><a href="http://docs.smarthealthit.org/">http://docs.smarthealthit.org/</a></td>
</tr>
</tbody>
</table>

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SMART Authorization

- Based on OAuth2 standard

- Two launch workflows
  - EHR/Portal Launch – user picks an app from within EHR (EHR can pass along context like encounter and patient)
  - Standalone Launch – user launches app and picks an EHR server (can run from mobile devices)
# Agree on actual codes

## LOINC codes for vital signs

Top-level vital sign codes are all LOINC codes with system of [http://loinc.org](http://loinc.org):

<table>
<thead>
<tr>
<th>Vital Sign</th>
<th>LOINC Code</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>8302-2</td>
<td>cm, m, [in_us], [in_i]</td>
</tr>
<tr>
<td>Weight</td>
<td>3141-9</td>
<td>kg, g, lb_av, [oz_av]</td>
</tr>
<tr>
<td>Heart rate</td>
<td>8867-4</td>
<td>{beats}/min</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>9279-1</td>
<td>{breaths}/min</td>
</tr>
<tr>
<td>Temperature</td>
<td>8310-5</td>
<td>cel, [degF]</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>39156-5</td>
<td>kg/m2</td>
</tr>
<tr>
<td>Oxygen saturation</td>
<td>2710-2</td>
<td>%{HemoglobinSaturation}</td>
</tr>
<tr>
<td>Head circumference</td>
<td>8287-5</td>
<td>cm, m, [in_us], [in_i]</td>
</tr>
<tr>
<td>Blood pressure (systolic and diastolic -- grouping structure)</td>
<td>55284-4</td>
<td>N/A</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>8480-6</td>
<td>mm[Hg]</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>8462-4</td>
<td>mm[Hg]</td>
</tr>
</tbody>
</table>
"No known allergies"

Encoded as List must have:

- 1 patient in List.subject
- 1 code value of 52473-6 and system of http://loinc.org in List.code
- 1 date in List.date
- 1 value of snapshot in List.mode
- 1 code value of nilknown and system of http://hl7.org/fhir/list-empty-reason in List.emptyReason

Example: https://fhir-open-api.smarthealthit.org/List/24

Grouping blood pressures

The representation of a blood pressure measurement makes systolic/diastolic pairings explicit by using a "grouping observation" with LOINC code 55284-4 (see above). The grouping observation has no value itself, but refers to two individual component s for systolic and diastolic values.

Example: blood pressure https://fhir-open-api.smarthealthit.org/Observation/691-bp
CDS-Hooks

EMR

Events in the EMR
- Medication-prescribe
- Order-review
- Patient-view

External services hooked to the events
Uses for CDS hooks

- Opening patient record prompts action in trial selection system
- Placing a medication order prompts (pricing/interaction) guidance in EHR
- Placing a medication order returns medication info in foreign language of patient
- Opening a patient adds links to apps with detailed genomic results
Common theme

- SMART and CDS-hooks open up the EMR as a platform in which 3rd-parties can become part of the workflow.

- 3rd party suppliers can provide more specialized functionality than an EMR would every implement.
FINALLY...
Gartner hype cycle

VISIBILITY

Peak of Inflated Expectations

Plateau of Productivity

Slope of Enlightenment

Trough of Disillusionment

Technology Trigger

TIME
Goal achieved?

- It is fast to learn, implement and troubleshoot
- It has a vibrant and open source community and has frequently held hackathons.
- Matures because we get LOADS of feedback
- Spontaneous adoption (of a standard!)
But...

- We can only make the technology bit easier

- Interoperability is hard, and is a human problem of common process and understanding

- FHIR cannot fix this. And it is no silver bullet.
Questions?