



SMART-on-FHIR on i2b2

Kavishwar B. Waghlikar, MBBS PhD

Instructor, Harvard Medical School, Boston, MA

Assistant, Massachusetts General Hospital, Boston, MA

Lab of Computer Science, MGH



SMART-FHIR i2b2 cell: architecture, installation

I2b2-quickstart: Rapid installation of i2b2

I2b2-docker: Demo network

Clinical deployment: architecture on RPDR, ONC

PCORI-i2b2-SMART-FHIR: REACHNET Codeathon,
Cross-institutional app deployment

i2b2

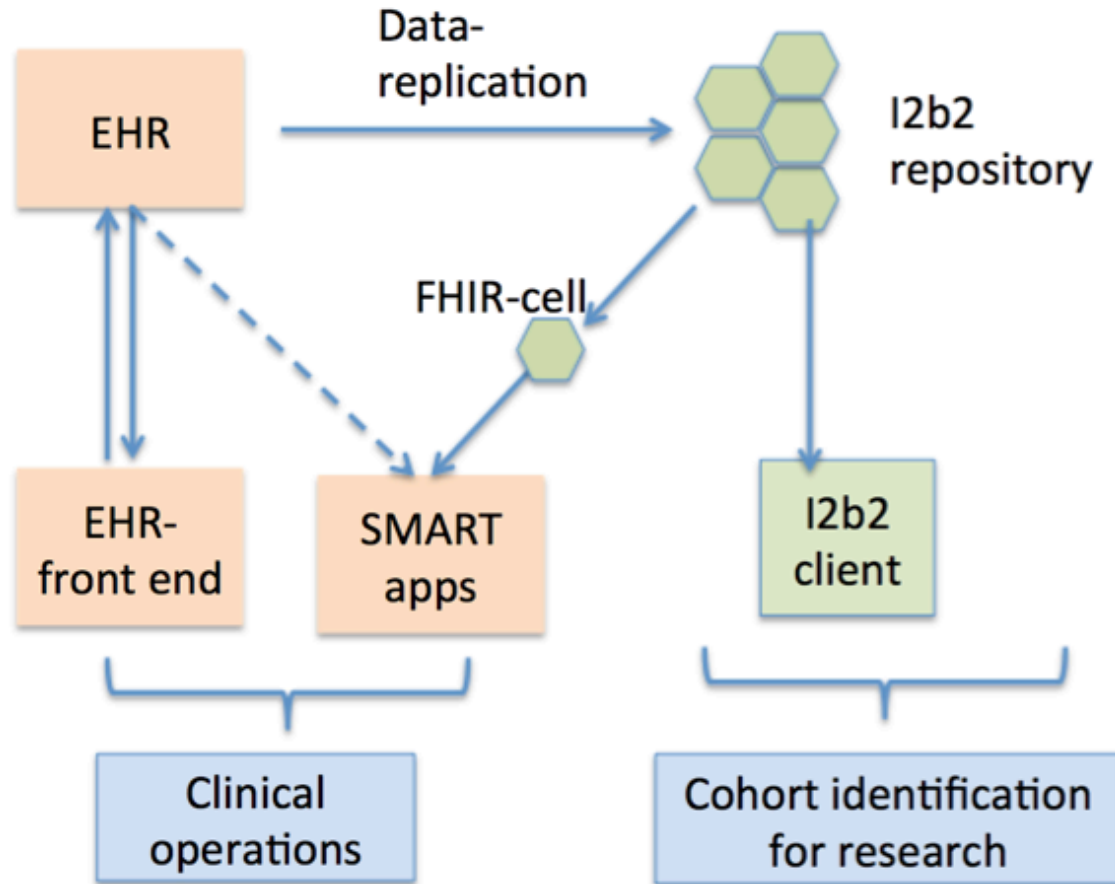
Tool for building research cohorts deployed at 150 institutions.

Set of open source technologies that extend the EHR and promote a culture/movement of innovation in medical informatics.

Educational role to improve robustness, collaboration, utilization and impact of research in informatics, besides serving as the platform to directly support innovation.



I2B2-SMART app platform



I2b2 as a Platform for running SMART-on-FHIR apps

FHIR

Freely available standard

Specification provides XSD: useful for code generation

<http://hl7-fhir.github.io>

Graham Grieves : Project lead

V2 example

```
MSH|^~\&|LABGL1||DMCRES||199812300100||ORU^R01|LABGL1199510221838581|P|2.3
||NE|NE
PID||6910828^Y^C8||Newman^Alfred^E||19720812|M|W|25 Centscheap Ave^^
Whatmeworry^UT^85201^^P|| (555)777-6666|(444)677-7777||M||773789090
OBR||110801^LABGL|387209373^DMCRES|18768-2^CELL COUNTS+DIFFERENTIAL TESTS
(COMPOSITE)^LN||199812292128||35^ML|||||
IN2973^Schadow^Gunther^^^^MD^UPIN
|||||||||^Once|||||CA20837^Spinosa^John^^^^MD^UPIN

OBX||NM|4544-3^HEMATOCRIT (AUTOMATED)^LN||45||39-49
||||F||199812292128||CA20837
OBX||NM|789-8^ERYTHROCYTES COUNT (AUTOMATED)^LN||4.94|10*12/mm3
|4.30-5.90||||F||199812292128||CA20837
```

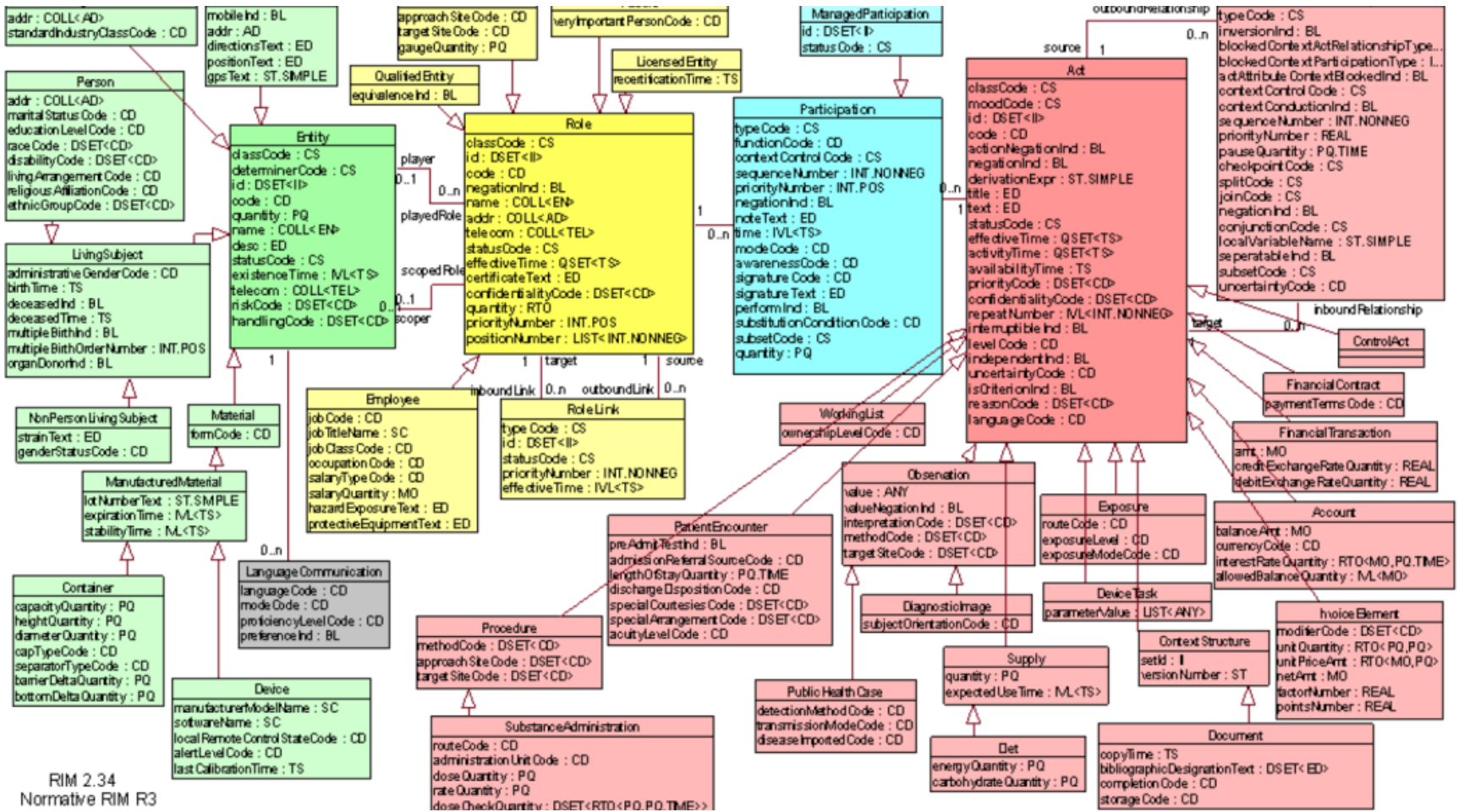
Segments

- MSH: Message Header
- PID: Patient Identification
- OBR: Observation Request
- OBX: Observation Result

Delimiters

- | Field
- ^ Component
- & Subcomponent
- ~ Repetition

V3: Xml structures derived from complex V3 model



FHIR:
implementer friendly
simpler model
predominantly composition approach

```
<Patient>  
  <id value="1000000003"/>  
  ....  
  <gender value="male"/>  
  <birthDate value="1969-03-01">  
    </birthDate>  
  <deceasedBoolean value="false"/>  
  ...  
</Patient>
```

<http://hl7-fhir.github.io/patient>

FHIR queries

<https://fhir.i2b2.org/srv-dstu21-0.3/api/Patient/1000000005>

Get particular Patient: [FHIR-base]/Patient/123

Get all Patients: [\[FHIR-base\]/Patient](#)

Get Prescriptions for particular Patient:
[FHIR-base]/MedicationPrescription?patient=123

SMART

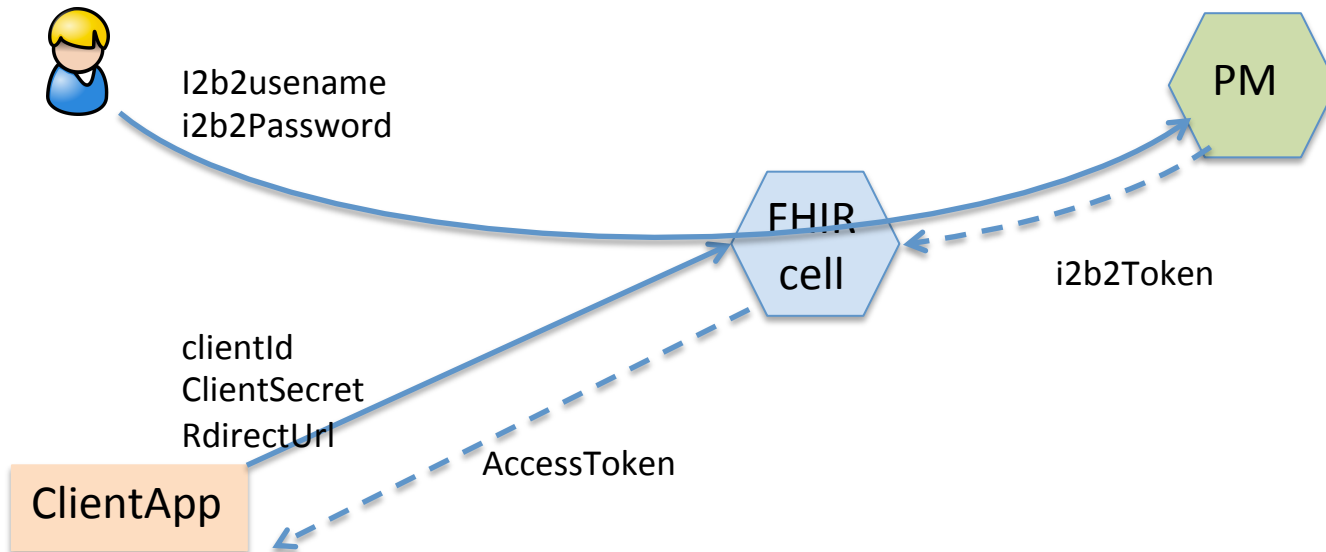
Specify [OAuth2](#) based authentication mechanism [e.g. click](#)

[Profiles on FHIR](#)

[SMART gallery](#)

Josh Mandel: Lead architect of SMART and co-chair of FHIR, Lead Argonaut Project

Authentication





I2b2 FHIR cell

Rewrite of [SMART classic](#) cell by [Nich Wattanasin](#)

Read-only

per patient retrieval from i2b2
provides SMART authentication.

Future, enable write, and population queries

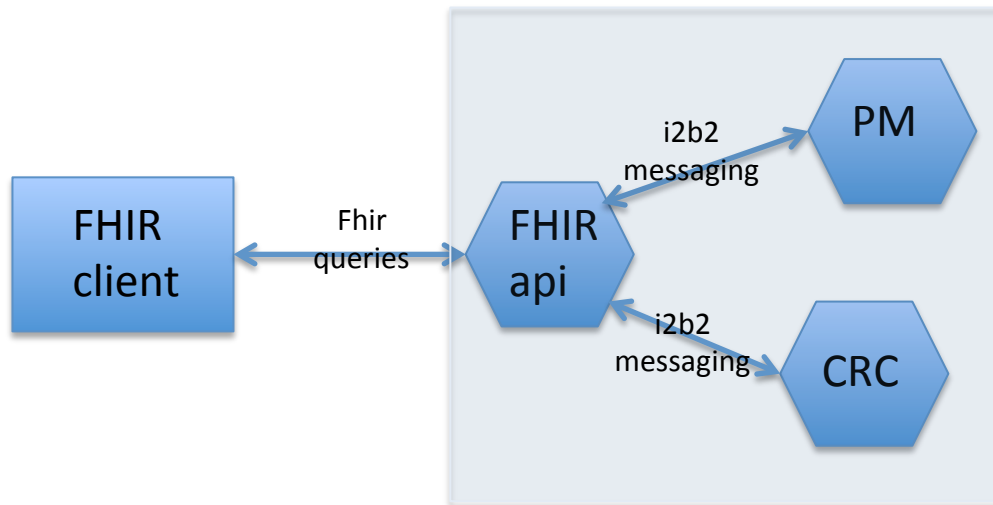
Participate in Argonaut

Demo: <http://fhir.i2b2.org>

Source : <https://github.com/i2b2plugins/cell-i2b2-fhir>

[Wattanasin N. Apps to display patient data, making SMART available in the i2b2 platform. AMIA Annu Symp Proc. 2012;2012:960-9](#)

[Waghlikar K. SMART on FHIR implemented on I2b2. JAMIA 2016](#)

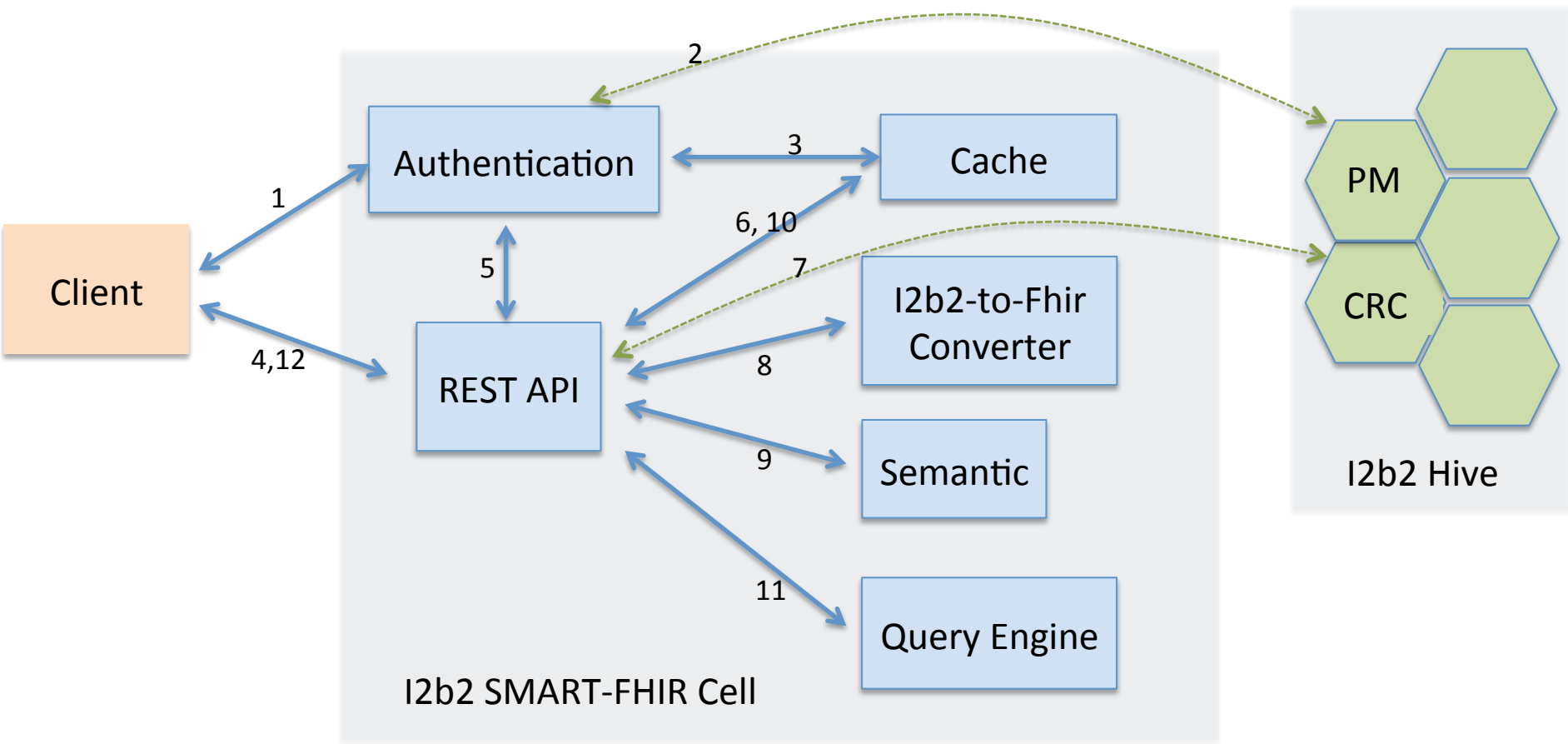


Architecture

<http://fhir.i2b2.org/>

<https://www.i2b2.org/webclient/>

FHIR cell Architecture



Architecture: Java EE7, JAXB, JAXRS

Mapping i2b2 medication observations to FhirResources

```

<observation>
  <concept_cd name="Albuterol Sulfate 4mg">NDC:00005306343
</concept_cd>
  <modifier_cd>@</modifier_cd>
  <instance_num>1</instance_num>
</observation>
  
```

1

```

<observation>
  <concept_cd name="Albuterol Sulfate 4mg">NDC:00005306343
</concept_cd>
  <modifier_cd>MED:FREQ</modifier_cd>
  <instance_num>1</instance_num>
  <valuetype_cd>T</valuetype_cd>
  <tval_char>QD</tval_char>
</observation>
  
```

2

```

<observation>
  <concept_cd name="Albuterol Sulfate 4mg">NDC:00005306343
</concept_cd>
  <modifier_cd>MED:ROUTE</modifier_cd>
  <instance_num>1</instance_num>
  <valuetype_cd>T</valuetype_cd>
  <tval_char>PO</tval_char>
</observation>
  
```

4

```

<observation>
  <concept_cd name="Albuterol Sulfate 4mg">NDC:00005306343
</concept_cd>
  <start_date>2009-03-09T00:00:00.000Z</start_date>
  <modifier_cd>MED:DOSE</modifier_cd>
  <instance_num>1</instance_num>
  <valuetype_cd>N</valuetype_cd>
  <nval_num>4</nval_num>
  <units_cd>mg</units_cd>
</observation>
  
```

```

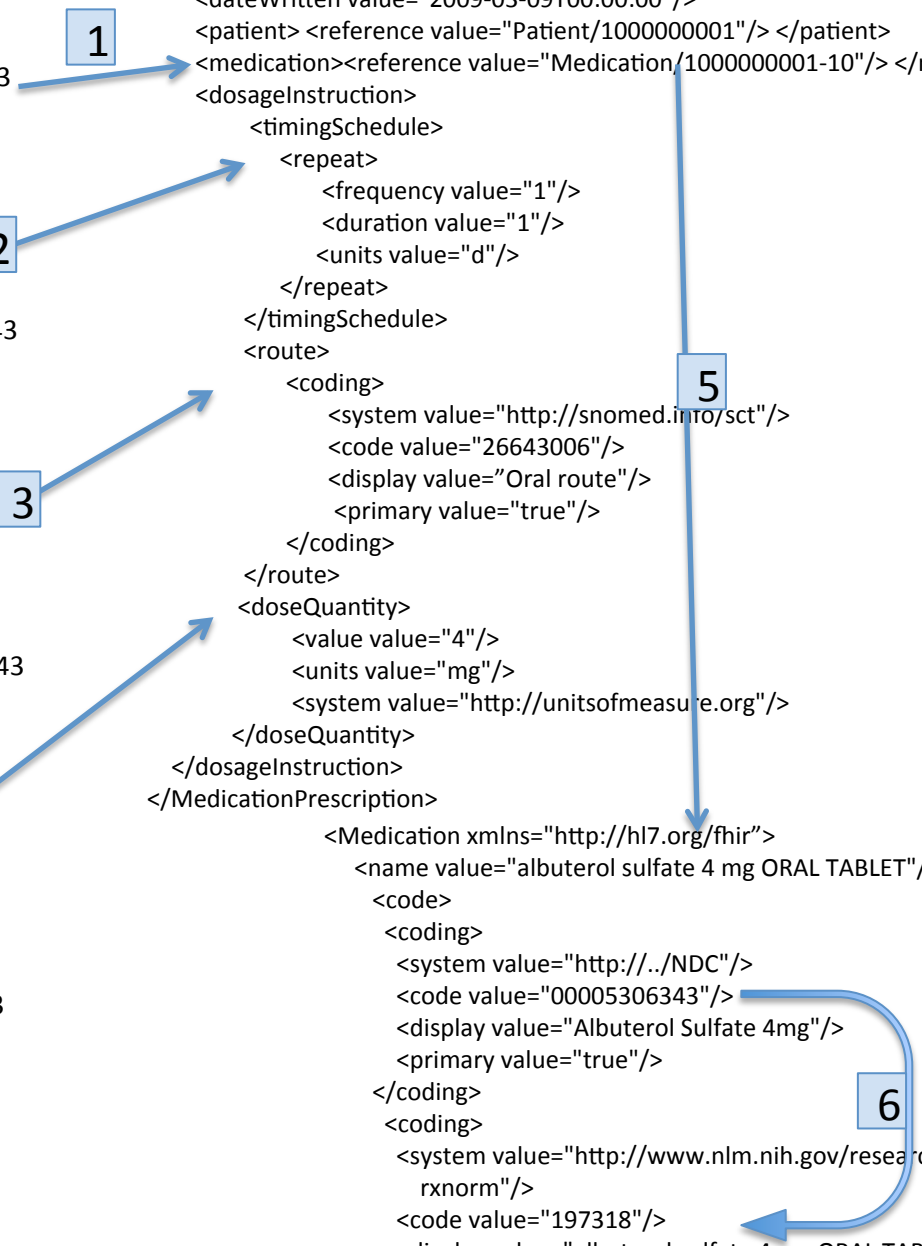
<MedicationPrescription xmlns="http://hl7.org/fhir" >
  <dateWritten value="2009-03-09T00:00:00"/>
  <patient> <reference value="Patient/1000000001"/> </patient>
  <medication><reference value="Medication/1000000001-10"/> </medication>
  <dosageInstruction>
    <timingSchedule>
      <repeat>
        <frequency value="1"/>
        <duration value="1"/>
        <units value="d"/>
      </repeat>
    </timingSchedule>
    <route>
      <coding>
        <system value="http://snomed.info/sct"/>
        <code value="26643006"/>
        <display value="Oral route"/>
        <primary value="true"/>
      </coding>
    </route>
    <doseQuantity>
      <value value="4"/>
      <units value="mg"/>
      <system value="http://unitsofmeasure.org"/>
    </doseQuantity>
  </dosageInstruction>
</MedicationPrescription>
  
```

5

```

<Medication xmlns="http://hl7.org/fhir">
  <name value="albuterol sulfate 4 mg ORAL TABLET"/>
  <code>
    <coding>
      <system value="http://..NDC"/>
      <code value="00005306343"/>
      <display value="Albuterol Sulfate 4mg"/>
      <primary value="true"/>
    </coding>
    <coding>
      <system value="http://www.nlm.nih.gov/research/umls/rxnorm"/>
      <code value="197318"/>
      <display value="albuterol sulfate 4 mg ORAL TABLET"/>
    </coding>
  </code>
</Medication>
  
```

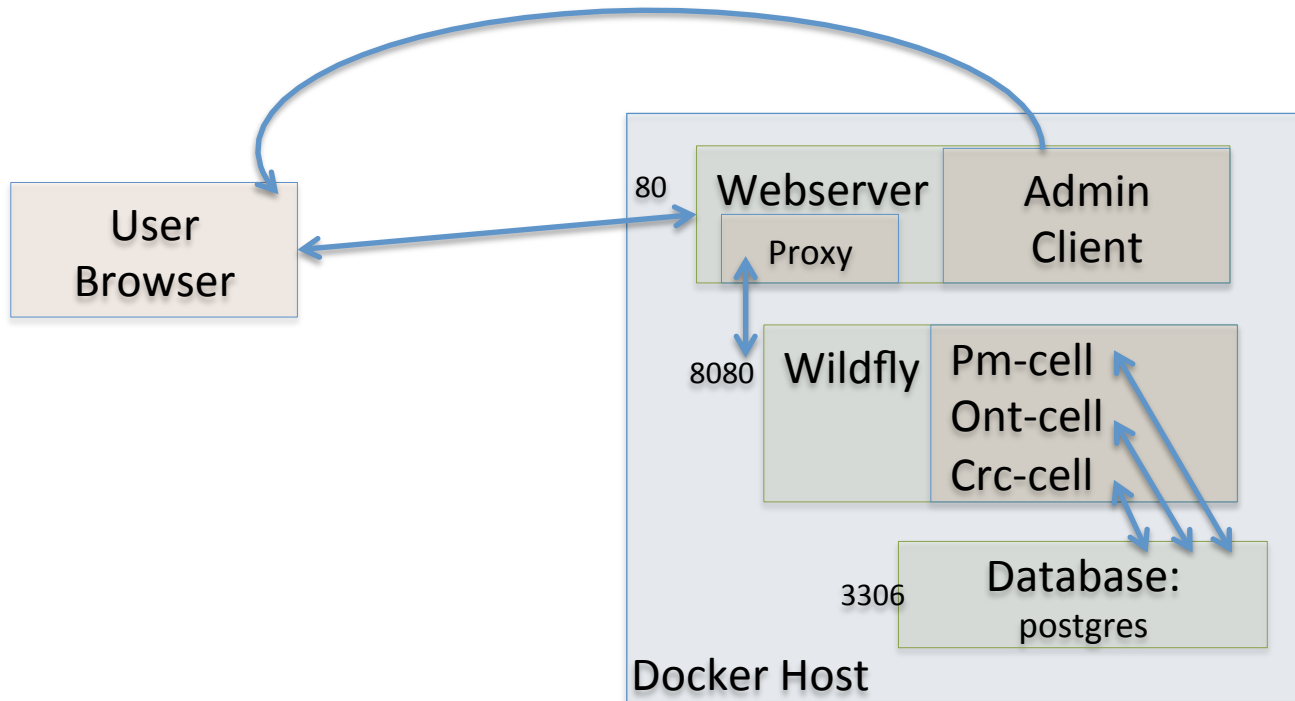
6



I2b2-quickstart

Install i2b2-demo on

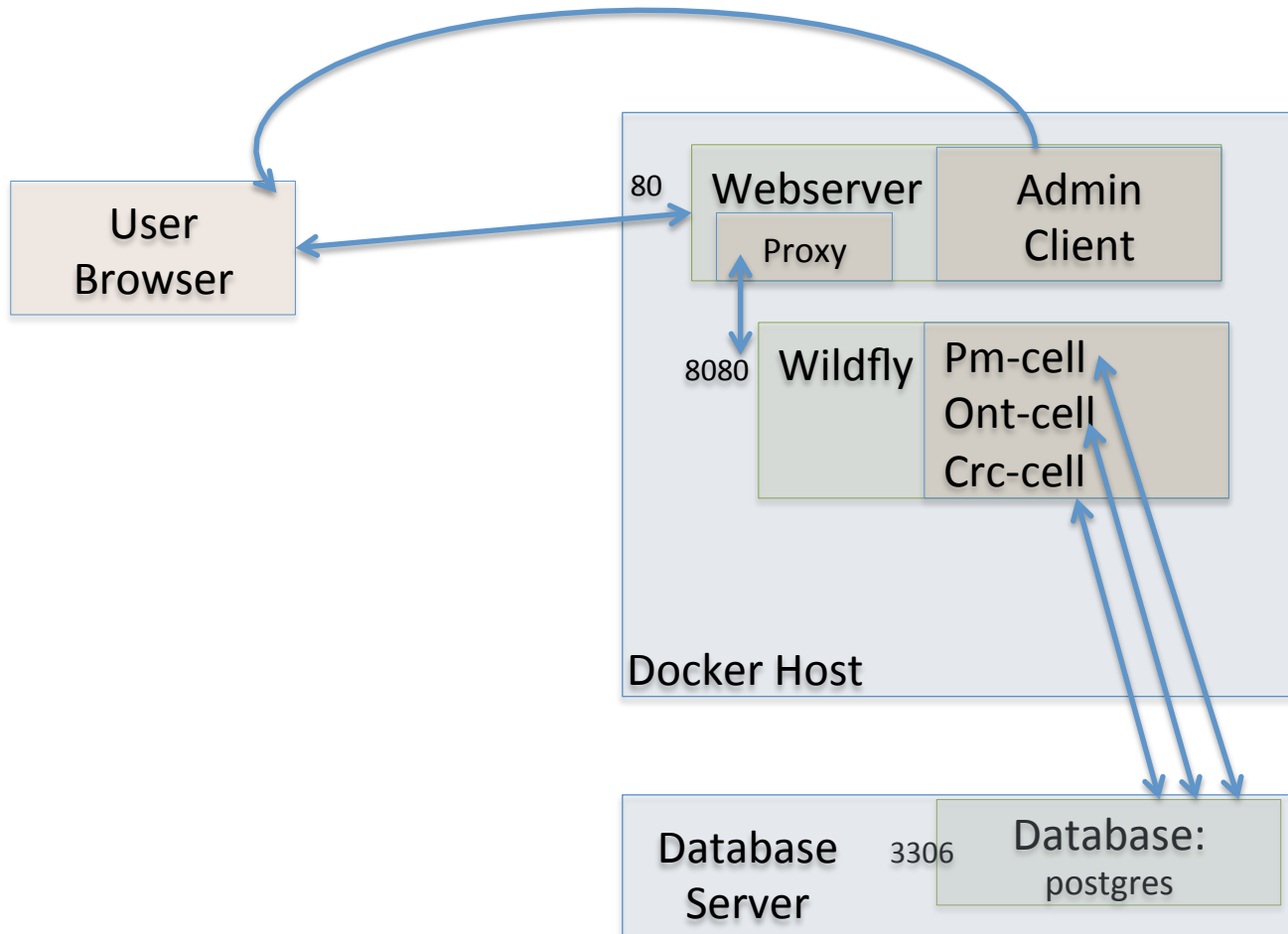
- Amazon Linux
- Centos
- Docker: lightweight VM, popular packaging



<https://hub.docker.com/u/i2b2/>

Three containers

- Wildfly containing core i2b2 cells
- Apache http server containing i2b2 admin and webclient
- Demo Database (currently only postgres is provided)



Externalized DB Server

Standardizing Docker containers

Current Docker generation pipeline

- automatically downloads i2b2 code from github i2b2 site,
- prepares three Docker containers for upload to the i2b2 Docker hub.

Install with bash/docker-compose script, in a docker network

To Do: Standardization

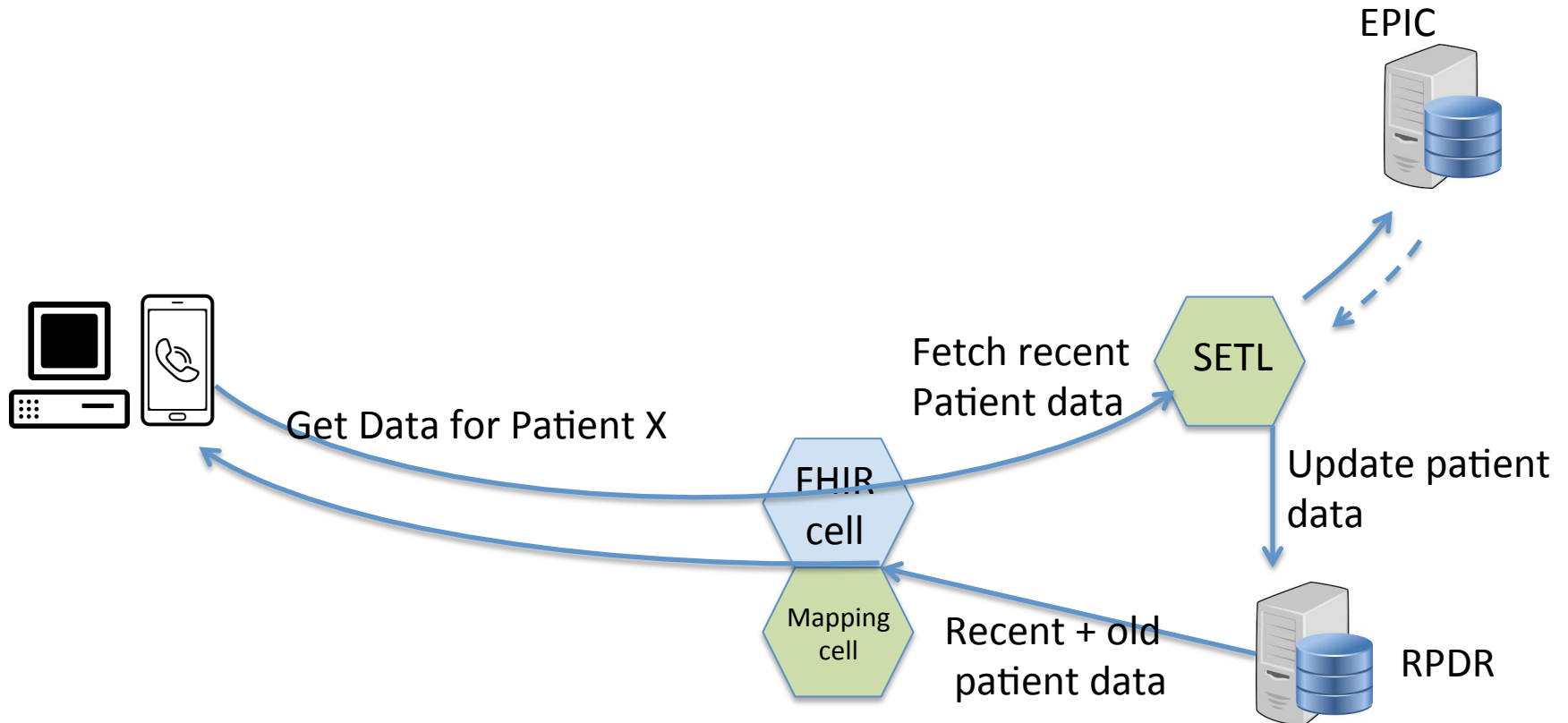
- Allow configuration of the containers for different use cases, with minimal and standardized set of operations.
- Signed Containers.

Paul Avillach, Micheal McDuffie

Marc Natter, Issac Pinol Catadau, Stanley Chan

Nich Wattanasin, Michael Mendis

Clinical deployment of I2B2-SMART app platform



Clinical deployment: architecture on RPDR, ONC

MGH SMART app for surgical rounding

Diabetes app with REACHNET

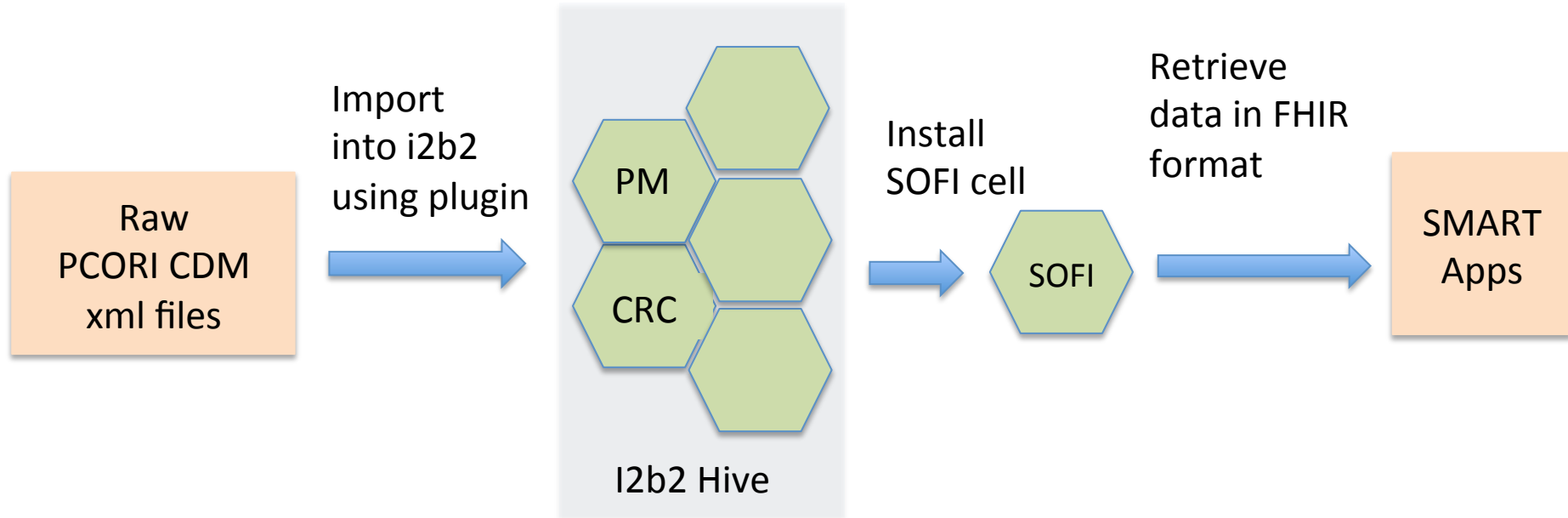
[ONC challenge](#)

*App using FHIR integrated with **min 3** unique health IT systems in 2 unique provider settings.*

Phase 1: May 30: wire frame and business plan

Phase 2 Nov 7: app tested in production setting

Cajun Code Fest 4.0 (CCF)



- Data for 300 real patients diagnosed with Diabetes.
- Data was anonymized by date-shifting and by substituting the patient identifier.
- Tutorials
- <https://github.com/pcori-sofi/sofip>

TRIAD:
Tooling
Education
Funding

Rahul Jain, Louisiana Public Health Institute
Eliel Oliveira, University of Louisiana
Harshal Shah, Persistent Systems India
Sohail Rao, Ochsner Health System, LA
Thomas Carton, REACHNET

Harvard Medical School, Boston
Research Action for Health Network, LA;
Louisiana Public Health Institute, New Orleans, LA;
Persistent Systems, India;

Acknowledgement and Funding

Shawn N. Murphy, MD, PhD, Partners
Kenneth D. Mandl, MD, Boston Children's Hospital
Henry Chueh, MD, Massachusetts General Hospital
Joshua C. Mandel, MD, Boston Children's Hospital
Jeffery G. Klann, PhD, Partners Healthcare
Nich Wattanasin, Partners Healthcare
Michael Mendis, Partners Healthcare
Christopher G. Chute, MD DrPH, John Hopkins
Rahul Jain, MPH CPHIM, Louisiana Public Health Institute
Eliel Oliveira, MBA MS, University of Louisiana
Henry Chu, PhD PE, University of Louisiana
Harshal Shah, Persistent Systems India
Sohail Rao, MD, MA, D.Phil, Ochsner Health System, LA
Thomas Carton, PhD, MS, REACHNET
Dominic Surrao, Massachusetts General Hospital
Michael Steigman, Massachusetts General Hospital

K99-R00 NLM:
K99LM011575 and R00LM011575,
and NIGMS: R01GM104303.