OpenCDS: a Clinical Decision Support Infrastructure Based on Drools

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Agenda

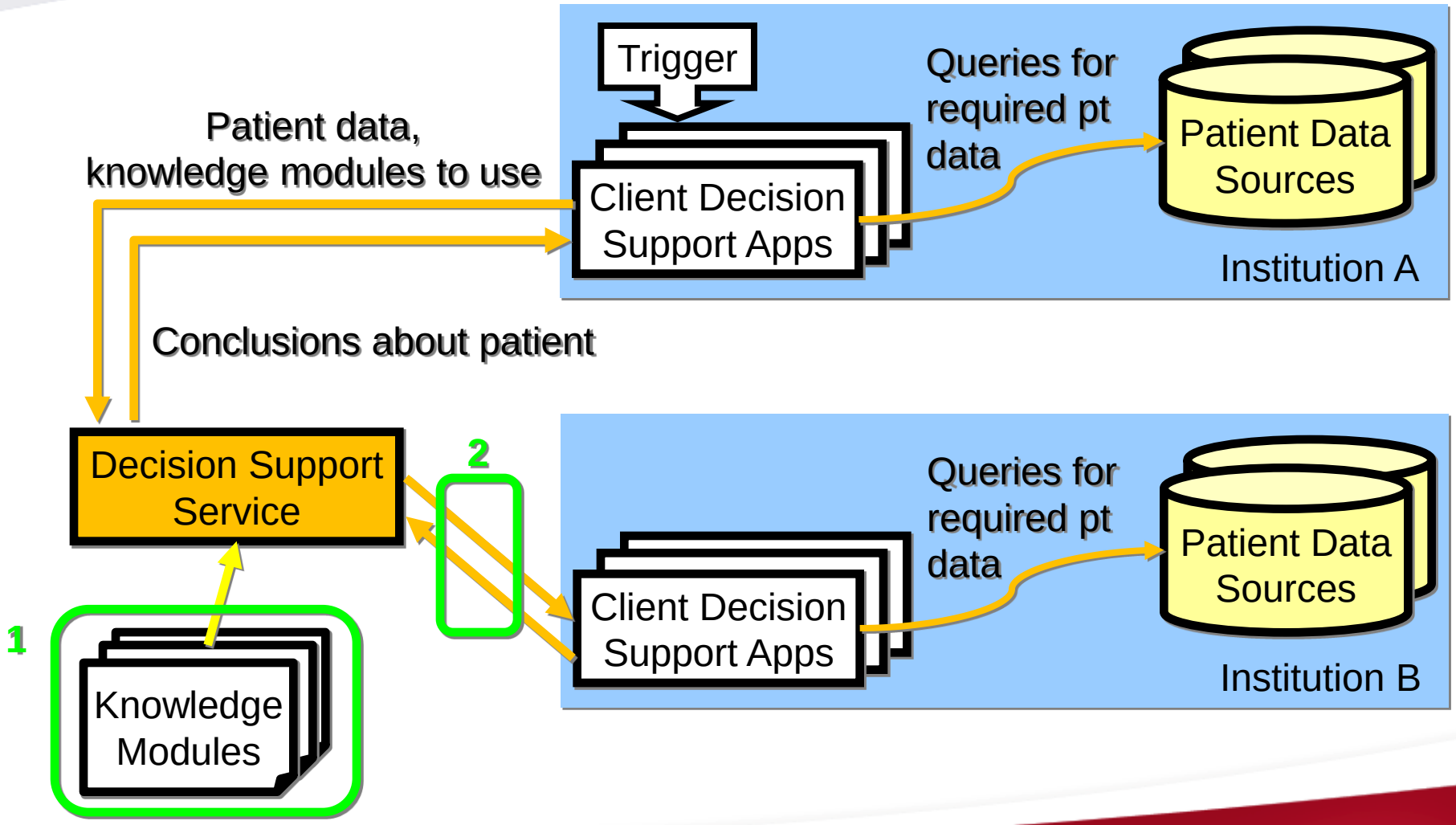
- HL7 Decision Support Service (DSS) standard
- HL7 Virtual Medical Record (vMR) standard
- OpenCDS
- Demo
- Discussion

HL7 Decision Support Service (DSS) Standard

Decision Support Service (DSS) – Overview

- Business purpose:
  - To facilitate implementation and maintenance of clinical decision support (CDS) applications
- Approach:
  - Evaluates patient data (inputs) using knowledge modules and returns machine-interpretable conclusions (outputs)
- Normative HL7/ANSI standard

DSS – Architectural Overview



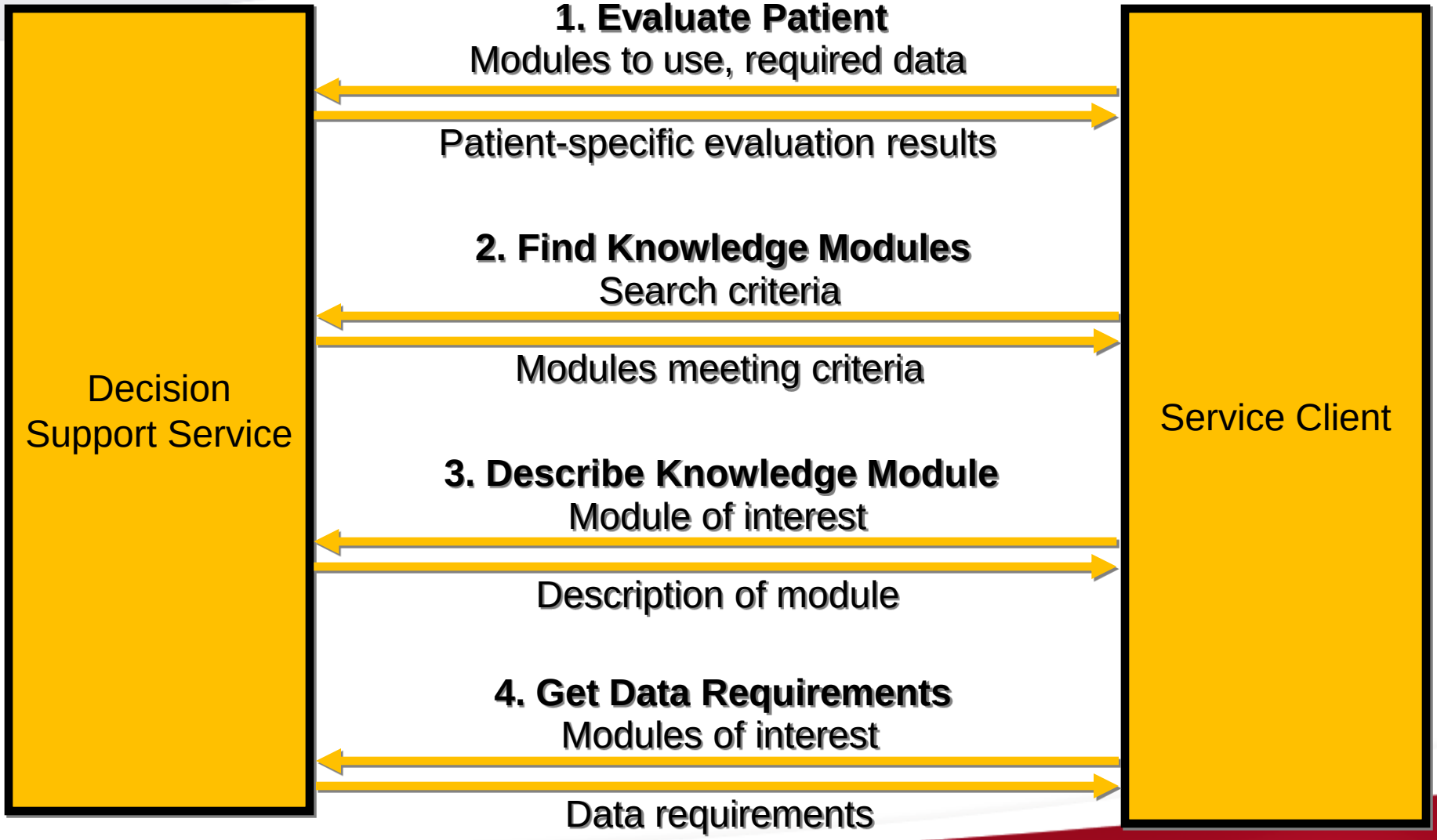
DSS Knowledge Module (KM) – Components

- Descriptive traits
  - E.g., authors, keywords, purpose, explanation
- Data requirements
  - Example
    - Input: patient's list of active problems and medications
    - Output: disease management recommendations
- Semantic requirements
  - Example
    - Input Requirement: HL7 Continuity of Care Document (CCD), HL7 vMR Input
    - Output Requirement: HL7 Care Plan, HL7 vMR Output

DSS KM – Sample Inferences

Sample Evaluation Input	Sample Evaluation Output
Patient age, gender, past health maintenance procedures	List of health maintenance procedures due or almost due
Medication identifier, age, gender, weight, serum creatinine level	Recommended maximum and minimum doses for medication given patient's estimated renal function
Insurance provider, data relevant to prescription	Prior authorization to prescribe medication
CCD	Wide range of care recommendations

DSS – Primary Service Operations



HL7 Virtual Medical Record (vMR) Standard

Background

- A “holy grail” of clinical informatics is scalable, interoperable CDS
- Key requirement for interoperable CDS and re-use of CDS knowledge resources = use of a common patient data model
  - Referred to as a “Virtual Medical Record” or vMR (Johnson *et al.*, *AMIA Annu Symp Proc*, 2001)
- Lack of a common vMR has been a major barrier to sharing knowledge and scaling CDS

Example Challenge without VMR

Observation
- Code = BP
- Value = 120/80 mmHg

Blood Pressure
- Systolic = 120 mmHg
- Diastolic = 80 mmHg

Observation
- Code = BP
  - Observation
    - Code = SBP
    - Value = 120 mmHg
  - Observation
    - Code = DBP
    - Value = 80 mmHg

Vital Sign
- Type = BP
- Value = 120/80
- Units = mmHg

vMR Goal

- Provide common information model upon which interoperable clinical decision support resources (e.g., rules) can be developed

Project History

- Analysis of data required by 20 CDS systems from 4 countries (Kawamoto *et al.*, AMIA 2010)
- Refinement of vMR via implementation within OpenCDS
- Adopted in September 2011 as Informative Specification

Why Not Just Use the CCD as the vMR?

- CCD does not include all needed information
  - E.g., Family history model suitable for CDS
- CCD is not sufficiently intuitive for direct use by CDS knowledge authors

Problem Model – CCD vs. VMR

```
<entry typeCode="DRIV">
  <act classCode="ACT" moodCode="EVN">
    <templateId root="2.16.840.1.113883.10.20.1.27"/>
    <!-- Problem act template -->
    <id root="6a2fa88d-4174-4909-aece-db44b60a3abb"/>
    <code nullFlavor="NA"/>
    <entryRelationship typeCode="SUBJ">
      <observation classCode="OBS" moodCode="EVN">
        <templateId root="2.16.840.1.113883.10.20.1.28"/>
        <!--
        <id
        <c
        <st
        <ef
        </e
        <va
        <entryRelationship typeCode="REFR">
          <observation classCode="OBS" moodCode="EVN">
            <templateId root="2.16.840.1.113883.10.20.1.50"/>
            <!-- Problem status observation template -->
            <code code="33999-4" codeSystem="2.16.840.1.113883.6.1" displayName="Status"/>
            <statusCode code="completed"/>
            <value xsi:type="CE" code="55561003" codeSystem="2.16.840.1.113883.6.96" displayName="Active"/>
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      </observation>
    </entryRelationship>
  </act>
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```

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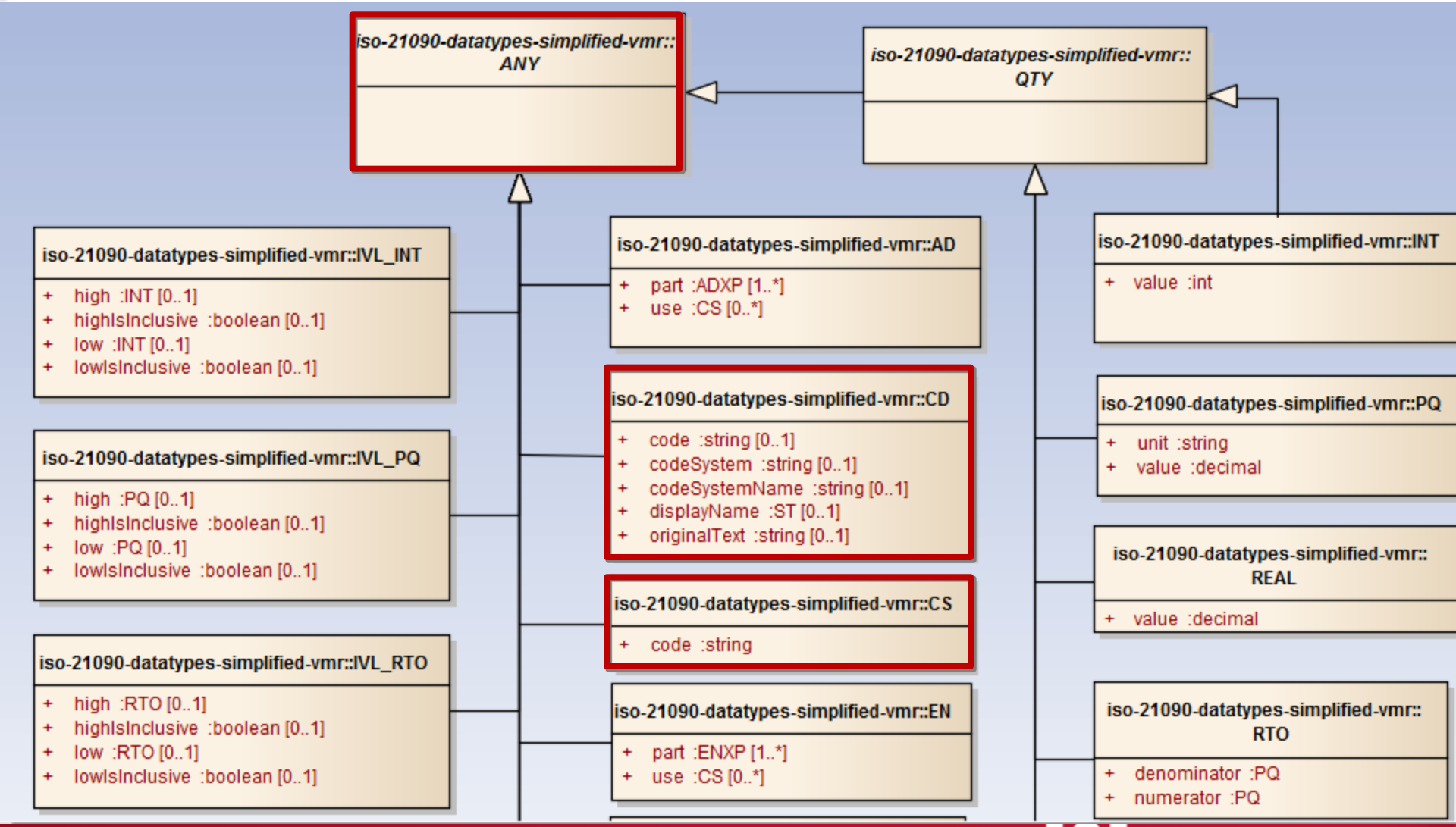
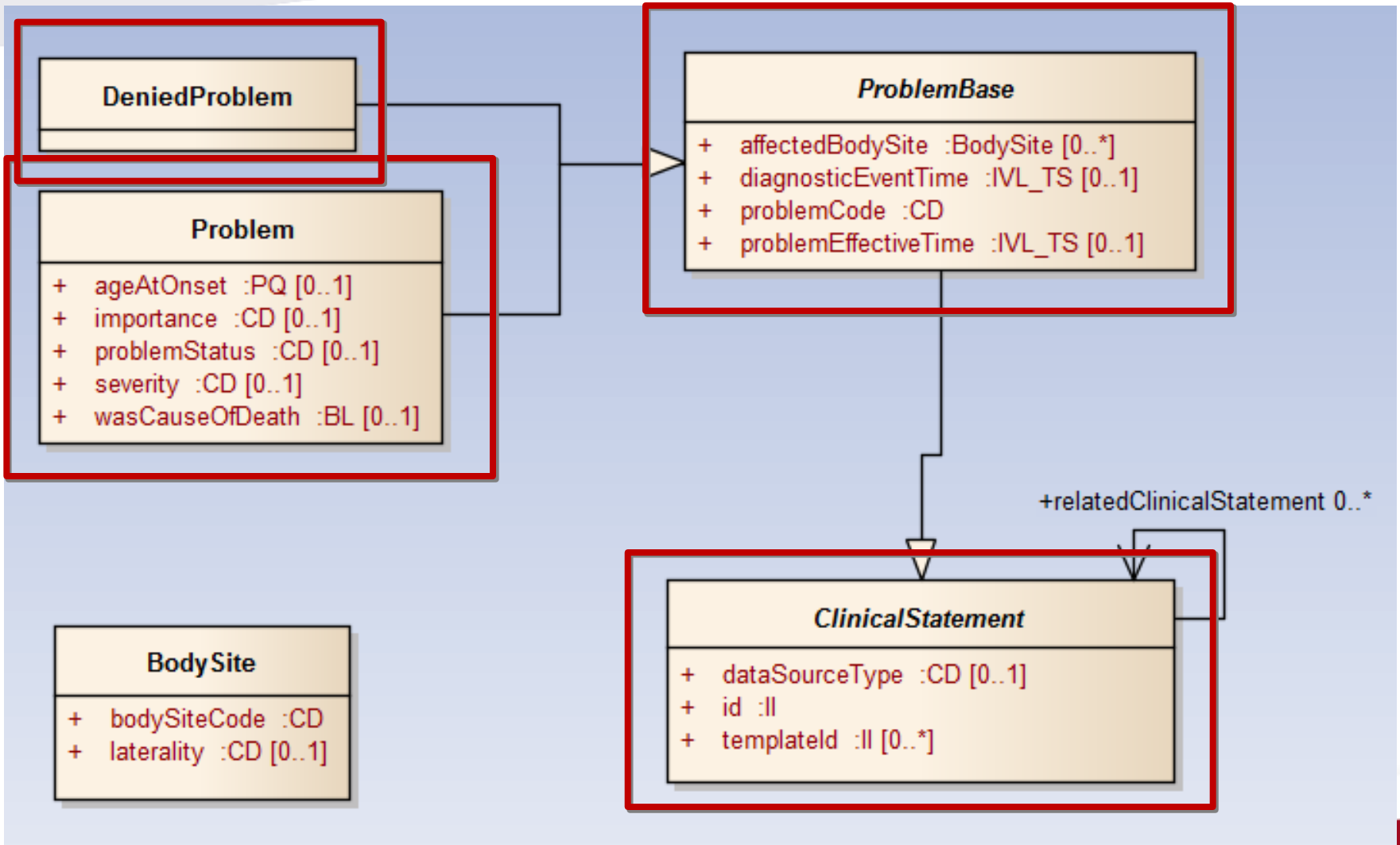
Simplified ISO 21090 Data Types



Example Clinical Statement



Further Information

DSS:

http://hssp-dss.wikispaces.com/hl7_specification

vMR:

http://wiki.hl7.org/index.php?title=Virtual_Medical_Record_(vMR)

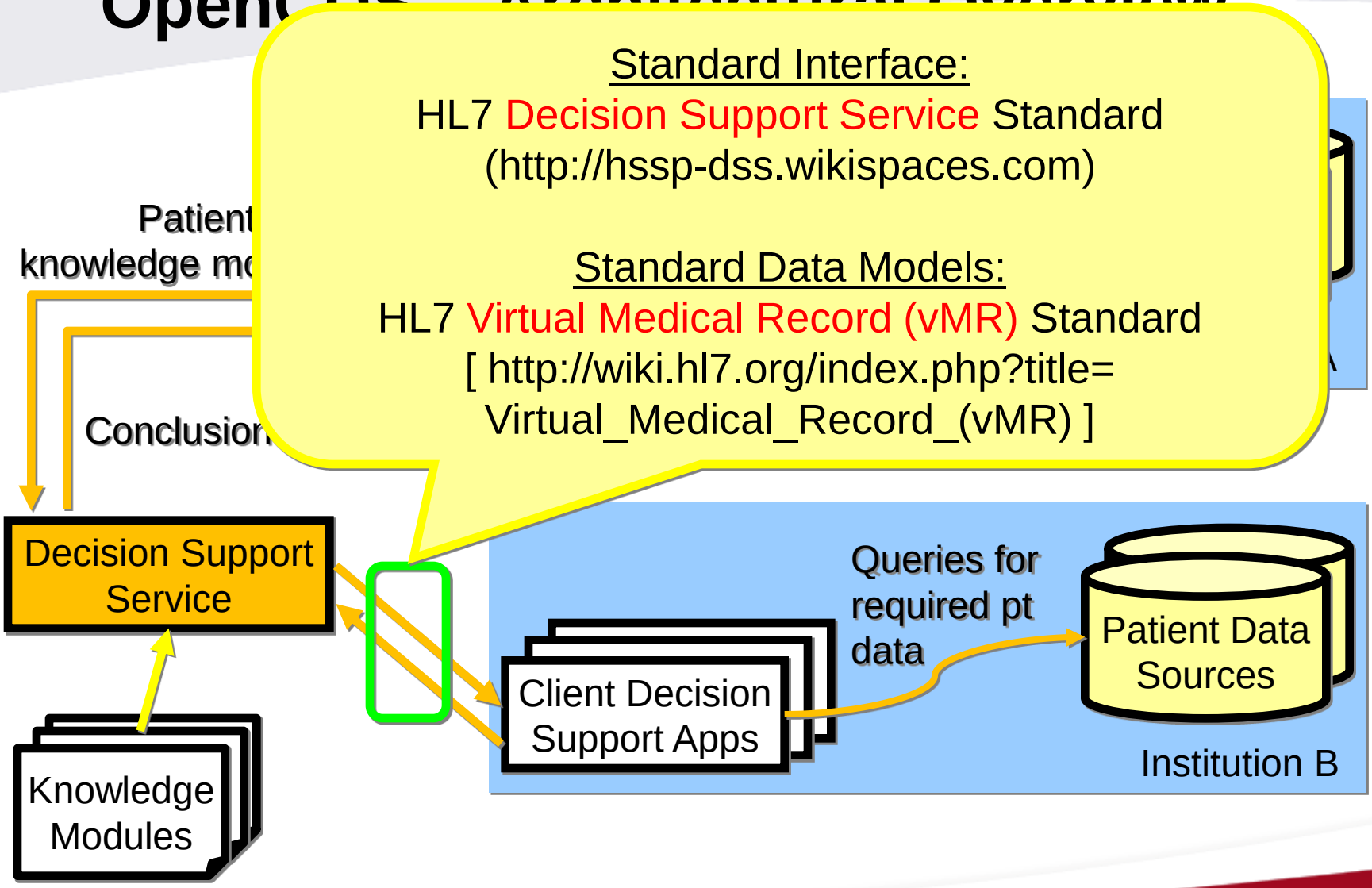
OpenCDS

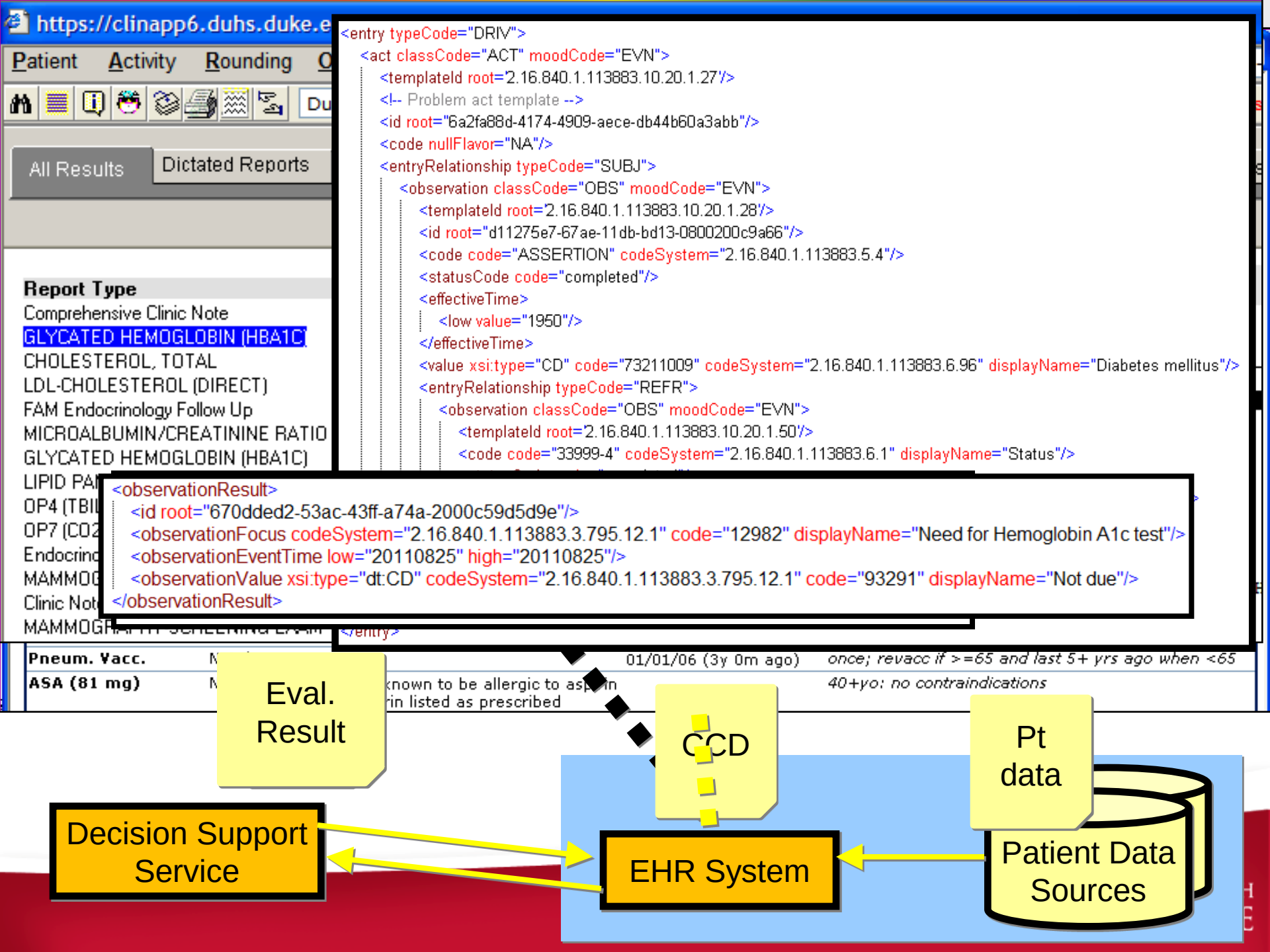
OpenCDS

- Goal
  - Facilitate widespread availability of advanced CDS capabilities through open-source, collaborative development of standards-based DSS infrastructure, tooling, and high-value services
- Methods
  - Support HL7 DSS and vMR standards
  - Leverage JBoss Drools and jBPM
  - Develop all components required to author, test, and operationally support standards-compliant DSSs
- 1.1 release freely available under Apache 2 open-source license

Collaborators

OpenCDS – Architectural Overview




https://clinapp6.duhs.duke.e
Patient
Activity
Rounding
All Results
Dictated Reports
Report Type
Comprehensive Clinic Note
GLYCATED HEMOGLOBIN (HBA1C)
CHOLESTEROL, TOTAL
LDL-CHOLESTEROL (DIRECT)
FAM Endocrinology Follow Up
MICROALBUMIN/CREATININE RATIO
GLYCATED HEMOGLOBIN (HBA1C)
<entry typeCode="DRIV">
<act classCode="ACT" moodCode="EVN">
<templateId root="2.16.840.1.113883.10.20.1.27"/>
<!-- Problem act template -->
<id root="6a2fa88d-4174-4909-aece-db44b60a3abb"/>
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<observation classCode="OBS" moodCode="EVN">
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</effectiveTime>
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<observation classCode="OBS" moodCode="EVN">
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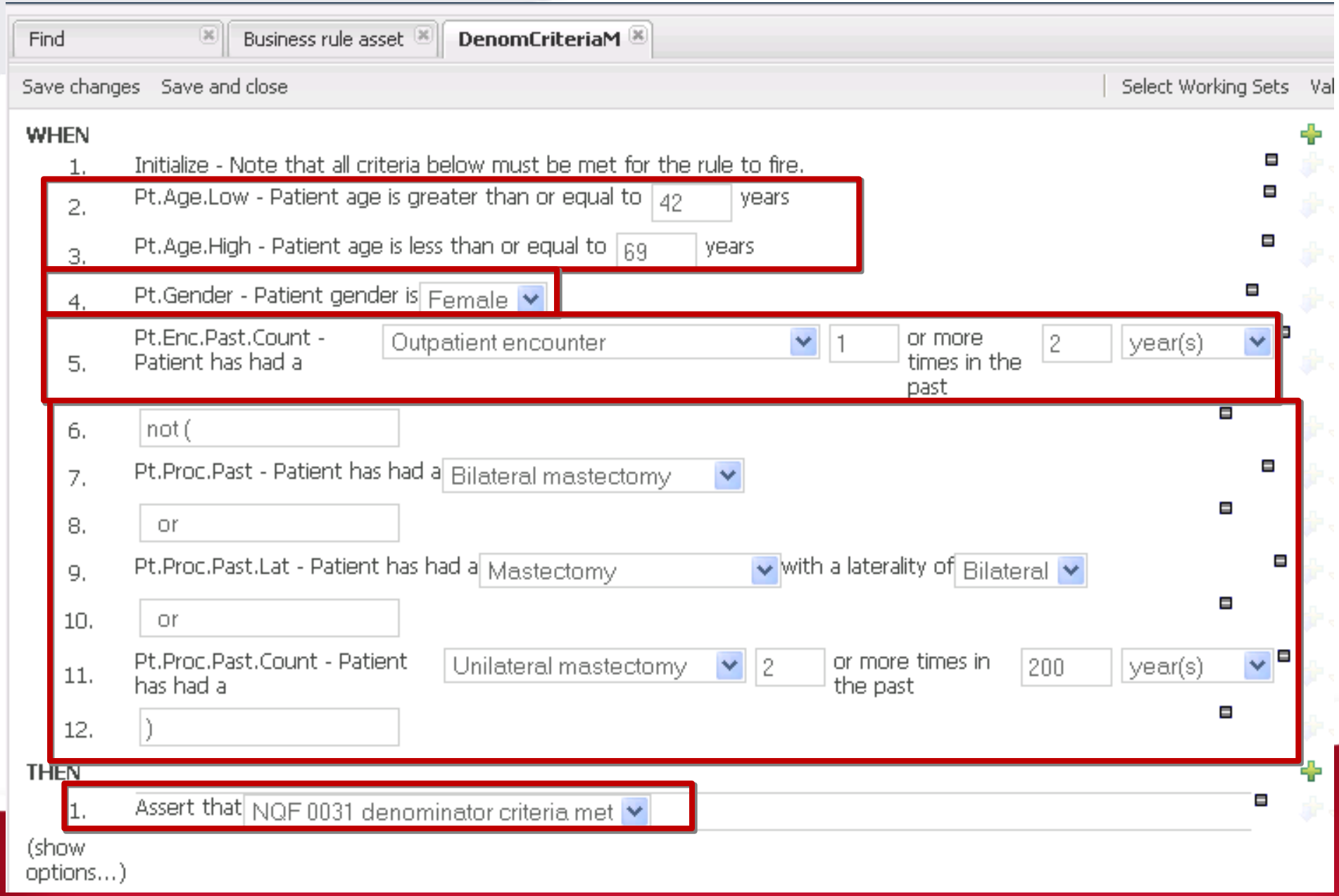
<observationFocus codeSystem="2.16.840.1.113883.3.795.12.1" code="12982" displayName="Need for Hemoglobin A1c test"/>
<observationEventTime low="20110825" high="20110825"/>
<observationValue xsi:type="dt:CD" codeSystem="2.16.840.1.113883.3.795.12.1" code="93291" displayName="Not due"/>
</observationResult>
Pneum. Vacc.
01/01/06 (3y 0m ago)
once; revacc if >=65 and last 5+ yrs ago when <65
ASA (81 mg)
40+yo: no contraindications
Eval. Result
CCD
Pt data
Decision Support Service
EHR System
Patient Data Sources

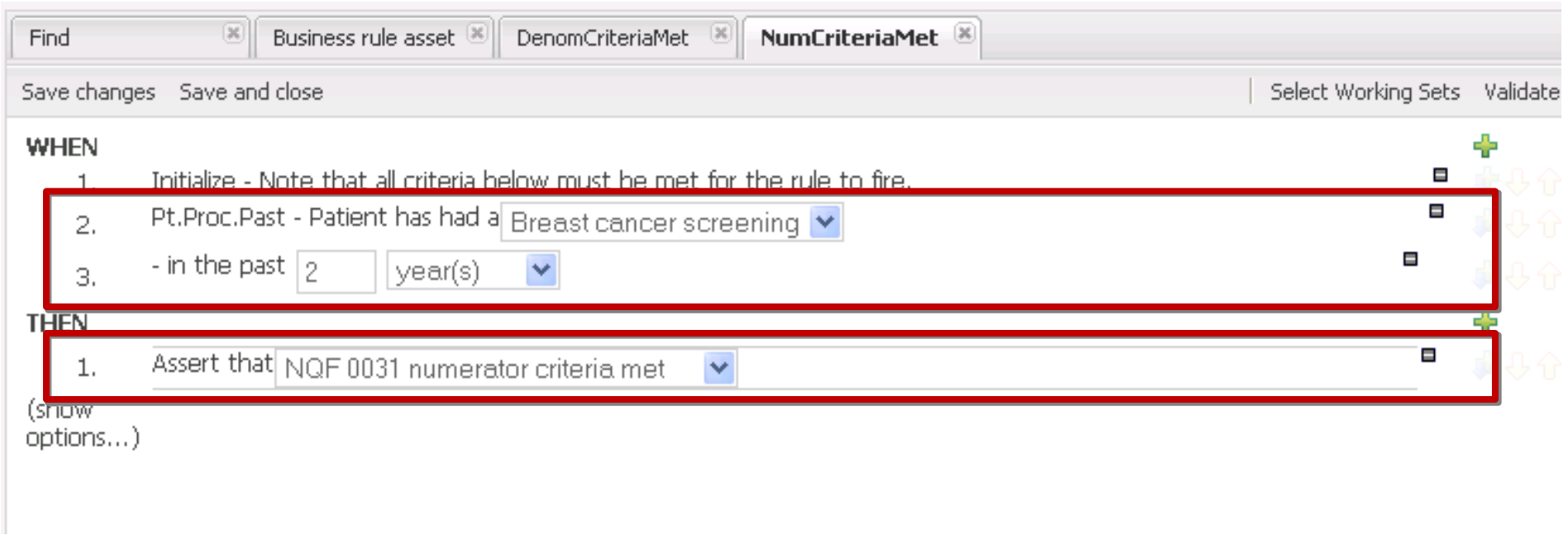
NQF Measure 31 for Meaningful Use

- **Initial Patient Population** =
  - AND: "Patient characteristic: birth date" >= 41 year(s) and <= 68 year(s) starts before start of "Measurement period"
  - AND: "Patient characteristic: Gender Female"
- **Denominator**=
  - AND: "Initial Patient Population"
  - AND: "Encounter: encounter outpatient" <= 2 year(s) starts before or during "Measurement end date"
  - AND NOT:
    - AND:
      - OR: "Procedure performed: bilateral mastectomy"
      - OR:
        - AND: "Procedure performed: unilateral mastectomy CPT"
        - AND: "Procedure performed: bilateral mastectomy modifier"
      - OR:
        - AND: > 1 count(s) of
          - AND: "Procedure performed: unilateral mastectomy"
        - AND:
          - AND NOT: FIRST:"Procedure performed: unilateral mastectomy" concurrent with SECOND :"Procedure performed: unilateral mastectomy"
      - starts before or during "Measurement end date"
- **Numerator** =
  - AND: "Diagnostic study performed: breast cancer screening" <= 2 year(s) starts before or during "Measurement end date"
- **Exclusions** =
  - None

OpenCDS Implementation – Denom.



OpenCDS Implementation – Numerator



OpenCDS Implement. – Underlying Details

Viewing source for: DenomCriteriaMet

Viewing source for: DenomCriteriaMet

```
1.  rule "DenomCriteriaMet"
2.      dialect "java"
3.      lock-on-active true
4.      when
5.          (EvalTime($evalTime : evalTimeValue) and FocalPersonId($focalPersonId : id)) //DslUsed==InitializeVariablesDsl
6.          ($PatientAgeLowDsl_focalPerson : Person(isFocalPerson == true) and PersonAgeAtEvalTime(personId == $PatientAgeLowDsl_focalPerson.id ,
    ageUnit == "year" , age >= 42)) //DslUsed==PatientAgeLowDsl|||n==42
7.          ($PatientAgeHighDsl_focalPerson : Person(isFocalPerson == true) and PersonAgeAtEvalTime(personId == $PatientAgeHighDsl_focalPerson.id ,
    ageUnit == "year" , age <= 69)) //DslUsed==PatientAgeHighDsl|||n==69
8.          ($PatientGenderDsl_focalPerson : Person(isFocalPerson == true) and GenderConcept(conceptTargetId == $PatientGenderDsl_focalPerson.id,
    openCdsConceptCode == "C31")) //DslUsed==PatientGenderDsl|||X==C31
9.          ($PatientEncounterEventCountDsl_encounterTypeConcepts_C44 : java.util.List (size >= 1 ) from collect ( EncounterTypeConcept(
    openCdsConceptCode == "C44" ) ) and $PatientEncounterEventCountDsl_encounters_C44 : java.util.List( size >= 1 ) from collect (
    EncounterEvent(subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime, id memberOf
    (LogicHelperUtility.getConceptTargetIds($PatientEncounterEventCountDsl_encounterTypeConcepts_C44)),
    eval(org.opencds.common.utilities.DateUtility.getInstance().timeDifferenceLessThanOrEqualTo($evalTime, subjectEffectiveTimeBegin, 1, 2)))) and
    (eval($PatientEncounterEventCountDsl_encounters_C44.size() >= 1)) )
    //DslUsed==PatientEncounterEventCountDsl|||X==C44|||n1==1|||n2==2|||timeUnits==1
10.         not (
11.         ($PatientProcedureEventDsl_procedureConcept_C46 : ProcedureConcept(openCdsConceptCode == "C46") and ProcedureEvent(id ==
    $PatientProcedureEventDsl_procedureConcept_C46.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime))
    //DslUsed==PatientProcedureEventDsl|||X==C46
12.         or
13.         ($PatientProcedureEventLateralityDsl_procedureConcept_C49 : ProcedureConcept(openCdsConceptCode == "C49") and
    $PatientProcedureEventLateralityDsl_bodySite_C49 : BodySite (clinicalStatementId ==
    $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId) and LateralityConcept(openCdsConceptCode == "C51",
    conceptTargetId == $PatientProcedureEventLateralityDsl_bodySite_C49.id) and ProcedureEvent(id ==
    $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <=
```

OpenCDS Implementation – Decision Table

Decision table

#	Desc	Vaccine	Gender	Dose #	Min Age	Units1	Max Age	Units2	Index Dose #	Min Interval	Units3	Rec Interval	Units4
1		HPV	Female	1	9	Yr	26	Yr					
2				2					1	24	Day	61	Day
3				3					2	80		121	
4									1	164		182	
5			Male	1	11								
6				2					1	24	Day	61	Day
7				3					2	80		121	
8									1	164		182	

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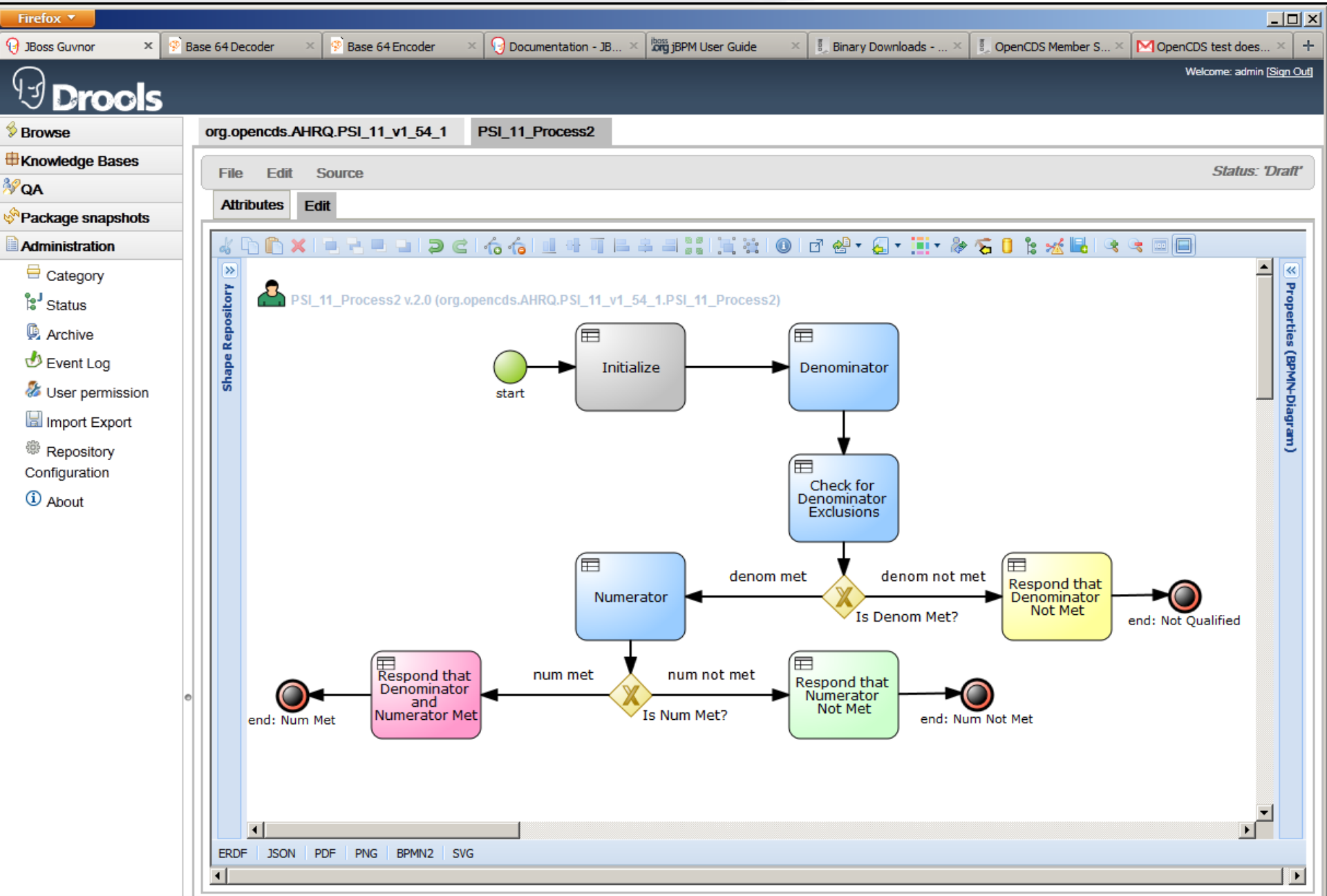
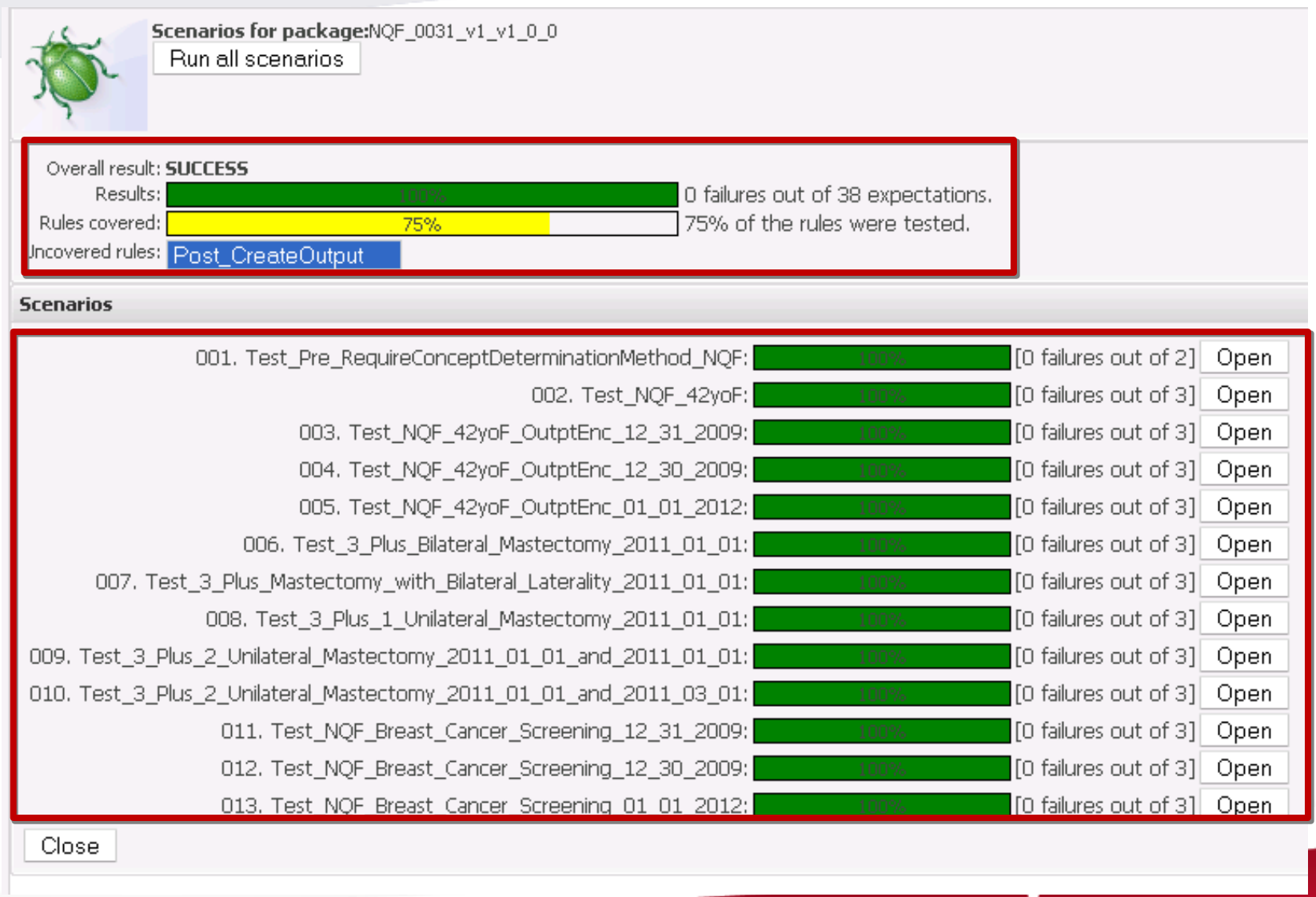
Web-Based Authoring – Flow Control



Testing Environment

Batch Regression Testing



www.opencds.org

OpenCDS

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Home | Collaborators | Architecture | Key Components | Screenshots | References | Acknowledgments | 1.0 Release | Join the Community

Home

What is OpenCDS?

OpenCDS is a **multi-institutional, collaborative effort** to develop **open-source, standards-based clinical decision support (CDS) tools and resources** that can be widely adopted to enable CDS at scale.

Who is Involved?

OpenCDS was founded by Dr. Kensaku Kawamoto, MD, PhD, who is a faculty member at the University of Utah Department of Biomedical Informatics and a co-chair of the HL7 CDS Work Group. OpenCDS

Breaking News

OpenCDS 1.0 Release Available The OpenCDS 1.0 Release is now available to collaborators. Please see the 1.0 Release tab for more information.
Posted Mar 31, 2012 11:25 AM by Kensaku Kawamoto

OpenCDS 1.0 Release Candidate Avaialble The OpenCDS 1.0 Release Candidate is now available to collaborators. Please see the 1.0 Release tab for more information.
Posted Jan 16, 2012 4:17 AM by Kensaku Kawamoto

OpenCDS Alpha Release Available An alpha release of OpenCDS is now available to collaborators.
Posted Jan 16, 2012 4:16 AM by Kensaku Kawamoto

EBSCO Joins as OpenCDS Collaborator The OpenCDS team is very excited to announce that EBSCO, one of the leading knowledge content providers in

Acknowledgements

- Financial support
  - NHGRI K01 HG004645 (PI: K. Kawamoto)
  - University of Utah Dept. of Biomedical Informatics
  - University of Utah Information Technology Services
  - Utah Beacon Community Subcontract (PI: Bruce Bray)
- Numerous OpenCDS collaborators
  - https://sites.google.com/site/opencdspublic/collaborators

Questions?

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