

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



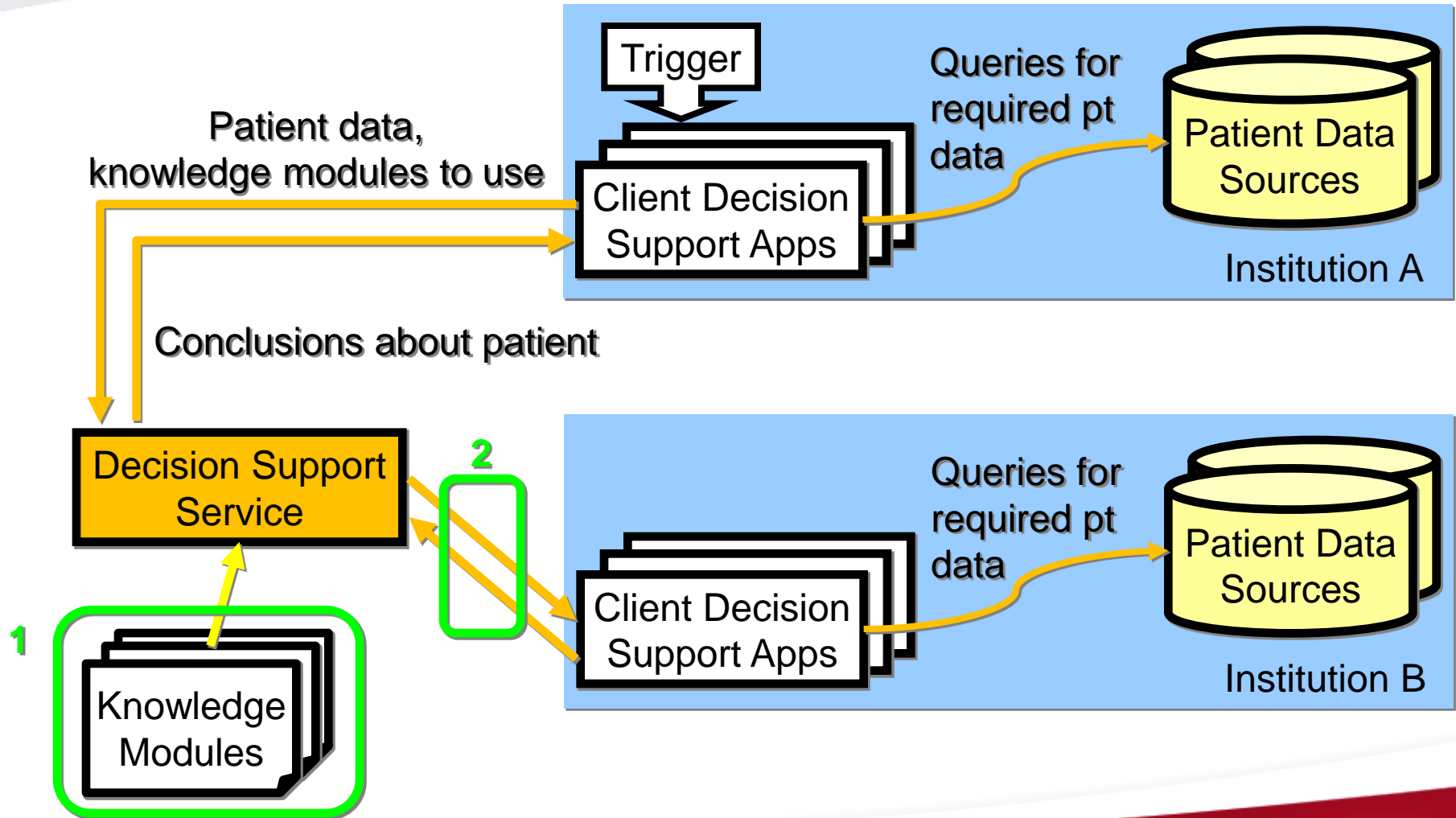
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Decision Support Service (DSS) – Overview

- 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

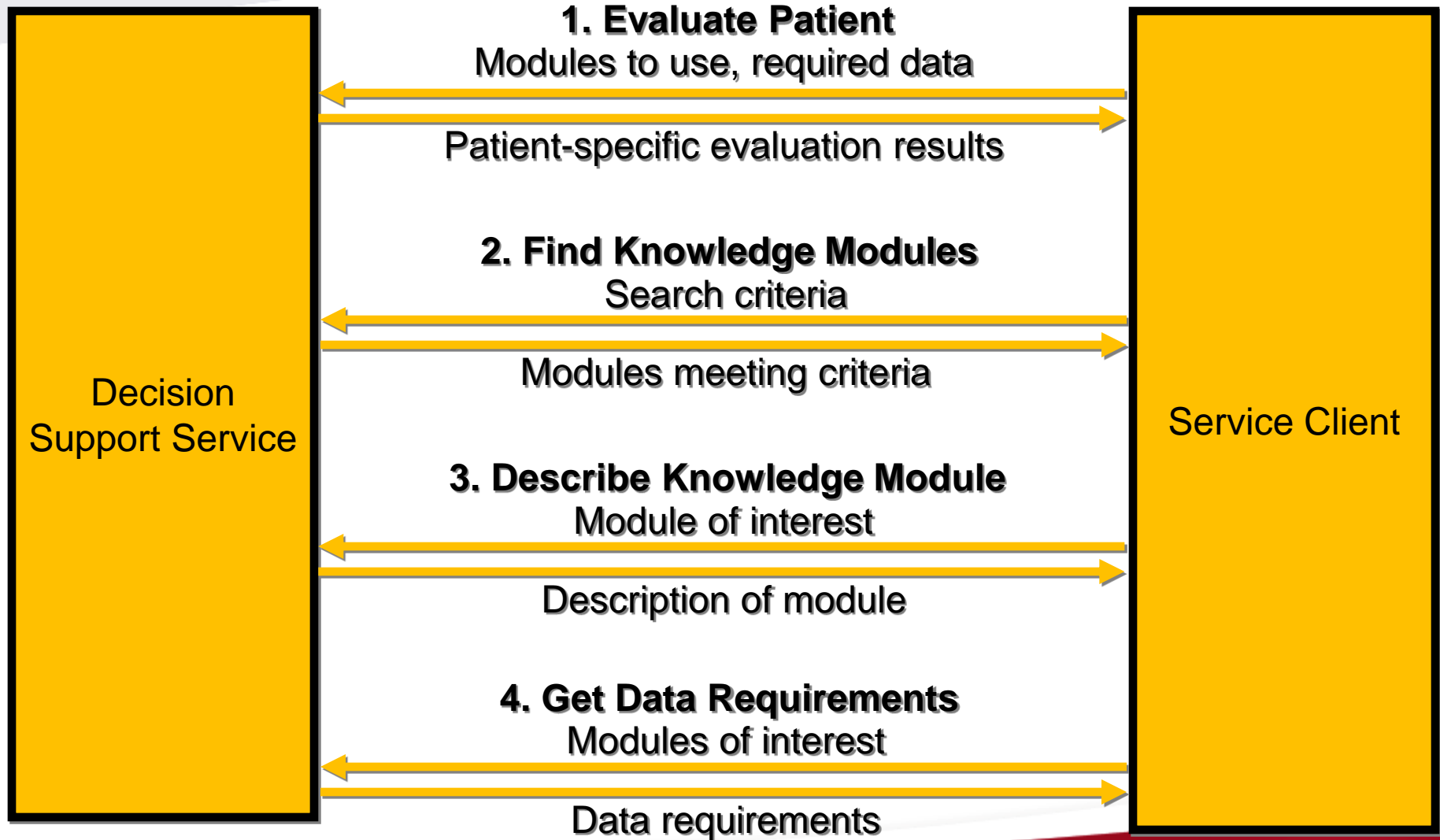


DSS KM – Sample Inferences

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



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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?

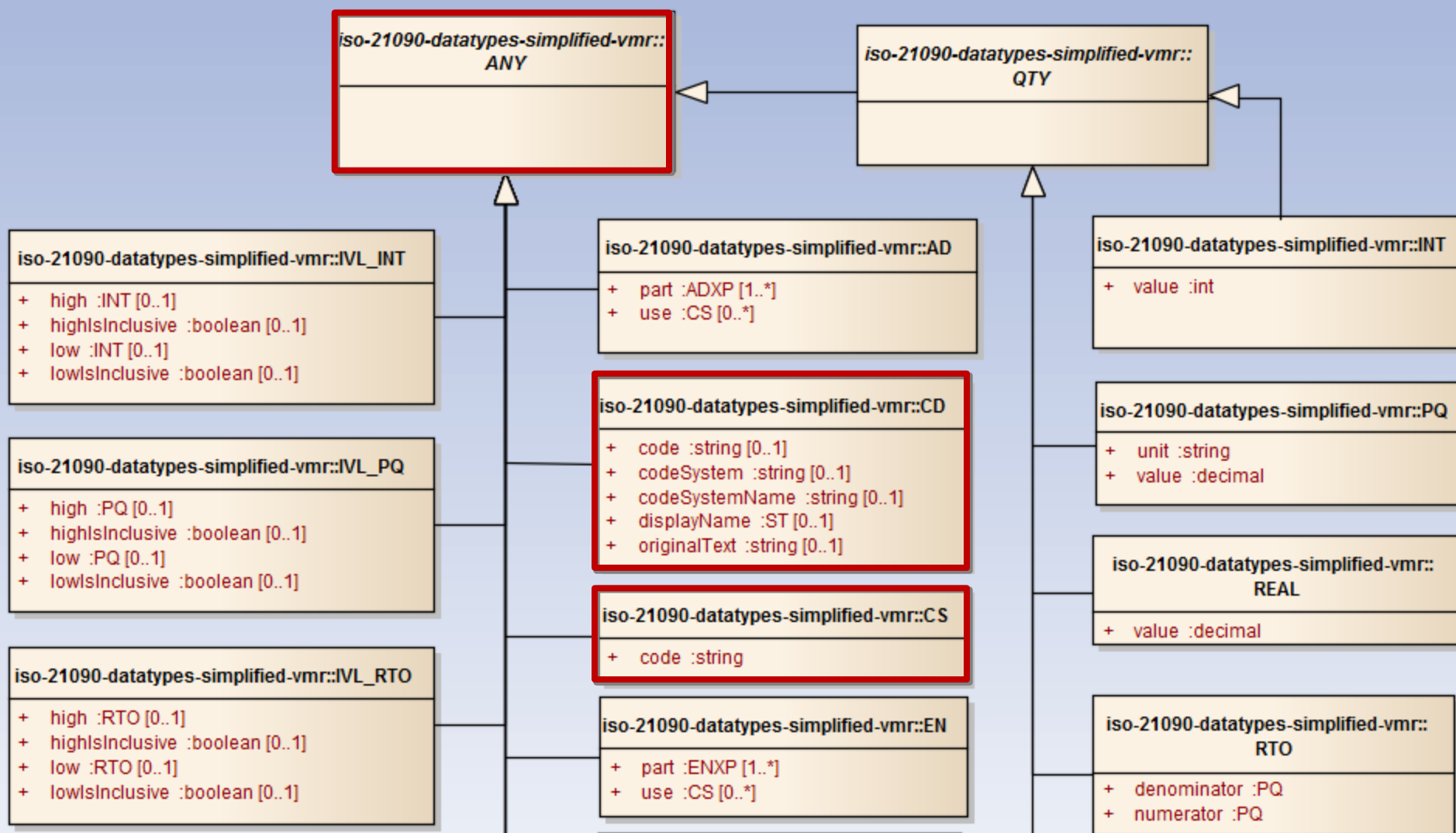
- CCD does not include all needed information
 - E.g., Family history model suitable for CDS
- CCD is not sufficiently intuitive for direct use by CDS knowledge authors



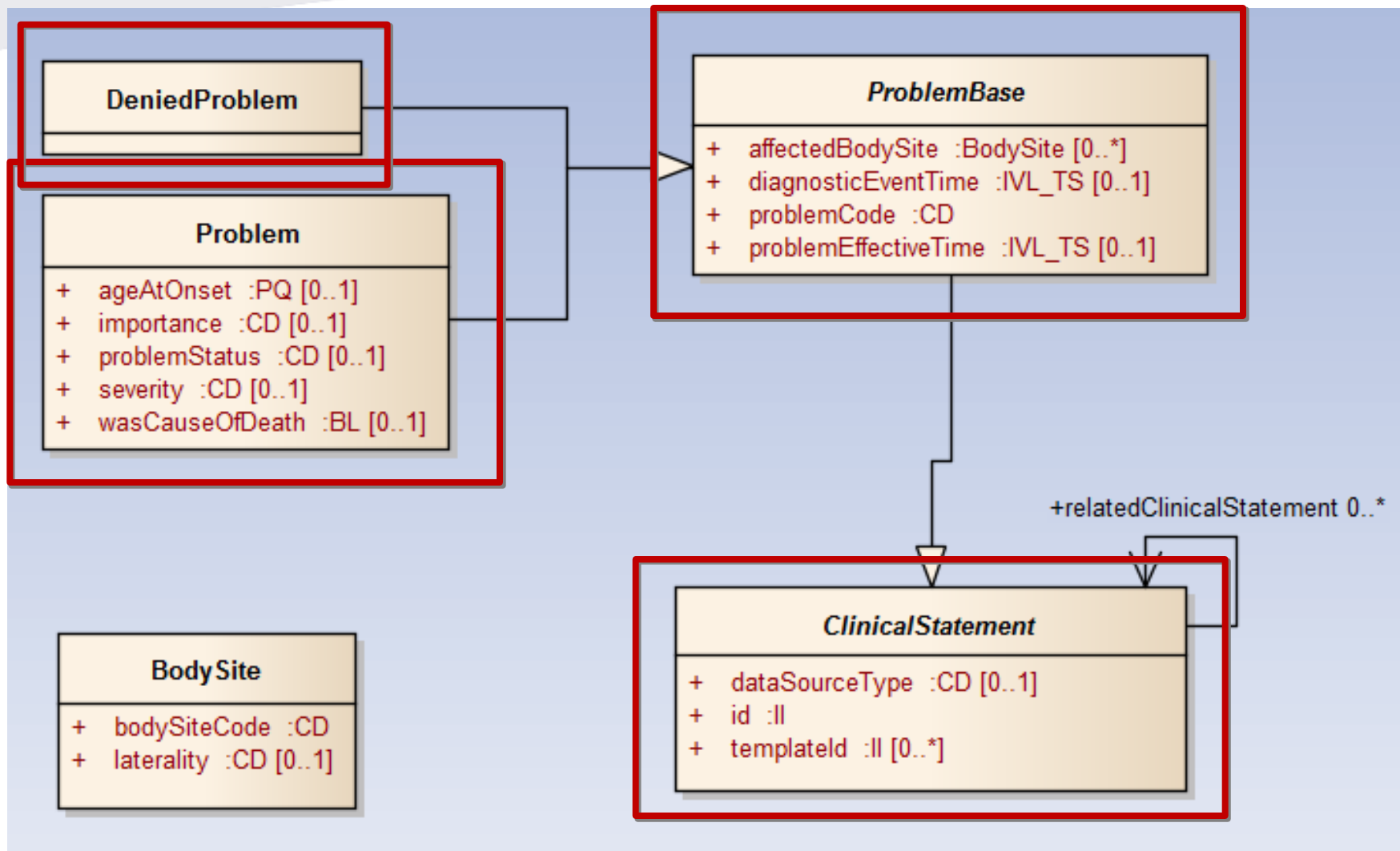
Problem Model – CCD vs. VMR

```
<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"/>
        <!-- Problem observation template -->
        <id root="6a2fa88d-4174-4909-aece-db44b60a3abb"/>
        <code code="195967001" codeSystem="2.16.840.1.113883.6.96" displayName="Asthma"/>
        <problemCode codeSystem="2.16.840.1.113883.6.96" code="195967001" displayName="Asthma"/>
        <problemEffectiveTime low="1950"/>
        <diagnosticEventTime low="20110825" high="20110825"/>
        <problemStatus codeSystem="2.16.840.1.113883.6.96" code="55561003" displayName="Active"/>
      </problem>
    </observation>
    <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"/>
      </observation>
    </entryRelationship>
  </act>
</entry>
```

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



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OpenCDS



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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



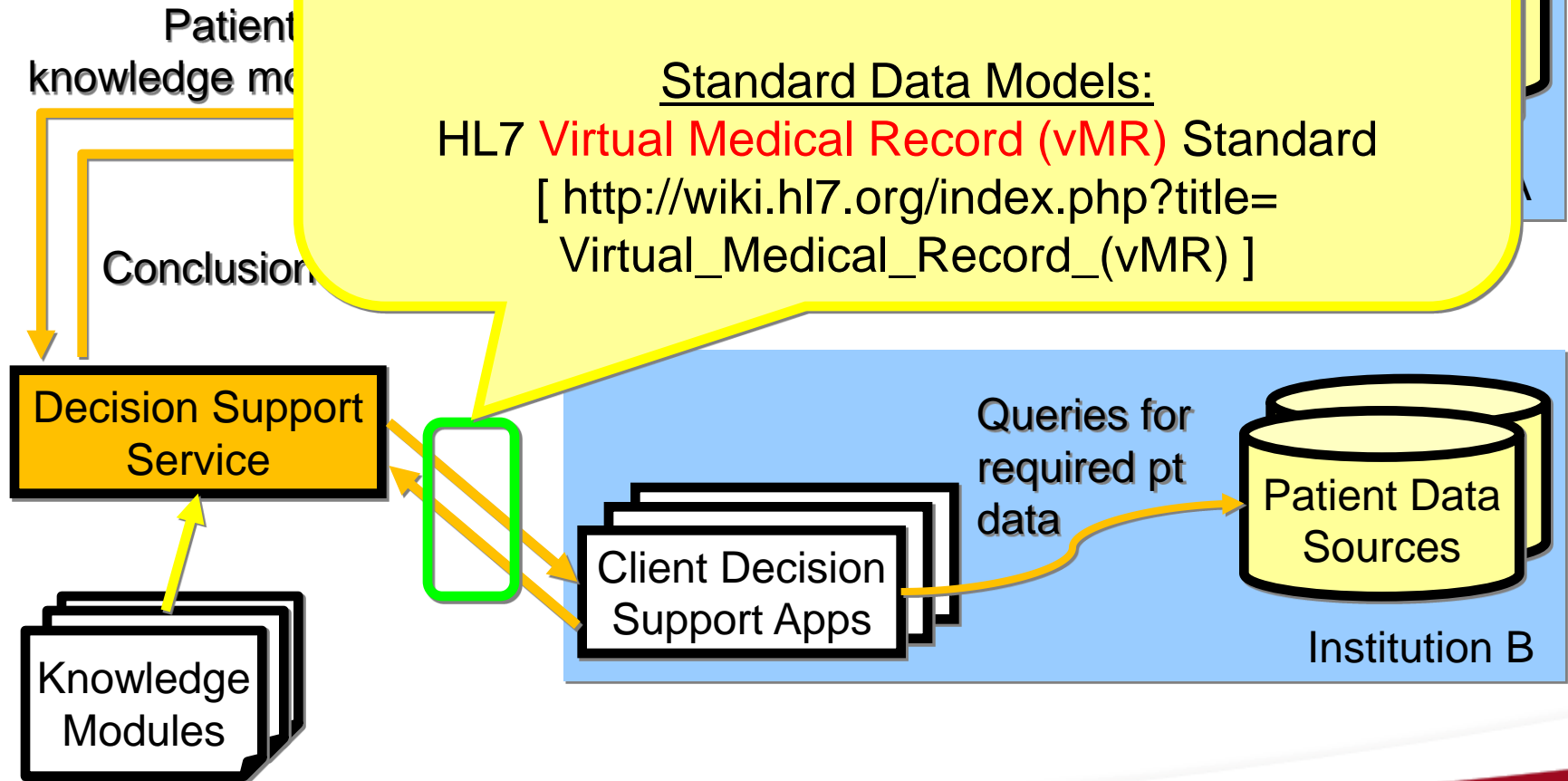
OpenCDS Architectural Overview

Standard Interface:

HL7 **Decision Support Service** Standard
(<http://hssp-dss.wikispaces.com>)

Standard Data Models:

HL7 **Virtual Medical Record (vMR)** Standard
[[http://wiki.hl7.org/index.php?title=Virtual_Medical_Record_\(vMR\)](http://wiki.hl7.org/index.php?title=Virtual_Medical_Record_(vMR))]



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)
 LIPID PANEL
 OP4 (TBII)
 OP7 (CO2)
 Endocrinology
 MAMMOGRAPHY
 Clinic Note
 MAMMOGRAPHY SCREENING EXAM

```
<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 root="d11275e7-67ae-11db-bd13-0800200c9a66"/>
        <code code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
        <statusCode code="completed"/>
        <effectiveTime>
          <low value="1950"/>
        </effectiveTime>
        <value xsi:type="CD" code="73211009" codeSystem="2.16.840.1.113883.6.96" displayName="Diabetes mellitus"/>
        <entryRelationship typeCode="REFR">
          <observation classCode="OBS" moodCode="EVN">
            <templateId root="2.16.840.1.113883.10.20.1.50"/>
            <code code="33999-4" codeSystem="2.16.840.1.113883.6.1" displayName="Status"/>
          </observation>
        </entryRelationship>
      </observation>
    </entryRelationship>
  </act>
  <observationResult>
    <id root="670dded2-53ac-43ff-a74a-2000c59d5d9e"/>
    <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>
</entry>
```

Pneum. Vacc.	M	01/01/06 (3y 0m ago)	once; revacc if >=65 and last 5+ yrs ago when <65
ASA (81 mg)	M	known to be allergic to aspirin aspirin listed as prescribed	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" \geq 41 year(s) and \leq 68 year(s) starts before start of "Measurement period"
 - AND: "Patient characteristic: Gender Female"
- **Denominator=**
 - AND: "Initial Patient Population"
 - AND: "Encounter: encounter outpatient" \leq 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" \leq 2 year(s) starts before or during "Measurement end date"
 - **Exclusions =**
 - None

OpenCDS Implementation – Denom.

Find

Business rule asset

DenomCriteriaM

Save changes Save and close

Select Working Sets Val

WHEN

1. Initialize - Note that all criteria below must be met for the rule to fire.

2. Pt.Age.Low - Patient age is greater than or equal to 42 years

3. Pt.Age.High - Patient age is less than or equal to 69 years

4. Pt.Gender - Patient gender is Female

5. Pt.Enc.Past.Count - Patient has had a Outpatient encounter 1 or more times in the past 2 year(s)

6. not (

7. Pt.Proc.Past - Patient has had a Bilateral mastectomy

8. or

9. Pt.Proc.Past.Lat - Patient has had a Mastectomy with a laterality of Bilateral

10. or

11. Pt.Proc.Past.Count - Patient has had a Unilateral mastectomy 2 or more times in the past 200 year(s)

12.)

THEN

1. Assert that NQF 0031 denominator criteria met

(show options...)

OpenCDS Implementation – Numerator

Find Business rule asset DenomCriteriaMet NumCriteriaMet

Save changes Save and close | Select Working Sets Validate

WHEN

1. Initialize - Note that all criteria below must be met for the rule to fire.
2. Pt.Proc.Past - Patient has had a Breast cancer screening
3. - in the past 2 year(s)

THEN

1. Assert that NQF 0031 numerator criteria met

(show options...)



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 == $PatientAgeLowDsl_focalPerson.id ,
7. | ageUnit == "year" , age >= 42)) //DslUsed==PatientAgeLowDsl|||n==42
8. |     ($PatientAgeHighDsl_focalPerson : Person(isFocalPerson == true) and PersonAgeAtEvalTime(personId == $PatientAgeHighDsl_focalPerson.id ,
9. | ageUnit == "year" , age <= 69)) //DslUsed==PatientAgeHighDsl|||n==69
10. |     ($PatientGenderDsl_focalPerson : Person(isFocalPerson == true) and GenderConcept(conceptTargetId == $PatientGenderDsl_focalPerson.id,
11. | openCdsConceptCode == "C31")) //DslUsed==PatientGenderDsl|||X==C31
12. |     ($PatientEncounterEventCountDsl_encounterTypeConcepts_C44 : java.util.List( size >= 1 ) from collect ( EncounterTypeConcept(
13. | openCdsConceptCode == "C44" ) ) and $PatientEncounterEventCountDsl_encounters_C44 : java.util.List( size >= 1 ) from collect (
14. | EncounterEvent(subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime, id memberOf
15. | (LogicHelperUtility.getConceptTargetIds($PatientEncounterEventCountDsl_encounterTypeConcepts_C44)),
16. | eval(org.opencds.common.utilities.DateUtility.getInstance().timeDifferenceLessThanOrEqualTo($evalTime, subjectEffectiveTimeBegin, 1, 2)))) and
17. | (eval($PatientEncounterEventCountDsl_encounters_C44.size() >= 1)) )
18. | //DslUsed==PatientEncounterEventCountDsl|||X==C44|||n1==1|||n2==2|||timeUnits==1
19. |     not (
20. |       ($PatientProcedureEventDsl_procedureConcept_C46 : ProcedureConcept(openCdsConceptCode == "C46") and ProcedureEvent(id ==
21. | $PatientProcedureEventDsl_procedureConcept_C46.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime))
22. |       //DslUsed==PatientProcedureEventDsl|||X==C46
23. |       or
24. |       ($PatientProcedureEventLateralityDsl_procedureConcept_C49 : ProcedureConcept(openCdsConceptCode == "C49") and
25. | $PatientProcedureEventLateralityDsl_bodySite_C49 : BodySite (clinicalStatementId ==
26. | $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId) and LateralityConcept(openCdsConceptCode == "C51",
27. | conceptTargetId == $PatientProcedureEventLateralityDsl_bodySite_C49.id) and ProcedureEvent(id ==
28. | $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <=
29. | $evalTime)) //DslUsed==PatientProcedureEventLateralityDsl|||X==C49|||n1==1|||n2==2|||timeUnits==1
```



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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		<input type="text" value="HPV"/>	<input type="text" value="Female"/>	1	<input type="text" value="9"/>	<input type="text" value="Yr"/>	<input type="text" value="26"/>	<input type="text" value="Yr"/>					
+	2				2					1	24	<input type="text" value="Day"/>	61	<input type="text" value="Day"/>
+	3				<input type="text" value="3"/>					2	80		121	
+	4									1	164		182	
+	5			<input type="text" value="Male"/>	1	<input type="text" value="11"/>								
+	6				2					1	24	<input type="text" value="Day"/>	61	<input type="text" value="Day"/>
+	7				<input type="text" value="3"/>					2	80		121	
+	8									1	164		182	



Web-Based Authoring – Flow Control

Firefox

JBoss Guvnor x Base 64 Decoder x Base 64 Encoder x Documentation - JB... x jboss.org JBPM User Guide x Binary Downloads - ... x OpenCDS Member S... x OpenCDS test does... x

Welcome: admin [Sign Out]

Drools

Browse

Knowledge Bases

QA

Package snapshots

Administration

- Category
- Status
- Archive
- Event Log
- User permission
- Import Export
- Repository Configuration
- About

org.opencds.AHRQ.PSI_11_v1_54_1 PSI_11_Process2

File Edit Source Status: 'Draft'

Attributes Edit

Shape Repository

PSI_11_Process2 v.2.0 (org.opencds.AHRQ.PSI_11_v1_54_1.PSI_11_Process2)

```
graph TD; start((start)) --> Initialize[Initialize]; Initialize --> Denominator[Denominator]; Denominator --> Check[Check for Denominator Exclusions]; Check -- "denom met" --> IsDenomMet{Is Denom Met?}; Check -- "denom not met" --> RespondDenomNotMet[Respond that Denominator Not Met]; RespondDenomNotMet --> endNotQualified((end: Not Qualified)); IsDenomMet -- "num met" --> Numerator[Numerator]; IsDenomMet -- "num not met" --> RespondNumNotMet[Respond that Numerator Not Met]; RespondNumNotMet --> endNumNotMet((end: Num Not Met)); Numerator -- "num met" --> RespondBothMet[Respond that Denominator and Numerator Met]; RespondBothMet --> endNumMet((end: Num Met));
```

Properties (BPMN-Diagram)

ERDF JSON PDF PNG BPMN2 SVG

Testing Environment

Run scenario

+ GIVEN

insert [EvalTime][\$evalTime]

evalTimeValue: 31-Dec-2011

insert [FocalPersonId][\$focalPersonId]

id: 1.2.3^person001

insert [Person][\$person]

id: 1.2.3^person001

isFocalPerson: true

insert [PersonAgeAtEvalTime][\$personAgeAtEvalTime]

age: 42

ageUnit: year

personId: 1.2.3^person001

insert [GenderConcept] [\$genderConcept]

id: 1.2.3^genderConcept00

conceptTargetId: 1.2.3^person001

openCdsConceptCode: Female

determinationMethodCode: NQF

+ EXPECT

Use real date and time

Expect rules

Pre_RequireConceptDeterminationMethod_NQF: did not fire

DenomCriteriaMet: did not fire

NumCriteriaMet: did not fire

Batch Regression Testing



Scenarios for package:NQF_0031_v1_v1_0_0

Run all scenarios

Overall result: **SUCCESS**

Results: 100% 0 failures out of 38 expectations.

Rules covered: 75% 75% of the rules were tested.

Uncovered rules: [Post_CreateOutput](#)

Scenarios

001. Test_Pre_RequireConceptDeterminationMethod_NQF:		[0 failures out of 2]	Open
002. Test_NQF_42yoF:		[0 failures out of 3]	Open
003. Test_NQF_42yoF_OutptEnc_12_31_2009:		[0 failures out of 3]	Open
004. Test_NQF_42yoF_OutptEnc_12_30_2009:		[0 failures out of 3]	Open
005. Test_NQF_42yoF_OutptEnc_01_01_2012:		[0 failures out of 3]	Open
006. Test_3_Plus_Bilateral_Mastectomy_2011_01_01:		[0 failures out of 3]	Open
007. Test_3_Plus_Mastectomy_with_Bilateral_Laterality_2011_01_01:		[0 failures out of 3]	Open
008. Test_3_Plus_1_Unilateral_Mastectomy_2011_01_01:		[0 failures out of 3]	Open
009. Test_3_Plus_2_Unilateral_Mastectomy_2011_01_01_and_2011_01_01:		[0 failures out of 3]	Open
010. Test_3_Plus_2_Unilateral_Mastectomy_2011_01_01_and_2011_03_01:		[0 failures out of 3]	Open
011. Test_NQF_Breast_Cancer_Screening_12_31_2009:		[0 failures out of 3]	Open
012. Test_NQF_Breast_Cancer_Screening_12_30_2009:		[0 failures out of 3]	Open
013. Test NQF Breast Cancer Screening 01 01 2012:		[0 failures out of 3]	Open

Close



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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 Available](#) 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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