

Sustaining a Community CDS Resource when External Funding Ends: Perspectives from the OpenCDS Experience

December 6, 2011

From Demonstration to Standard Practice: Developing Sustainable Tools and Processes for CDS
AHRQ CDS Meeting, Rockville, Maryland

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UNIVERSITY OF UTAH
HEALTH CARE

Disclosures

- I am or have recently been a consultant to Partners HealthCare and RAND Corporation for the ONC Advancing CDS Task Order, which is related to the AHRQ CDSC effort.
- I was formerly a consultant for Religent, Inc. and formerly a co-owner and consultant for Clinica Software, Inc., which holds IP rights to a CDS technology known as SEBASTIAN.
- I have no financial competing interests related to OpenCDS.



Agenda

- OpenCDS background and journey
- Lessons learned
- Recommendations
- Discussion



OpenCDS: the 10,000-foot View

- Multi-institutional, collaborative effort to develop scalable, open-source CDS tools and resources
- Primary deliverables:
 - For CDS consumers: CDS services with HL7 Decision Support Service (DSS) interface (~CDSC rules service)
 - For CDS developers: fully-featured, open-source knowledge authoring platform
 - For CDS developers with existing knowledge resources: open-source “wrappers” to share capabilities via HL7 DSS interface



OpenCDS: History

- Early 2000s to 2009: focus on OpenCDS predecessor (SEBASTIAN)
 - Due to commercialization efforts, became difficult to collaborate and scale
- Late 2009: initiation of OpenCDS effort
 - Funding via NHGRI K01 Career Development Award
- Nov 2010: alpha release at AMIA 2010; rapid accrual of collaborators
- Apr 2011: internal funding begins (Univ. of Utah)
- Aug 2011: external funding ends
- Dec 2011: 1.0 release (scheduled)



Collaborators

- University of Utah
- HP Advanced Federal Healthcare Innovation Lab
- HLN Consulting, LLC
- Apelon, Inc.
- Intermountain Healthcare
- New York Citywide Immunization Registry
- Alabama Department of Public Health
- Veterans Health Administration
- Wolters Kluwer Health
- EBSCO
- Univ. of NC at Chapel Hill
- Main Line Health
- Hospital Universitario Virgen del Rocío, Spain
- Keona Health
- Mass. General Hospital
- Stanford University
- MaRS Innovation, Canada
- SmartCare, Africa
- Emetra AS, Norway
- Visumpoint, LLC
- Genesys, LLC
- df8health
- IsoDynamic, Inc.
- Calcudos.com, Inc.
- CogniTech Corporation



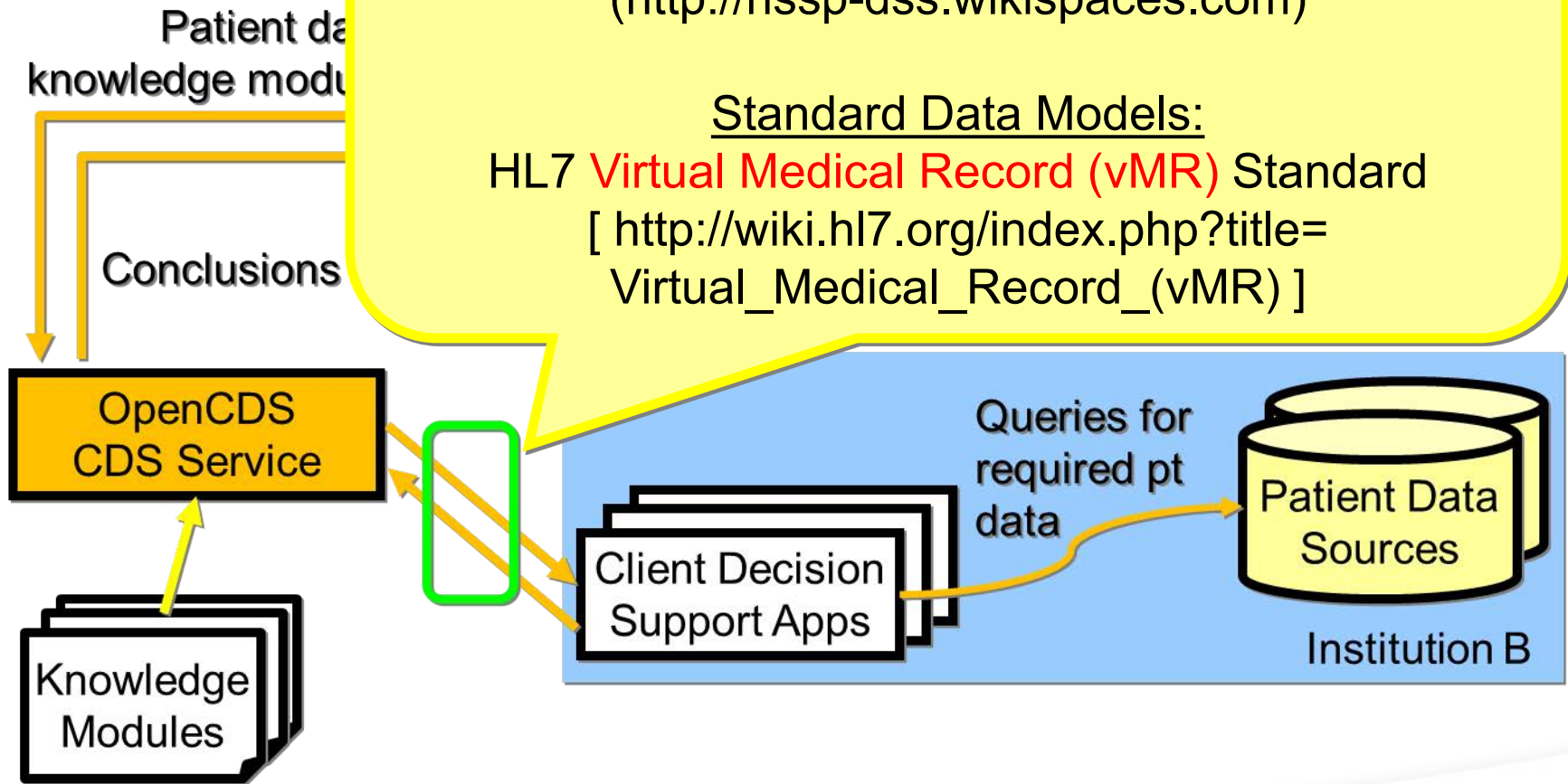
OpenCDS – Architectural Overview

Standard Interface:

HL7/OMG **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))]



Report Type

Comprehensive Clinic Note

GLYCATED HEMOGLOBIN (HBA1C)

CHOLESTEROL, TOTAL

LDL-CHOLESTEROL (DIRECT)

FAM Endocrinology Follow Up

MICROALBUMIN/CREATININE RATIO

GLYCATED HEMOGLOBIN (HBA1C)

LIPID PA

OP4 (TBII

OP7 (CO2

Endocrin

MAMMOG

Clinic Not

MAMMOG

Pneum. Vacc.

ASA (81 mg)

Eval.
Result

Decision Support
Service

EHR System

Pt
data

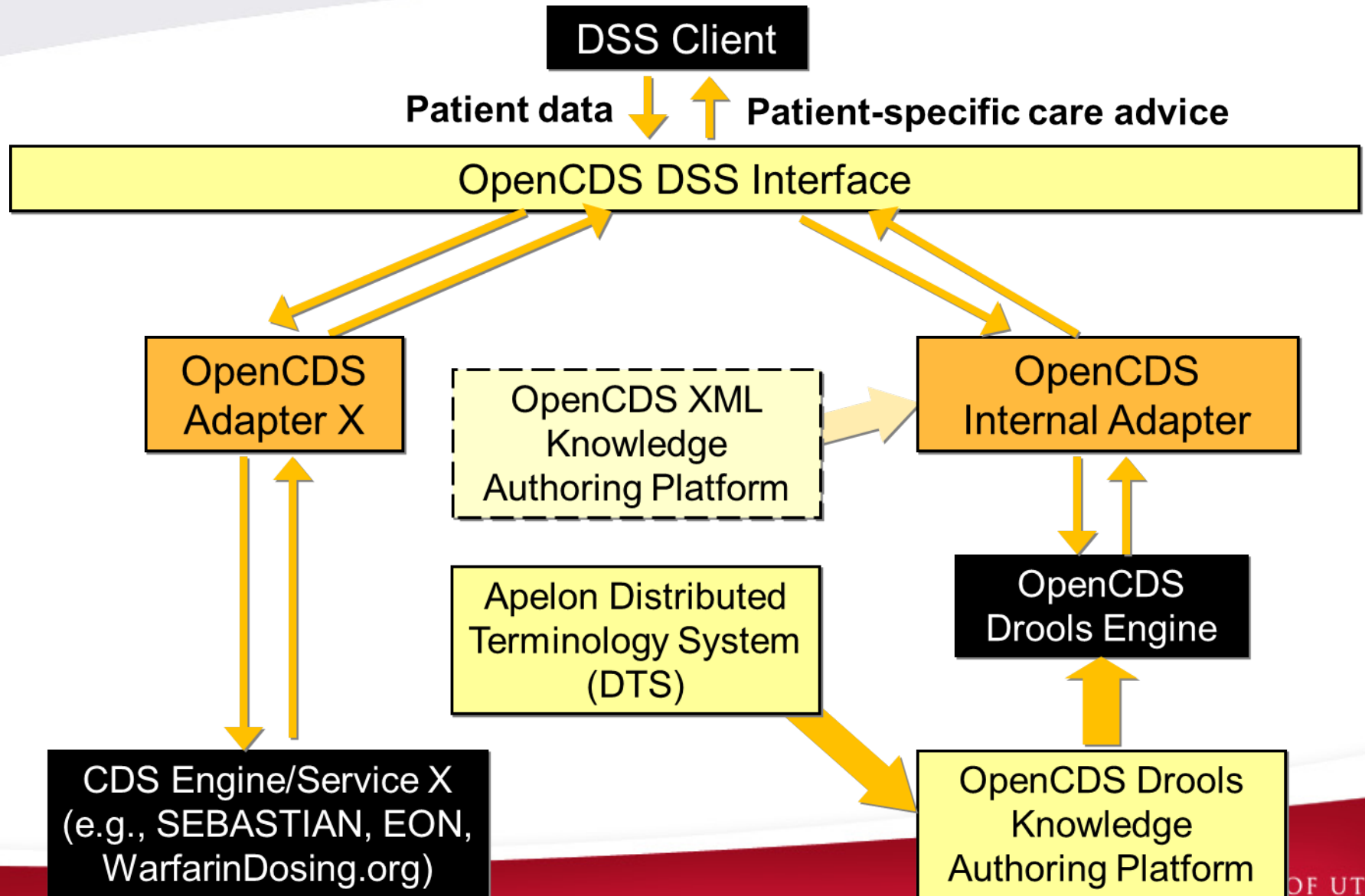
Patient Data
Sources

```
<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>
    </act>
  </entry>
```

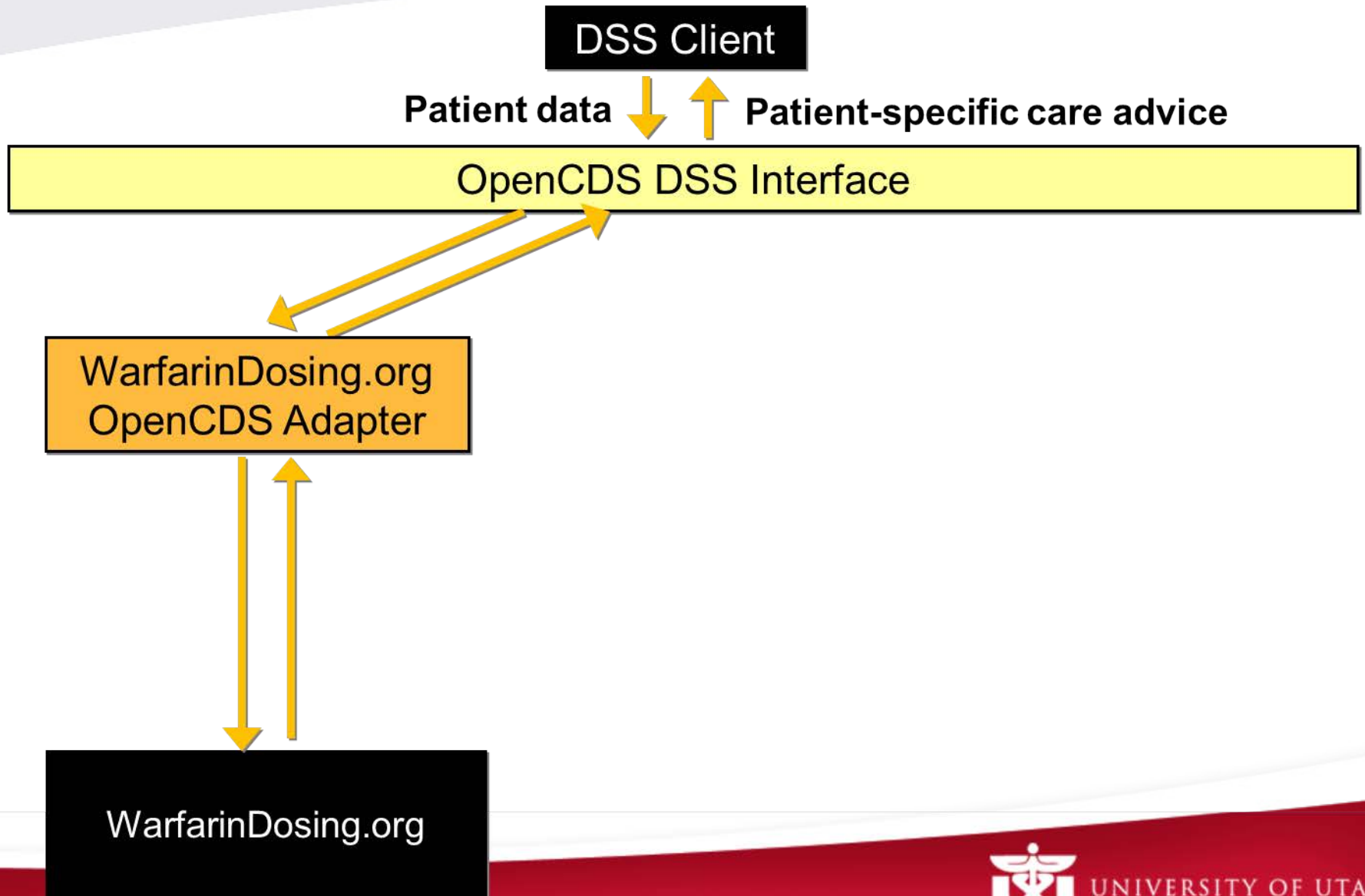
```
<observationResult>
  <id root="670dded2-53ac-43ff-a74a-2000c59d5d9e"/>
  <observationFocus codeSystem="2.16.840.1.113883.3.795.12.1" code="12982" displayName="Need for Hemoglobin A1c test"/>
  <observationEventTime low="20110825" high="20110825"/>
  <observationValue xsi:type="dt:CD" codeSystem="2.16.840.1.113883.3.795.12.1" code="93291" displayName="Not due"/>
</observationResult>
```

01/01/06 (3y 0m ago) once; revacc if >=65 and last 5+ yrs ago when <65
known to be allergic to aspirin listed as prescribed 40+yo: no contraindications

Support for Multiple Knowl. Rep. Approaches



WarfarinDosing.org Integration



> [Warfarin Dosing](#)

> [Clinical Trial](#)

> [Outcomes](#)

> [Hemorrhage Risk](#)

> [Patient Education](#)

> [Contact Us](#)

> [References](#)

> [Glossary](#)

> [About Us](#)

User:
Patient:
Version 2.34
Build : Oct 30, 2011

Required Patient Information

Age: Sex: Ethnicity:
 Race:
 Weight: lbs or kgs
 Height: (feet and inches) or (cms)
 Smokes: Liver Disease:
 Indication:
 Baseline INR: Target INR: ☐ Randomize & Blind
 Amiodarone/Cordarone® Dose: mg/day
 Statin/HMG CoA Reductase Inhibitor:
 Any azole (eg. Fluconazole):
 Sulfamethoxazole/Septra/Bactrim/Cotrim/Sulfatrim:

Genetic Information

VKORC1-1639/3673:
 CYP4F2 V433M:
 GGCX rs11676382:
 CYP2C9*2:
 CYP2C9*3:
 CYP2C9*5:
 CYP2C9*6:

☐ [Accept Terms of Use](#)

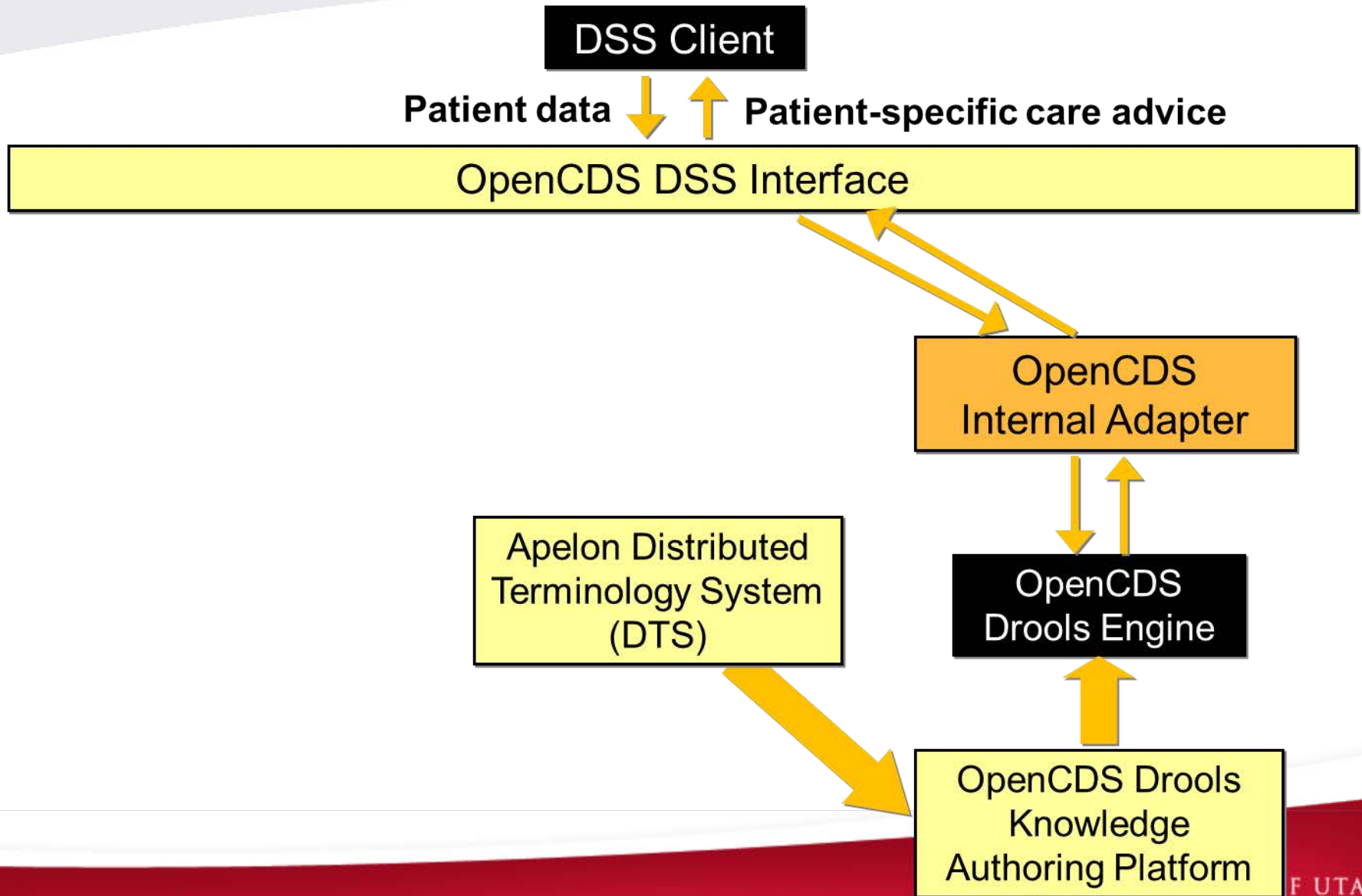
> ESTIMATE WARFARIN DOSE

WarfarinDosing.org Integration via OpenCDS

Baseline INR: <input type="text" value="1.2"/>	Current Smoker: <input type="radio"/> Yes <input checked="" type="radio"/> No	Liver Disease: <input type="radio"/> Yes <input checked="" type="radio"/> No	Current or recent NPO: <input type="radio"/> Yes <input checked="" type="radio"/> No	Estimated blood loss from recent surgery: <input type="text" value="0"/> mL	Calculated body surface area: <input type="text" value="1.492"/> m ²																										
On Direct Thrombin Inhibitor (e.g., hirudin, bivalirudin): <input type="radio"/> Yes <input checked="" type="radio"/> No	Statin use: <input type="text" value="Pravastatin/Pravachol®"/>	Amiodarone use: <input type="text" value="0"/> mg/day																													
On Azole Antifungal (e.g., ketoconazole, fluconazole): <input type="radio"/> Yes <input checked="" type="radio"/> No	On Metronidazole: <input type="radio"/> Yes <input checked="" type="radio"/> No	On Rifampin: <input type="radio"/> Yes <input checked="" type="radio"/> No																													
On Carbamazepine: <input type="radio"/> Yes <input checked="" type="radio"/> No	On Propafenone: <input type="radio"/> Yes <input checked="" type="radio"/> No	On Steroid: <input type="radio"/> Yes <input checked="" type="radio"/> No																													
On Fluoroquinolone (e.g., moxifloxacin, ciprofloxacin): <input type="radio"/> Yes <input checked="" type="radio"/> No	On Phenytoin (e.g., Dilantin): <input type="radio"/> Yes <input checked="" type="radio"/> No	On Sulfonamide: <input type="radio"/> Yes <input checked="" type="radio"/> No																													
CYP2C9 genotype: <input type="text" value="*2/*3"/>	VKORC1-1639/3673 genotype: <input type="text" value="AA"/>																														
Prior Doses and Recent Labs:																															
Prior doses (past week):	<table border="1"><thead><tr><th>7/13 (Tue)</th><th>7/14 (Wed)</th><th>7/15 (Thu)</th><th>7/16 (Fri)</th><th>7/17 (Sat)</th><th>7/18 (Sun)</th><th>7/19 (Mon)</th></tr></thead><tbody><tr><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td></tr></tbody></table>	7/13 (Tue)	7/14 (Wed)	7/15 (Thu)	7/16 (Fri)	7/17 (Sat)	7/18 (Sun)	7/19 (Mon)	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	Most Recent Labs <table border="1"><tbody><tr><td>PTT</td><td>37</td><td>07/20/2010 13:56:33</td></tr><tr><td>INR</td><td>1.5</td><td>07/20/2010 13:56:33</td></tr><tr><td>Platelets</td><td>180</td><td>07/20/2010 13:56:33</td></tr><tr><td>Hemoglobin</td><td>14.9</td><td>07/20/2010 13:56:33</td></tr><tr><td>Hematocrit</td><td>0.42</td><td>07/20/2010 13:56:33</td></tr></tbody></table>	PTT	37	07/20/2010 13:56:33	INR	1.5	07/20/2010 13:56:33	Platelets	180	07/20/2010 13:56:33	Hemoglobin	14.9	07/20/2010 13:56:33	Hematocrit	0.42	07/20/2010 13:56:33
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Hemoglobin	14.9	07/20/2010 13:56:33																													
Hematocrit	0.42	07/20/2010 13:56:33																													
Unless manually entered, above doses do not reflect held doses or outside doses. Edit as needed to ensure validity of dosing guidance provided below.																															
Warfarin Order																															
Dosing																															
Dosing Guidance: Dosing guidance received from http://www.warfarindosing.org																															
Consider following dosing: - dose 1: 2.9 mg/day - dose 2: 1.6 mg/day - dose 3: 1.6 mg/day																															
<input type="radio"/> Consistent:	<input type="text" value=""/> mg PO QHS x <input type="text" value="3"/> day(s)																														
<input type="radio"/> Custom QHS:	<table border="1"><thead><tr><th>7/20 (Tue)</th><th>7/21 (Wed)</th><th>7/22 (Thu)</th><th>7/23 (Fri)</th><th>7/24 (Sat)</th><th>7/25 (Sun)</th><th>7/26 (Mon)</th></tr></thead><tbody><tr><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td><td><input type="text" value=""/> mg</td></tr></tbody></table>		7/20 (Tue)	7/21 (Wed)	7/22 (Thu)	7/23 (Fri)	7/24 (Sat)	7/25 (Sun)	7/26 (Mon)	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg	<input type="text" value=""/> mg															
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OpenCDS Knowledge Workbench



Web-based Authoring – Decision Rules

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 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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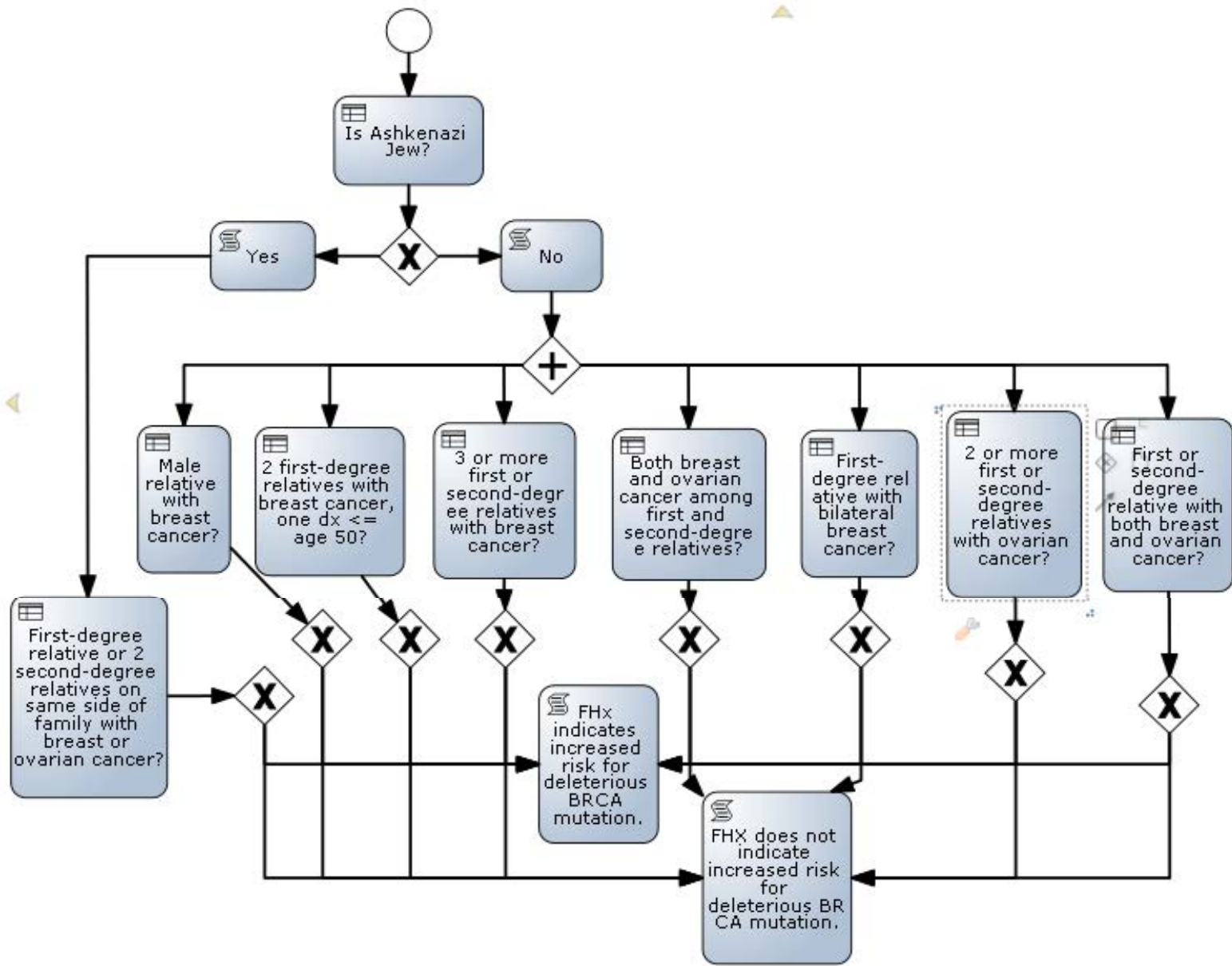
Web-Based Authoring – Decision Table

+ 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	



Web-Based Authoring – Decision Diagram



Web-based 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

Web-based Batch Regression Testing



Scenarios for package: NQF_0031_v1_v1_0_0

Run all scenarios


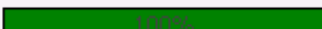
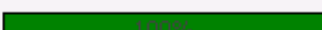









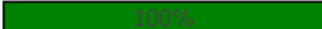
Overall result: **SUCCESS**

Results:  100% 0 failures out of 38 expectations.

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

Incovered 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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OpenCDS Status

- Alpha release available
- 1.0 preview available to collaborators
- 1.0 release scheduled December 2011
- Multiple ongoing initiatives



Sample Initiatives

- Vaccine forecasting
 - Contributors
 - HLN Consulting, New York Citywide Immunization Registry, Alabama Department of Public Health, University of Utah
 - Developing next-generation immunization CDS knowledge management and delivery platform
- Personalized medicine
 - Contributors
 - Intermountain Healthcare, Washington University, IsoDynamic, University of Utah, potentially others
 - Implementing family history-informed risk assessment algorithms
 - Supporting genetically-guided warfarin dosing via www.WarfarinDosing.org



Sample Initiatives (cont'd)

- Patient-centered medication CDS
 - Contributors
 - HP Advanced Federal Healthcare Innovation Lab, Apelon, University of Utah
 - Developed prototype medication CDS platform for smartphones within a simulated VHA environment
- Enterprise analytics and population health management
 - Contributors
 - University of Utah, others in discussion
 - Part of enterprise Knowledge Management & Mobilization (KMM) initiative



Current Staffing of Core Team

- University of Utah
 - Project director (~0.5 FTE)
 - Senior informaticist (full-time)
 - Senior data warehouse architect (part-time)
 - Multiple graduate students
- HLN Consulting
 - 2 senior software engineers (full-time)
 - Business analyst (part-time)



OpenCDS Funding Sources

- (completed) NHGRI K01 HG004645
- University of Utah Health Care
 - Using OpenCDS to meet institutional business needs
 - Key to sustainability
- University of Utah Dept. of Biomedical Informatics
 - Investing in OpenCDS as platform for future funding
- ONC Beacon Community program
 - Using OpenCDS for public health reporting
- In-kind contributions of various collaborators



Key Lessons Learned

- Local operational support is essential
 - Meeting internal institutional needs must be #1 priority
 - Collaborators may make significant in-kind contributions but are generally reluctant to pay for services
- Grant/contract funding is still very important
 - Significantly strengthens business case for developing a CDS infrastructure that scales beyond local institution
 - Necessary to provide sufficient attention to needs of the community (vs. needs of the local institution)
- An open-source, freely available technology stack significantly facilitates adoption



Key Lessons Learned (cont'd)

- Ask not what the community can do for you; ask what you can do for the community
 - Contributions generally arise because (i) the CDS resource targets an important business need and (ii) the collaborator must enhance the CDS resource to meet its own business need
- Most CDS implementers with established knowledge representation approaches are very reluctant to adopt a new approach
 - Conversely, they are very interested in having their resource made accessible to a wider audience through an open-source, standard service “wrapper”



Key Lessons Learned (cont'd)

- Many organizations are exploring alternate CDS approaches but are reluctant to go “all-in” with any given effort because of multiple competing approaches
 - Collaboration is likely in everybody’s interest, especially if external funders can foster such collaboration
- It is incredibly fulfilling to work with like-minded collaborators to establish a community CDS resource



Recommendations

- Ensure local operational support
- Continue to identify and meet community needs
- Move towards low-cost, open-source technology stack
- Support stakeholders who utilize different approaches to knowledge representation
- Coordinate (merge?) efforts with other like-minded initiatives (e.g., OpenCDS)
- Federal agencies: support coordination and further development of community CDS resources



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 Duke Center for Health Informatics and a co-chair of the HL7 CDS Work Group. OpenCDS collaborators include the University of Utah, Intermountain Healthcare, the Veterans Health Administration, the University of North Carolina at Chapel Hill, and Apelon, Inc.

Breaking News

[OpenCDS Alpha Release Available](#) An alpha release of OpenCDS is now available to collaborators. Please see the Alpha Release tab for more information.

Posted Apr 26, 2011 9:51 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 healthcare, has joined OpenCDS as a collaborator. The OpenCDS team will be ...

Posted Apr 26, 2011 9:51 AM by Kensaku Kawamoto

[OpenCDS at AMIA 2010](#) OpenCDS collaborators will be discussing OpenCDS and/or its component technologies at the following sessions of the 2010 American Medical Informatics Association (AMIA) Fall Symposium, which will be held in ...

Posted Apr 26, 2011 9:50 AM by Kensaku Kawamoto

Thank You!

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