



Semantic Web: Benefits For Clinical Decision Support At The Bedside

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Clinical Decision Support (CDS)

A system providing “knowledge and person specific or population information intelligently filtered or presented at appropriate times”.

--Osheroff et al

- Effective CDS systems manage four dimensions
 - Data structure
 - Semantics
 - Processes
 - Inference
- Semantic Web promises to affect each of these





“Lost in Translation”

- Subject Matter Experts spend hours/days
 - Describing functional objectives
 - Detailing process orchestration
 - Explaining domain semantics
- Engineers spend hours/days/weeks translating requirements into designs, implementing prototypes, developing pilots, etc
- Endless, costly rework fixing mistakes and functionality “lost in translation”



Data Structure and Aggregation

- CDS requires information to be:
 - Appropriately comprehensive in detail and scope
 - Structurally consistent
- RDF / Linked Data advantages:
 - Facilitates data aggregation and enrichment across distributed stores ensuring an adequate corpus of detailed clinical information
 - Constructs such as *sameAs*, *equivalentClass*, and *equivalentProperty* help merge data into canonical representations



Terminology

- CDS requires information to be semantically consistent
- Current terminologies struggle with context, part-whole relations, semantic equivalence, and pre- /post-coordination, concept quantity and complexity
- OWL Advantages:
 - A uniform, rigorous, and understandable schema that includes negation, disjunction and context
 - Clear, logical organization to hierarchies and relationships
 - Improved recognition of semantic equivalence between post-coordinated and pre-coordinated terms



Domain Knowledge Alignment

- CDS requires information be aligned and consistent with the domain processes they support
 - Care processes cross multiple domains – medical, nursing, quality, fiscal
 - Effective care is coordinated, multi-disciplinary care
- OWL facilitates ontology alignment through:
 - Constructs such as *sameAs*, *equivalentClass*, etc.
 - Rule-based mapping using SWRL
- The Ontology Alignment process encourages different community perspectives/data/vocabularies to dialog/merge/harmonize – a natural fit for building systems that support multi-disciplinary teams

World Wide Reasoning

- Reasoning systems should delivery the inference functionality required for a particular problem.
 - Classic “production rules” are not optimal for all clinical decisions
 - CDS is ideally a hybrid system of different tools (fuzzy logic, defeasible logic, etc.)
- Reasoning with a world wide, distributed clinical data
 - Closed World Assumption (CWA) - any statement not known to to be true is false
 - Open World Assumption (OWA) – any statement not known to to be true is considered unknown as opposed to false



Using The Right Tool For The Job

- Ontology tools such as Protégé or Topbraid:
 - Focus clinical experts on knowledge vs. object modeling
 - Facilitate translation of domain concepts into engineering artifacts
 - Complement model-driven approaches like UML
- By representing domain knowledge explicitly, Semantic Web technologies will have profound functional implications for building affordable, shareable, and clinically effective CDS systems



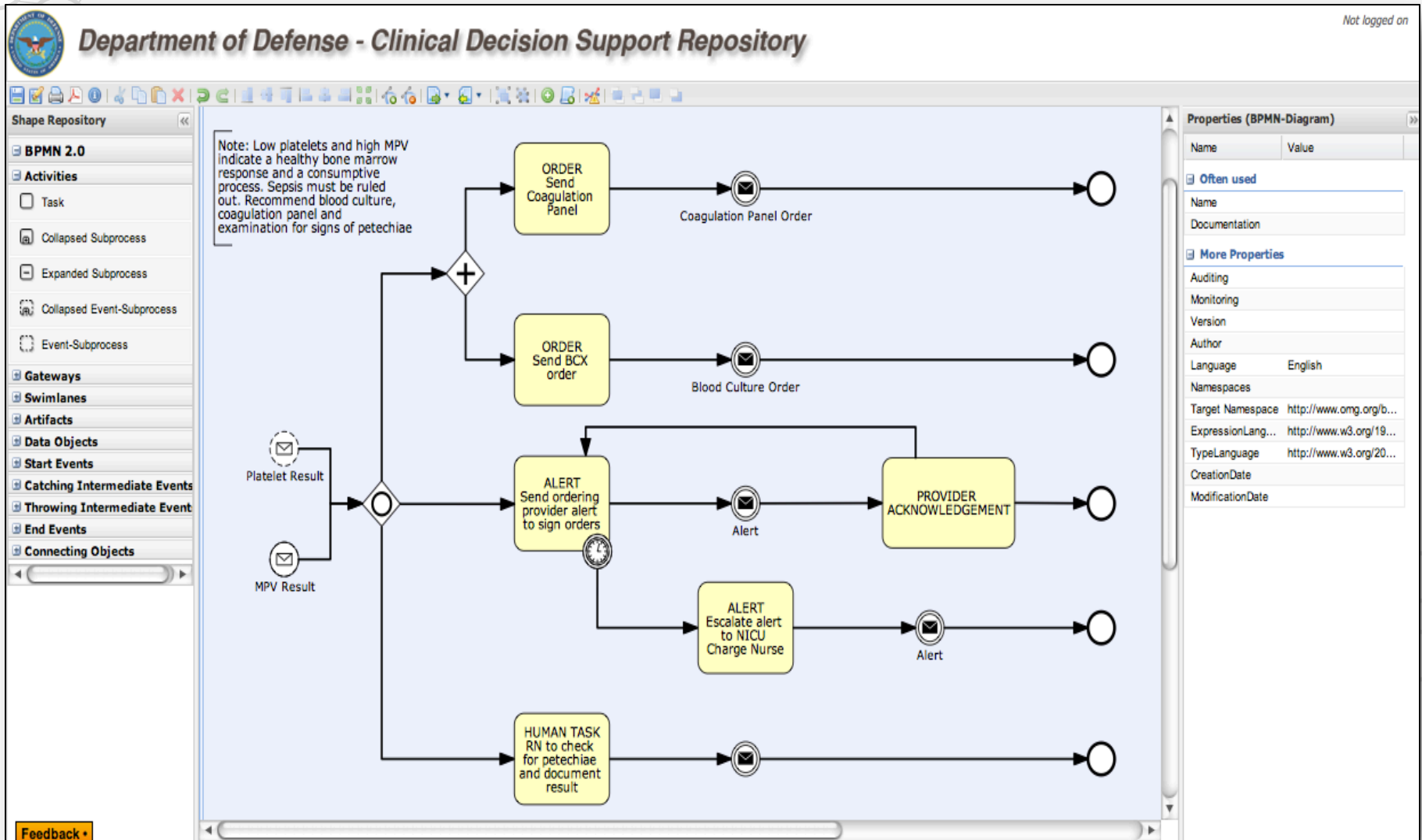
But Really...Where Are We?

- Dec 2008 – NwHIN / FHA Connect demonstrations
- Feb 2010 – VLER (VA, DoD, Kaiser) Demonstrations in San Diego
- Dec 2010 - President's Council of Advisors on Science and Technology (PCAST)
- April 2011 - DoD DCMO Mandates BPMN, RDF and OWL Semantic Technologies
- MHS/VHA/IHS -slow to recognize and invest in Semantic Web's potential vs. bio-research or non-medical agencies
- Policy mandates, political climate, and agency ecosystems still drive traditional Relational Database, Service Oriented Architecture and model-driven system development

Knowledge Management Repository

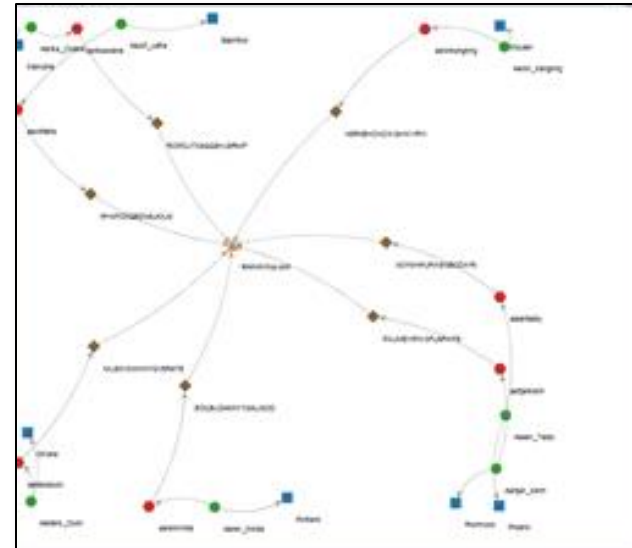
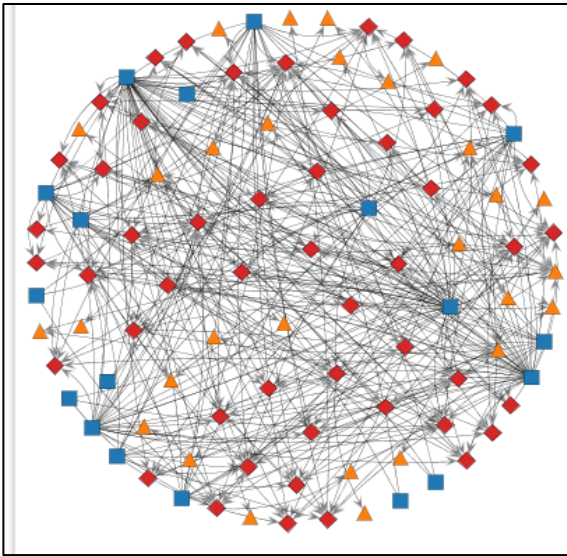
- Developed a prototypic EMR ontology in OWL
- Assembled an open source tool chain to generate:
 - XSDs for use with SOAP web services
 - Java classes for rule authoring in JBoss Drools and building clinical facts for its Production Rule Engine
- Used a Triple Store, RDF, and mapping triples to transform patient data (AHLTA, VistA and RPMS) into canonical, ontology-defined XML and Java objects
- Shared rules in common repository – executable by all three agencies

Clinical Decision Support Workbench



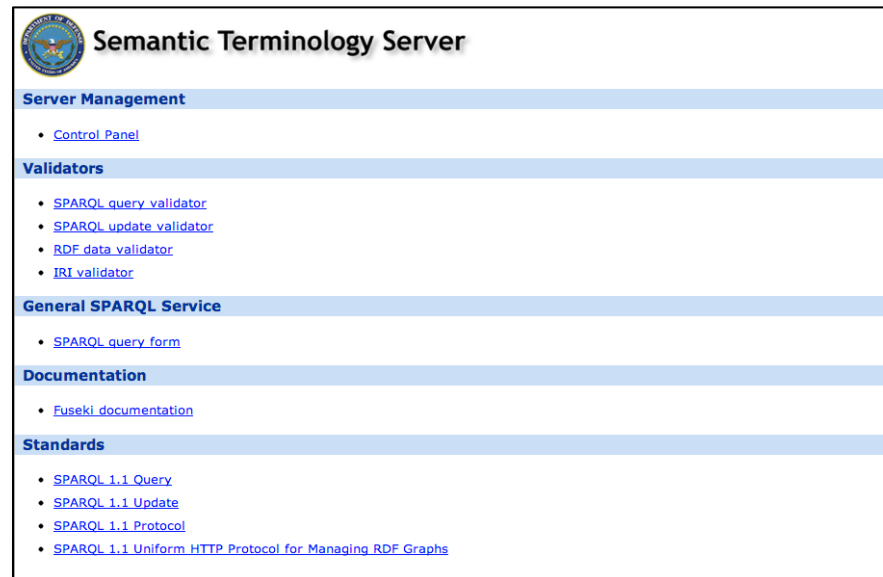
SEMOSS

- RDF framework to explore and uncover connections between clinical data sources, interfaces



SKOS Terminology Service

- SKOS ontologies for RXNORM, SNOMED, LOINC, and NDFRT; stored in Jena triple store searchable using SPARQL; exposed using HL7 CTS2 SOA Service; deployed on iEHR ESB




The screenshot displays the Semantic Terminology Server interface. It features a header with the Department of Health and Human Services logo and the title "Semantic Terminology Server". Below the header, the interface is organized into several sections, each with a blue header bar and a list of links:

- Server Management**
 - [Control Panel](#)
- Validators**
 - [SPARQL query validator](#)
 - [SPARQL update validator](#)
 - [RDF data validator](#)
 - [IRI validator](#)
- General SPARQL Service**
 - [SPARQL query form](#)
- Documentation**
 - [Fuseki documentation](#)
- Standards**
 - [SPARQL 1.1 Query](#)
 - [SPARQL 1.1 Update](#)
 - [SPARQL 1.1 Protocol](#)
 - [SPARQL 1.1 Uniform HTTP Protocol for Managing RDF Graphs](#)

Special Product Label Graphs

- VA NLP project that processed SPLs to extract drug “facts” including indications, side-effects, box warnings, etc.
- Triples validated by clinical SMEs within IHTSDO Workbench
- Exported as RDF for “mash-up” with other RDF graphs (SNOMED, NDFRT, RXNORM) and VA VistA data
- Presented in CCOW portal that obtains patient context directly from EMR thick client.

SPL "Triples" At The Bedside

 CDS Evaluation Lab Portal Jun 02 2013 | Log Out

Patient: EIGHT BCMA - 07 Apr 1935 - Male Full Screen | A | A

Medications Print | Close Record

| Active | Expired | Medication | Formulation | Dose | Route | Schedule | OrderDate | Drug Class | Prescriber |
|--------|---------|------------------------------|-------------|--------|-------|----------|------------|-------------------------------|--------------|
| | | DILTIAZEM HCL 60MG TAB | TAB | 60 MG | PO | QAM | 2013-05-14 | CALCIUM CHANNEL BLOCKERS | PROVIDER,ONE |
| | | METOPROLOL TARTRATE 50MG TAB | TAB | 50 MG | PO | BID | 2013-05-14 | BETA BLOCKERS/RELATED | PROVIDER,ONE |
| | | PROPRANOLOL HCL 40MG TAB | TAB | 40 MG | PO | BID | 2013-05-14 | BETA BLOCKERS/RELATED | PROVIDER,ONE |
| | | SIMVASTATIN 20MG TAB | TAB | 20 MG | PO | QAM | 2013-05-14 | ANTILIPEMIC AGENTS | PROVIDER,ONE |
| | | METFORMIN HCL 500MG TAB | TAB ORAL | 500 MG | PO | TID | 2013-05-14 | ORAL HYPOGLYCEMIC AGENTS ORAL | PROVIDER,ONE |

FDA Special Product Label (SPL) **SPL "Facts"**

| Indications | Monitoring | Box Warning | Side Effects | Additional Associated Triples |
|---|-------------------------|---|---|---|
| Angina Myocardial infarction Hypertensive disorder Acute myocardial infarction | Arterial pulse pressure | Dizziness Angina Myocardial infarction Sweating Coronary arteriosclerosis Hypoglycemia | Laryngismus Dizziness Dyspnea Thrombocytopenic purpura Insomnia Abdominal pain Congestive heart failure Arterial insufficiency Claudication Mood swings Vomiting Angina Constipation Rhinitis Heart block Sleep disorder Depressive disorder Disoriented | increases worsens Detail Alkaline phosphatase level - finding |

FEB 2013 iEHR Announcement

"Rather than building a single integrated system from scratch, we will focus our immediate efforts on integrating VA and DoD health data as quickly as possible, by focusing on interoperability and using existing solutions."

--Defense Secretary Leon Panetta

Future Prospects?

- Renewed agency interest in Semantic Web
- Significant opportunity for:
 - Infrastructure products and services (plumbing)
 - Vocabulary and ontology modeling (knowledge)
 - Privacy and data segmentation solutions for federated data (security)
- Continued need for product/studies/demonstrations of how Semantic Web improves outcomes – sustains health