Semantic Web: Benefits For Clinical Decision Support At The Bedside

Emory Fry, MD
SemTechBiz 2013
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 deliver 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 be true is false
  – Open World Assumption (OWA) – any statement not known 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

Department of Defense - Clinical Decision Support Repository

Note: Low platelets and high MPV indicate a healthy bone marrow response and a consumptive process. Sequestra must be ruled out. Recommend blood culture, coagulation panel, and examination for signs of petechiae.
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
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
"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