semedy

HEALTHCARE KNOWLEDGE TO THE POINT

RULE-BASED CLINICAL DECISION SUPPORT

Jürgen Angele, RuleML, Prague, August 2014
Introduction
CKMS (clinical knowledge management system)
Rules within CKMS
Rule Engine
Summary
Admission to the hospital…. Medical specialist available?

It’s reassuring to know that they have the Clinical Knowledge Management System from semedy.

It supports Physicians and nurse staff with best practice clinical knowledge.

Collaboratively developed with and in use at Partners HealthCare (Harvard Medical School).
Widespread distribution of Electronic Health Record (EHR) and Hospital Information Systems (HIS)

Clinical knowledge management and decision support

Clinical knowledge:
• Explosive growth
• High dependencies between knowledge assets
• Usage across multiple IT applications
• Centralized management and reuse of knowledge is NOT available.

Increase in effort and costs

Regulatory and Cost drivers in healthcare

Hospitals’ challenges trigger a strong demand for CKMS
semedy offers clinical knowledge management and decision support for physicians and nurse staff

Software
• Web based software solution for centralized management and maintenance of all clinical knowledge assets.

Services
• Integration, import and update of clinical knowledge at the right context at the right moment into the clinical workflow.

Content
• Prepackaged clinical content is available and co-developed with Partners HealthCare / Harvard Medical School
Clinical knowledge is the hospital’s USP! We manage it!

Clinical knowledge must be owned by the hospital, not by the application vendor! It has to be released from applications to target for a centralized management and maintenance.
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semedy offers intelligent, automated clinical knowledge management and decision support technology

**semedy memory**

- Clinical Knowledge Management System (CKMS)
- Improves the efficiency and reliability of clinical knowledge creation and management
- Enables consistent and comprehensive knowledge use across a hospital group
- “Clinical Content App Store”

**semedy reasoner**

- Leading edge rule-based, powerful reasoning engine
- Supports automatic intelligent decision support, taking the patient context into account
- Semantic understanding and ontology management capabilities
semedy’s CKMS is generated in an editing environment (left) and then deployed, with innovative CDS Modules (right).

**Cisco & CDS Use**

- **Hospital Info. System**
  - CDS Module
  - CKMS
  - CKMS GUI
- **Easy Deployment**
- **Inferencing**
- **Preconfigured Clinical Content**
- **Knowledge Acquisition & Editing**
- **Knowledge Representation & Reasoning / Interpretation**
- **Real-time use of in-house patient data**
- **Knowledge Representation & Reasoning / Interpretation**
- **Intelligent Decision Support**
- **optional update / feedback loop**

**USP = combination of top content with top technology**
## Innovative CDS Applications Pipeline

### CDS Categories (HIMSS Classification):

1. Alerts and Reminders
2. Clinical Guidelines / Care Plans
3. Patient Data Reports, Templates, Summaries
4. Multi-Patient Monitors and Dashboards
5. Diagnostic Support
6. Predictive & Retrospective Analytics
7. Reference Information & Knowledge Resources
8. Order Sets

### Potential CDS Pipeline

- ** Prescription alerts in patient context
- ** Real-time adverse event monitoring & reporting
- ** Optimize Prescriptions in Patient Context
- ** Optimize clinical pathways with real-world data
- ** Automated Patient Summaries for Anaesthesia
- ** Acute-care documentation templates in context
- ** tbd
- ** tbd
- ** Risk management for care delivery
- ** Enhanced analysis of treatments and outcomes
- ** Integrated Medication Dictionary
- ** tbd
 Situation today:
Complex questionnaires required from patients prior to anaesthesia for surgery, usually hospital visits required to fill out

Solution:
- Web-based questionnaire
- Questions linked to EHR information, drug dictionaries, etc.
- Inference engine only asks selected questions based on specific patient context
- Patient has no travel effort and can provide all info from home

CDS Module
"Automated Patient Summary for Anaesthesia"
- Solution provides summary of questionnaire listing relevant information only
  -> saves time of physician,
  -> avoids risks due to information missed in voluminous texts
  -> avoids risks due to additional analyses running in the background
- Administrative effort is reduced
  -> saves cost

Patient Data (EHR/HIS):
- Name: A.
- Gender: male
- Age: 65
- Insurance Status: xxx
- GP/physician: xxx
- Disease History: xxx
- Drug History: xxx
- X-Ray: xxx
- Lab Values: xxx
- Diagnosis:
  - Xxx
  - Xxx
  - Xxx
  - Xxx

Automatically Executable Medical Knowledge
Product Portfolio and Pipeline
CDS Modules – Example:
Optimize Prescriptions in Patient Context

**Event:** (true recent case)
Mr. H., 70 yrs., collapsed in the cemetery, thereby injured his foot and was transported by ambulance to the local hospital

**Patient History:**
- Severe age-related diabetic
- Water detected in lung twice
- Had cardiovascular problems (already had a stroke)
- Had nervous cough treated with calcium-antagonist
- Has bad liver values

**Emergency Room**

**Physician**

**CDS Module**
"Automated Medication Prescription Support"

**Question:** Which drugs are fitting?

**Answer:**
- Clopidogrel (Plavix®) – Blood thinning drug
- Ezetimib (Ezetrol®) – Lipid lowering drug
- Simvastatin (Generic) – Lipid lowering drug
- Valsartan (Diovan®) – Lowering blood pressure
- Metformin (Glucophage®) - Antidiabetic
- Insuline-Cocktails (short & long) - Antidiabetics
- Furosemid (Lasix®) – dehydration drug
- HCT (Generic) - dehydration drug
- Ibuprofen (Generikum) – pain drug

**Patient data (EHR/HIS)**
- Name: H.
- Gender: male
- Age: 70
- Insurance Status: xxx
- GP / physician: xxx

**Disease history:**
- Diabetes
- Vessels narrowed
- Foot broken
- No heart insufficiency and no rhythm dysfunction

**Blood values:**
- Transaminase increase, diabetes status X, Lipides X

**Diagnose:**
- Diabetes
- Vessels narrowed
- Foot broken
CKMS - technical view

Frame based knowledge representation system for clinical knowledge

- Authoring/collaboration system
  - Ontology editor
  - Instance editor
  - Community functionality
  - Publication process

- Sophisticated versioning

- Rules for
  - Validation of the knowledge
  - Representing complex knowledge
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CKMS – Domain Model

- Patient
  - Has Active Problems
  - Has Allergies
  - Has Lab Results
  - Has Immunizations

- Problem
- Allergy
- Lab Result
- Immunization Record
PQRS Rules – HbA1c Rule

• If a patient with 5-75 years of age, has diabetes in his/her problem list and has no reported HbA1c during the measurement period, then alert the user (rule is true).

• The last measured value for HbA1c has to be < 1 year
Patient – Schema definition
Patient Cristina
Validating the rules
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Needed logic

- Data log
- Normal logic
- Horn logic (FOL)
- First order logic (FOL)

Syntactic inclusion
Needed logic

Normal logic (stratified negation) selects ONE minimal model.
FOL considers all models.

Horn logic = Normal logic without negation.

Data log

Semantic inclusion

First order logic
Needed logic

Expressive power

first order logic

Horn logic

Datalog

SQL
sem.reasoner – History

SiLRI: Simple Logic-based RDF Interpreter

Originally developed for KA2 initiative by Stefan Decker, FLogic-Compiler, Jürgen Angele, Inference Engine 1995 - 1997

Extended for Reasoning in RDF with FLogic Rules, 1998
S. Decker, D. Brickley, J. Saarela und J. Angele: A Query and Inference Service for RDF.
Inference Engine Benefits

**Multi Purpose**
- Big Data + Ontologies + Rules
- Online data integration
- Stream based reasoning (CEP)

**High Performance**
- Deductive db algorithms strongly improve performance
- Fast loading (a billion triples / 5h)
- Fast processing via encoding of contents
- Fast (automatic) index generation

**Flexibility and Scalability**
- 8+ billion triples
- Seamless integration of relational technology into reasoning
- Only a few tables (graph based model) - supports high flexibility & performance
sem.reasoner components

Big Data + Ontologies + Rule Based Reasoning

Server

Compiler

Inference Kernel

Rewriter System

<table>
<thead>
<tr>
<th>IDB (intensional DB)</th>
<th>Reasoner</th>
<th>Builtin System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensional Database (RAM based or persistent based on B+ Trees)</td>
<td>Symbol Table (RAM based or persistent based on B+ Trees)</td>
<td></td>
</tr>
</tbody>
</table>

- Blue components: existing
- White components: in development
Fast reasoning

join1, no query binding,
250000 triples

See http://rulebench.projects.semwebcentral.org/
Integration into reasoning

- relational technology
- directly integrated into our reasoning
- deductive database
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Next challenges

**Bringing**

Different business rule technologies
  - ILOG
  - Tipco
  - Fair Isaac
  ...

From different applications

**Into CKMS and back**

- rule execution
- rule editor
Benefits of Next-Generation CKMS Solutions

- **Reducing hospitalization rates**, e.g. through improved chronic disease management
- **Less re-hospitalization** due to fewer drug side-effects when leaving the hospital
- **Shorter hospitalization** due to shorter drug adjustment time by context-based prescription support; also reduces physician workload / time
- **Higher profitability of hospitals / DRG codes**, e.g. drug portfolio optimization and integrated analysis of drug purchasing, prescription and utilization
- **Higher quality of care** due to improved clinical pathways correlated with clinical outcomes
- **Improved ability to conduct clinical research**, e.g. automated patient recruitment for clinical trials
- **Proven quality risk management practices** applied to hospital setting
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HEALTHCARE KNOWLEDGE TO THE POINT

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