

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

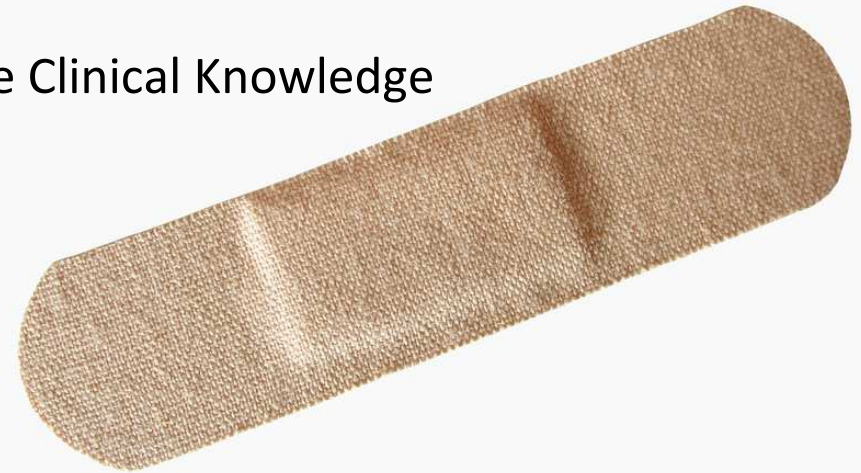
Summary

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).



Hospitals' challenges trigger a strong demand for CKMS

Clinical knowledge management and decision support



Widespread distribution of Electronic Health Record (EHR) and Hospital Information Systems (HIS)

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

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

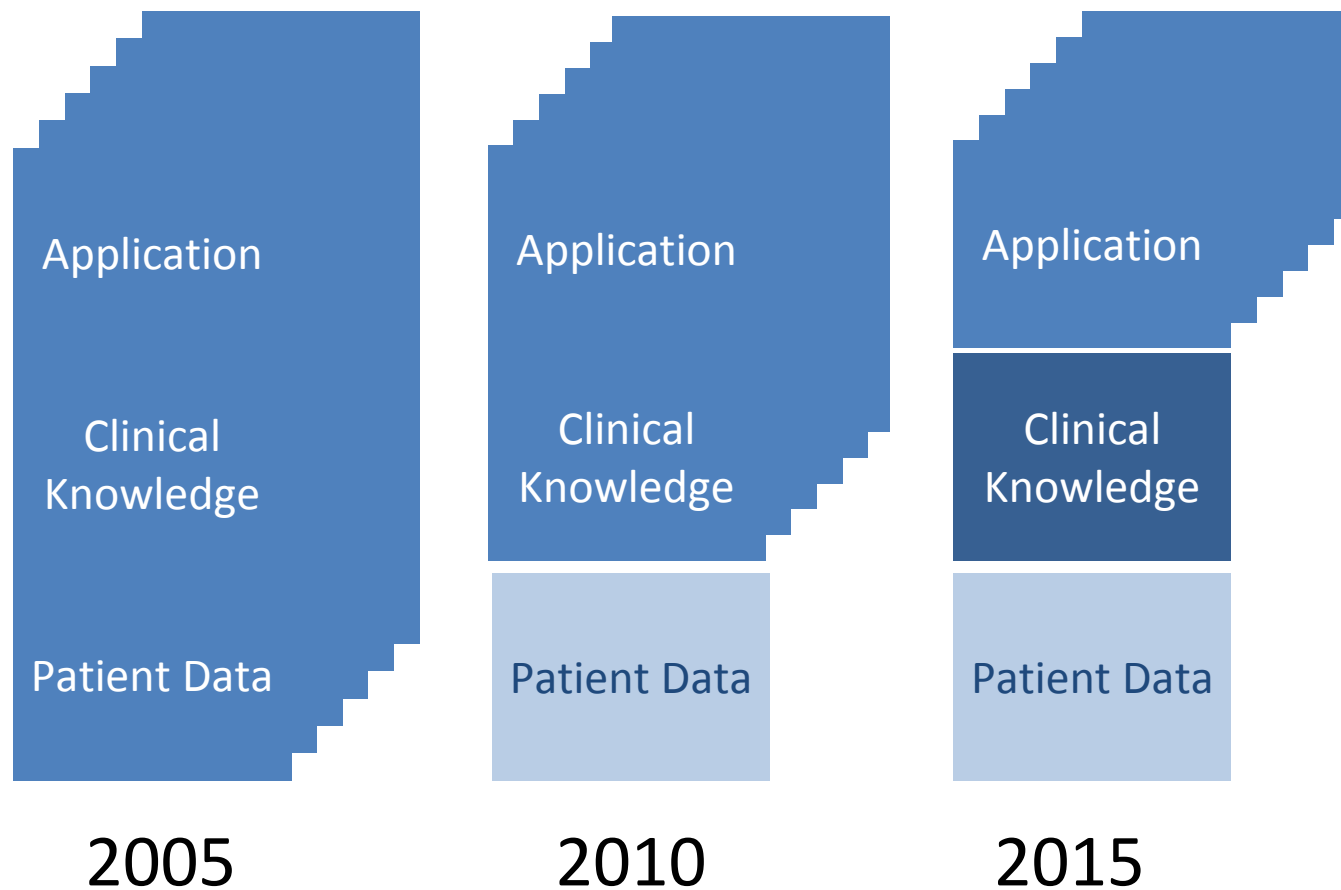
- Integration, import and update of clinical knowledge at the right context at the right moment into the clinical workflow.

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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Summary

semedy offers intelligent, automated clinical knowledge management and decision support technology

sem●memory

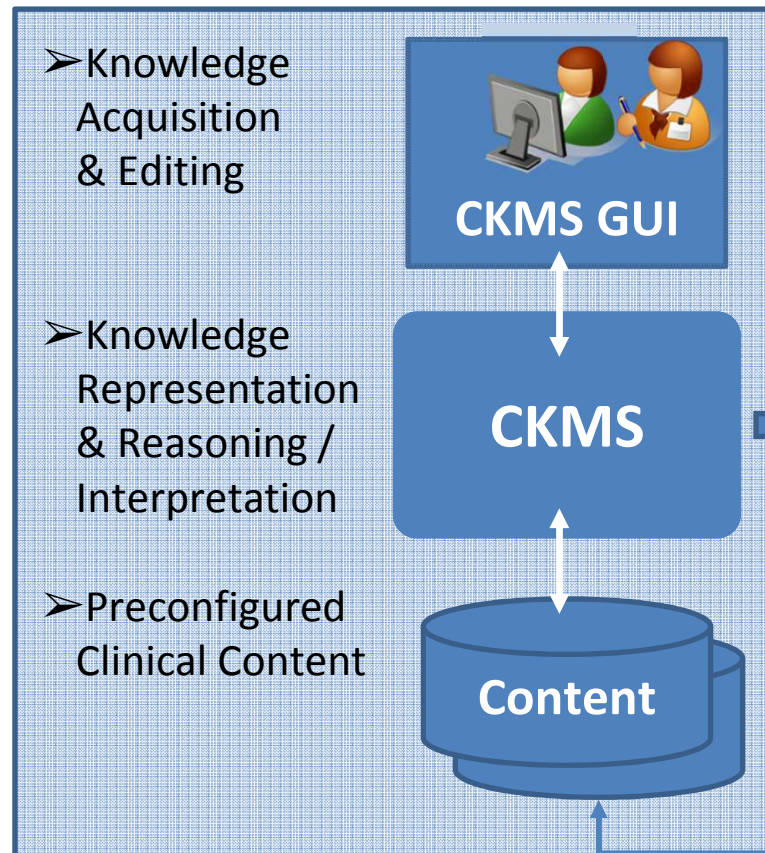
- **Clinical Knowledge Management System (CKMS)**
- Improves the efficiency and reliability of clinical knowledge creation and management
- Enables consistent and comprehensive knowledge use across a hospital group
- “Clinical Content App Store”

sem●reasoner

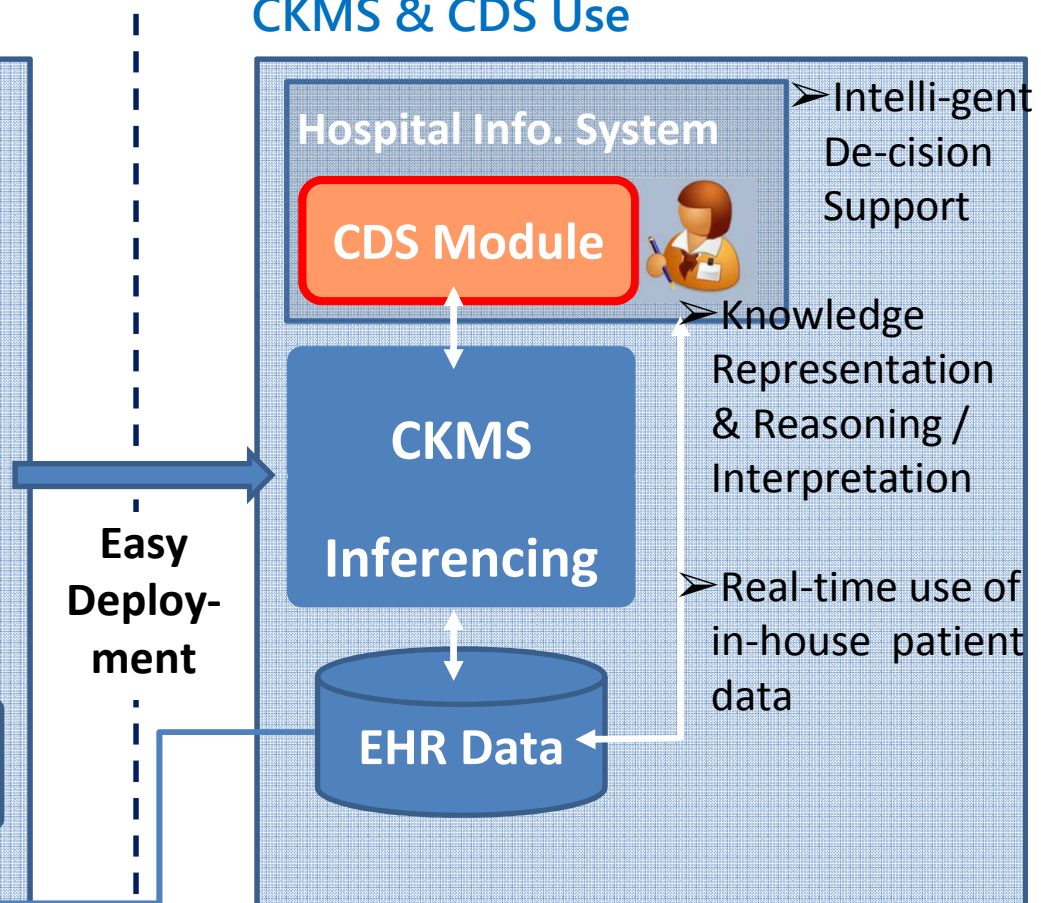
- Leading edge rule-based, powerful **reasoning engine**
- Supports automatic intelligent decision support, taking the patient context into account
- Semantic understanding and ontology management capabilities

semedy's CKMS is generated in an editing environment (left) and then deployed, with innovative CDS Modules (right)

CKMS



CKMS & CDS Use



Easy Deployment

optional update / feedback loop

sem.apps - 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

Product Portfolio and Pipeline

CDS Modules – Example:

Automated Patient Summaries for Anaesthesia




Patient


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“


Physician

- 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

semedy **CKMS**

Automatically Executable Medical Knowledge

Patient Data (EHR/HIS)

- Name: A.	- Disease History: xxx	- Diagnosis:
- Gender: male	- Drug History: xxx	•Xxx
- Age: 65	- X-Ray: xxx	•Xxx
- Insurance Status: xxx	- Lab Values: xxx	•Xxx
- GP / physician: xxx		•xxx

Product Portfolio and Pipeline

CDS Modules – Example:

Optimize Prescriptions in Patient Context



Patient

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

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

No Aspirine !
(stroke history)

No Calcium-Antago-nist !
(Cough)

No Parace-tamol !
(Liver)



semedy **CKMS**

Automatically Executable Medical Knowledge

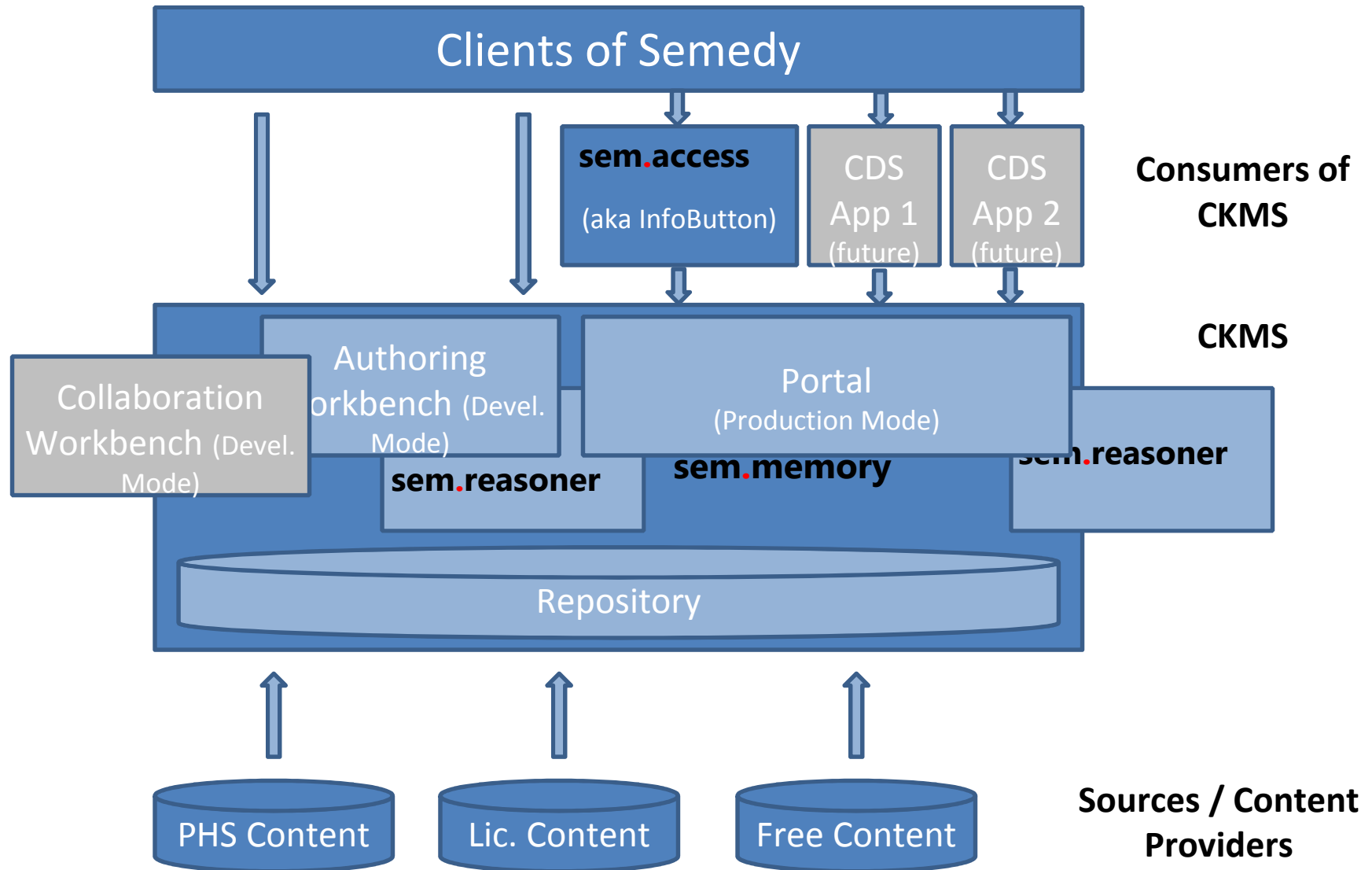
Patient data(EHR/HIS)

- Name: H.
- Gender: male
- Age: 70
- Insurance Status: xxx
- GP / physician: xxx

- Disease history: xxx
- Drug history: xxx
- X-ray (foot): xxx
- Blood values: Transaminase increase, diabetes status X, Lipides X

- Diagnose:
 - Diabetes xxx
 - Vessels narrowed xxx
 - Foot broken xxx
 - No heart insufficiency and no rhythm dysfunction

High-Level CKMS Architecture



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



Introduction

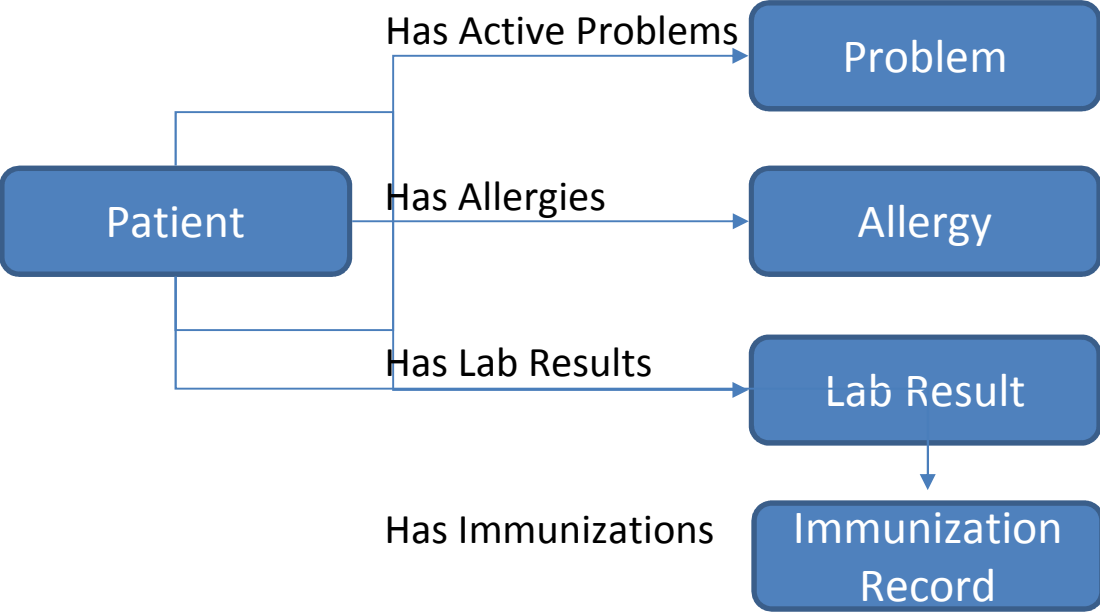
CKMS (clinical knowledge management system)

Rules within CKMS

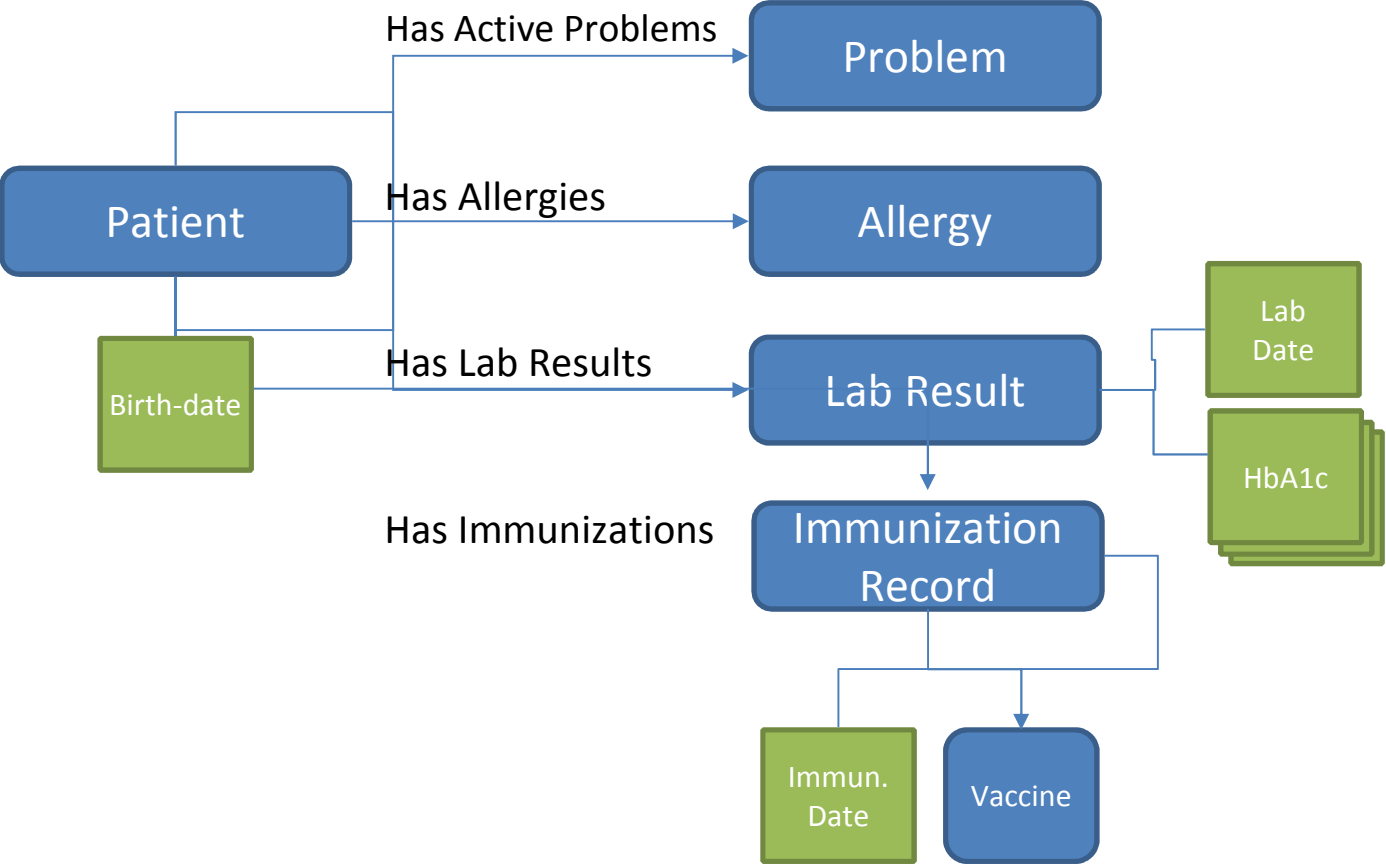
Rule Engine

Summary

CKMS –Domain Model



CKMS –Domain Model



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

The screenshot displays the CKMS interface. At the top, there is a header with the CKMS logo, the text "Clinical Knowledge Management System", and "Test Mode". A search bar is present with the text "Type here" and a "Search" button. The user is logged in as "admin" on "01.08.2014". The main navigation menu includes "HOME", "ADMINISTRATION", "CONTACT US", "HELP", "ACTIONS", "COLLABORATION", and "LOGOUT".

The main content area is titled "Patient [1]" and shows "Details for Patient". The "Actions" menu includes: "Create entity", "Create Subtype", "Create Revision", "To Approved", "To Non-publishable", "Change Curator", "Validate", "Refresh", "Preview", and "Contact curator". There are also checkboxes for "Highlight changes to prior revision" and "Subscribe to entity changes". A "Revisions: 1" dropdown is visible.


The "Properties" section is expanded, showing the following details:

Initial Lifecycle State for Instances	Work In Progress
Parent Type	Entity
Type Is Final	false

The "Property Declarations" section is also expanded, showing the following details:

Active Problem	Problem (min:0, max:unbounded)
Allergy	Allergy (min:0, max:unbounded)
Birthdate	http://www.w3.org/2001/XMLSchema#dateTime (min:1, max:1)
Immunization	Immunization Record (min:0, max:unbounded)
Lab Result	Lab Result (min:0, max:unbounded)
Authority	Authority (min:1, max:1)
Base LSID	ckms:Lsid (min:1, max:1)
Constrain	Constraint (min:0, max:unbounded)
Creator	User (min:1, max:1)
Curator	User (min:1, max:1)
Date Created	http://www.w3.org/2001/XMLSchema#dateTime (min:1, max:1)
Date Last Appraised	http://www.w3.org/2001/XMLSchema#dateTime (min:0, max:1)

Patient Cristina



Test Mode

Welcome, admin | 01.08.2014

Search

[Advanced Search](#)

HOME | ADMINISTRATION | CONTACT US | HELP | ACTIONS ▾ | COLLABORATION ▾ | LOGOUT

Dashboard Cristina [1] Cristina Lab Result 1 [1]

Details for Cristina

Revisions: 1 ▾


Highlight changes to prior revision
 Subscribe to entity changes

Actions [Create Revision](#) [To Approved](#) [To Non-publishable](#) [Change Curator](#) [Validate](#) [Clone](#) [Refresh](#) [Preview](#) [Contact curator](#)

- Identifier
- Metadata
- Designations
- Constraints
- Exclusions
- Properties
 - Active Problem [Diabetes](#)
 - Allergy [Egg Allergy](#)
 - Birthdate 1. Januar 1975 01:00:00
 - Immunization
 - Lab Result [Cristina Lab Result 1](#)
- Associations
- Notes
- Value of

Test mode
Partners Healthcare Systems
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HOME | ADMINISTRATION | CONTACT US | HELP



FOUNDED BY BRIGHAM AND WOMEN'S HOSPITAL
AND MASSACHUSETTS GENERAL HOSPITAL

<Nr.>

Validating the rules

The screenshot displays the CKMS Authoring Workbench interface. At the top, the CKMS logo is visible, along with the text 'Clinical Knowledge Management System' and 'Authoring Workbench'. A search bar is present with the placeholder text 'Type here' and a 'Search' button. The user is logged in as 'admin' on 'Jun 16, 2014'. The main navigation bar includes links for 'ADMINISTRATION', 'CONTACT US', 'HELP', 'ACTIONS', 'COLLABORATION', and 'LOGOUT'. The dashboard shows several tabs: 'Overview', 'My Tasks', 'My WIP', 'My Under Review', 'My Instances', and 'My Queries'. The 'My Instances' tab is active, displaying a table of entities. The table has columns for 'Entity Name', 'ID', 'Entity Type', 'State', 'Created', and 'Modified'. The entities listed are Cristina, Meredith, Richard, and Callie, all of type 'Patient' and state 'Under Review'. A 'Validation Result' dialog box is open in the foreground, displaying a yellow warning message: 'HbA1c lab result is due Rule1 (LSID=urn:lsid:semedy.com:example2:Rule1, State=Under Review) - Cristina : HbA1c is due (381 days since last HbA1c lab result)'. The dialog box has 'OK' and 'Cancel' buttons at the bottom.

CKMS
Clinical Knowledge Management System
Authoring Workbench

Welcome, admin | Jun 16, 2014

Type here Search

ADMINISTRATION | CONTACT US | HELP | ACTIONS | COLLABORATION | LOGOUT

Dashboard

Overview My Tasks My WIP My Under Review My Instances My Queries + Create Entity

Authority
semedy.com (4)

Namespace
example2 (4)

Entity Type
Patient (4)

State
Under Review (4)

Created
Modified
Last Appraised

50 ITEMS/PAGE Filter by name PAGE

Entity Name	ID	Entity Type	State	Created	Modified
Cristina	example2:...stina:1	Patient	Under Review	16-Jun-2014	16-Jun-2014
Meredith	example2:...edith:1	Patient	Under Review	16-Jun-2014	16-Jun-2014
Richard	example2:...chard:1	Patient	Under Review	16-Jun-2014	16-Jun-2014
Callie	example2:...allie:1	Patient	Under Review	16-Jun-2014	16-Jun-2014

Edit Create Revision Clone To Approved To Non-publishable Change Curator Update Appraisal Date Create Collection

Add to Collection Validate

Validation Result

HbA1c lab result is due
Rule1 (LSID=urn:lsid:semedy.com:example2:Rule1, State=Under Review)
- Cristina : HbA1c is due (381 days since last HbA1c lab result).

OK Cancel

Authoring Workbench
Partners Healthcare Systems
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Introduction

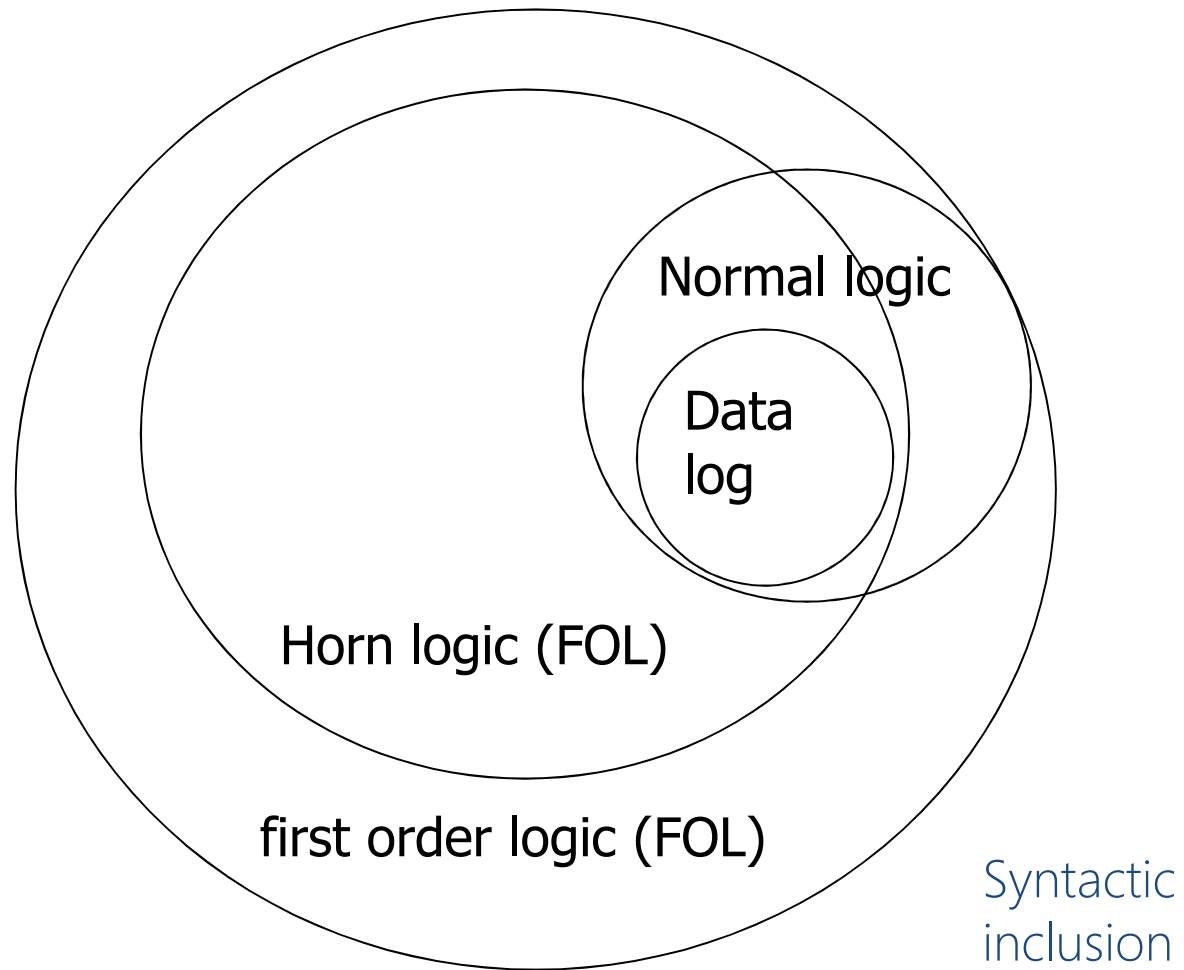
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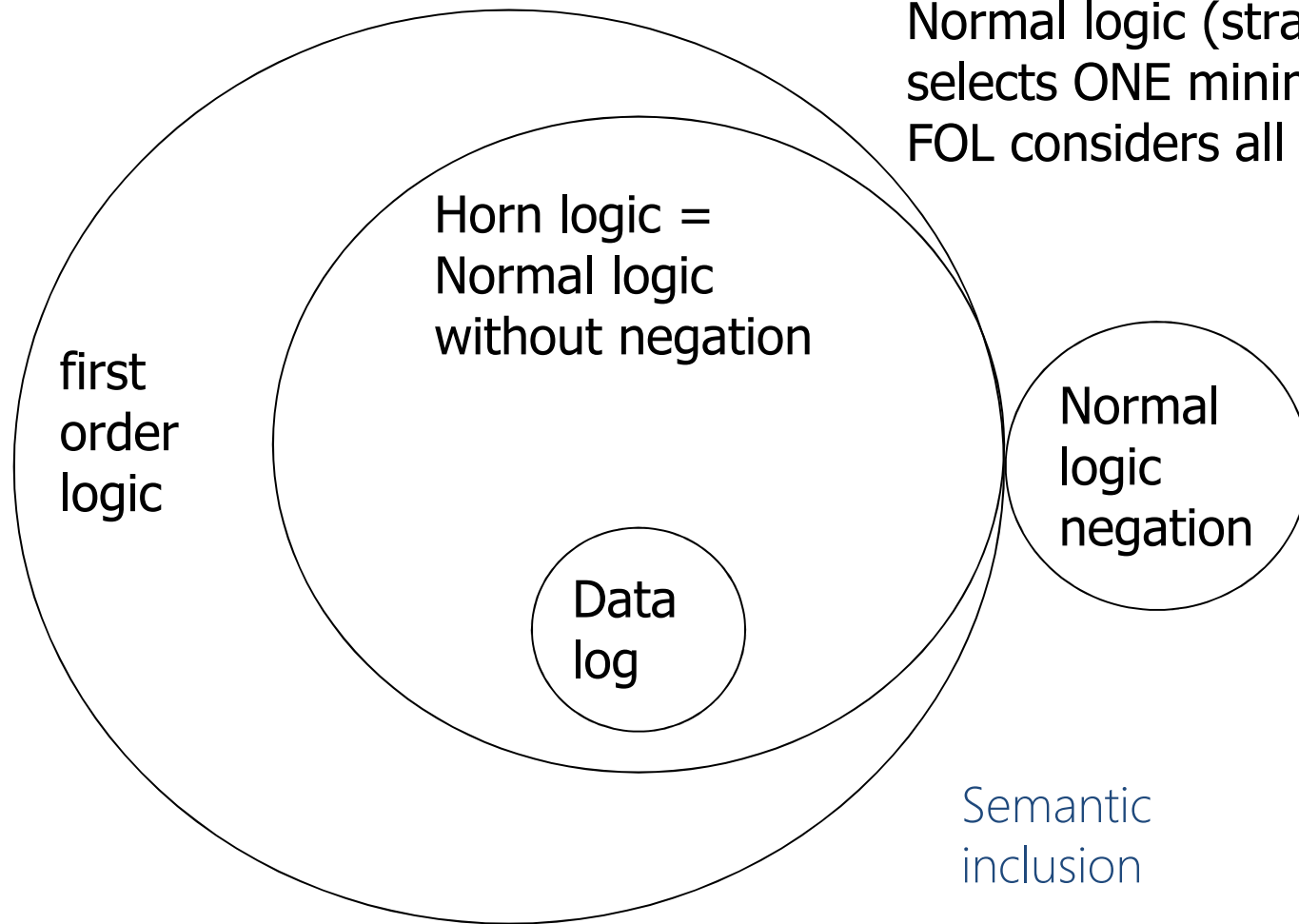
Rule Engine

Summary

Needed logic

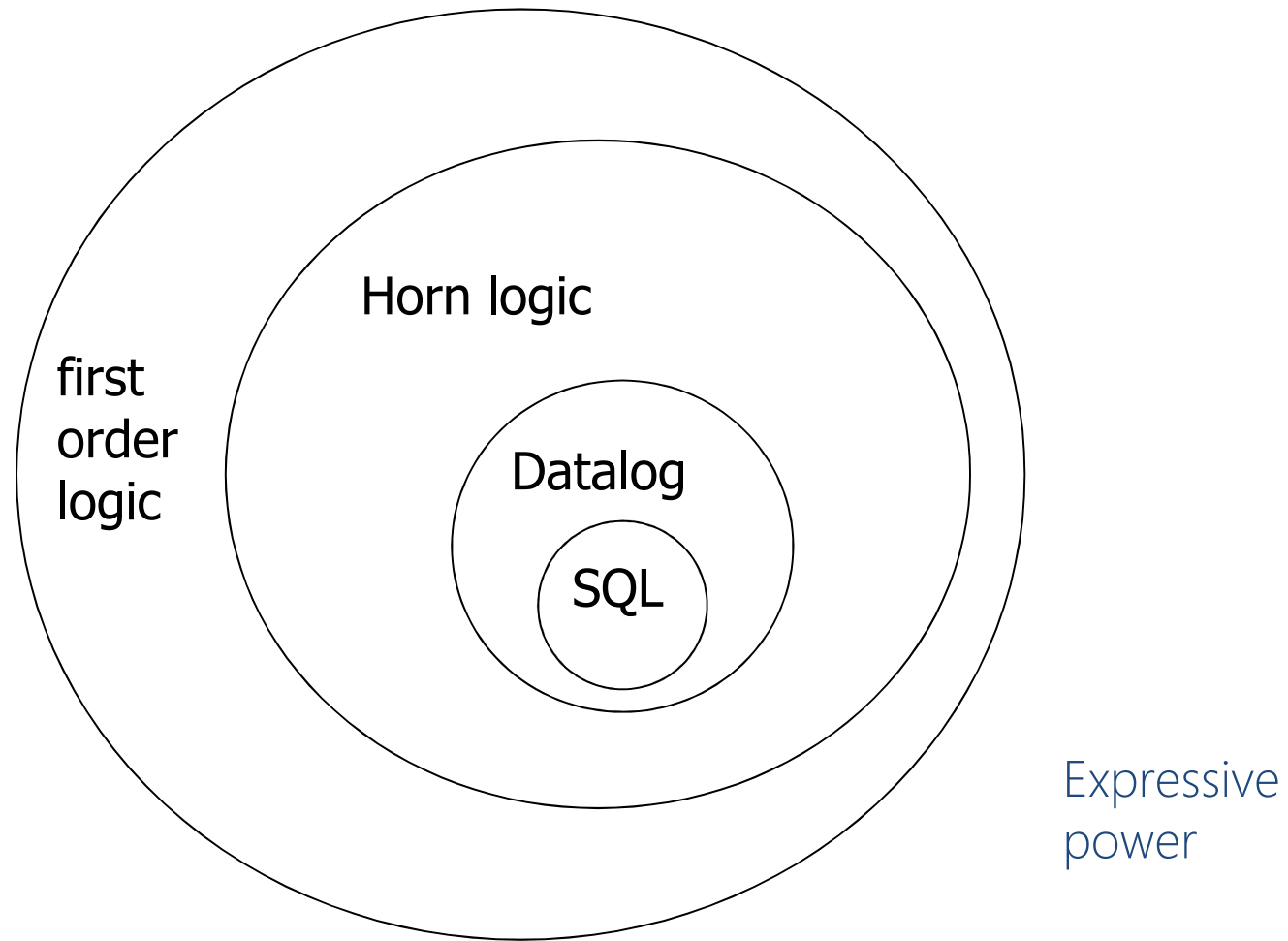


Needed logic



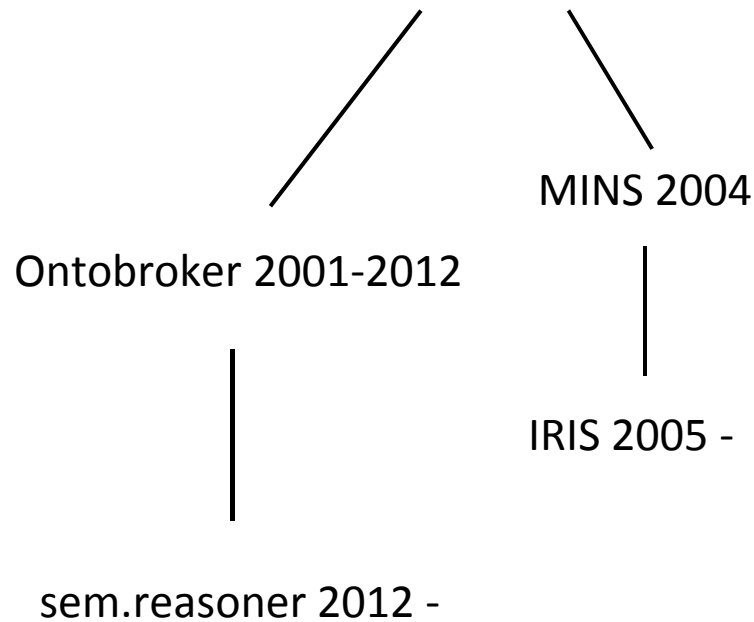
Normal logic (stratified negation)
selects ONE minimal model
FOL considers all models

Needed logic



sem.reasoner – History

SiLRI: Simple Logic-based RDF Interpreter

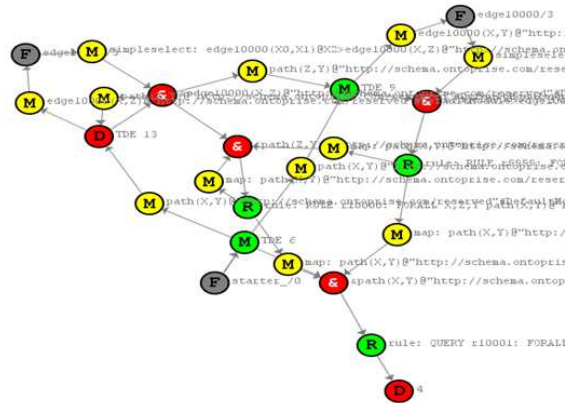


Originally developed for KA2 initiative by Stefan Decker, FLogic-Compiler, Jürgen Angele, Inference Engine 1995 - 1997

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. In Proceedings of the W3C Query Language Workshop (QL-98), Boston, MA, 3.-4. Dezember, 1998.

sem.reasoner – Inference Engine Benefits



- **Multi Purpose**

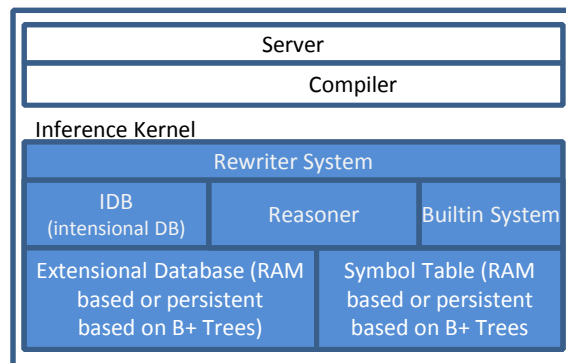
- Big Data + Ontologies + Rules
- online data integration
- Stream based reasoning (CEP)

- **High Performance**

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

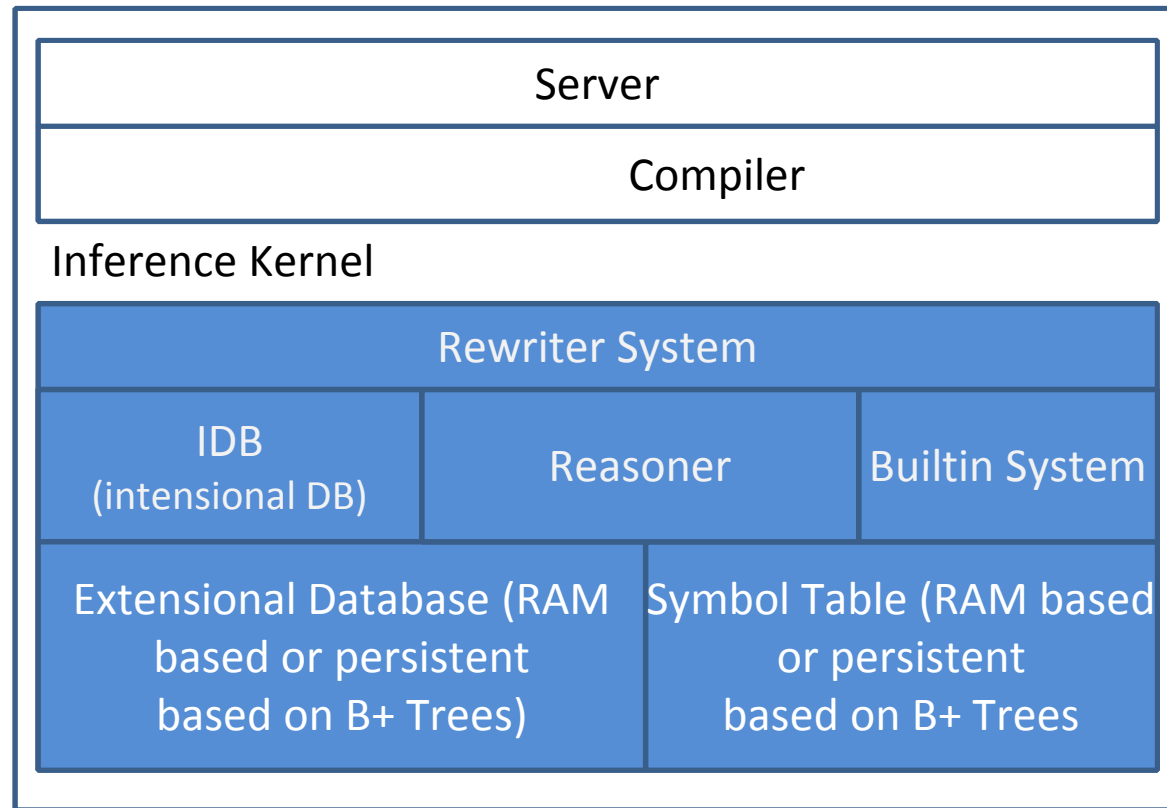
- **Flexibility and Scalability**

- 8+ billion triples
- Seamless integration of relational technology into reasoning
- Only a few tables (graph based model) - supports high flexibility & performance



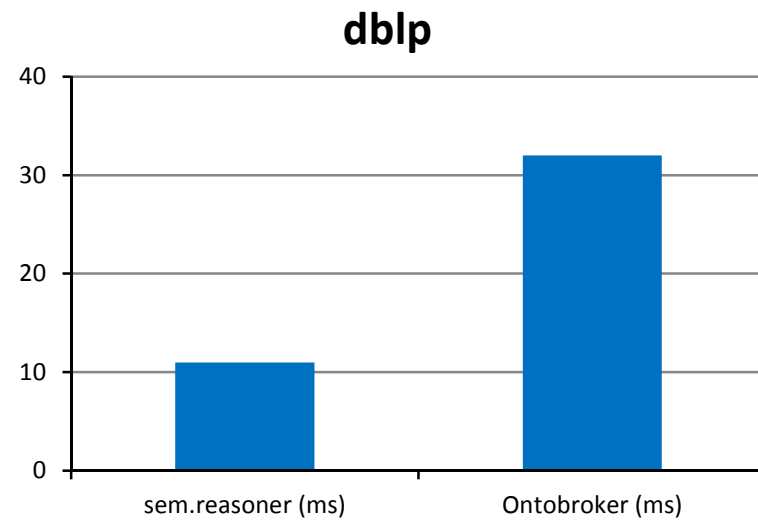
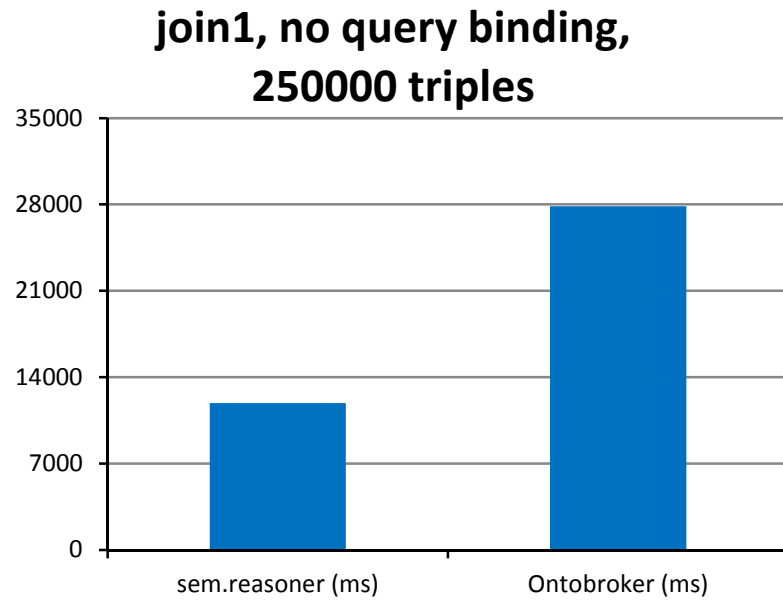
sem.reasoner components

Big Data + Ontologies + Rule Based Reasoning



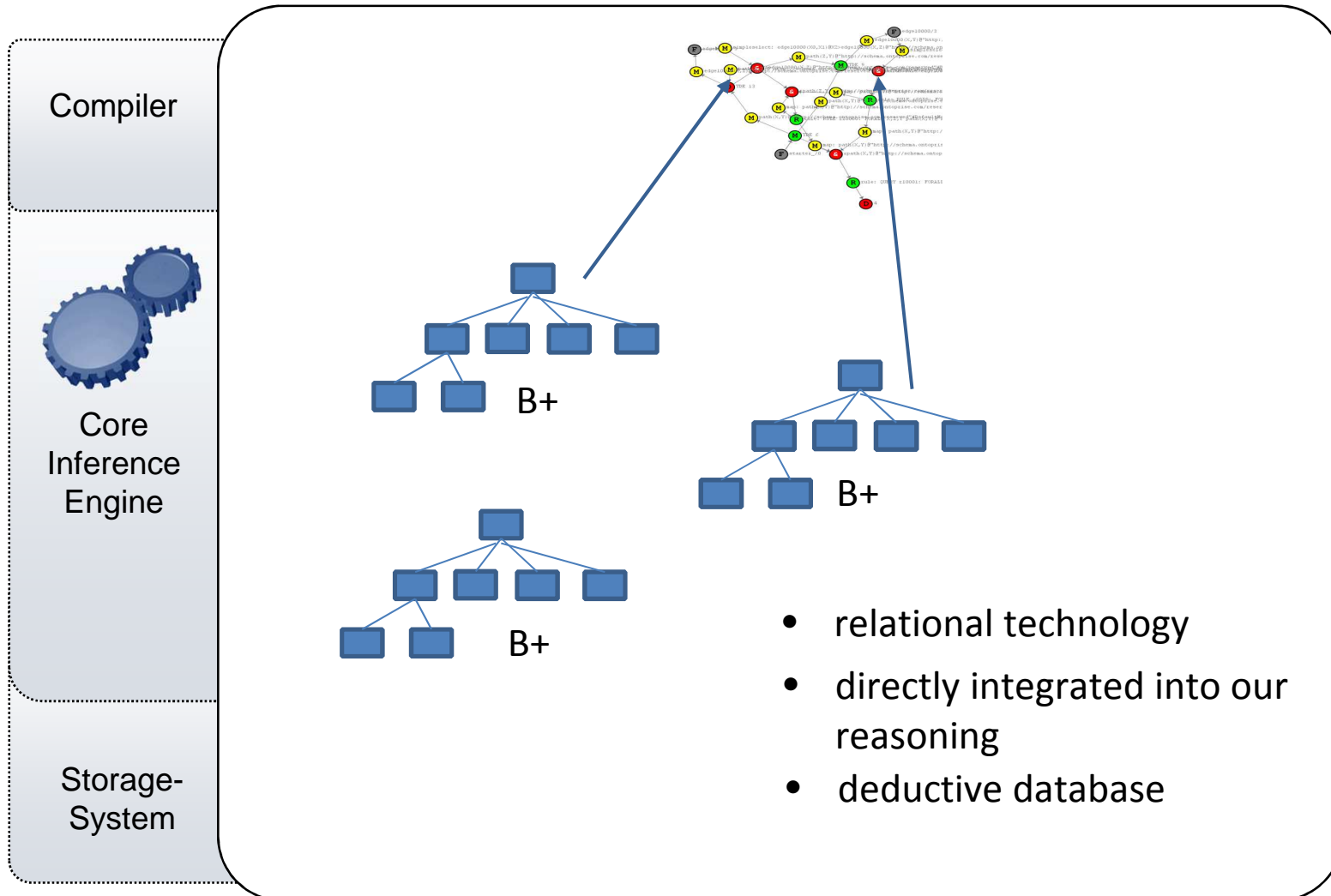
- Blue components: existing
- White components: in development

Fast reasoning



See <http://rulebench.projects.semwebcentral.org/>

Integration into reasoning





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Summary

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

semedy
CKMS

and rules play
an important role

- **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

semedy

HEALTHCARE KNOWLEDGE TO THE POINT

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