

***Sharing* Clinical Decision Support
Rules Using *openEHR*
Archetypes and
SNOMED CT**

IHTSDO Showcase 2012

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Outline

- **Background**
 - Who, why, how
- **Guide Definition Language (GDL)**
 - Scope, aims, design
- **Implementation of GDL**
 - GDL Editor, some examples
- **SNOMED CT related implementation issues**
- ***Live* Demo of GDL Editor**
- **Summary & Questions**



Cambio Healthcare Systems

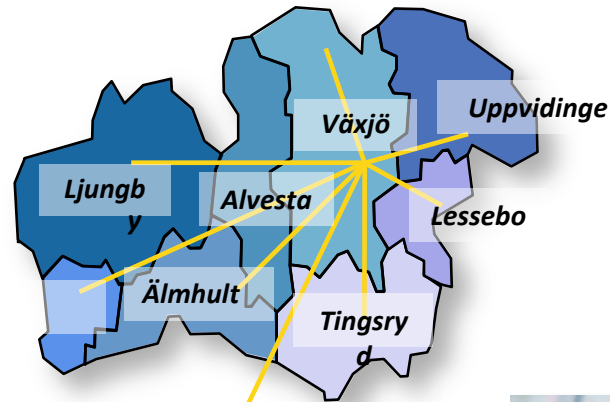
- Founded in 1993
 - 330 staff across the globe
 - Private and Venture funded
- The leading provider of **Regional EHR solutions** in Scandinavia - presence in Sweden, Denmark, UK, others to follow
- COSMIC is an international standard product
- Close to 95 000 staff users when current projects are fully implemented
- Our solutions are open, scalable and flexible based on *industry standards*
- Cambio invests 150 000 hours annually in COSMIC
- ISO 9001 certification and CE Marked EHR

One Patient – One Record – Anytime – Anywhere



County of Kronoberg

7% of the working people in Kronoberg are COSMIC users.



National Patient and Care provider portal

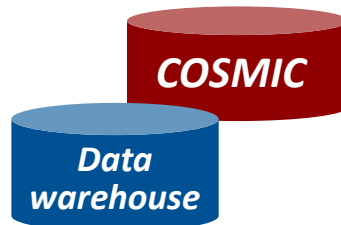
- Wireless Network in hospitals
- VPN over Mobile network
- VPN over Internet
- Network of Municipalities
- National Network for Healthcare in Sweden
- 95 % of the population in Kronoberg have an EHR in COSMIC

Cambio COSMIC:

- Main application and platform for process support
- Common repository for all healthcare information

Integrated with:

- Clinical care support system
- Medical equipment
- Digital archives and PACS
- Decision support



Background

- **Computerized Clinical Decision Support (CDS)**
 - Evidenced-based medicine, improved efficacy
 - Improved patient safety
- **Update-to-date CDS content is critical**
 - Fully computerized
 - Terminology bound
 - Based on common EHR models
- **Sharing of CDS Rules**
 - Sharing within our customer group
 - Sharing with external clinical groups
 - Medical knowledge is open, and should be shared !!

Stroke Prevention in Atrial Fibrillation

- **20% of strokes** caused by atrial fibrillation
- **European guideline on management of atrial fibrillation**, European Heart Journal (2010) 31, 2369–2429

Table 8 CHA₂DS₂VASc score and stroke rate

(a) Risk factors for stroke and thrombo-embolism in non-valvular AF	
'Major' risk factors	'Clinically relevant non-major' risk factors
Previous stroke, TIA, or systemic embolism Age ≥75 years	Heart failure or moderate to severe LV systolic dysfunction (e.g. LV EF ≤40%) Hypertension - Diabetes mellitus Female sex - Age 65–74 years Vascular disease ^a
(b) Risk factor-based approach expressed as a point based scoring system, with the acronym CHA ₂ DS ₂ -VASc (Note: maximum score is 9 since age may contribute 0, 1, or 2 points)	
Risk factor	Score
Congestive heart failure/LV dysfunction	1
Hypertension	1
Age ≥75	2
Diabetes mellitus	1
Stroke/TIA/thrombo-embolism	2
Vascular disease ^a	1
Age 65–74	1
Sex category (i.e. female sex)	1
Maximum score	9

Tromboembolirisk och behandlingsrekommendation vid förmaksflimmer enligt CHA₂DS₂VASc⁽¹⁻²⁾

	Risikfaktor	Poäng
C	Hjärtsvikt (EF ≤40 %)	1
H	Hypertoni	1
A	Ålder ≥75 år	2
D	Diabetes	1
S	Tidigare stroke/emboli	2
V	Aterosklerotisk sjukdom	1
A	Ålder 65–74 år	1
S	Kvinnligt kön*	1

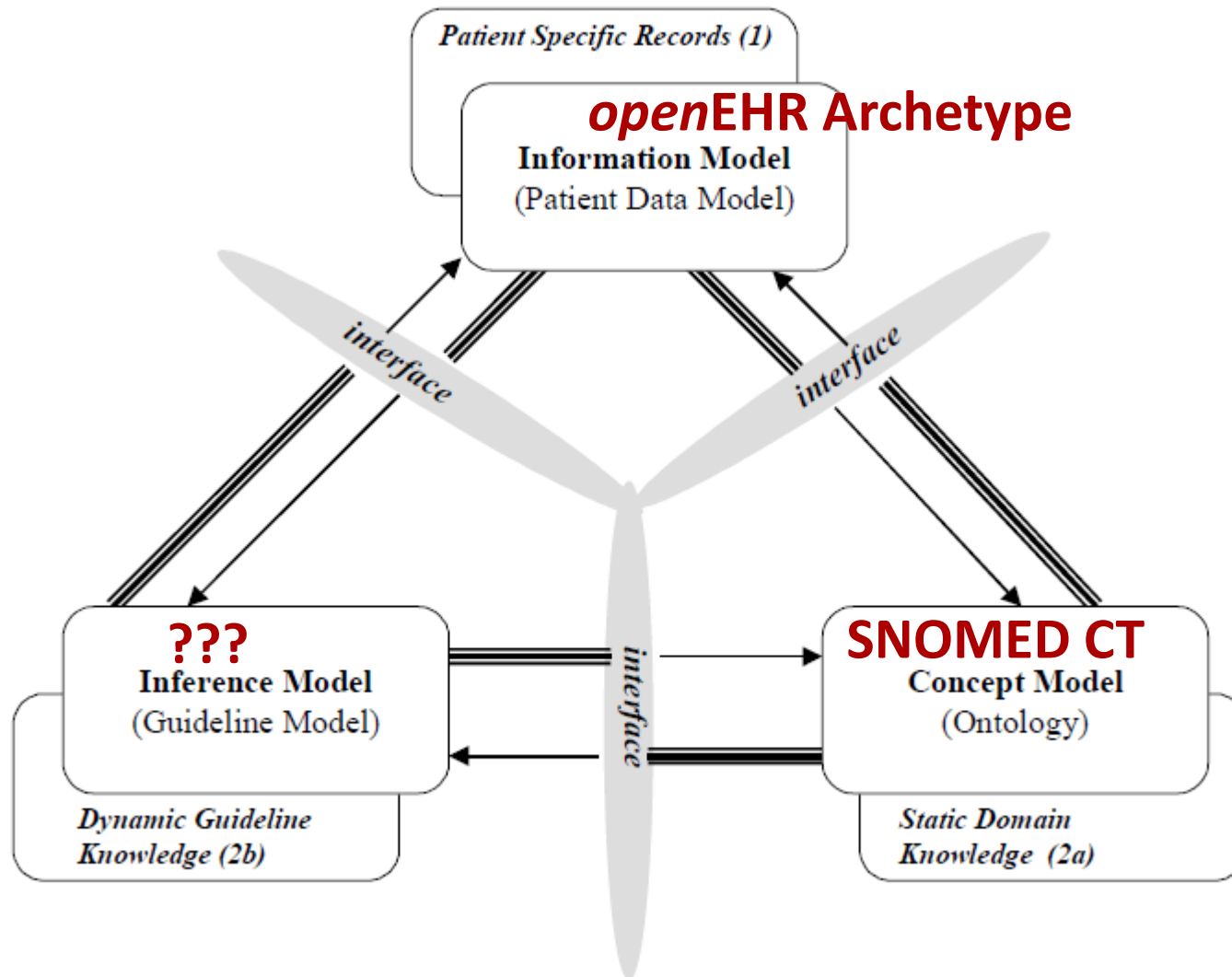
* kvinnor under 65 årsålder utan andra riskfaktorer har tveksam nytta av antitrombotisk behandling.

CHAD ₂ DS ₂ -VASc-poäng:	0 = ingen behandling (ev. ASA)
	1 = warfarin (ev. ASA)
	≥2 = warfarin

WAR11.06134

Scope & Aims

- **A formal language to express CDS rules**
- **Natural language independent**
 - Easy to add translations
- **Terminology independent**
 - Easy to add term bindings
- **EHR model independent**
 - Reuse of common EHR models both for input and output
- **Rules for single decision making**
 - Process handling not in scope
- **Coherent and reusable**
 - Encapsulated and possible to chain the rules
- **Technical platform independent**



A L Rector PD Johnson S Tu C Wroe and J Rogers (2001) Interface of inference models with concept and medical record models. in S Quaglini, P Barahona and S Andreassen (eds) *Proc Artificial Intelligence in Medicine Europe (AIME-2001)* Springer:314-323

Guide Definition Language (GDL) Design

A minimum language to **glue** together
archetypes, terminologies and rules

Three Pillars

- Bindings between archetype elements and variables in the rules
- Rule expressions easily converted to industry rule engine languages
- Bindings between local concepts used in the rules and concepts from reference terminologies

1st Pillar: Bindings between archetype elements and rule variables

```
[2] = (ARCHETYPE_BINDING) <
  archetype_id = <"openEHR-EHR-OBSERVATION.body_weight.v1">
  domain = <"EHR">
  elements = <
    ["gt0005"] = (ELEMENT_BINDING) <
      path = <"/data[at0002]/events[at0003]/data[at0001]/items[at0004]">
    >
  >
  function = <"LAST">
>
```

Each rule variable is unique identified by a gt code and mapped to a Archetype ID and a path to access an element

```
["gt0012"] = (RULE) <
  when = <"$gt0002>=20.0 yr", "$gt0003==local::at0005|Male|">
  then = <"$gt0011.magnitude=(( (1.23*(140-$gt0002.magnitude)) *$gt0005.magnitude)">
  priority = <2>
>
```

The same gt code is used to represent the variable in all rules in the same guide

```
["gt0005"] = (TERM) <
  text = <"Weight">
  description = <"The weight of the individual.">
>
```

Then the gt code is translated into terms in different natural languages (English, Swedish..)

2nd Pillar: Rule expressions easily converted to industry rule engine languages

```
["gt0012"] = (RULE) <  
  when = <"$gt0002>=20.0 yr", "$gt0003==local::at0005|Male|">  
  then = <"$gt0011.magnitude=((1.23*(140-$gt0002.magnitude))*$gt0005.magnitude)  
  priority = <2>  
>
```

- **when & then** statements are commonly supported by rule languages
- **Expressions** used in these statements are based on common design (similar to assertions in openEHR Archetype Definition Language)

3rd Pillar: Bindings between local term used in the rules and concepts from reference terminologies

```
["gt0017"] = (RULE) <
  when = <"$gt0003|diagnosis| is_a local::gt0100|Heart failure|",...>
  then = <"$gt0012=1|local::at0028|Present|",...>
  priority = <10>
>
```

```
term_bindings = <
  ["SNOMEDCT"] = (TERM_BINDING) <
    bindings = <
      ["gt01000"] = (BINDING) <
        codes =<[SNOMEDCT::84114007],...>
      >
    >
  ["ICD10"] = (TERM_BINDING) <
    bindings = <
      ["gt01000"] = (BINDING) <
        codes =<[ICD10::I50],...>
      >
    >
  ["ICD9"] = (TERM_BINDING) <
    bindings = <
      ["ICD9"] = (BINDING) <
        codes =<[ICD9::428.0],...>
      >
    >
  >
  >
  >
  >
  >
```

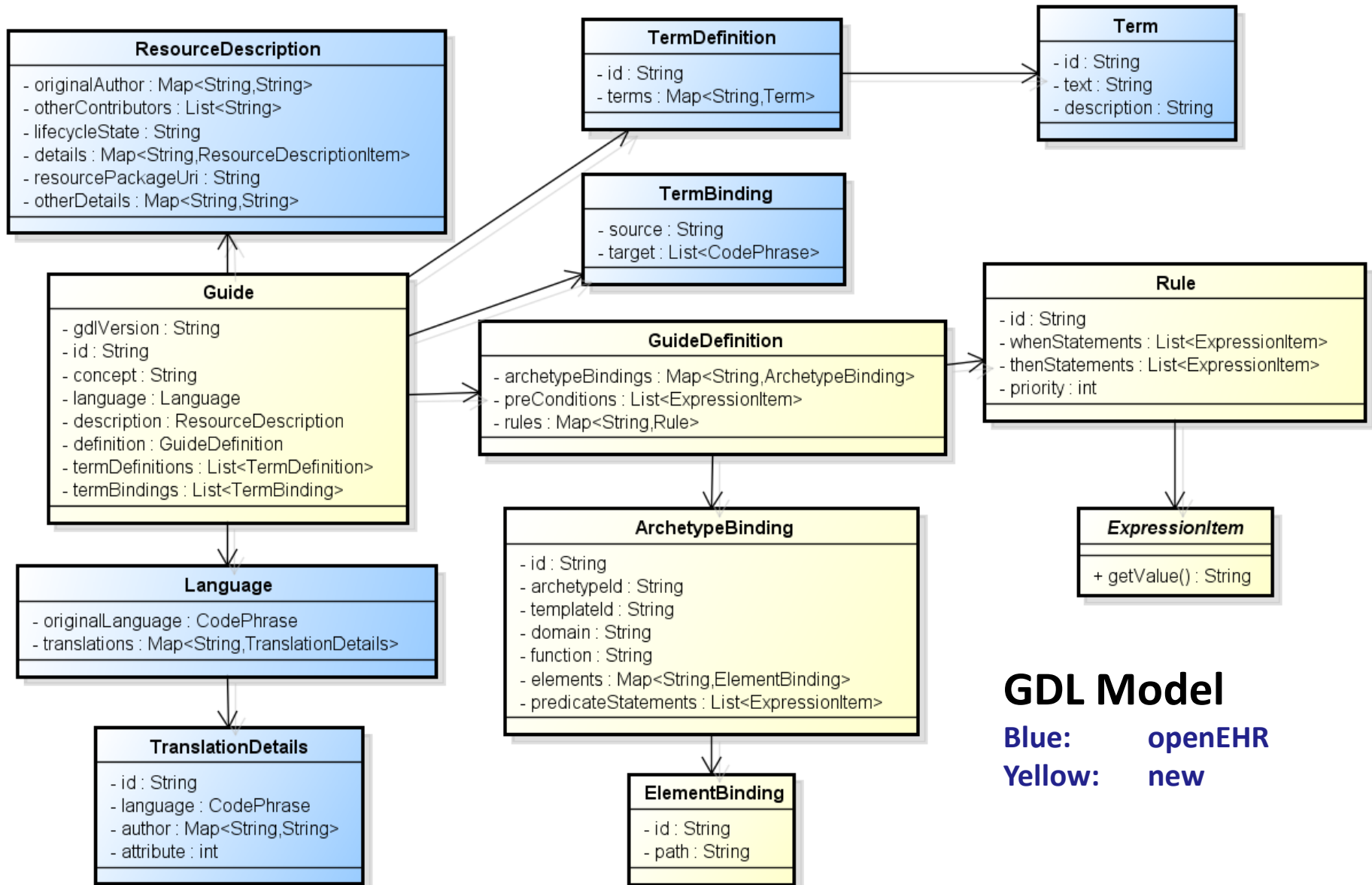
a local term is used as a proxy to externally defined concepts in reference terminologies

a local term can be bound to list of concepts or a refset in different target reference terminologies

Guide Definition Language (GDL) Design Cont.

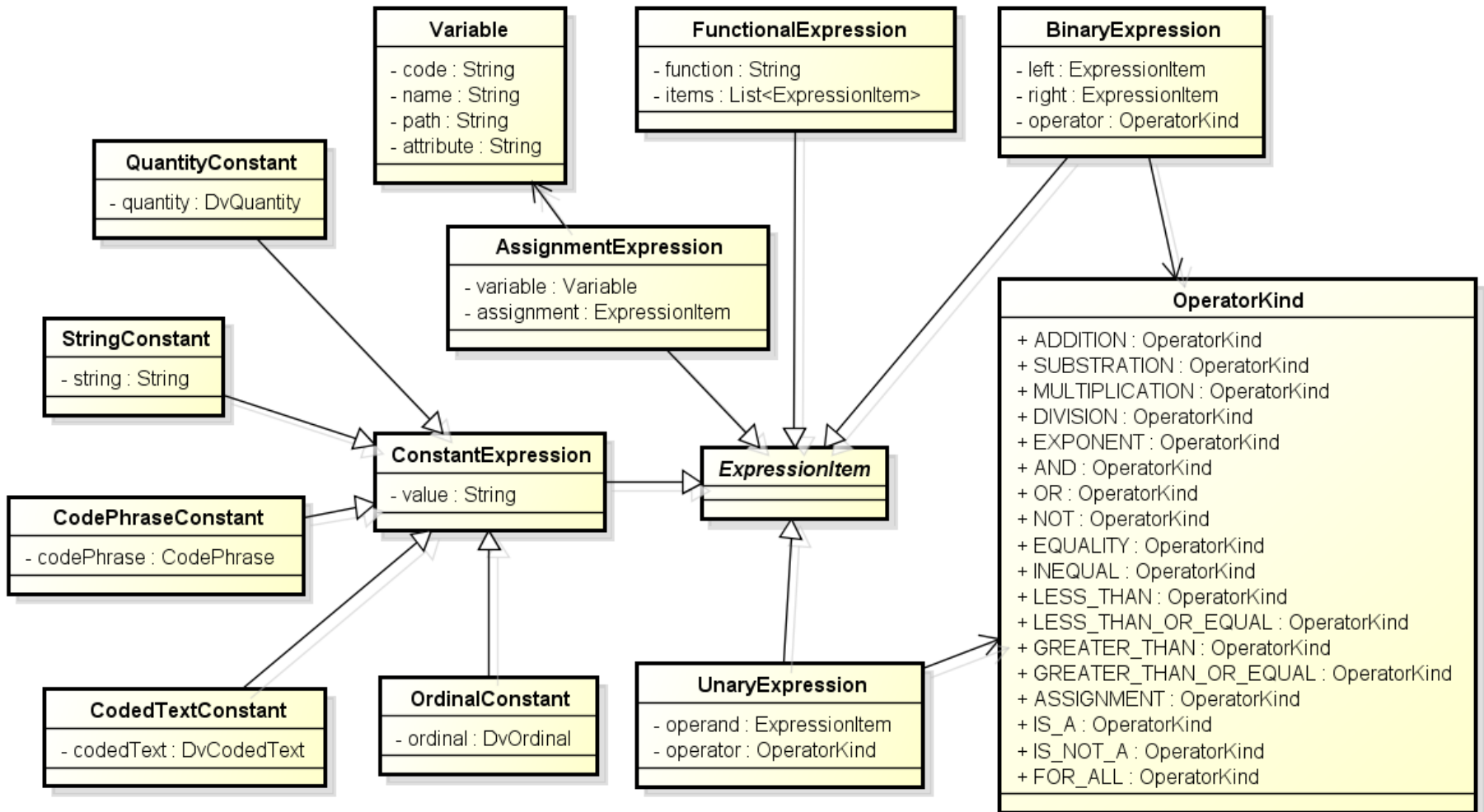
- **A formal language based on openEHR d-ADL**
 - Machine-readable format
- **The main object model consists of**
 - Header: Id, concept, language, description, translation
 - Archetype binding
 - Guide definition, pre-condition and list of rules
 - Each rule has when and then expressions
 - Term_definitions for language-dependent labels
 - Term_bindings for terminology bindings
- **Expressions model**

Extensive reuse of existing openEHR specifications



GDL Model

Blue: openEHR
 Yellow: new



GDL - expressions

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CHA₂DS₂-VA

Table 8 CHA₂DS₂VASc score and stroke rate

*Ocean Archetype Editor [CHADSVAS

File Edit Språk Terminologi Tools

openEHR-EHR-OBSERVATI

Huvud Definition Terminologi Visa G

*Protocol (en)

Data *Protocol (en)

Träd Händelser | *Person State (en)

Ordnad

Kardinaliet

Min: 1 Max 1

- Congestive Heart Failure
- Hypertension
- Age
- Diabetes
- Previous stroke
- Vascular diseases
- Gender
- Total score

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Vascular disease ^a	1
Age 65–74	1
Sex category (i.e. female sex)	1
Maximum score	9

ory (en)

1 *Unbounded

Text	Desc
0 Under 65	*
1 Between 65-74	*
2 Above or equals to 75	*
*	

GDL Guide for calculating CHA₂DS₂-VASc score

Rule Editor - CHADSVAS score.en_EN.v1

CHADSVAS score.en_EN.v1

Rule list | DSL | Head

- Set CHF present
- Set hypertension
- Set diabetes
- Set previous stroke
- Set age between 65-74
- Set age above or equals to 75
- Set gender female
- Calculate total score
- Set default

EHR queries + reasoning

Direct EHR queries

Add Rule

Edit rules

The CHA₂DS₂-VASc score archetype servers both as intermediate results place holder and final output from CDS

Test guide | Restore | View source | Generate form

Rule for Checking Congestive Heart Failure

Rule Editor - CHADSVAS score.en_EN.v1

CHADSVAS score.en_EN.v1 > Set CHF present

Definitions Conditions & Actions DSLR DLR Configuration

Conditions

EHR Element PatientDiagnosis is a Congestive heart failure [disorder]

If patient has any diagnosis that is kind of congestive heart failure?

Actions

Set element CongestiveHeartFailure with value Present

If so, set the congestive heart failure sub-component to 'present (1)'.

Add Condition/Action

Filter:

- Conditions & Actions
 - Conditions
 - Compare
 - Element Element equals to Value
 - Element Element different from Value
 - Element Element less than Value
 - Element Element less/equals to Value
 - Element Element greater than Value
 - Element Element greater/equals to Value
 - Element Element is a Value
 - General
 - Actions
 - Set
 - Set element Element with value Value

Edit conditions and actions in rule

Back to guide Test rule Restore View source Generate form

Simulation of CHA₂DS₂-VASc Guide

Input

EHR cT Diagnosis: + -

EHR cT Diagnosis: + -

EHR cT Diagnosis: + -

EHR cT Gender: ▼

EHR Q Age: yr

⚡ Calculate 📄 (13)

Result

CDS Previous stroke 0 - Absent

CDS Congestive Heart Failure 1 - Present

CDS Diabetes 1 - Present

CDS Gender 1 - Female

CDS Age 2 - Above or equals to 75

CDS Hypertension 1 - Present

CDS ¹/₂/₃ Total score

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Support for Natural Languages - Header

The image displays three overlapping windows of the Cambio Healthcare Systems software, demonstrating support for natural languages. Each window shows a 'GFR Calculation' guide with fields for author details, keywords, and a description.

- English Window (Left):** Shows the guide 'GFR Calculation' with author 'Rong Chen' and keyword 'Estimated GFR'. The text 'English' is overlaid in red.
- Swedish Window (Top Right):** Shows the guide 'GFR Calculation (SE?)' with author 'Rong Chen'. The text 'Swedish' is overlaid in red.
- Chinese Window (Bottom Center):** Shows the guide '计算估计肾小球滤过率' (Calculation of estimated glomerular filtration rate) with author 'Rong Chen' and keyword '肾小球滤过率' (Glomerular filtration rate). The text 'Chinese' is overlaid in red.

Each window includes a 'File Language' menu and various toolbars (Description, Definitions, Rule list, Preconditions, Terminology, GDL, Drools). The Chinese window also features a 'Generate form' button at the bottom right.

Support for Natural Languages - Expressions

The image displays three overlapping screenshots of the 'Expression editor' window, demonstrating the support for natural languages in expressions. Each window shows the same mathematical formula:
$$\frac{(((1.23 * (140 - \text{Age})) * \text{Weight}) / \text{Creatinine})$$

The three versions are:

- English:** The formula is displayed in its original form with variables like 'Age' and 'Weight' in English. The word 'English' is written in red.
- Swedish:** The formula is translated into Swedish:
$$\frac{(((1.23 * (140 - \text{Ålder})) * \text{Vikt}) / \text{Kreatinin})$$
. The word 'Swedish' is written in red. A blue box highlights the Swedish formula, and the word 'unchanged' is written in blue below it.
- Chinese:** The formula is translated into Chinese:
$$\frac{(((1.23 * (140 - \text{年齡})) * \text{體重}) / \text{肌酐})$$
. The word 'Chinese' is written in red.

Each window also includes an 'Expression viewer' section and a list of 'Attributes' on the right side, such as 'magnitude', 'precision', 'units', 'value', 'terminologyId', and 'code'. The Swedish window has 'Accept' and 'Cancel' buttons at the bottom.

SCT Related Implementation

- **Use cases**
 - Subsumption relationship: IS_A
 - Semantic equivalence check: post-coordination expressions
- **OWL representation of SNOMED CT content**
 - Converted by Perl scripts included in the release
- **Protégé OWL editor v4.1**
 - OWL Module Extraction by DL Query Plugin
- **Runtime terminology service (experimental)**
 - SCT Concept ID => OWL identifier
 - OWL API v3.3, reasoner: Hermit 1.3.6

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Summary

- Guide Definition Language (GDL) is a way to **share** CDS rules using **openEHR archetypes** and reference terminologies, e.g. **SNOMED CT**
- GDL rules are natural language, terminology and technical platform independence
- **open specification, open source** reference implementation of tools will be available
- GDL design is still evolving, and will improve through more CDS rules modeling in different domains

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- **Nadim Anani**, HIC, Karolinska Institute, Sweden
- **Daniel Karlsson**, IMT, Linköping University, Sweden
- **Gustavo Barcelar**, Porto Univeristy Hosptial, Portugal

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