

# *open***EHR** An open e-health computing platform

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# What is openEHR?



# Some simple questions:

Why can't existing systems keep up with **changing requirements**?

Why do we REPLACE clinical information systems every few years?

Why are **clinical users** usually left out of system design?



Most current (clinical)  
information systems are not  
**adaptive**

Their capabilities diverge  
continually from needs

# Cost of System Replacement

- ▶ Cost of new system O(€10 – 200m)
- ▶ Costs of retraining
- ▶ Costs of data migration
  - Cost of data loss
  - Cost of data migration errors

# Cost of Inability to adapt

- ▶ Docs create secret departmental Access DBs
- ▶ Other 'peripheral' systems added to compensate
- ▶ Free-text soaks up more content
- ▶ User frustration

# Cost of not engaging clinical users

- ▶ System doesn't do what they want
- ▶ Users develop 'workarounds'

# Some simple questions:

Why is there no decision support industry in health?

Why do computerised clinical guidelines remain a largely academic activity?



# Historically...



- ▶ No standard way to talk to the EHR
- ▶ No standard way to query the EHR

# Cost of CDS queries today

- ▶ 500 clinical guidelines
- ▶ Average of 5 queries each, some complex
  - e.g. find any BP over 160 not related to exercise
- ▶ Average of 8h professional work to design & validate a query
- ▶ ➔  $500 \times 5 \times 8h = 20,000h = 8 \text{ person years}$
- ▶ OK if we do it once...
- ▶ Not OK if we do it for each vendor product
- ▶ And that's assuming standard EHR data!

# The openEHR approach

- ▶ A semantic architecture designed to **flexibly** standardise:
  - Data, Content structures, Terminology use, APIs
- ▶ Content developed by **clinicians**
- ▶ Build **adaptive** systems – software not dependent on content models
- ▶ Make **querying based on content**, not physical databases

# The openEHR approach

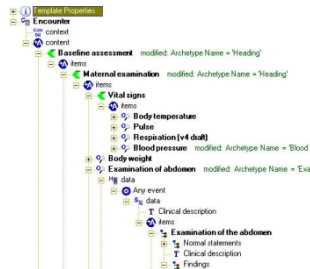
- ▶ A Services-oriented Architecture (SOA) designed to standardise how applications talk to systems
  - APIs
- ▶ And how systems talk to each other
  - EHR Extracts
  - Generated message schemas
  - Generated document schemas

# Levels of Information Semantics

Discharge  
summary UI  
form

Concrete: GUI, messages,  
documents

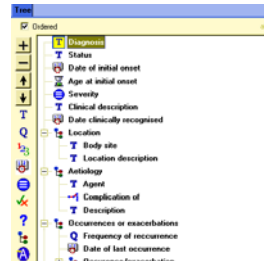
Discharge  
summary  
content  
model



Use-case specific  
data sets - Templates

Terminology  
Interface

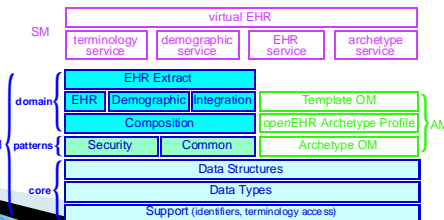
HbA1C,  
phys. exam,  
meds list,  
vital signs  
etc



Theme-based models  
of content – Archetypes  
(library of content definitions)

Querying


Observation,  
Quantity,  
coded text etc



Data Representation and  
sharing - Reference Model

# GUI & Templates

[illegible]

<b>Birth Plan</b> 12062 (R01)  <b>Archibald THABAS Thabas</b> 06-Jan-1981 26 years Male <b>Aliases:</b> <b>Admission:</b> <b>Encounter:</b> <b>Accident and Emergency:</b> 09-Jan-7...	
<b>36 Birth plan</b>	
<b>Pleural delivery options</b> Does the patient have a preference?	<input type="text"/> Not specified <input type="button" value="OK"/>
Preferred pleural delivery options	<input type="text"/> Not specified <input type="button" value="OK"/>
Has a suggestion been made?	<input type="text"/> Not specified <input type="button" value="OK"/>
Suggested pleural delivery options	<input type="text"/> Not specified <input type="button" value="OK"/>
Reason for suggested pleural delivery options	<input type="text"/> Not specified <input type="button" value="OK"/>
<b>Feeding options</b> Does the patient have a preference?	
Preferred infant feeding options	<input type="text"/> Not specified <input type="button" value="OK"/>
Has a suggestion been made?	<input type="text"/> Not specified <input type="button" value="OK"/>
Suggested infant feeding options	<input type="text"/> Not specified <input type="button" value="OK"/>
Reason for suggested infant feeding options	<input type="text"/> Not specified <input type="button" value="OK"/>

Diagnosis data

Diagnosis

Status

Date of initial onset 19 April 2007

Age at initial onset

Severity

Clinical description

Date clinically diagnosed 19 April 2007

Location

Body site

Location description

Aetiology

Agent

☐ Correlation of

Description

Occurrences or exacerbations

Frequency of recurrence 2.00

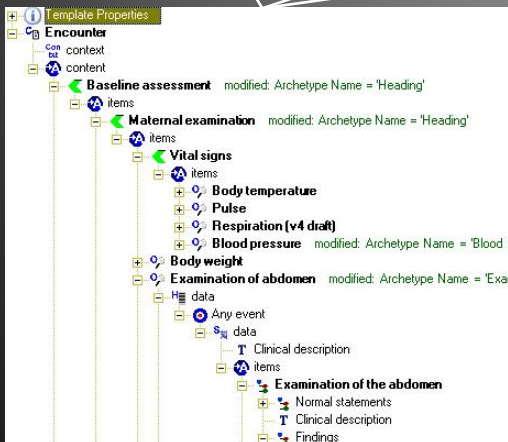
Date of last occurrence 19 April 2007

Occurrence/exacerbation

Clinical description

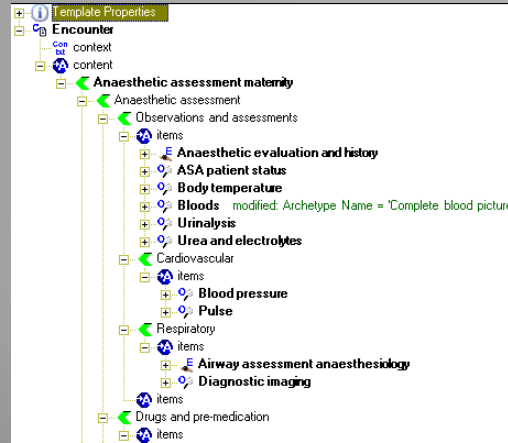
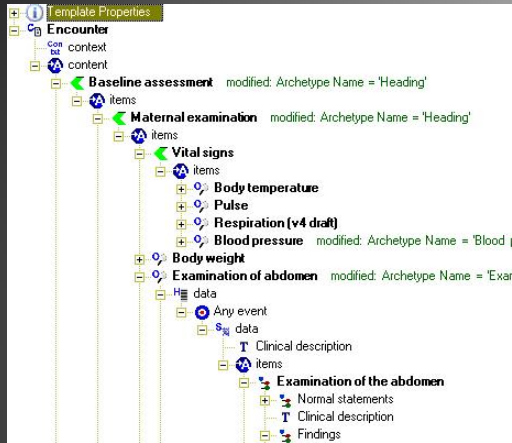
Subunit

# The cognitive User interface: Different ways of Presenting & Capturing the Same information

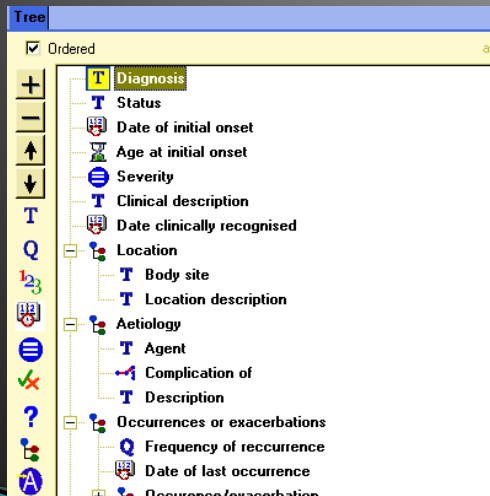


**Logical data-sets:**  
Achieved by templates  
That re-use and  
Organise underlying  
Standardised data  
Points *according to  
Business process event*

# Templates & Archetypes



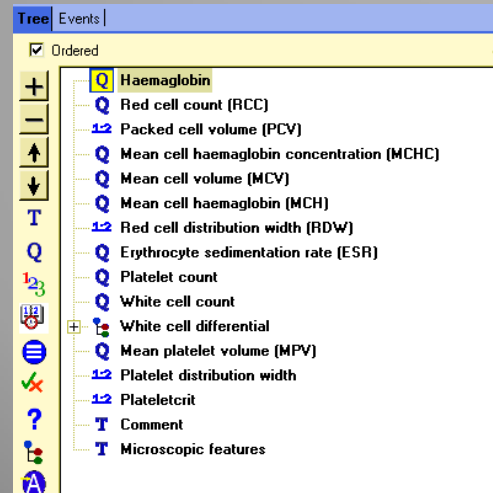
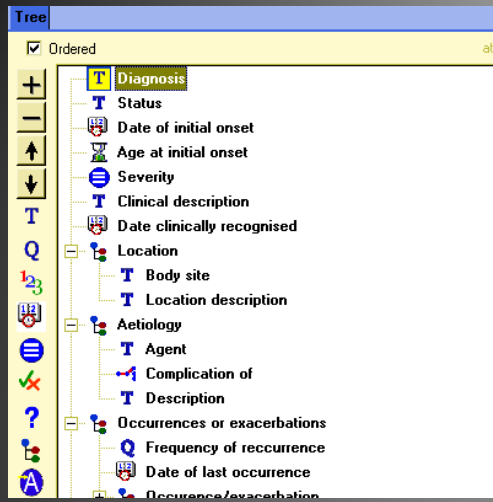
**Logical data sets:**  
Templates – using  
Selected items from a  
Number of archetypes



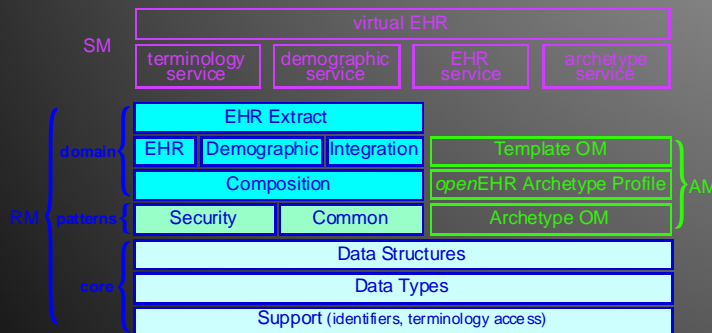
**Standardised models of  
The data:**  
Achieved by archetypes  
Organised by topic,  
*Independent of use*



# Archetypes and Reference Model



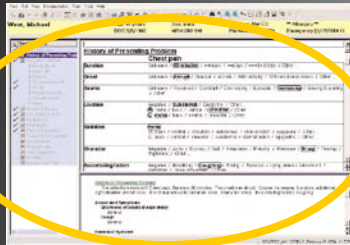
**Standardised clinical models of the data:**  
Archetypes – all based  
On same reference model



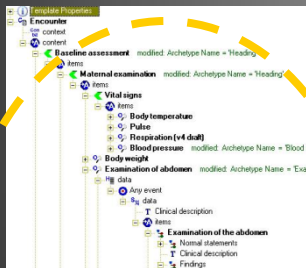
**Standardised technical representation of the data:**  
The reference model –  
Enables interoperability



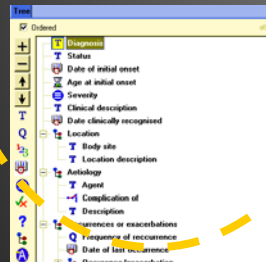
# Why Current Health Information Systems don't solve the problem



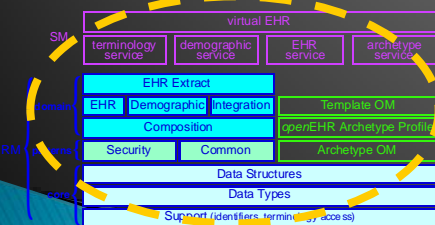
They have a form-builder



Possibly a library of 'elements'

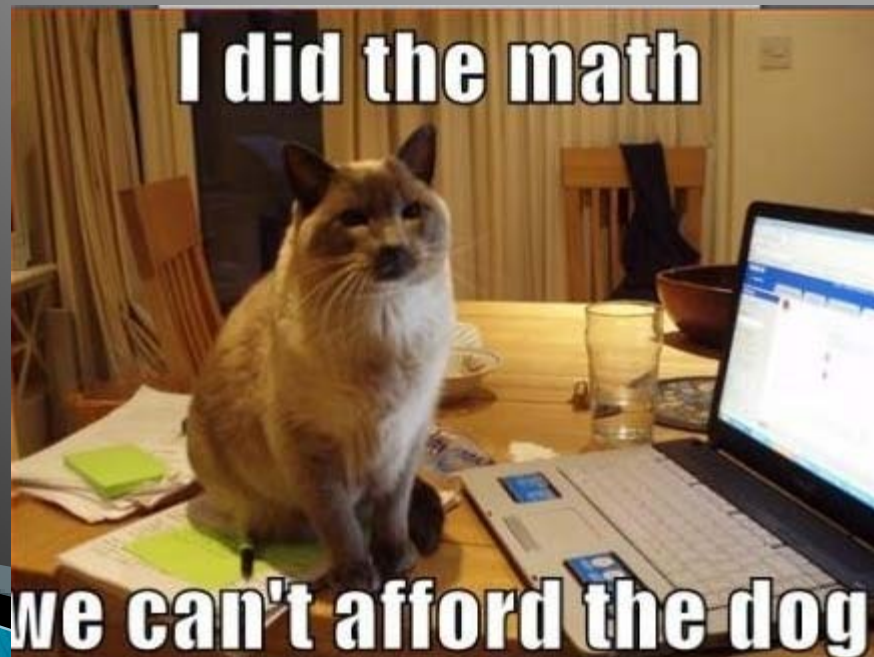


And only SQL, against  
The proprietary database

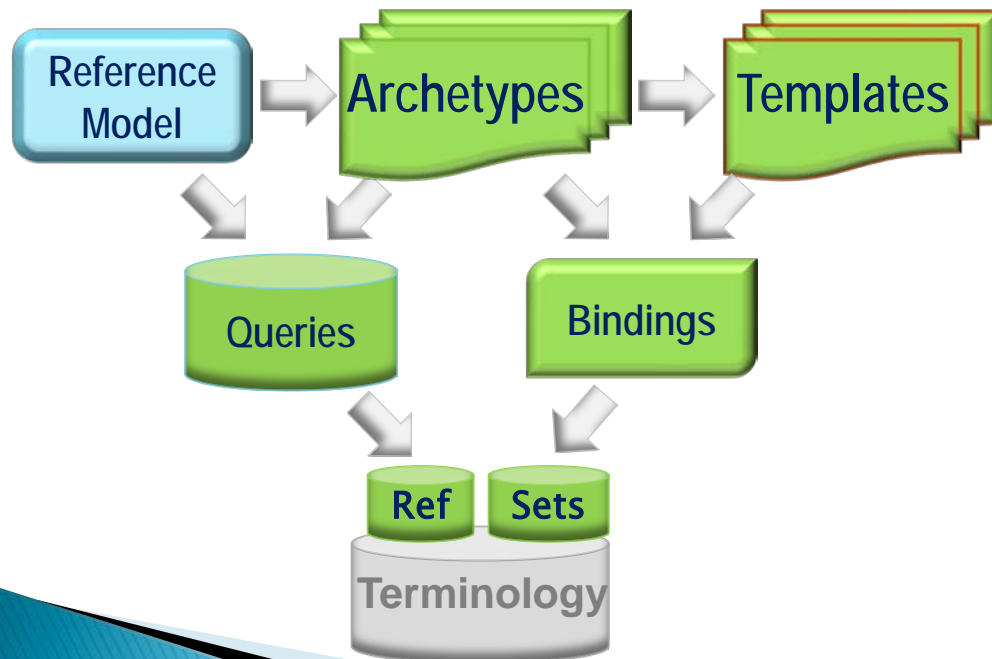


And a proprietary database

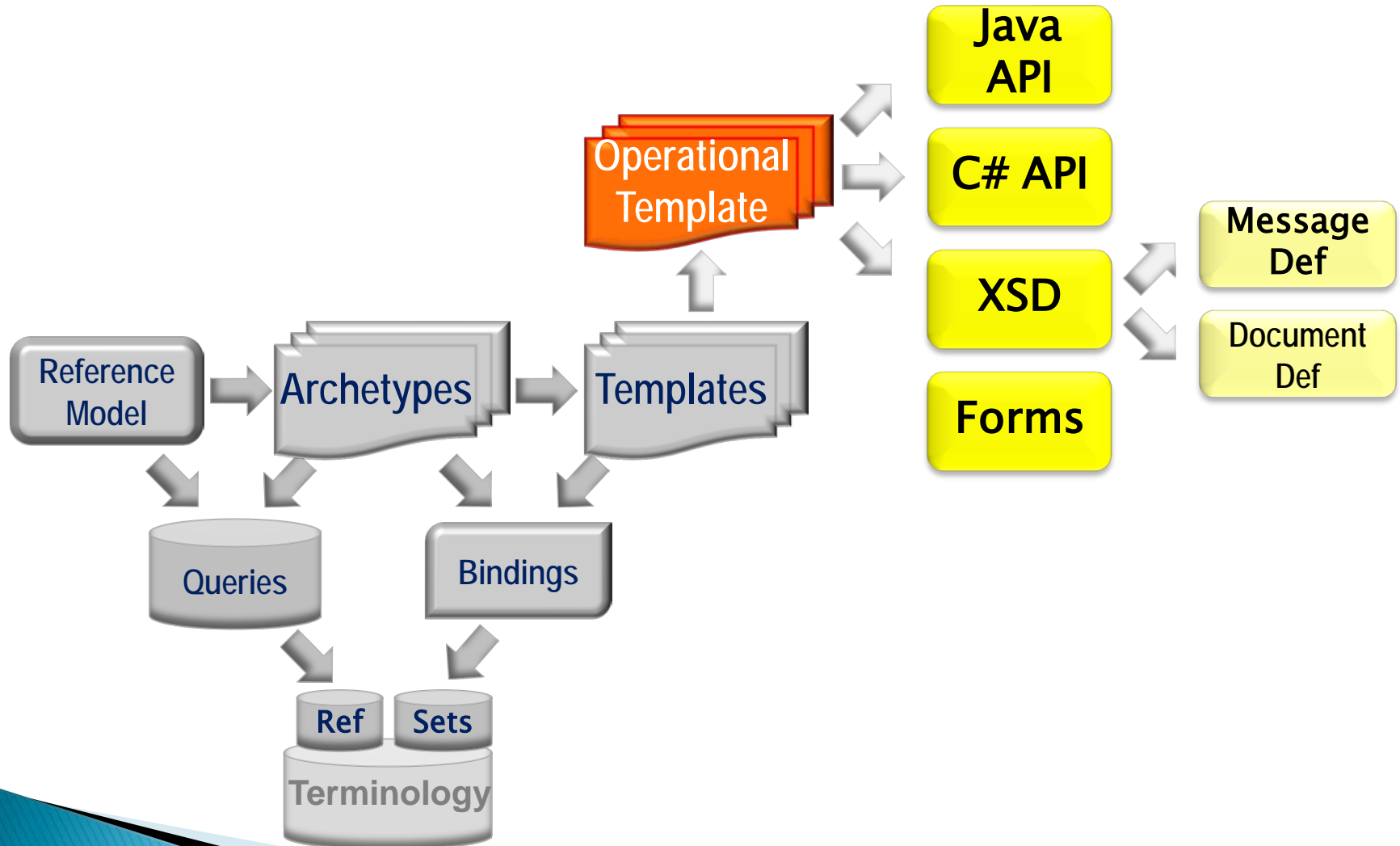
# Now the seamless part...



# Models...



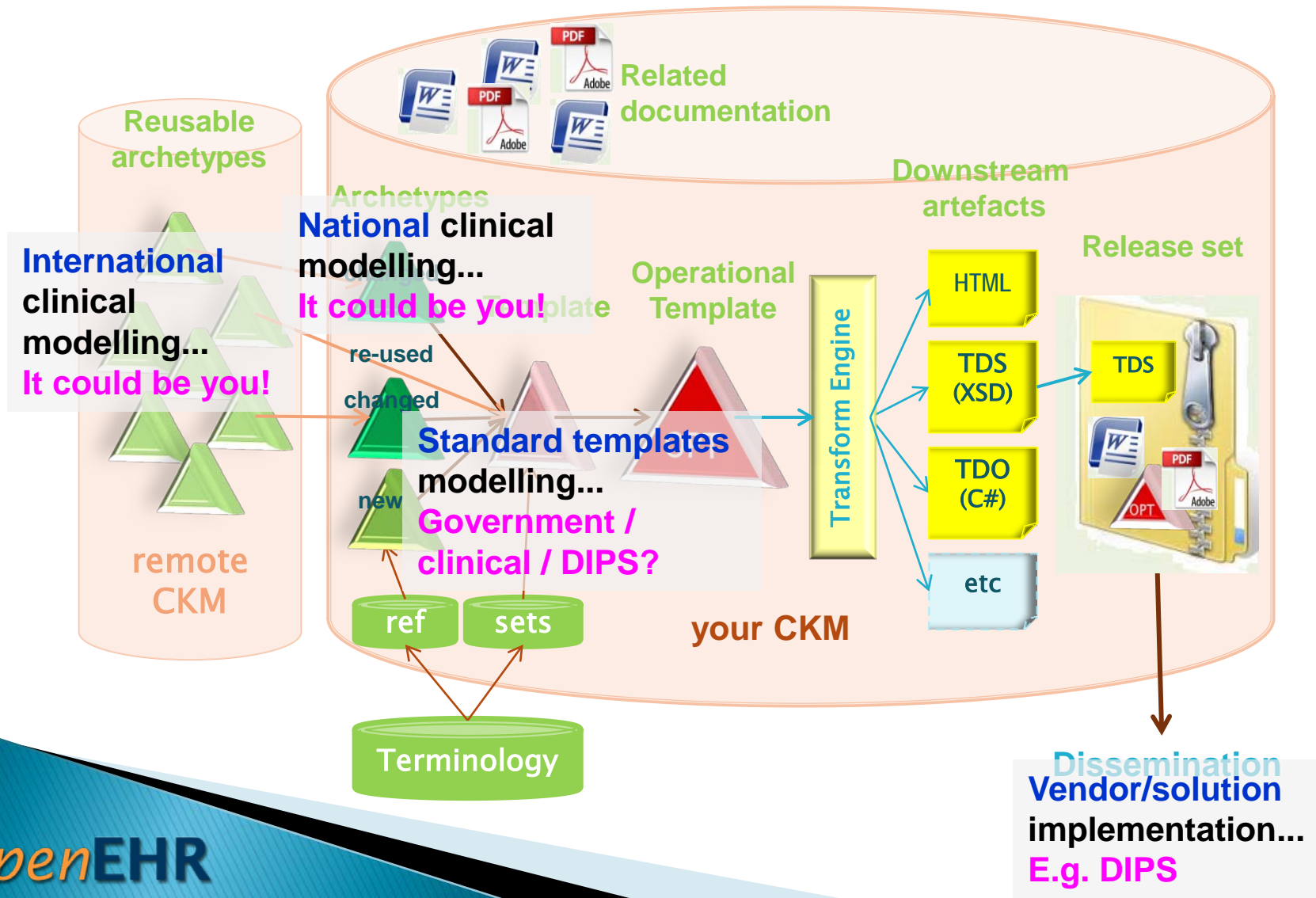
# And downstream artefacts



# Engaging software developers

- ▶ We generate 'normal' downstream artefacts
  - XSDs, facade classes, HTML, GUI XML
- ▶ These can be used by typical developers
- ▶ The data they create can always be converted back to canonical form

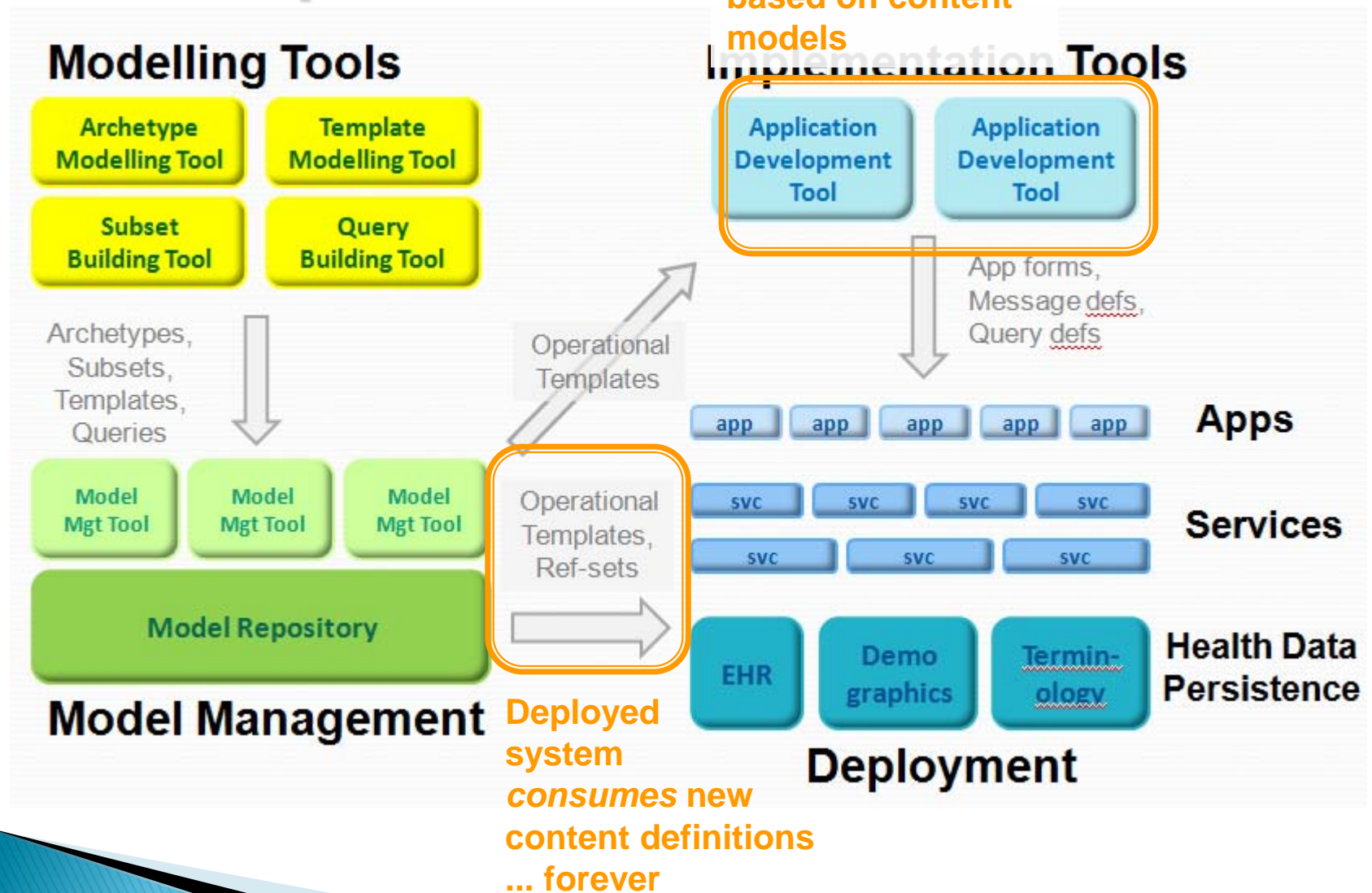
# Who does what?



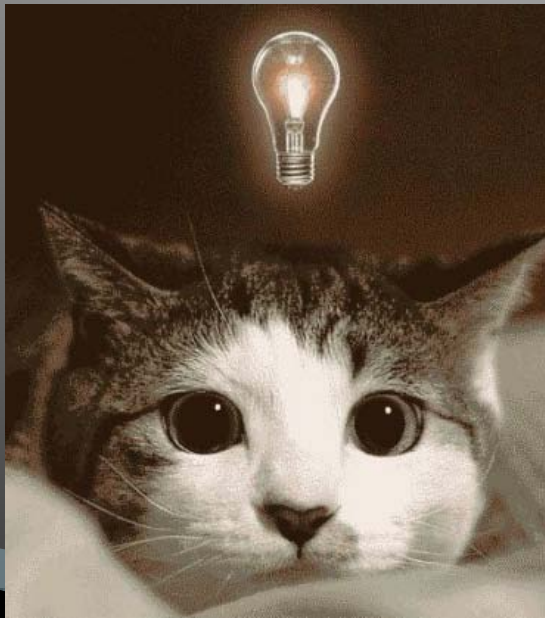


# Development Ecosystem

Forms and messages *formally* based on content models



# Query architecture





# Why do we care?

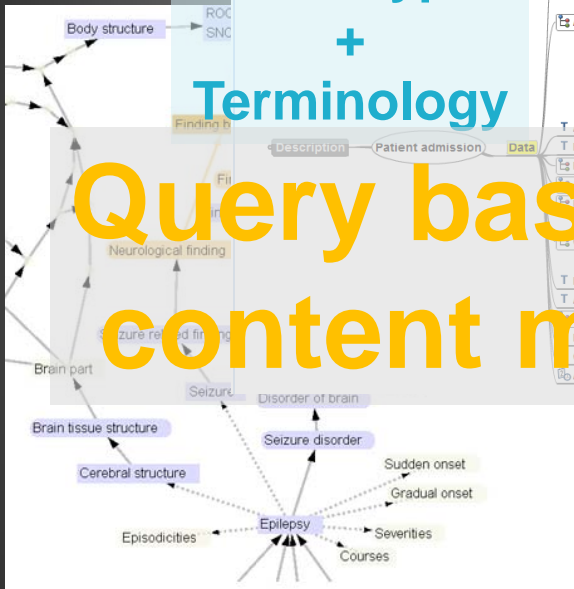
- ▶ You only put data in once...
- ▶ You get it out a hundred times, in a dozen different ways
- ▶ → huge economic value in the data
- ▶ → querying matters...

Patient admission

English

Archetype  
+  
Terminology

Query based on  
content models



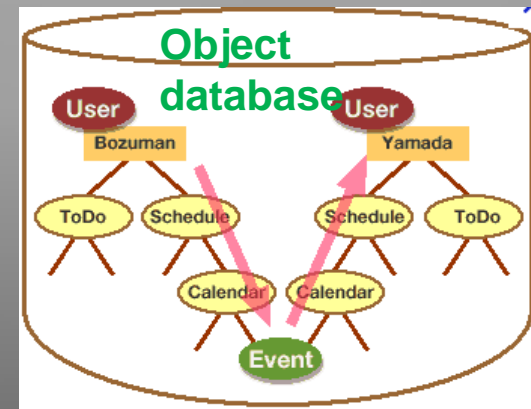
Portable query mentioning  
'data/consulting doctor/last name'

Sales ID	Customer ID	Sales Date	Sales Amount
1	101	12/09/2008	10000
2	101	01/09/2008	23789
3	102	02/07/2008	45000
4	103	11/06/2008	25345

Relational  
database

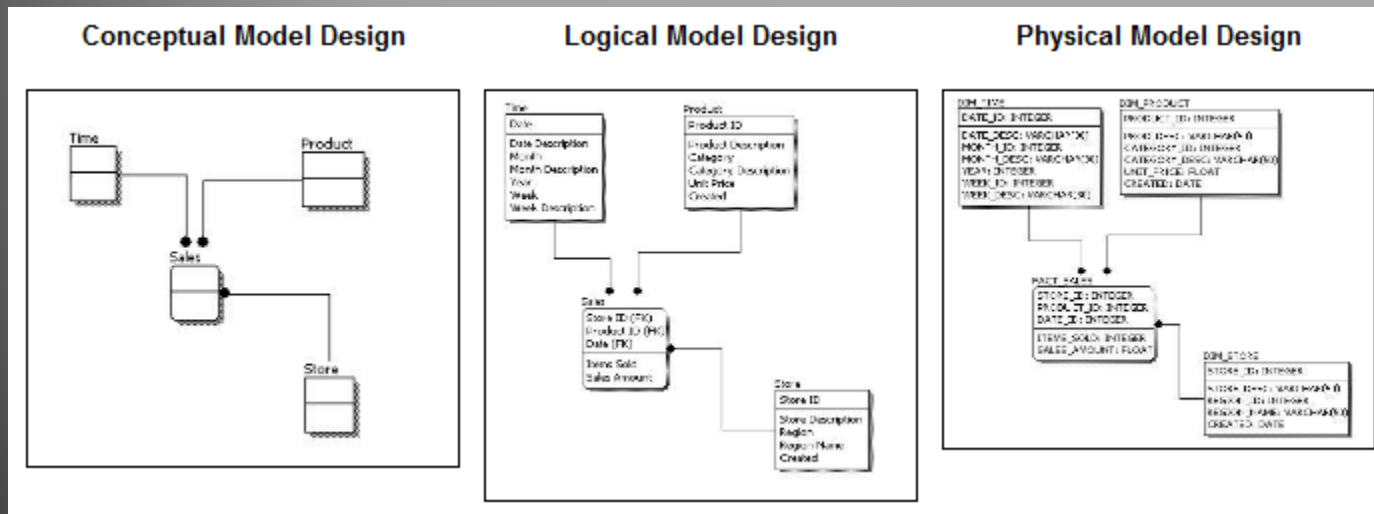
Customer ID	Customer Code	Customer Name	Customer Address	Customer Phone
101	C00101	All sec Corp	Houston, Texas	001-325-789-321
102	C00102	John S	Chennai	0091-44-273910
103	C00103	Bridge Inc.	Delhi	0091-11-456801
104	C00104	Symphony Org	Bombay	0091-22-568902

SQL query based on physical  
schema of relational database  
Vs  
Query based on  
storage model  
DB is different!



OQL query based on physical  
object storage model

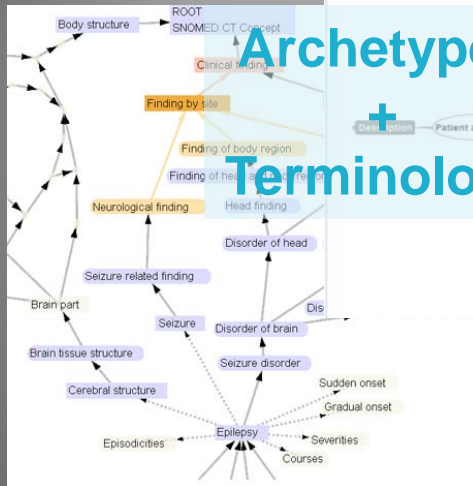
# Not to be confused with: Logical / Physical levels of relational modelling... These are ALL models of storage



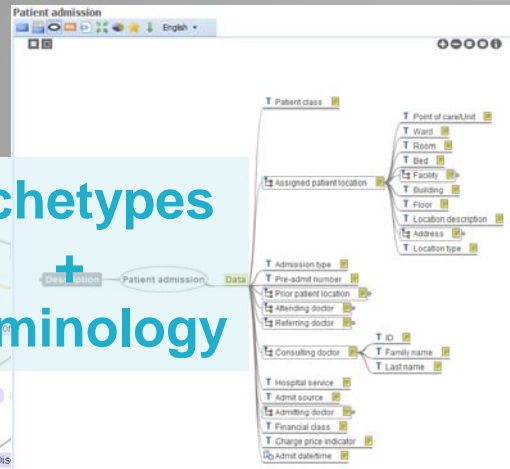
# Not quite for free...

- ▶ It means the need for a *query interpreter* to process **portable** queries, performing any necessary conversions between the logical information model form and the physical storage form

Logical



# Archetypes + Terminology

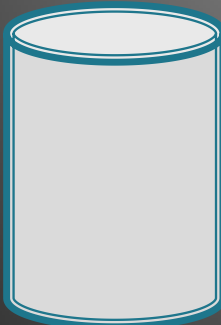


Portable query  
based on  
content model



SQL query based on  
physical schema  
+ object in-memory  
data access

Physical



Sales ID	Customer ID	Sales Date	Sales Amount
1	101	12/09/2008	10000
2	101	01/09/2008	23789
3	102	02/07/2008	45000
4	103	11/06/2008	25345

Customer ID	Customer Code	Customer Name	Customer Address	Customer Phone
101	C00101	All sec Corp	Houston, Texas	001-325-789-321
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103	C00103	Bridge Inc.	Delhi	0091-11-456801
104	C00104	Symphony Org	Bombay	0091-22-568902

Relational  
database

# Advantages

- ▶ Currently, there are ~no portable queries in health, nor in most other industries
- ▶ Preventing any meaningful business analytics or decision support industry
- ▶ Why? Because BI, CDS etc queries are complex and expensive to design. Having to replicate the work for each site database and/or vendor proprietary database is not economically feasible

# The Result

It should not matter if the patient BP was captured in a GP visit, via a nurse form used in a hospital, or at home – a longitudinal query for BPs should return all the results

HIS ED screen

Screenshot of a HIS ED screen showing patient information and vital signs. The screen displays fields for Patient Critical Information, Vital Signs, and a list of medications. The BP is recorded as 120/80.

BP = 120/80

Specialist app

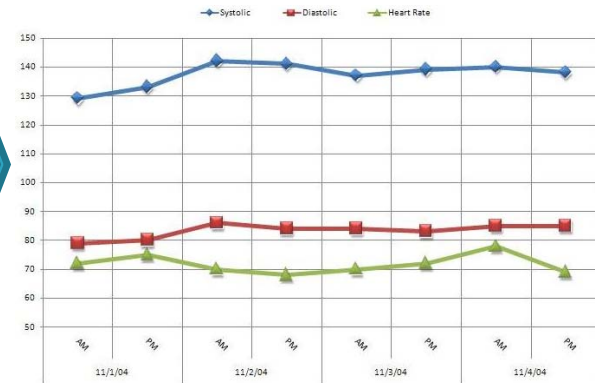
Screenshot of a Specialist app showing patient information and vital signs. The screen displays fields for Patient Critical Information, Vital Signs, and a list of medications. The BP is recorded as 140/95.

BP = 140/95

GP app

Screenshot of a GP app showing patient information and vital signs. The screen displays fields for Patient Critical Information, Vital Signs, and a list of medications. The BP is recorded as 170/108.

BP = 170/108





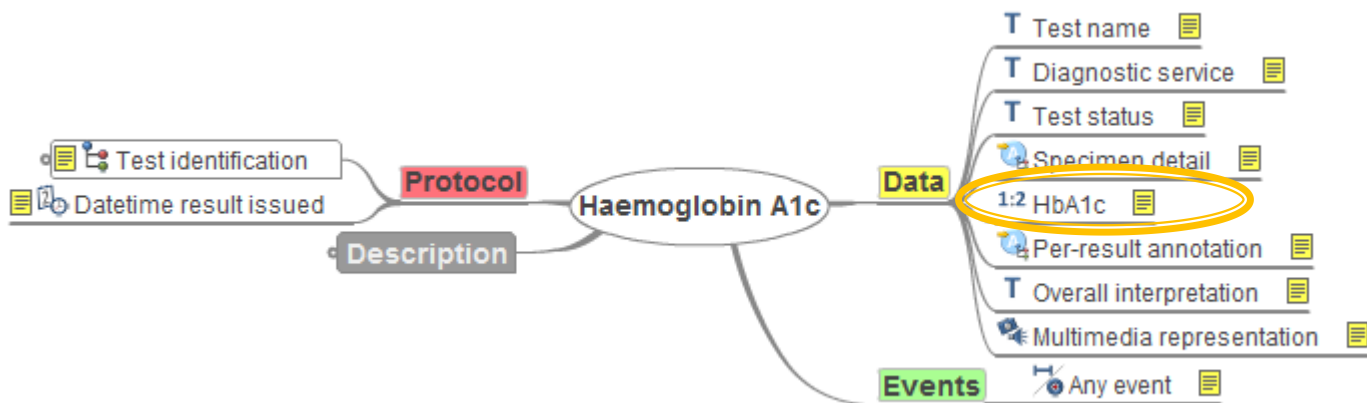
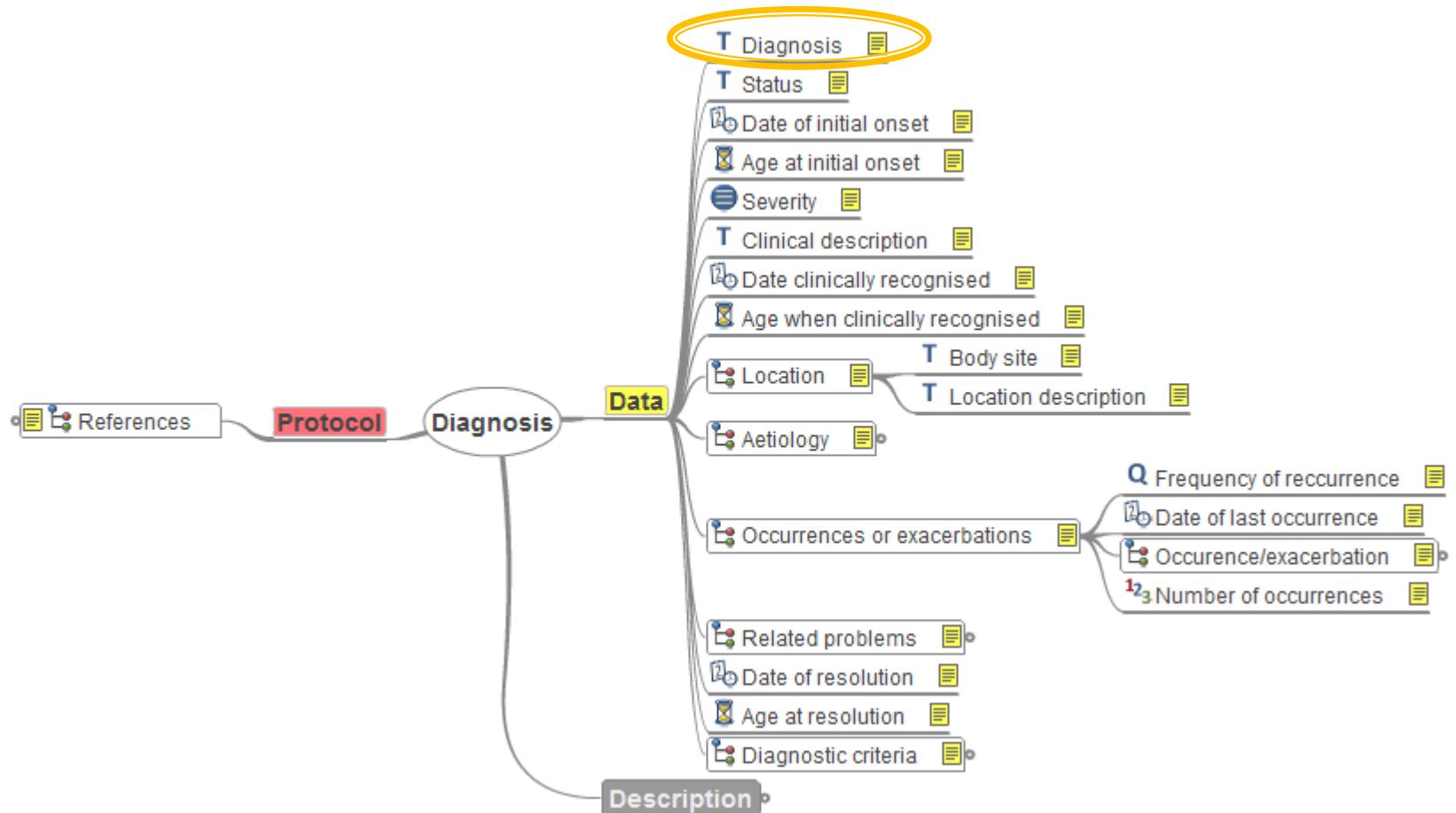
# How do we do it?





# Scenario

- ▶ Get the number of patients with diabetes who have HbA1c results greater than 7.0 in last 12 months.



EVA.problem-.v1

openEHR-EHR-EVALUATION.problem-diagnosis.v1

FormLanguage

Description

Definition

Terminology

Annotations

Paths

Slots (0/0)

Source

Serialised (flat)

Validity

Statistics

RM name

EVA.problem-.v1

Constraint

Diagn

openEHR-EHR-EVALUATION.problem-diagnosis.v1

Description

Definition

Terminology

Annotations

Paths

Slots (0/0)

Source

Serialised

Path	RM Type	AOM Type
/	EVALUATION	C_COMPLEX_OBJECT
/data[at0001]	ITEM_TREE	C_COMPLEX_OBJECT
/data[at0001]/items[at0.32]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0.32]/value	DV_CODED_TEXT	C_COMPLEX_OBJECT
/data[at0001]/items[at0.32]/value/defining_code	CODE_PHRASE	C_CODE_PHRASE
/data[at0001]/items[at0.35]	CLUSTER	C_COMPLEX_OBJECT
/data[at0001]/items[at0.35]/items[at0.36]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0.35]/items[at0.36]/value	DV_TEXT	C_COMPLEX_OBJECT
/data[at0001]/items[at0002.1]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0002.1]/value	DV_CODED_TEXT	C_COMPLEX_OBJECT
/data[at0001]/items[at0002.1]/value/defining_code	CODE_PHRASE	CONSTRAINT_REF
/data[at0001]/items[at0003]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0003]/value	DV_DATE	C_COMPLEX_OBJECT
/data[at0001]/items[at0004]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0004]/value	DV_DURATION	C_COMPLEX_OBJECT
/data[at0001]/items[at0005]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0005]/value	DV_CODED_TEXT	C_COMPLEX_OBJECT
/data[at0001]/items[at0005]/value/defining_code	CODE_PHRASE	C_CODE_PHRASE
/data[at0001]/items[at0009]	ELEMENT	C_COMPLEX_OBJECT
/data[at0001]/items[at0009]/value	DV_TEXT	C_COMPLEX_OBJECT
/data[at0001]/items[at0010]	ELEMENT	C_COMPLEX_OBJECT
Occurrences or exacerbations		0..1
items		
Frequency of recurrence		0..1
Date of last occurrence		0..1
Occurrences from resolution		0..*

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openEHR

# Scenario

```
SELECT COUNT(e/ehr_id)
FROM EHR e
CONTAINS
  (COMPOSITION probs [openEHR-EHR-COMPOSITION.problem_list.v1]
  CONTAINS EVALUATION dx
    [openEHR-EHR-EVALUATION.problem-diagnosis.v1] AND
  COMPOSITION lab_rpt [openEHR-EHR-COMPOSITION.report.v1]
  CONTAINS OBSERVATION hba1c
    [openEHR-EHR-OBSERVATION.lab_test-hba1c.v1])
WHERE
  dx/data/items[at0002.1]/value/defining_code/code_string matches
    {terminology:SNOMEDCT?refset_id=1234567} AND
  lab_rpt /context/other_context/items[at0006]/items[at0013]/value >
    current-date() - P1Y AND
  hba1c /data/events[at0002]/data/items[at0013.1]/value/numerator > 7
```

- ▶ This query is based solely on the information model and the content models....
- ▶ No knowledge of the physical persistence, which can differ across vendors and even single vendor in different locations.

# Querying requires a query language



# openEHR AQL- Archetype Query Language

Added by [Heath Frankel](#), last edited by [Bostjan Lah](#) on 13-Jan-2012 ([view change](#))

The Archetype Query Language (AQL) is a proposed query specification for openEHR data developed

## Contributors

Dr. Chunlan Ma  
Heath Frankel  
Thomas Beale

## Proposal

[Archetype Query Language Description](#)

## Grammars

It is possible for more than one grammar to support the same syntax. The following are the grammars c

Grammar	Release	Maintainer	Description
'Original' AQL grammar	v0.6 (2009)	Ocean Informatics contact: <a href="#">Chunlan Ma</a>	Hand-built grammar. In production use since 2009
ANTlr AQL grammar	v0.0.28 (2012)	Marand, contact: Bostjan Lah	Built from 'Original' AQL gram



# openEHR Archetype Query Language Description

5 Added by [Thomas Beale](#), last edited by [ssharonas](#) on 16-Apr-2011 ([view change](#))

## Developer

[Ocean Informatics](#).

Team: Chunlan Ma MD, Heath Frankel, Thomas Beale

## Overview

### Existing Query Languages

Currently, the available query languages, such as SQL, XQuery, or Object-Oriented Query Language, do not allow a user to write an appropriate query. The query statement cannot be used by other systems which have a different query language required by integrated care EHRs

### What is AQL?

Archetype Query Language (AQL) is a declarative query language developed specifically for expressing queries over the openEHR clinical archetypes, but the syntax is independent of applications, programming languages, or database terminology. The syntax (terminology) is for the data to be marked at a fine granularity with the appropriate archetype codes (and terminology codes) have been added. Unlike other query languages, such as SQL or XQuery, AQL is designed to be used across system boundaries or enterprise boundaries.



# The big picture



# What openEHR provides...

- ▶ A standard logical information model, describing basic data types and structural relations
  - On which quality software can be based
- ▶ Ability to build trustworthy, open content models
- ▶ Reliable, known use of terminology
- ▶ Language in which to write portable queries

# Archetype formalism – ADL 1.5

- ▶ There is growing acceptance of standardised content–modelling in health using archetypes
  - CIMI taskforce, led by Dr Stan Huff (Intermountain)
  - openEHR.org archetypes
  - Other national programmes
  - New OMG Archetype Modelling Language (AML) RfP
  - VA's Model-driven Health Tools (MDHT) now moving to incorporate archetype semantics



Page [Discussion](#)

[Main Page](#)

# Where is openEHR used?



The screenshot shows the openEHR website. The browser's address bar displays [www.openehr.org](http://www.openehr.org), which is circled in yellow. Below the address bar is a navigation bar with links to Home, Programs, Entry Points, and Downloads. The main content area features three columns. The first column, titled 'What is openEHR?', contains a diagram of the openEHR architecture and a brief description. The second column, titled 'Who is using openEHR?', features a world map and a list of users. The third column, also titled 'Who is using openEHR?', lists specific user categories. The 'Who is using openEHR?' section is circled in yellow.

**What is openEHR?**  
openEHR is about enabling ICT to effectively support all aspects of healthcare.  
[Learn more](#)

**Who is using openEHR?**  
Companies, governments, universities, research centres all around the world.  
[Learn more](#)

**Who is using openEHR?**

- [Healthcare Providers and Authorities](#)
- [Funded Research Projects](#)
- [Non-profit and Open Source Organisations](#)
- [Governments](#)
- [Academic Research](#)

# Large / national programmes

- ▶ Australia
- ▶ New Zealand
- ▶ UK now starting to use archetypes again
- ▶ Moscow health

# What can Norway do?

- ▶ DIPS will be formally involved in openEHR Foundation as a vendor
- ▶ Norwegian clinical modelling is already happening
  - Get involved in international effort
  - Share your models
  - Some leadership probably needed going forward
- ▶ Various academic efforts
- ▶ The future is very exciting

# Resources

- ▶ <http://www.openEHR.org>