openEHR: from theory to implementation

Ian McNicoll, Ocean Informatics
Anže Droljc, Marand
Rong Chen, Cambio systems

Agenda

13.00 – Introduction and Welcome

13.10 – 13.40	Ian McNicoll – Clinical modeller perspective
13.40 – 13.50	Discussion
14.50 – 15.20	Rong Chen – Experiences from Cambio
14.20 – 15.30	Discussion
15.30 – 16.00	Coffee break
16.00 – 16.30	Anže Drojc – Marand Case Study
16.30 – 17.00	Discussion

openEHR

openEHR: from theory to practice –Clinical modeller perspective

openEHR

Ian McNicoll
Clinical modelling consultant
Ocean Informatics

What is openEHR?

- Not-for-profit Foundation based at UCL CHIME delivering **open specifications** for a clinical information model allowing commercial and open source use
  - www.openehr.org

- collaboratively develops open-source clinical content specifications based on
  - **Archetypes, Templates**
  - **Termsets**

  - openEHR Clinical Knowledge Manager (CKM)
    - www.openehr.org/knowledge

openEHR

openEHR for clinical content standards development

- Ability to separate out clinical models from technical infrastructure makes openEHR an excellent way to develop national/international clinical content standards
  - Australia, New Zealand
  - Sweden,Brazil, Slovenia

  - International repository
    - openEHR Clinical Knowledge Manager
    - www.openehr.org/knowledge

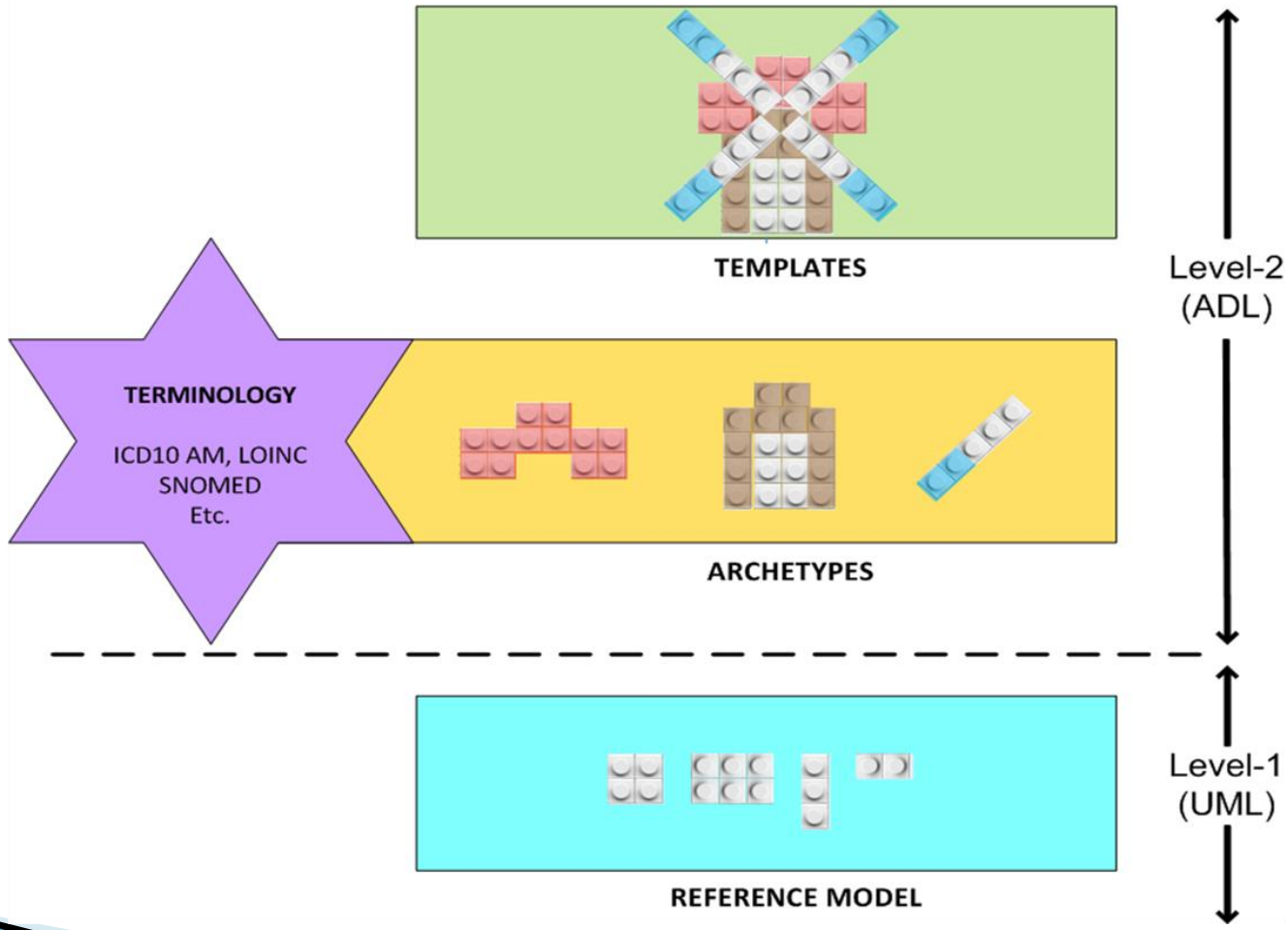
openEHR

openEHR for application developers

- Specification for an information model
  - Multi-layer modelling approach
    - Technical layer
      - openEHR Reference model (RM)
      - openEHR Archetype Object Model (AOM)
      - Specified in UML, detailed documentation
      - Reference implementations in Eiffel, Java
    - Clinical layer
      - Archetypes
      - Templates
      - Specified in Archetype Definition Language (ADL) and / or XML

openEHR

openEHR: Multi-level modelling



openEHR

Multi-layer modelling - why?

- Relatively static Technical Reference layer
  - Updated occasionally
  - Allows software to be built against a stable standard
- Agile Clinical Archetype layer
  - Updated relatively frequently as new clinical requirements emerge
  - Maximal dataset approach
  - Technical infrastructure hidden
  - **Accessible to clinical review**
- Localising Template layer
  - Allows re-use of small number of archetypes in differing specific clinical contexts

Traditional application information model

Fields

	Name	Description
S	TypeId	Retrieves the unique identifier for the item type.

Properties

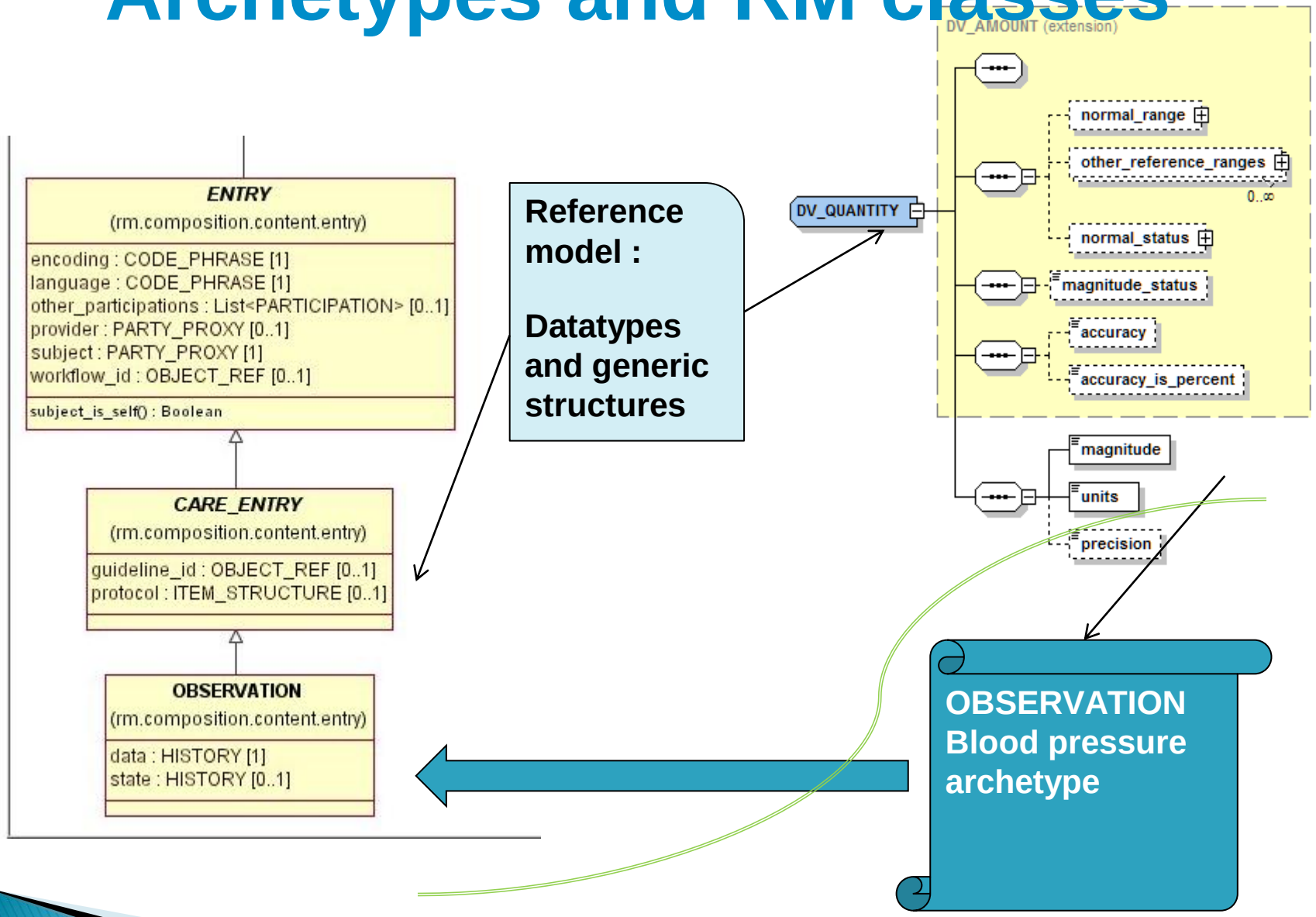
Name	Description
AllergenCode	Gets or sets the code for the allergen that causes an allergic reaction.
AllergenType	Gets or sets the type of allergen that causes an allergic reaction.
CommonData	Gets the common data for the HealthRecordItem. (Inherited from HealthRecordItem.)
Created	Gets the audit information associated with the creation of this health record item. (Inherited from HealthRecordItem.)
EffectiveDate	Gets the date and time that the health record item data was taken. (Inherited from HealthRecordItem.)
EffectivePermissions	Gets the effective permissions on the item granted to the person retrieving the HealthRecordItem. (Inherited from HealthRecordItem.)
FirstObserved	Gets or sets the approximate date of the first occurrence of the allergy.
Flags	Gets the HealthRecordItem flags. (Inherited from HealthRecordItem.)
HealthRecordItemSignatures	Gets the signatures for the HealthRecordItem. (Inherited from HealthRecordItem.)
IsDownVersioned	Gets the value indicating if the HealthRecordItem is down-versioned. (Inherited from HealthRecordItem.)
IsImmutable	Gets a value indicating whether the HealthRecordItem is immutable. (Inherited from HealthRecordItem.)
IsNegated	Gets or sets a value indicating whether the allergic reaction is negated with treatment.
IsPersonal	Gets or sets the value indicating if the HealthRecordItem is private. (Inherited from HealthRecordItem.)

openEHR

Reference Model (RM)

- Generic technical artefacts specific for representing health information
  - Data structures and types
  - Health record organisation
  - Security
  - Versioning
  - People, Dates, Times etc.
- Hidden from clinicians in content modelling and review tools

Archetypes and RM classes



openEHR

openEHR Archetypes

- Computable models of discrete clinical concepts
  - Generally “Maximal data set”, Universal use case
  - Include bindings to terminology
- Familiar components of a health record
  - Blood pressure, Body weight
  - Medication order, Family history
  - Prostate cancer histopathology result
- Designed for persistence
  - Use within apps as well as between apps
  - System agnostic querying

openEHR

Archetypes: Clinically-led

- Clinically and collaboratively authored
  - Direct individual governance by clinical informaticians
  - Open CC-BY-SA licence
- Secondary assurance by professional standards groups

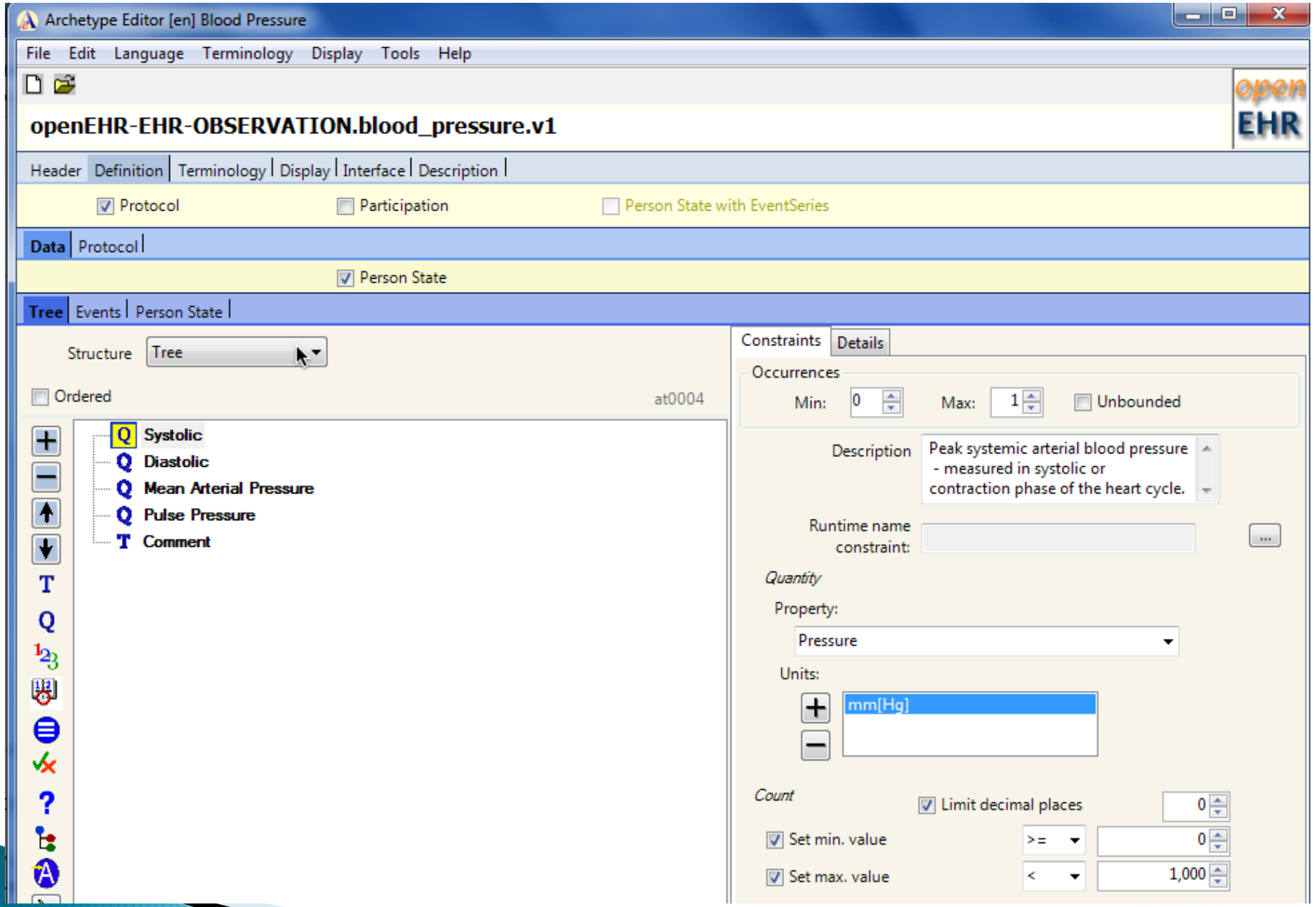
Archetypes – local or shared?

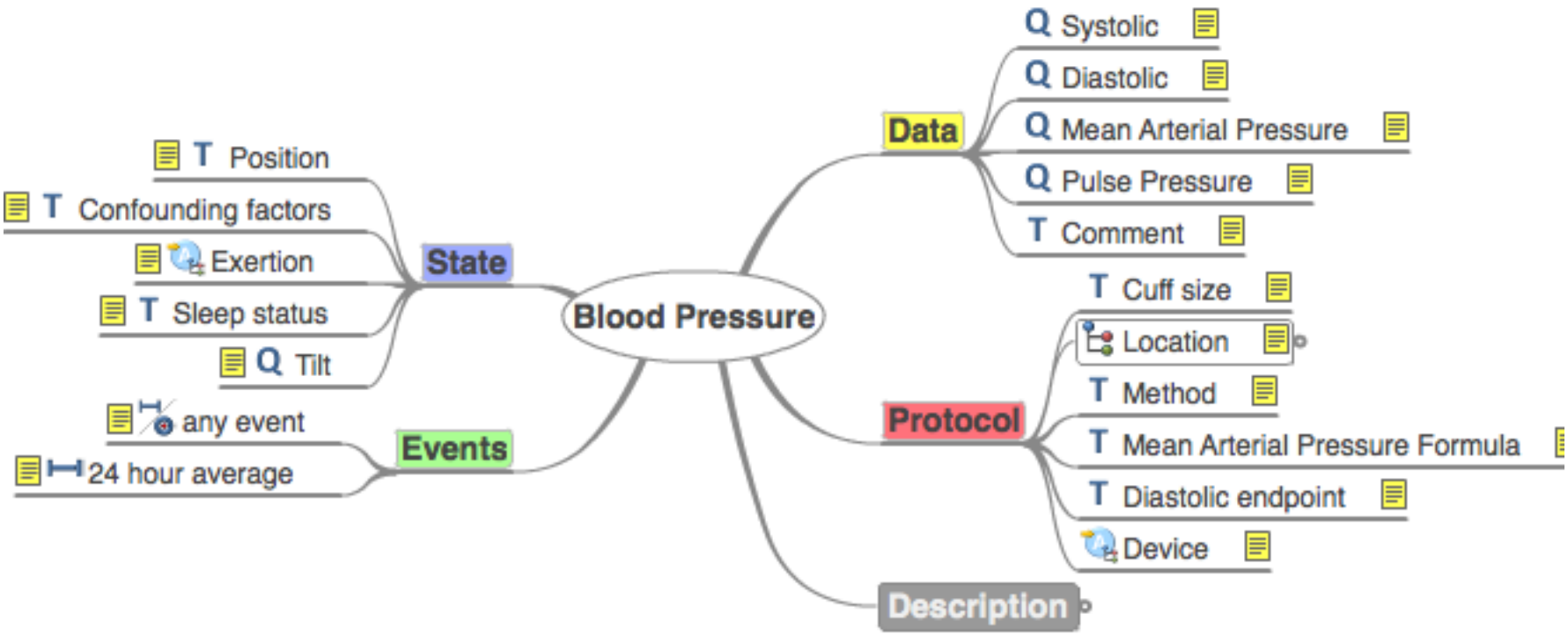
- Can be designed for specific local use case
  - local message
  - particular data entry screen

- But archetypes are most useful when designed to be ..
  - Shared
  - Reused

Potential for a SINGLE, SEMANTIC MODEL of clinical content

openEHR


Archetype Editor [en] Blood Pressure
File Edit Language Terminology Display Tools Help
openEHR-EHR-OBSERVATION.blood_pressure.v1
Header Definition Terminology Display Interface Description
Protocol
Participation
Person State with EventSeries
Data Protocol
Person State
Tree Events Person State
Structure Tree
Ordered
at0004
Systolic
Diastolic
Mean Arterial Pressure
Pulse Pressure
Comment
Constraints Details
Occurrences
Min: 0
Max: 1
Unbounded
Description
Peak systemic arterial blood pressure - measured in systolic or contraction phase of the heart cycle.
Runtime name constraint:
Quantity
Property:
Pressure
Units:
mm[Hg]
Count
Limit decimal places
0
Set min. value
>=
0
Set max. value
<
1,000


Blood Pressure
Data
Systolic
Diastolic
Mean Arterial Pressure
Pulse Pressure
Comment
State
Position
Confounding factors
Exertion
Sleep status
Tilt
Events
any event
24 hour average
Protocol
Cuff size
Location
Method
Mean Arterial Pressure Formula
Diastolic endpoint
Device
Description

openEHR

Blood Pressure

English

Archetype: Blood Pressure (openEHR-EHR-OBSERVATION.blood_pressure.v1)

Header | **Data** | State | Proto | Events | Reference model

Structure: Tree
Occurrences: 1..1 (mandatory)
Cardinality: 0..* (*optional, repeating, unordered*)

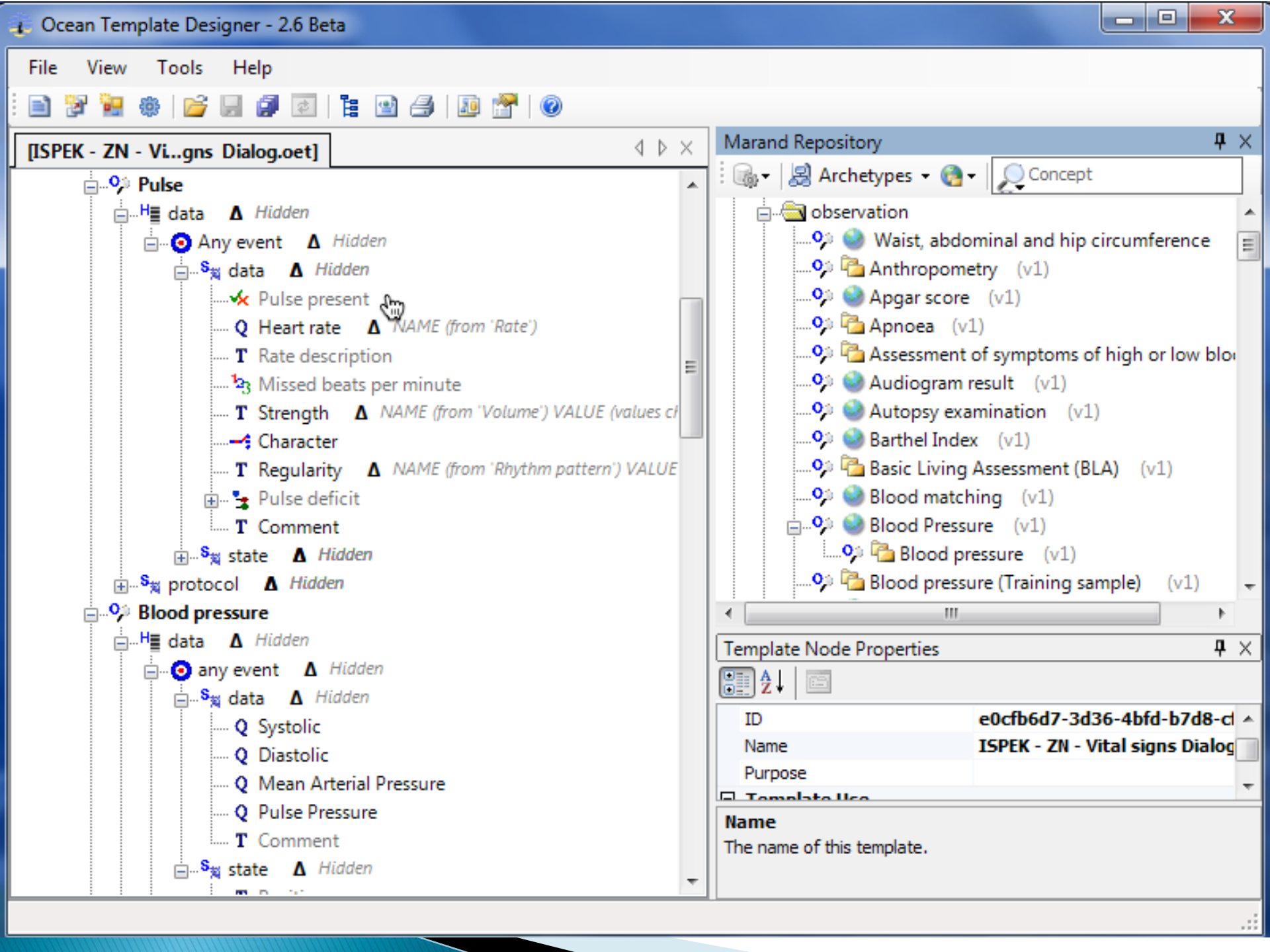
Q	**Systolic** Quantity Occurrences: 0..1 (optional) [**SNOMED-CT(2003)**::163030003] (On examination - Systolic BP reading (finding))	Peak systemic arterial blood pressure - measured in systolic or contraction phase of the heart cycle.	Property: Pressure Units: • 0.0..<1000.0 mm[Hg] Limit decimal places: 0
Q	**Diastolic** Quantity Occurrences: 0..1 (optional) [**SNOMED-CT(2003)**::163031004] (On examination - Diastolic blood pressure reading (finding))	Minimum systemic arterial blood pressure - measured in the diastolic or relaxation phase of the heart cycle.	Property: Pressure Units: • 0.0..<1000.0 mm[Hg] Limit decimal places: 0
Q	**Mean Arterial Pressure** Quantity Occurrences: 0..1 (optional)	The average arterial pressure that occurs over the entire course of the heart contraction and relaxation cycle.	Property: Pressure Units: • 0.0..<1000.0 mm[Hg] Limit decimal places: 0
Q	**Pulse Pressure** Quantity Occurrences: 0..1 (optional)	The difference between the systolic and diastolic pressure.	Property: Pressure Units: • 0.0..<1000.0 mm[Hg] Limit decimal places: 0
T	**Comment** Text Occurrences: 0..1 (optional)	Comment on blood pressure measurement.	Free or coded text

openEHR

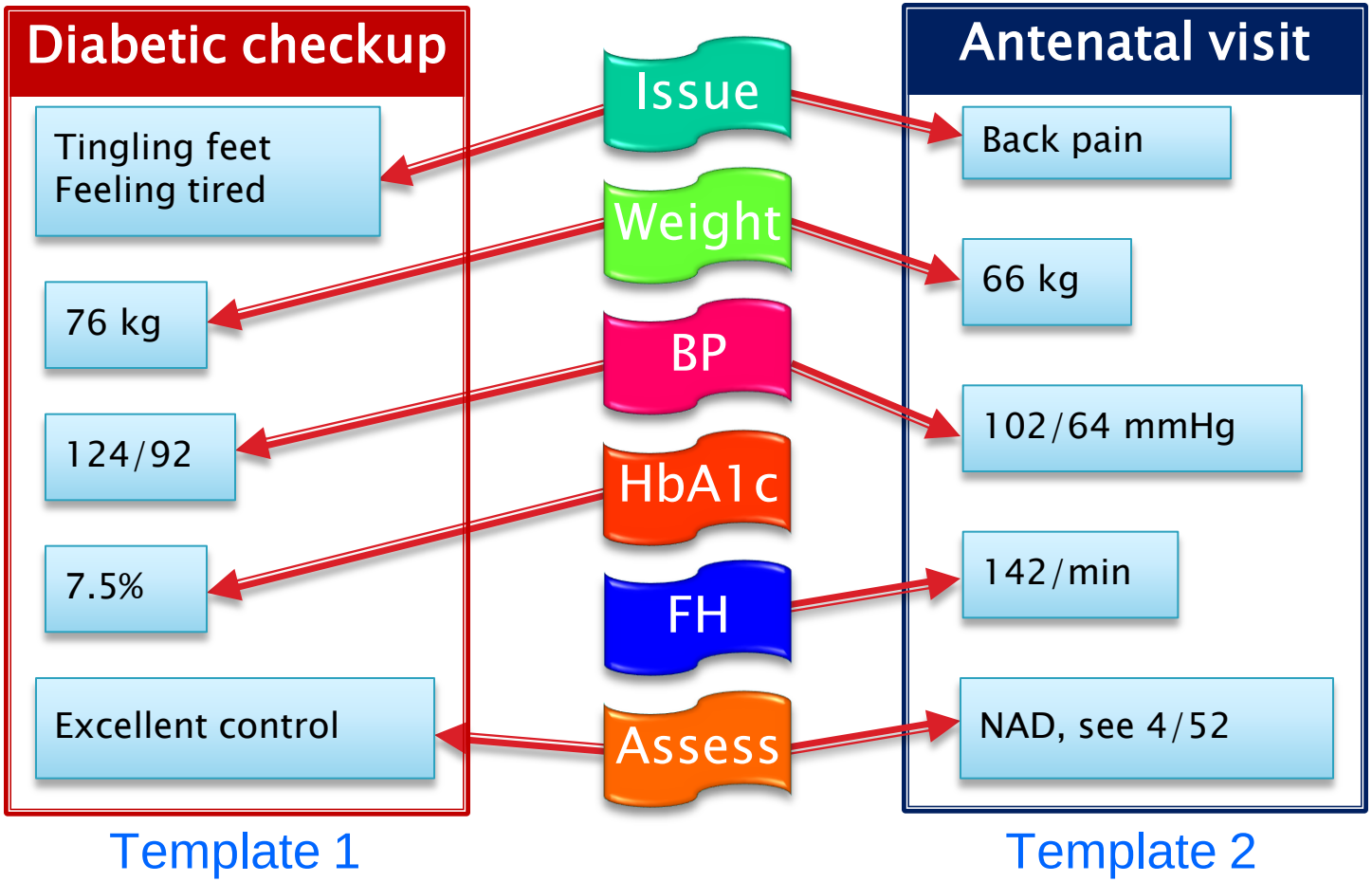
openEHR Templates

- Formal specifications defining specific aggregation of archetypes
  - For a particular clinical setting or use-case.
  - Constrain the component archetypes to make the maximal dataset 'fit for purpose', including
    - making items mandatory, assign default values
    - specifying terminology subsets for real-time usage

- Create ‘minimum datasets’ to underpin …
  - Data entry screens ,messages, clinical standards
  - Model-driven development


Ocean Template Designer - 2.6 Beta
File
View
Tools
Help
[ISPEK - ZN - Vi..gns Dialog.oet]
Pulse
data Hidden
Any event Hidden
data Hidden
Pulse present
Heart rate Δ NAME (from 'Rate')
Rate description
Missed beats per minute
Strength Δ NAME (from 'Volume') VALUE (values cl
Character
Regularity Δ NAME (from 'Rhythm pattern') VALUE
Pulse deficit
Comment
state Hidden
protocol Hidden
Blood pressure
data Hidden
any event Hidden
data Hidden
Systolic
Diastolic
Mean Arterial Pressure
Pulse Pressure
Comment
state Hidden
Marand Repository
Archetypes
Concept
observation
Waist, abdominal and hip circumference
Anthropometry (v1)
Apgar score (v1)
Apnoea (v1)
Assessment of symptoms of high or low blo
Audiogram result (v1)
Autopsy examination (v1)
Barthel Index (v1)
Basic Living Assessment (BLA) (v1)
Blood matching (v1)
Blood Pressure (v1)
Blood pressure (v1)
Blood pressure (Training sample) (v1)
Template Node Properties
ID e0cfb6d7-3d36-4bfd-b7d8-cl
Name ISPEK - ZN - Vital signs Dialog
Purpose
Name
The name of this template.

Archetype re-use in Templates

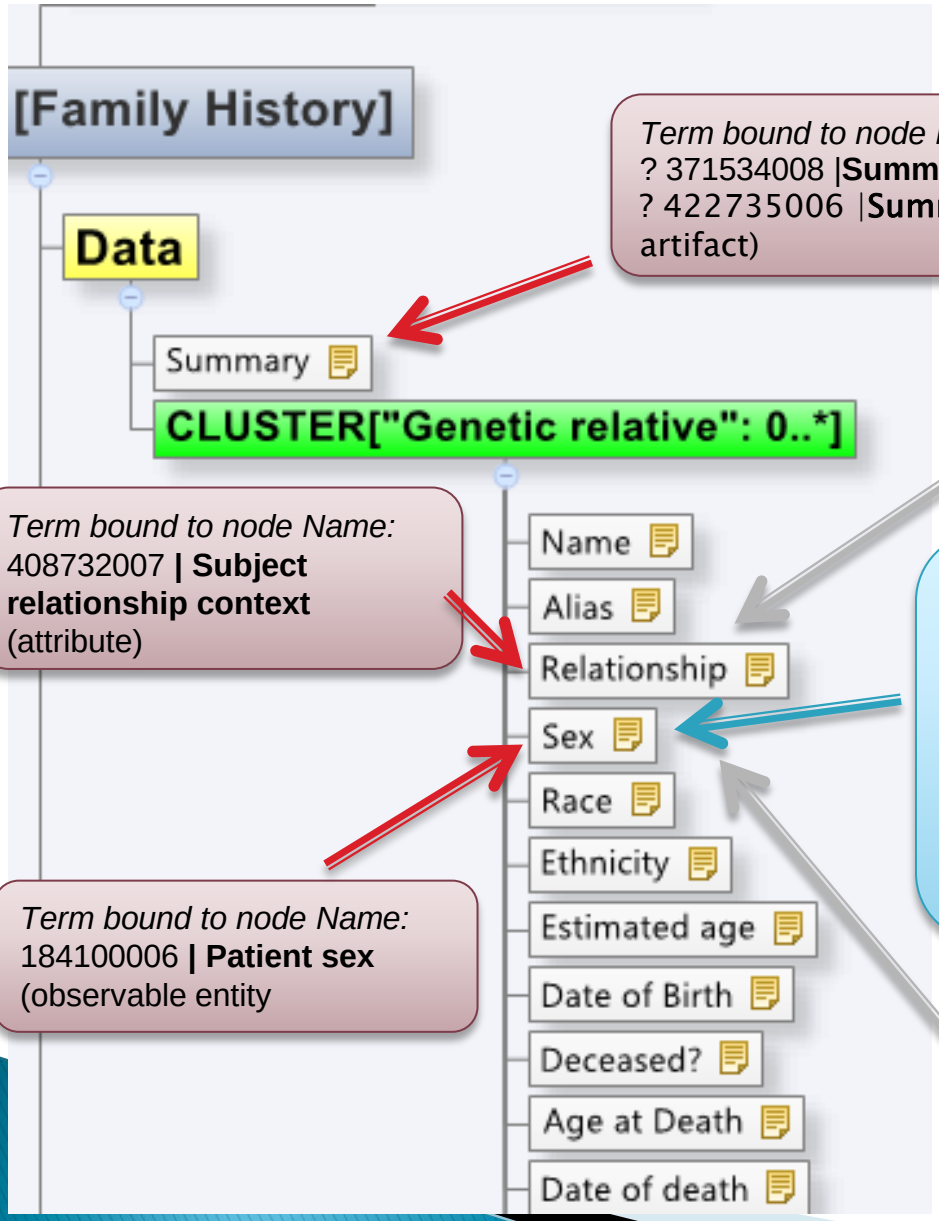


openEHR

Archetypes and terminology

- Each archetypes has its own internal terminology
  - Unique ID
  - may be mapped to >= 1 external terminologies
- The Archetype terminology provides “names”
  - in name/value pairs
  - on internal valuesets
- External terminology may be ‘bound’ to provide values for coded text nodes

Example: “Family history”



Term bound to node Name
? 371534008 |**Summary report** (record artifact)
? 422735006 |**Summary clinical document** (record artifact)

*Termset-bound to node Value: (*Is_a genetic relation)
444148008 **| Person in family of subject**

Term bound to node Name:
408732007 **| Subject relationship context** (attribute)

Term bound to node internal Valueset:
[at0004|Not known] =365873007**|Gender unknown** (finding)
[at0004|Not known] =UNK**|Gender unknown**

[at0005|Male] = SNOMEDCT::248153007 | **Male** (finding)
[at0005|Male] = KITH-SEX::M| **Male**

[at0006|Female] = 248152002 | **Female**(finding)
[at0006|Female] = KITH-SEX::F | **Female**

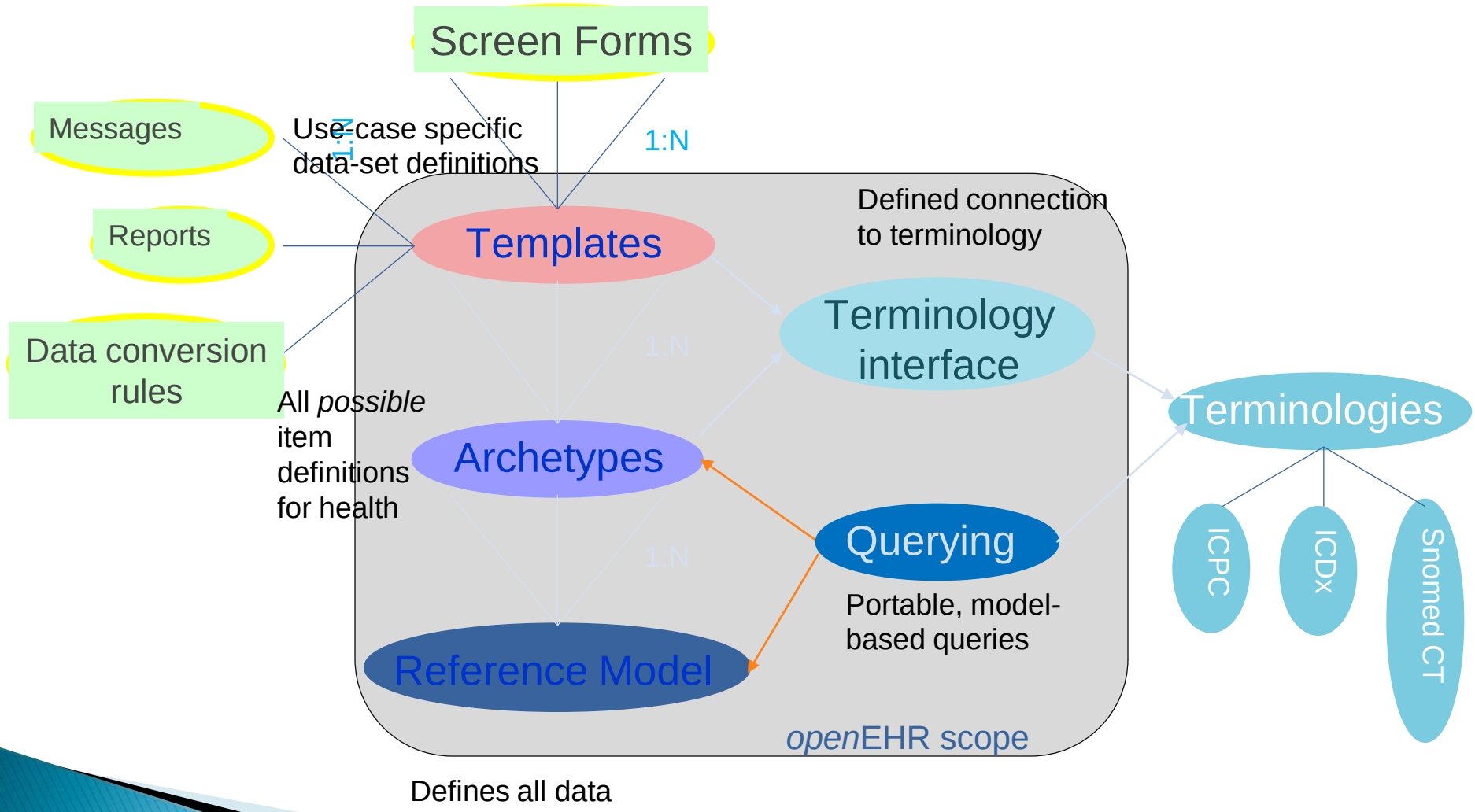
OR

Term bound to node Name:
184100006 **| Patient sex** (observable entity

Termset-bound to node Value: (??????)
429019009 **| Finding related to biological sex**

openEHR

*open*EHR Semantic architecture



openEHR Data Repositories

- Persistence mechanism is not defined by openEHR
  - but clinical data exposed via API / export must conform to openEHR specification “canonical openEHR”
  - Various approaches but blobbed xml + indexing is common

- Most have an AQL Archetype Query Language implementation
- Most have a common service layer aligned with OceanEHR
  - Formal openEHR service layer will be defined on the basis of emerging experience but likely to be close to OceanEHR

Advantages of openEHR Data Repositories

- Sophisticated audit / change control mechanism in-built
- Data format is portable between repositories
  - Reduced vendor lock-in
- Data and therefore querying schema is defined by archetypes
  - No need to rebuild database when archetypes change
  - Potential for distributed querying using AQL if repositories share archetypes

Available openEHR Data repositories

- Open source
  - Opereffa : opereffa.chime.ucl.ac.uk/introduction.jsf
  - EHRGen : www.openehr.org/wiki/display/projects/Open+EHR-Gen+Framework

- Proprietary
  - OceanEHR : www.oceaninformatics.com
  - Critical Clinical Repository : www.criticalsoftware.com
  - Base24 : www.code24.nl

openEHR

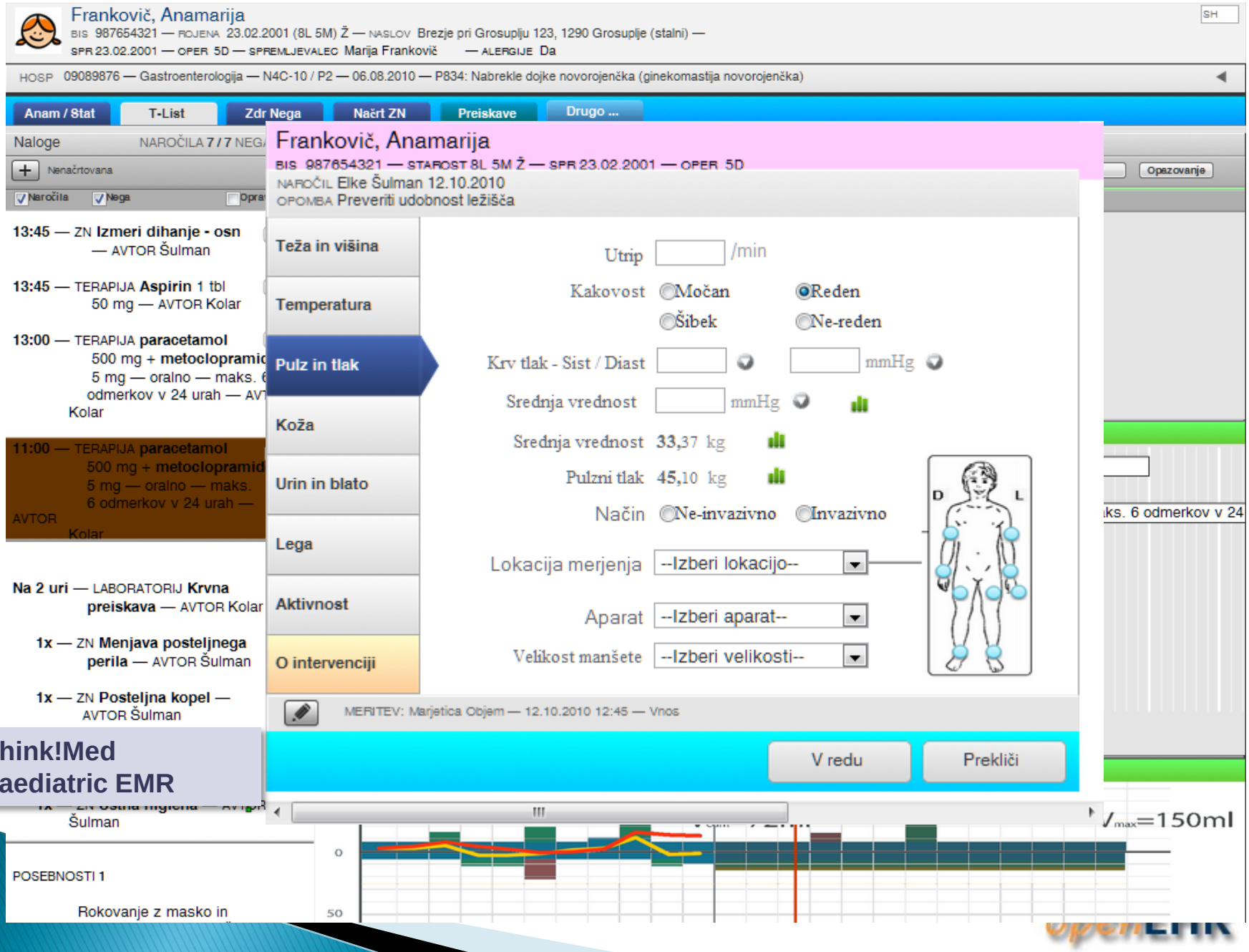
Application development with openEHR

- No shortcuts for good business analysis
  - Prototyping tools
  - Agile requirements gathering process
    - Clinicians <-> BA <-> clinical modeller
  - Business analyst is critical part of team
    - Needs understanding of openEHR but need not be expert
    - Will start to take over some clinical modelling
  - Good documentation

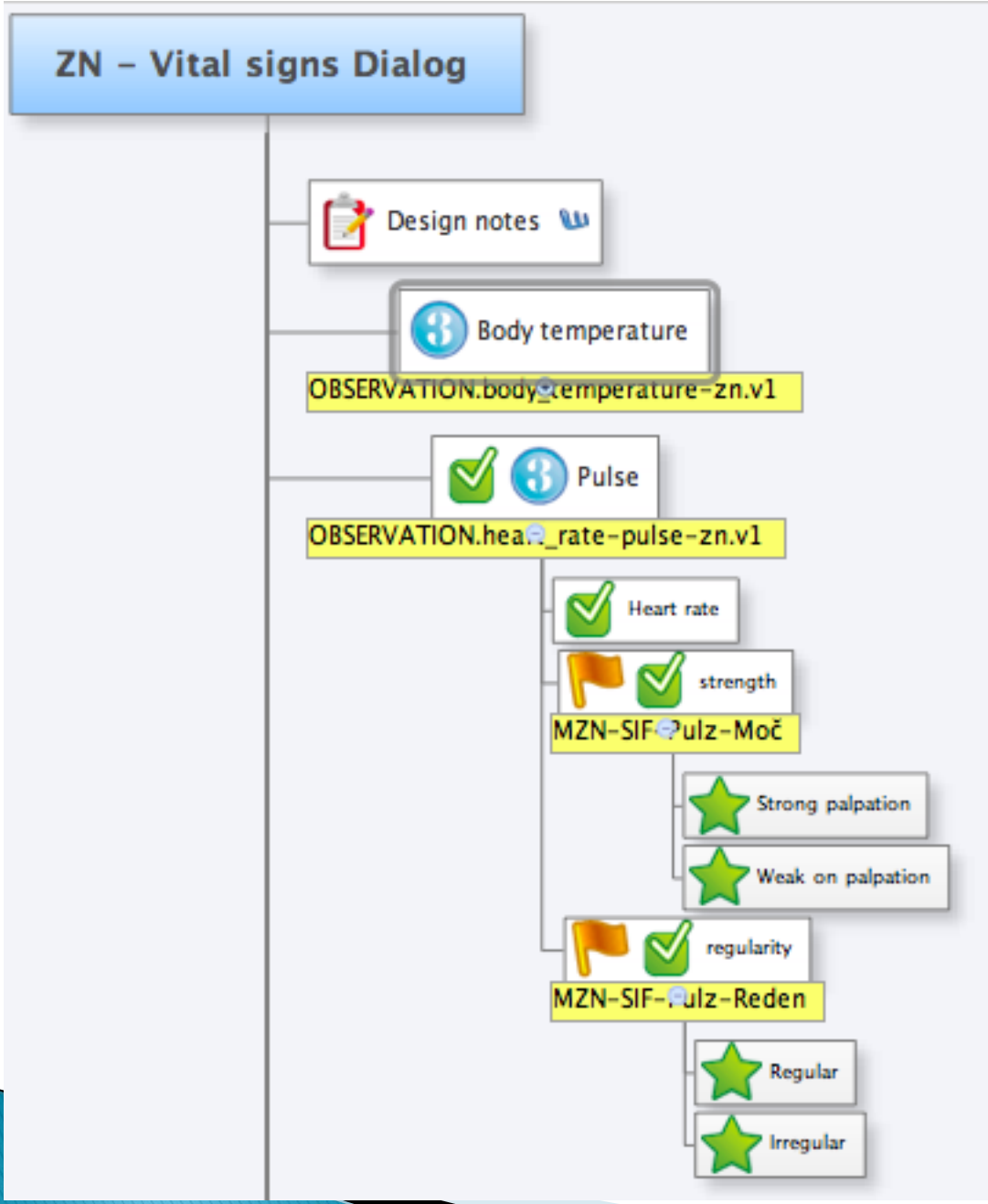
openEHR

The role of the clinical modeller

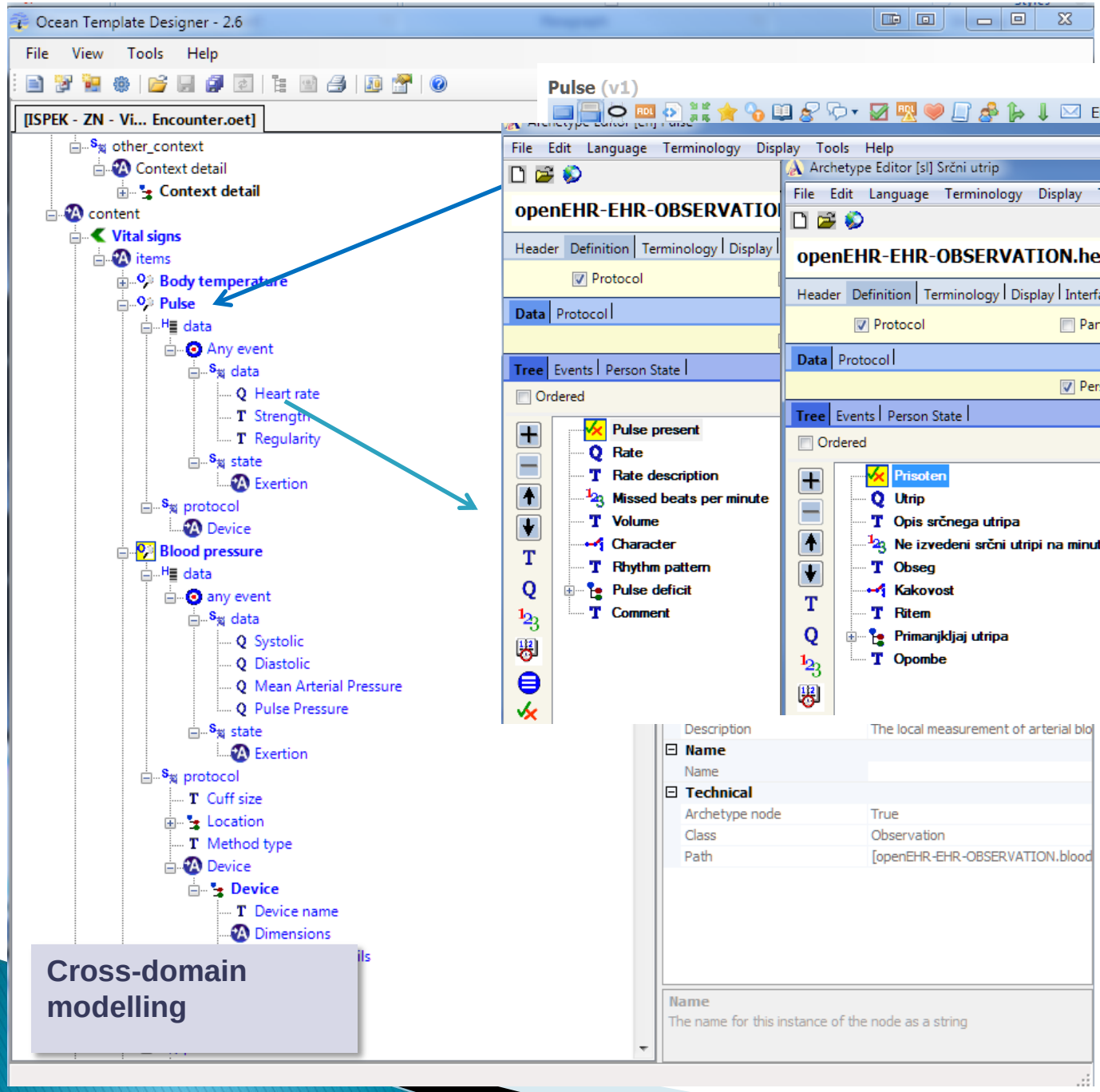
- From clinical requirements to clinical models
  - Work from clinical requirements / prototypes
  - Extensive mindmapping to understand the scope and shape of the models required
  - Which archetypes
    - Can we re-use from a national/int. repository?
    - Can we adapt "specialise" …
    - Should be purely local?
  - Advise on terminology use / binding approaches
- Requires detailed openEHR and clinical informatics expertise
  - Ideally a clinician (as much for political reasons)



Think!Med paediatric EMR


ZN – Vital signs Dialog
Design notes
Body temperature
OBSERVATION.body_temperature-zn.v1
Pulse
OBSERVATION.hea_rate-pulse-zn.v1
Heart rate
strength
MZN-SIF-Pulz-Moč
Strong palpation
Weak on palpation
regularity
MZN-SIF-Pulz-Reden
Regular
Irregular

openEHR



Cross-domain modelling

openEHR

Template-driven artefacts

- OPT “Operational Template”
  - Key artefact from which those below are derived
- TDS “Template Data Schema”
  - Simplified ‘flattened’ openEHR schema unique to each template but transformable to canonical openEHR schema
  - Very useful for integration /messaging
  - May provide a quick’n’dirty persistence format
  - Populated instances can be commited to openEHR data repository with a single call (WS or API)

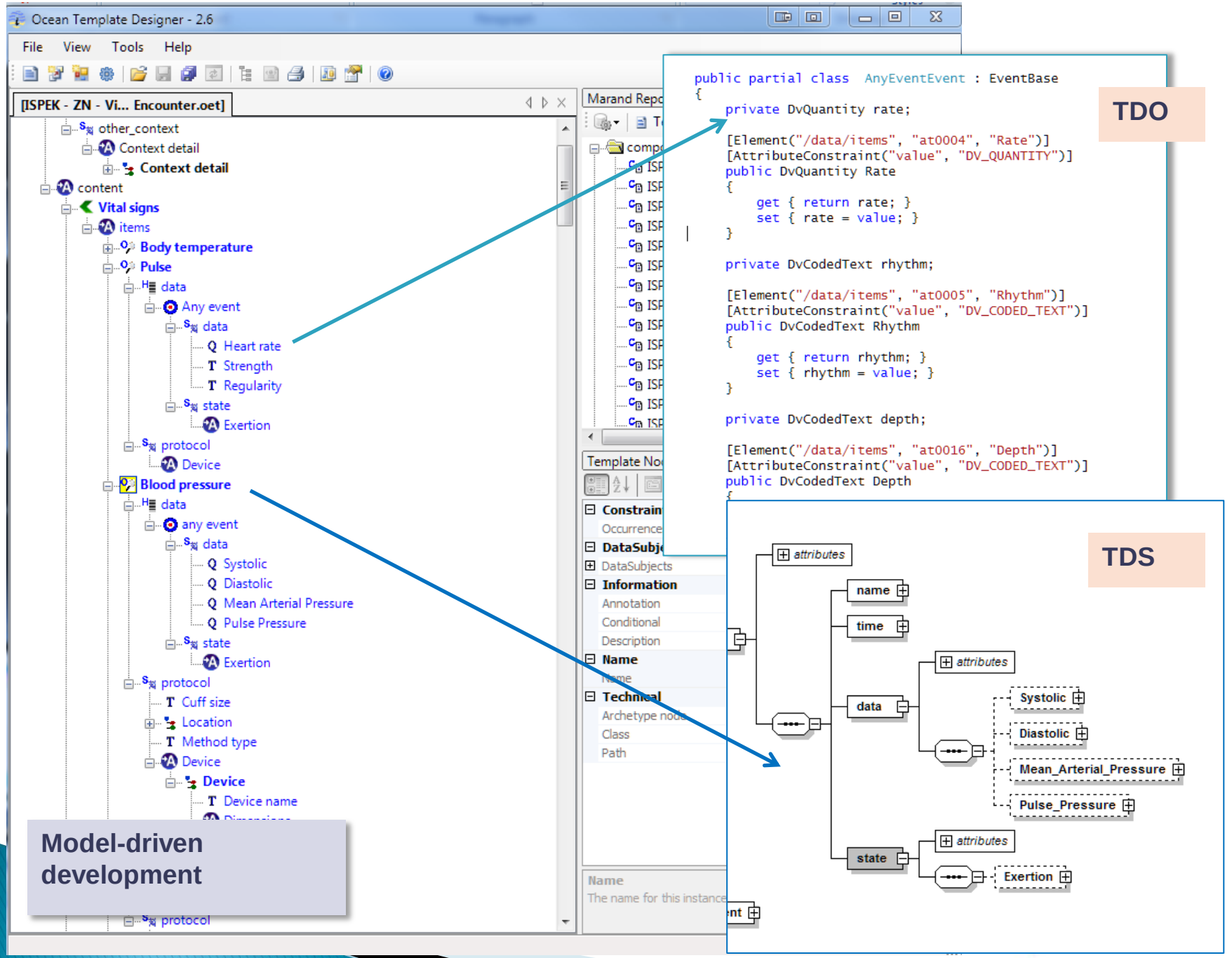
TDS to CDA Header transform

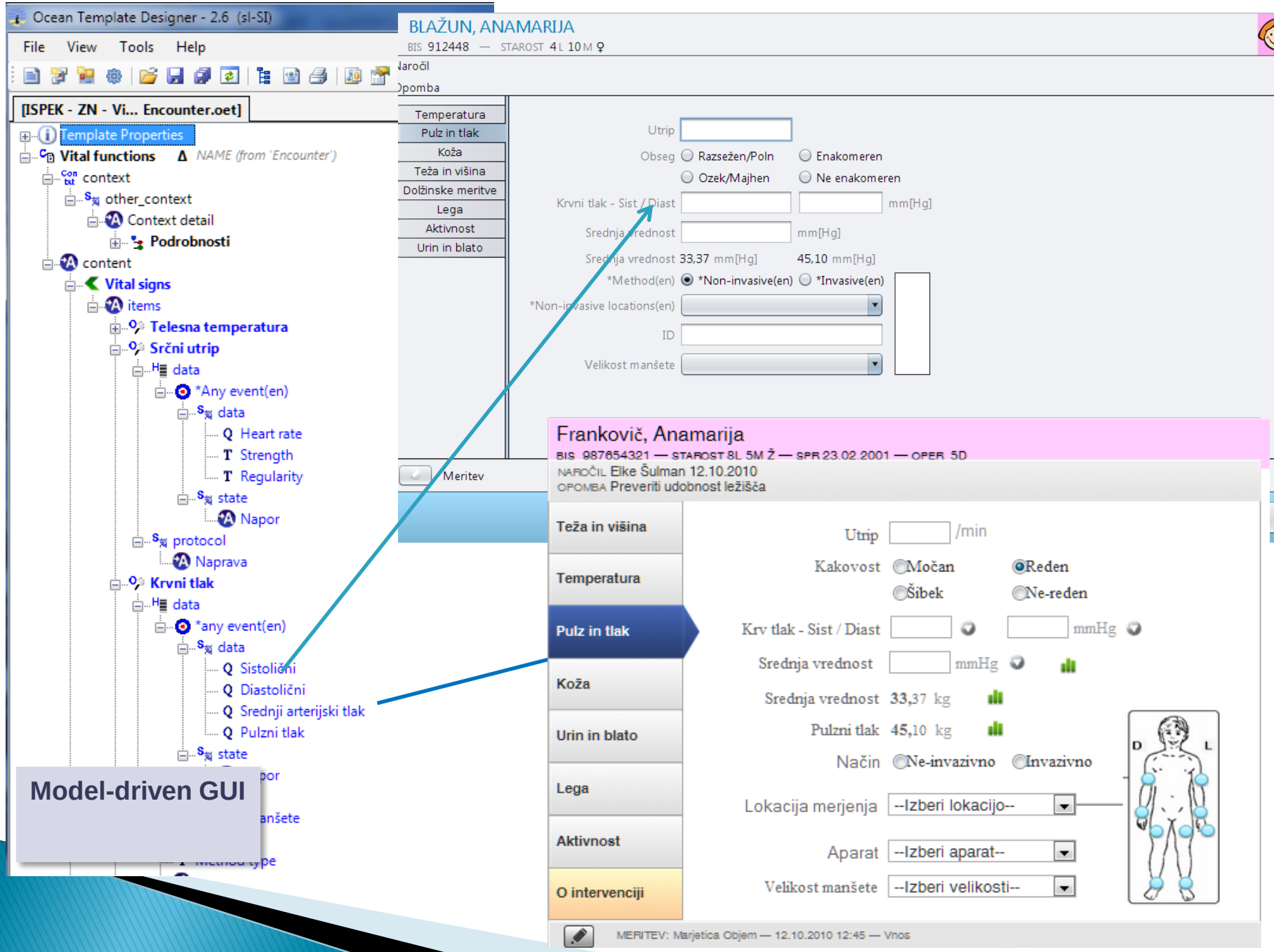
```
<!-- Document Subject -->
<xsl:call-template name="recordTarget">
    <xsl:with-param name="subject" select="ex:Subject"/>
</xsl:call-template>

<!-- Document composer -->
<xsl:call-template name="author">
    <xsl:with-param name="composer" select="$templateData/tdd:composer"/>
    <xsl:with-param name="startTime" select="$templateData/tdd:context/tdd:start_time"/>
</xsl:call-template>

<!-- CDA Header -->
<xsl:call-template name="CDAHeader">
    <xsl:with-param name="context" select="$templateData/tdd:context"/>
</xsl:call-template>

<!-- encompassing encounter -->
<xsl:call-template name="componentOf">
    <xsl:with-param name="context" select="$templateData/tdd:context"/>
</xsl:call-template>

<!-- CDA Body-->
<component typeCode="COMP">
    <structuredBody classCode="DOCBODY" moodCode="EVN">
        <xsl:apply-templates select="$templateData/child::*[@type]" mode="text"/>
    </structuredBody>
</component>
```

openEHR

Template-driven artefacts

- TDO “Template Data Objects”
  - Data-binding class libraries
  - C# , Java
  - Derived by transfrom
  - Classes properties are populated from GUI data fields, then the template is persisted by a single call to openEHR data repository
- Skeleton GUI generation
  - Limited but useful “First pass”

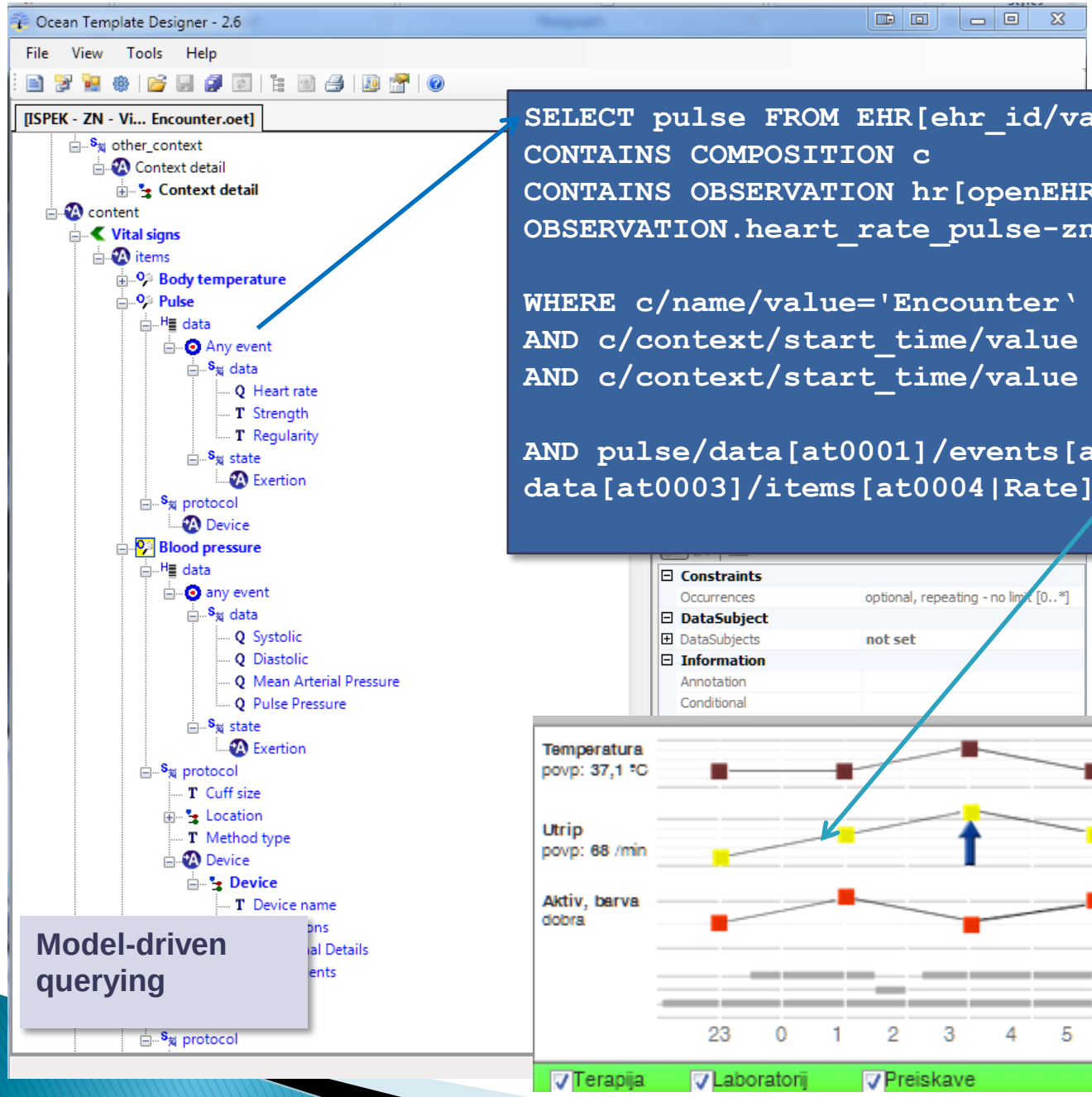

Ocean Template Designer - 2.6
File View Tools Help
[ISPEK - ZN - Vi... Encounter.oet]
other_context
Context detail
Context detail
content
Vital signs
items
Body temperature
Pulse
data
Any event
data
Heart rate
Strength
Regularity
state
Exertion
protocol
Device
Blood pressure
data
any event
data
Systolic
Diastolic
Mean Arterial Pressure
Pulse Pressure
state
Exertion
protocol
Cuff size
Location
Method type
Device
Device
Device name
protocol
Marand Repo
Template No
Constrain
Occurrence
DataSubj
DataSubjects
Information
Annotation
Conditional
Description
Name
Technical
Archetype node
Class
Path
Name
The name for this instance
public partial class AnyEventEvent : EventBase
{
private DvQuantity rate;
[Element("/data/items", "at0004", "Rate")]
[AttributeConstraint("value", "DV_QUANTITY")]
public DvQuantity Rate
{
get { return rate; }
set { rate = value; }
}
private DvCodedText rhythm;
[Element("/data/items", "at0005", "Rhythm")]
[AttributeConstraint("value", "DV_CODED_TEXT")]
public DvCodedText Rhythm
{
get { return rhythm; }
set { rhythm = value; }
}
private DvCodedText depth;
[Element("/data/items", "at0016", "Depth")]
[AttributeConstraint("value", "DV_CODED_TEXT")]
public DvCodedText Depth
TDO
TDS
attributes
name
time
attributes
data
Systolic
Diastolic
Mean_Arterial_Pressure
Pulse_Pressure
attributes
state
Exertion
Model-driven development



Model-driven GUI

AQL – Archetype Query Language

- Persistence layer independent Information model querying
- Querying schema defined by archetype not by persistence schema
- Clinical modeller role
  - Advise developers on appropriate AQL statements to retrieve data

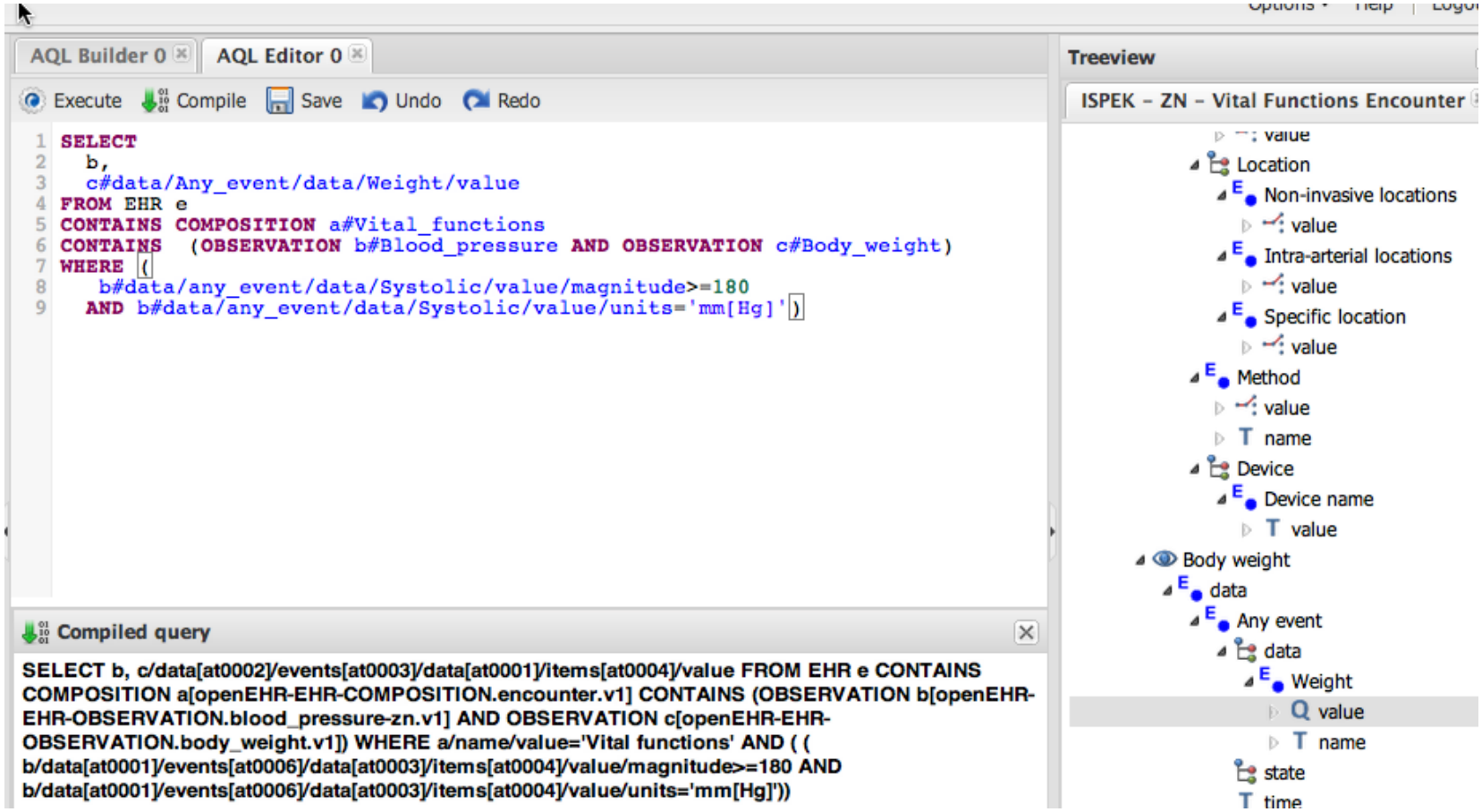



```
SELECT pulse FROM EHR[ehr_id/value=$ehruid]
CONTAINS COMPOSITION c
CONTAINS OBSERVATION hr[openEHR-EHR-
OBSERVATION.heart_rate_pulse-zn.v1]

WHERE c/name/value='Encounter'
AND c/context/start_time/value <= $endperiod
AND c/context/start_time/value >= $startPeriod

AND pulse/data[at0001]/events[at0006|Anyevent]/
data[at0003]/items[at0004|Rate]/value/value < 60
```

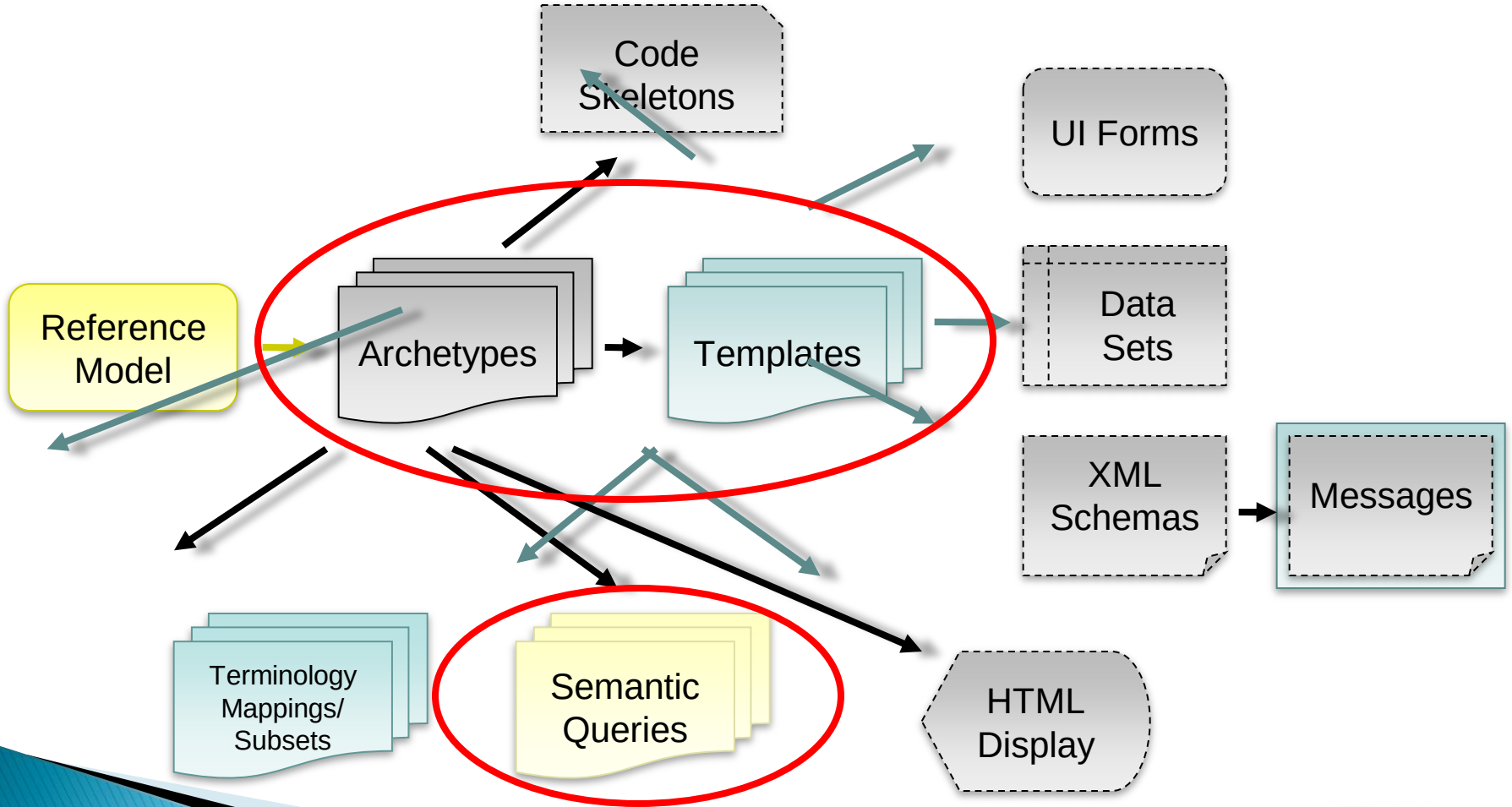
AQL

Model-driven querying

Marand AQL tooling



The openEHR artefact ecosystem



openEHR

Questions