

Exploiting Electronic Health Record Standard openEHR to Manage Experimental Data in Computational Physiology

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Outline

- Physiome/VPH & Data Linkages
- Experimental Data
- openEHR fundamentals
- Beyond Experimental > Health Data



Experimental Data

- For Simulation Experiments mature standards (MIASE/MIBBI and COMBINE) for both data and meta-data
- For Wetlab Experiments there is limited agreement on standard data and meta-data formats;
- Some examples (for meta-data)
 - The Cardiac Electrophysiology Ontology (EP);
 - The Ontology for Biomedical Investigations (OBI)
 - Just Enough Results Model (JERM) Ontology;
 - Bioassay Ontology (BAO);
 - ISA-Tab experimental metadata from FAIRDOM
- Motivation of this study: handle experimental data and meta-data using openEHR Information Modelling
 - Very flexible, model driven
 - Supports ontology based semantic linkages

Study Source (Wetlab) Data

- Time-series type experimental data
- 1Hz steady state pacing membrane potential data from dog myocytes

Johnstone RH, Chang ETY, Bardenet R, de Boer TP, Gavaghan DJ, Pathmanathan P, et al. Uncertainty and variability in models of the cardiac action potential: Can we build trustworthy models? Journal of Molecular and Cellular Cardiology

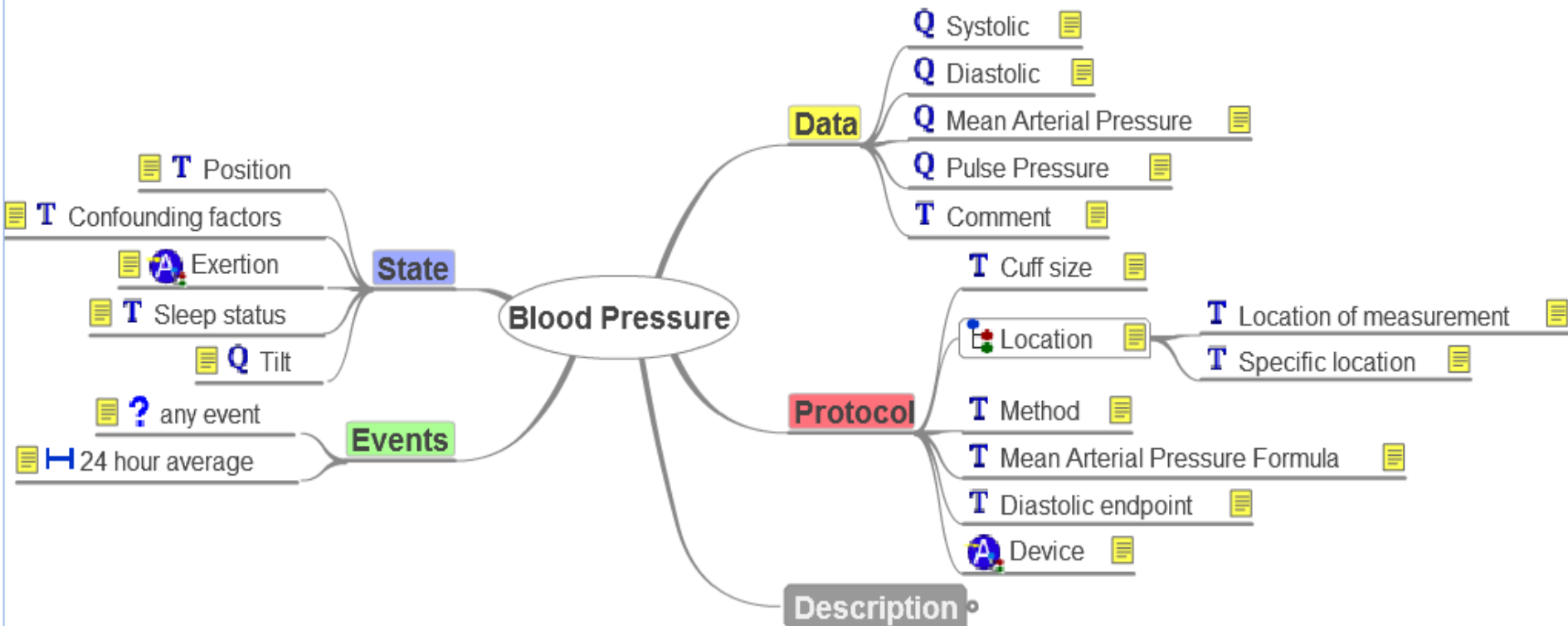
- 572 traces as .csv files each containing 3248 rows of two data points:
 - measurement time (in seconds)
 - membrane potential (in volts)
- No structured set of meta-data

Information Modelling (IM)

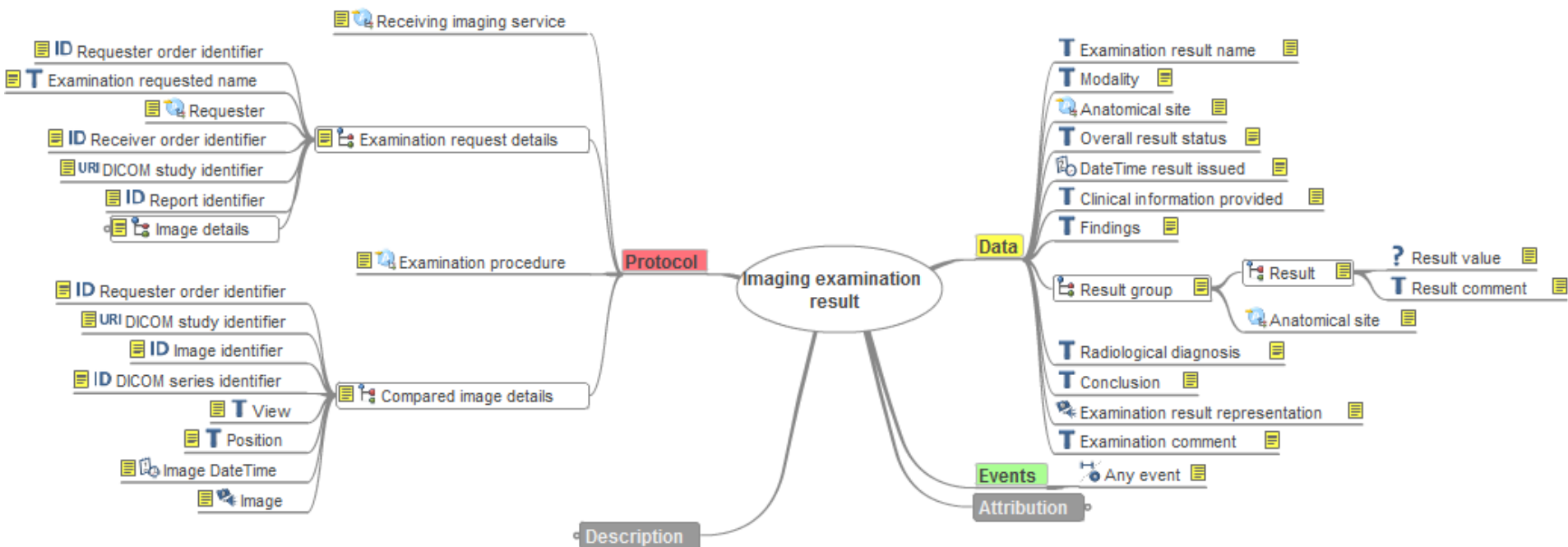
Archetypes, Detailed Clinical Models, Clinical Models etc.

- Computable representations of **data+context = information**
- Define both the **information structure** and **formal semantics** of documented concepts
- They facilitate:
 - Domain \leftrightarrow technical communication
 - Managing size, complexity and changeability (of biomedicine)
 - Organizing, storing, querying & displaying data
 - Data exchange & distributed computing
 - Data linkage, analytics & decision support

Clinical IM Examples: Blood Pressure Measurement

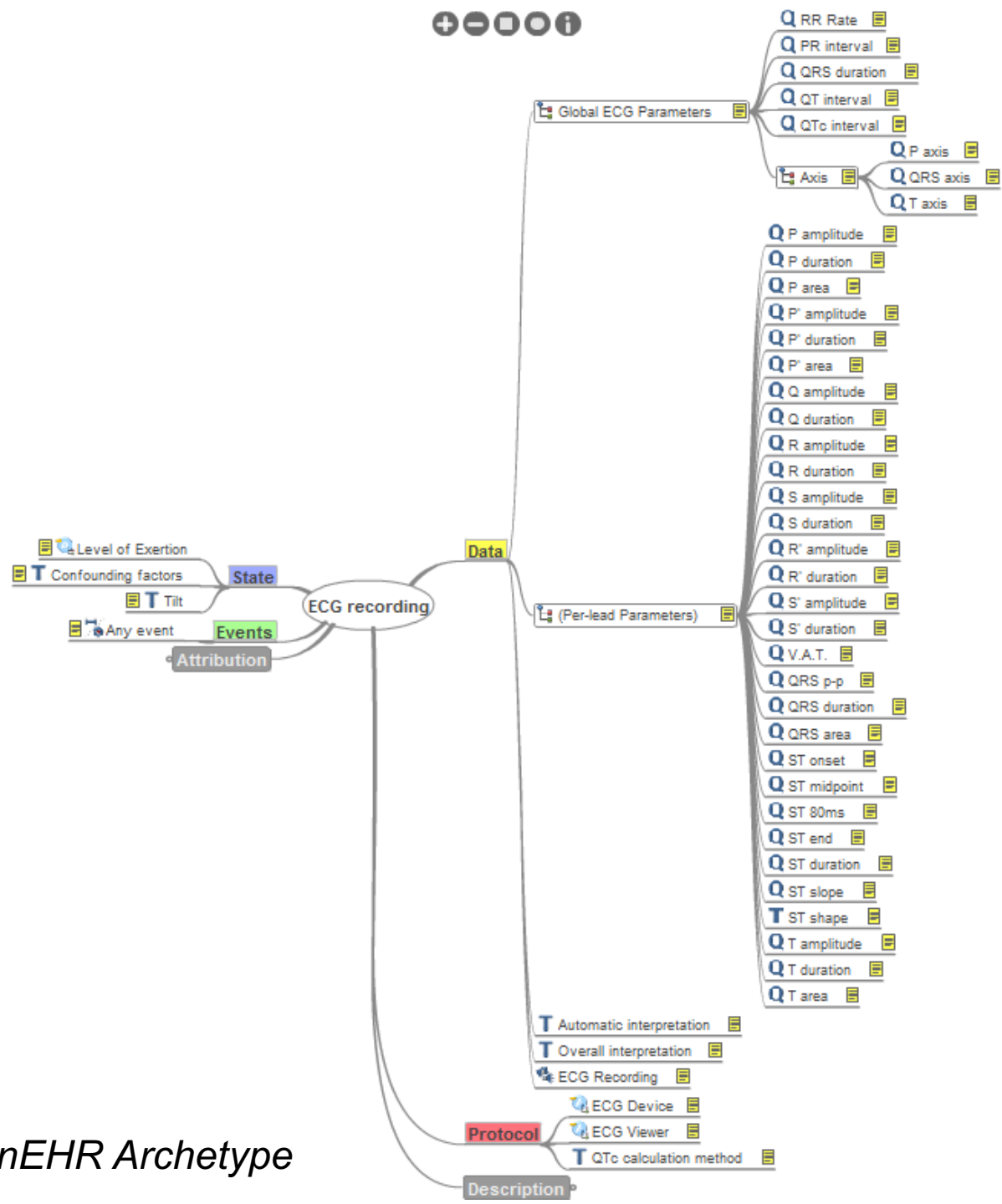


Imaging exam result



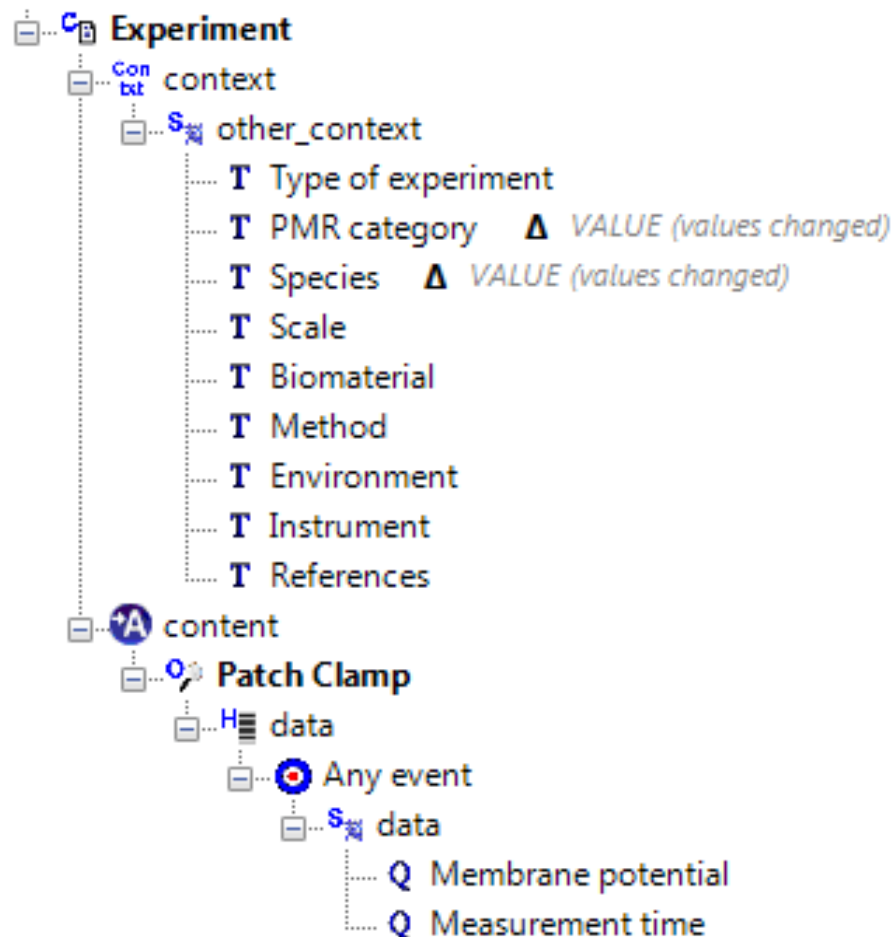
mindmap representation of openEHR Archetype

ECG recording



mindmap representation of openEHR Archetype

Study Information Model (with meta-data)



openEHR

- Open source specs & tooling for representing health information and building EHRs
 - Based on 20 years of international research
 - Also an ISO/CEN standard
- Not-for-profit organisation - established in 2001
www.openEHR.org
- Extensively used in research
- Separation of clinical and technical worlds
- Big international community
- Open Access online models repository
<http://openehr.org/ckm>

*open***EHR IM: Archetypes**

- **Constraints (OCL) on Data**
 - Structural constraints: List, table, tree
 - What labels can be used?
 - What data types can be used?
 - What values are allowed for these data types?
 - How many times a data item can exist?
 - Whether a particular data item is mandatory
 - Whether a selection is involved from a number of items/values
- Formal semantics via **terminology bindings**
- Flexible Meta-data definition

openEHR Clinical Knowledge Manager

openehr.org/ckm/

openEHR Clinical Knowledge Manager

Archetypes Templates Termsets Release Sets Reviews Projects General Discussion Reports Tools Help

Find Resources Dashboard Introduction to CKM Blood Pressure

Blood Pressure

English Adopted

| Header | Data | State | Protocol | Events | Reference model |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------|--------|-----------------|
| Archetype ID | openEHR-EHR-OBSERVATION.blood_pressure.v1 | | | | |
| Concept name | Blood Pressure Bound to: [SNOMED-CT(2003)::163020007] (On examination - blood pressure reading (finding)) | | | | |
| Concept description | The local measurement of arterial blood pressure which is a surrogate for arterial pressure in the systemic circulation. Most commonly, use of the term 'blood pressure' refers to measurement of brachial artery pressure in the upper arm. | | | | |
| Keywords | observations, measurement, bp, vital signs, mean arterial pressure, pulse pressure, systolic, diastolic, RR, NIBP | | | | |
| Copyright | © openEHR Foundation | | | | |
| Purpose | To record the systemic arterial blood pressure of an individual. | | | | |
| Use | <p>Use to record all representations of systemic arterial blood pressure measurement, no matter which method or body location is used to record it. The archetype is intended to capture blood pressure measurements in all clinical scenarios - for example, self-measurement with a home blood pressure machine; an emergency assessment of systolic using palpation and a sphygmomanometer; measurements taken in clinical consultations or during exercise stress testing; and a series of measurements made by a machine in Intensive Care.</p> <p>There is a rich state model that supports interpretation of measurements through identifying patient position, exercise, confounding factors and angle of a tilt table in research.</p> <p>Named events have been limited to average over a 24 hour period, however templates can further constrain the default 'any event' to cater for specific requirements for blood pressure measurements such as recording Blood Pressure against specific points in time, or over a range of intervals (+/- mathematical functions).</p> | | | | |
| Misuse | <p>Not to be used for intravenous pressure.</p> <p>Not to be used for the measurement of arterial blood pressure which is NOT a surrogate for arterial pressure in the systemic circulation eg specific measurement of right Pulmonary artery pressure.</p> <p>Use OBSERVATION.intravascular_pressure and related specialisations in both of these situations.</p> | | | | |
| Author | <p>Author name: Sam Heard Organisation: Ocean Informatics Email: sam.heard@oceaninformatics.com Date of Origin: 2006-03-22</p> | | | | |

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Printable version Share with Colleague

All Resources

Projects

Incubators

New and modified Resources

Resource Watchlist

Latest search

Archetypes

EHR Archetypes

- Cluster
 - Level of exertion (v1)
- Entry
 - Observation
 - Blood Glucose Test Result (v1)
 - Blood Pressure (v1)
 - Blood gas assessment (v1)
 - Blood glucose (v1)
 - Blood matching (v1)
 - Blood matching (v1)
 - Full blood count (v1)
 - Intraocular pressure measurement
 - Intravascular pressure (v1)
 - Central venous pressure (v1)
 - Jugular venous pressure (v1)
 - Modified Early Warning Score (v1)
 - Respirations (v1)
- Section
 - Vital signs (v1)

Clinical Knowledge Manager

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openEHR

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 - Modified Early Warning Score (v1)
 - Respirations (v1)
- Section
 - Vital signs (v1)

Blood Pressure

English Adopted

Collapse all Expand all Compare Archetypes

Trunk

TRUNK (REV. 29)

Current state: Published

Modified: 24.02.2014 10:46:56 by ian.mcnicoll

Log message: Translated archetype from English to Korean. Updated md5 hash

Compare

Details

TRUNK (REV. 28)

Modified: 03.02.2014 15:31:58 by ian.mcnicoll

Log message: MD5 hash updated. Stylistic errors corrected

Compare

Details

TRUNK (REV. 27)

Modified: 29.01.2014 16:53:36 by ian.mcnicoll

Log message: Translated archetype from English to Chinese (PRC).

Compare

Details

Branches

Active branch

SEUNGJONG.YU (REV. 29.1)

SEUNGJONG.YU (REV. 29.2)

Committed branch

SEUNGJONG.YU (REV. 28.1)

SEUNGJONG.YU (REV. 28.2)

SEUNGJONG.YU (REV. 28.3)

SEUNGJONG.YU (REV. 28.4)

SEUNGJONG.YU (REV. 28.5)

SEUNGJONG.YU (REV. 28.6)

TRUNK 29= SEUNGJONG.YU (REV. 28.7)

Committed branch

IAN.MCNICOLL (REV. 27.1)

IAN.MCNICOLL (REV. 27.2)

TRUNK 28= IAN.MCNICOLL (REV. 27.3)

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Sign out.

Archetypes ▾ Templates ▾ Termsets ▾ Release Sets ▾ Reviews ▾ Projects ▾ General Discussion ▾ Reports ▾ Tools ▾ Help ▾

Find Resources Dashboard Introduction to CKM Blood Pressure Round 8 Review Summary: Blood Pressure

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 - Jugular venous pressure (v1)
 - Modified Early Warning Score (v1)
 - Respirations (v1)
- Section
 - Vital signs (v1)

Content Review Summary: Blood Pressure

Switch to summary view

Content Review Summary: Blood Pressure (Revision: 15) (Summary view of 14 reviews)

InvitationHeaderDataStateProtocolEventsReference modelOverall Comments

Udo Müller on the completeness and missing elements

Seems complete

Koray Atalag on who else should be invited to review

Re. hyperbaric medicine I do not have a particular name in mind - but will try to find. Same for space medicine.

Editor Feedback:

Thanks Koray - will be interested in the feedback, maybe for the next revision!

Sebastian Garde's overall comments

Can be accepted as is. Suggest discussing the modelling of location as a choice, instead of a cluster with two elements

Editor Feedback:

This has been a deliberate design choice, as above

Sebastian Garde's overall recommendation (20-Apr-2010):

Accept

Evelyn Hovenga's overall recommendation (20-Apr-2010):

Minor Revision

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Mindmap Download Next >

Printable version

Semantics in openEHR

- Whole-of-model meta-data:
 - Description, concept references (terminology/ontology), purpose, use, misuse, provenance, translations
- Item level semantics (**Schema level**)
 - Trees/Clusters (Structure)
 - Leaf nodes (Data Elements)

Formally: different types of **terminology bindings**:

- 1) linking an item to external terminology/ontology for the purpose of defining its real-world clinical/biological **meaning**
- 2) Linking data element **values** to external terminology (e.g. a RefSet or terminology query)

Also→Instance level semantic annotations – applies to actual data collected

1) Linking data items to Ontology to define real-world meaning (~semantic annotation)

The screenshot displays the Archetype Editor interface for a blood pressure archetype. The main window shows the 'Term Bindings' tab, where the 'SNOMED International Clinical Terms, 2002' terminology is selected. A table lists the mapped terms, including Cuff size, Systolic, Diastolic, and Blood Pressure, each with a corresponding SNOMED code and release year (2003). The 'Data' node is highlighted in yellow, and a list of data items (Systolic, Diastolic, Mean Arterial Pressure, Pulse Pressure, Comment) is shown to its right. Other nodes like 'Position', 'Confounding factors', 'Location of measurement', and 'Specific location' are also visible in the background.

Archetype Editor [en] Blood Pressure

File Edit Language Terminology Display Tools Help

openEHR-EHR-OBSERVATION.blood_pressure.v1

Header Definition Terminology Display Interface Description

Terms **Term Bindings** Constraints Languages & Terminologies

Terminology **SNOMED International Clinical Terms, 2002**

| Node | Complex | Node | Code | Release |
|------|---------|----------------|-----------|---------|
| ▶ | | Cuff size | 246153002 | 2003 |
| | | Systolic | 163030003 | 2003 |
| | | Diastolic | 163031004 | 2003 |
| | | Blood Pressure | 163020007 | 2003 |
| * | | | | |

Data

- Systolic
- Diastolic
- Mean Arterial Pressure
- Pulse Pressure
- Comment

Position

Confounding factors

Location of measurement

Specific location

Cuff size

Method

Mean Arterial Pressure Formula

Diastolic endpoint

Device

2) Linking data element values to an ontology (or subset)

Ocean Template Designer - 2.7 Beta

File View Tools Help

[ANZACS-ACS.oet]

Template Properties

- Encounter
 - context
 - content
 - Risk Prediction and Diagnosis Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - CVD Risk Factors & Lab Data Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - Acute Management Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - Investigations Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - Coronary Angiography Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - Invasive Management Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - Medication at Discharge from Cardio/Medical Care Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')
 - items
 - Medication action
 - description
 - Medicine Δ VALUE (types set=CODED_TEXT)
 - Instructions
 - Ingredients and form
 - Reason
 - Quantity
 - Comment
 - Sequence number
 - Administration
 - Brand substituted
 - protocol
 - Exclusion statement - Medications
 - Contraindication
 - In-hospital Outcomes Δ [0..*] to [0..1], NAME (from 'Adhoc Heading')

ANZACS-QI Repository

- Templates
 - composition
 - ANZACS-QI ACS
 - ANZACS-QI CathLab
 - ANZACS-QI Device
 - ANZACS-QI EHR
 - entry
 - section
 - structure
 - cluster
 - element

Properties - Medicine

Select a value set terminology query

Terminology Service Generic Valueset

Terminology Name New Zealand Universal List of Medicines

Terminology Subset Name

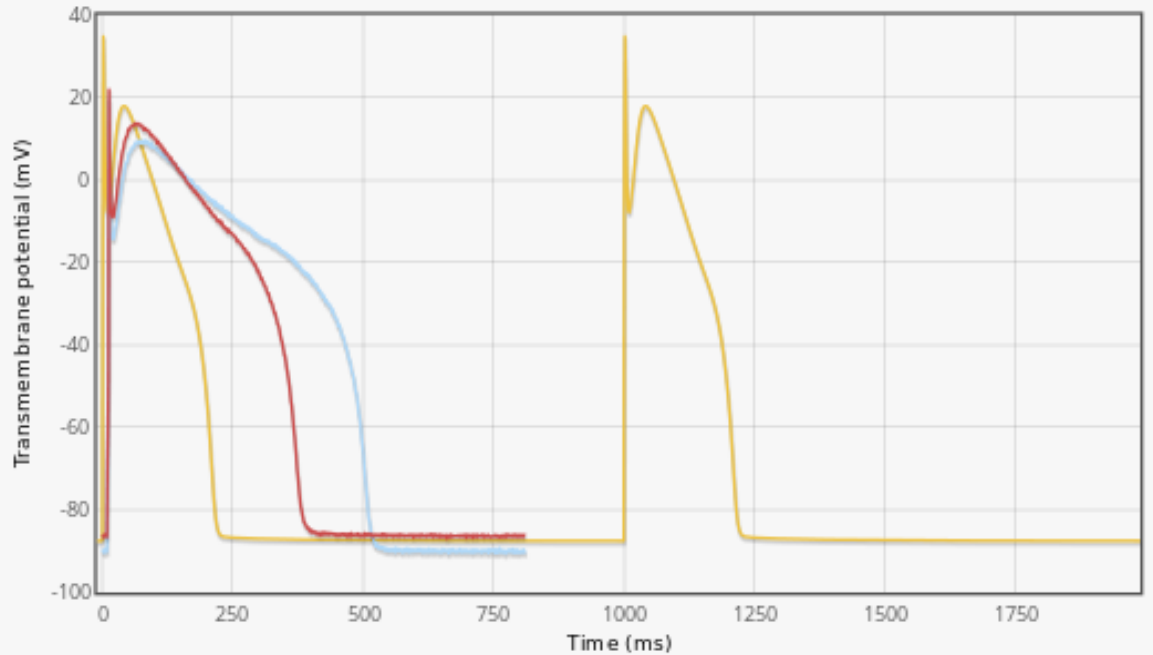
Terminology Version 2015

Cancel Select

Properties - Medicine Annotations - Medicine RM Attributes - Medicine

Result: Experimental & Simulation Data Integration

-Extended WebLab
(doi: 10.1016/j.bpj.2015.12.012)



☒ select all reset zoom

☒ line 1 ☒ dog_AP_trace_423.csv ☒ dog_AP_trace_152.csv

A

Msg: Successful!

Experimental data :

CellML : ☐

Related : Variation by ...

| CellML | Protocol |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------|
| category (i.e. not only 'electrophysiology') | <input checked="" type="checkbox"/> pacingPeriod (i.e. not only '1Hz') <input checked="" type="checkbox"/> |
| location (i.e. not only 'cardiac') | <input checked="" type="checkbox"/> |

Retrieve candidates

B

Related experimental data candidates ("✓" indicates variation) :

| Display | Dataset | category | species | location | type | pacingPeriod |
|-------------------------------------|------------------------|-------------------|---------|----------|------|--------------|
| <input checked="" type="checkbox"/> | dog_AP_trace_423.csv ⓘ | electrophysiology | | cardiac | 1Hz | ✓ unknown |
| <input checked="" type="checkbox"/> | dog_AP_trace_152.csv ⓘ | electrophysiology | | cardiac | 1Hz | ✓ unknown |
| <input type="checkbox"/> | dog_AP_trace_170.csv ⓘ | electrophysiology | | cardiac | 1Hz | ✓ unknown |

Conclusion

- Experimental data and meta-data can be modelled using mature EHR standard
 - No need for a concrete persistence model
 - Supports model based querying
 - Auto-generated GUI for data and meta-data entry
- Good open source tooling and data platforms
- Models can be created and maintained collaboratively
 - Including semantic annotations
 - Supports provenance and version control
- Same tools and methods can be used for managing real-world healthcare data

Beyond Experimental Data: Healthcare Data

- Healthcare data/longitudinal EHRs are sinks of valuable knowledge/causality
 - Embody effects of environment/psychosocial factors
- Therefore linking with EHRs will enable:
 - Better understanding (genotype>enviro>phenotype)
 - Large scale validation of computational models
 - Personalised computational models
 - ➔ Predictive tools & decision support systems

Another emerging IM standard:

HL7 FHIR (Fast Healthcare Interoperability Resources)

- Purpose: Information Exchange (not persistence)
 - Scope smaller than openEHR
 - Support simpler use-cases (for exchange)
- Rapid adoption
- Developer oriented / pragmatic
- RESTful API
- Inspired by modern Web technologies – leveraging W3C standards (XML family, ATOM, RDF etc.)
- Information models defined as **Resources**;
 - Semantic linkages supported



Big Picture: Linking Computational Models to Data

Computational Systems / Modelling and Simulation

Modelling Formalism

*CellML, FieldML,
SBML, SED-ML,
BioSignalML*

Tooling & Software

*openCOR
OpenCMISS
SemGen/SemSim
RICORDO/ApiNATOMY*

Physiome Model Repository

CellML, FieldML

- biological/biophysical concepts
- maths
- experiment protocols
- annotations
- versioning / exposures
- web view / API

Imaging Data

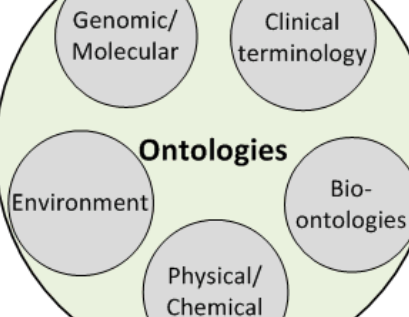
>CT, MRI, X-Ray etc.
>Biosignals (ECG, EEG)

Measurement Data

>Reference phenotypes/
study specific biomarkers
>Experimental data
>Simulation results

Semantic Web / Knowledge Engineering

Ontologies



Identifiers

URI, GUID, OID

W3C Standards

XML, RDF, OWL,
SPARQL, LOD

Tooling & Software

*XML tools
Ontology editors
Inference engines
Lexical tools
Open Data frameworks
Discovery/visualisation*

Shared Semantic
Annotations

Shared Semantic
Annotations

Information Systems / Clinical Data

Modelling Formalism

*openEHR,
HL7 FHIR*

Tooling & Software

*Archetype Editors
Template Designers
Software frameworks
Data transformation
Terminology service*

Clinical Model Repository

Archetypes, Terminology

- clinical/administrative objects
- provenance / peer review
- annotations and term bindings
- versioning
- web view / API

openEHR

Biobanks/
Research Data

EMR / EHR

Clinical
Systems

National/Regional
Clinical Data Repositories

Personal
Health Records

Some concluding thoughts

Linking the two universes – shared semantics!

- Semantic annotation mechanisms & tooling already exist in both universes
 - CellML annotations → openCOR, SemGen
 - openEHR Archetypes, SNOMED, CTSII etc.

→ **Key considerations should be:**

- Shared ontologies / identifiers
 - SNOMED > UMLS > FMA/GO etc.
 - But SNOMED and FMA anatomy not same but similar!
Bodenreider O, Zhang S. Comparing the Representation of Anatomy in the FMA and SNOMED CT. AMIA Annu Symp Proc. 2006;2006:46–50.
- Shared annotation approach
 - RICORDO, PMR2, SemGen etc.
 - More research on joint semantic annotations.
- Shared modelling patterns & governance?