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Escola de Engenharia

KEG
Knowledge Engineering Group

CENTROALGORITMI

OpenEHR - The solution for an interoperable development

António Abelha

May, 5th, 2021

BACKGROUND

Manual Health Record

Informatization

1960

Electronic Health Record (EHR)

Modelling
Automatization

Present

Structured Electronic Health Record (EHR)

Interoperability — Why?

Standards — How?

CONTEXTUALIZATION

Clinical Data Sets

+ Volume Data
+ Reading and writing speed
+ Adaptation to changing needs

Importance of Structured Data

New Clinical Model

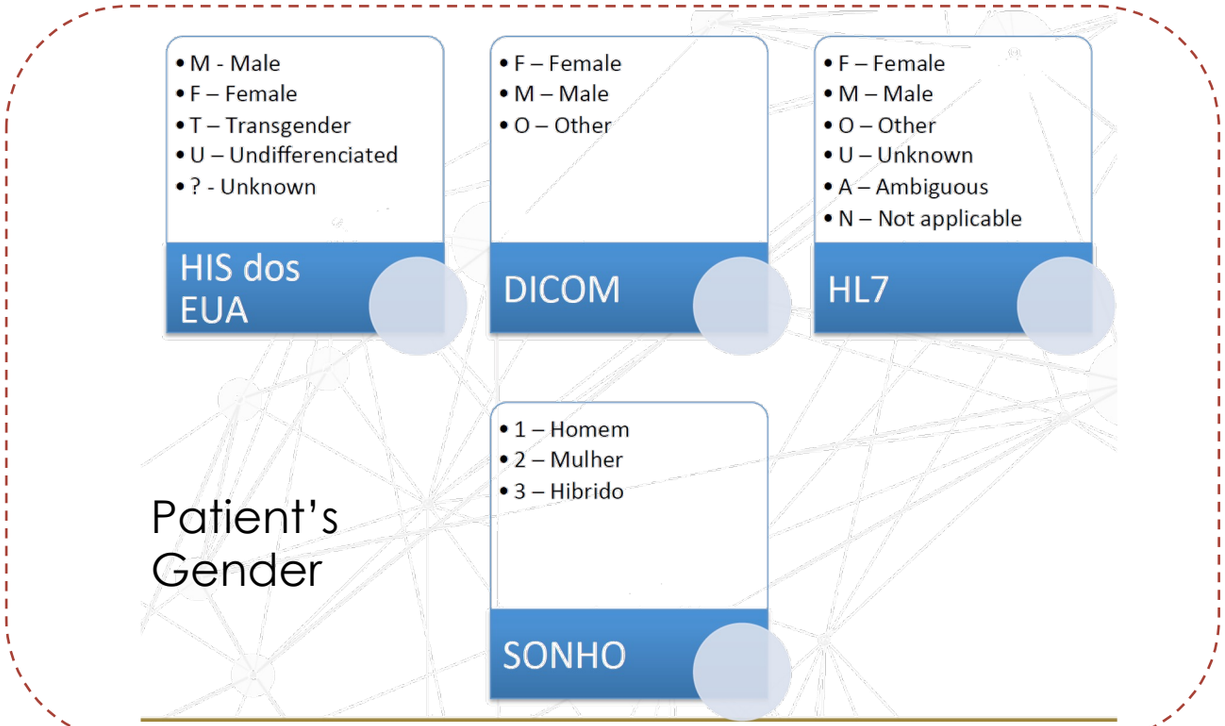
- Records sharing
- Data aggregation
- Decision Support Systems

Software

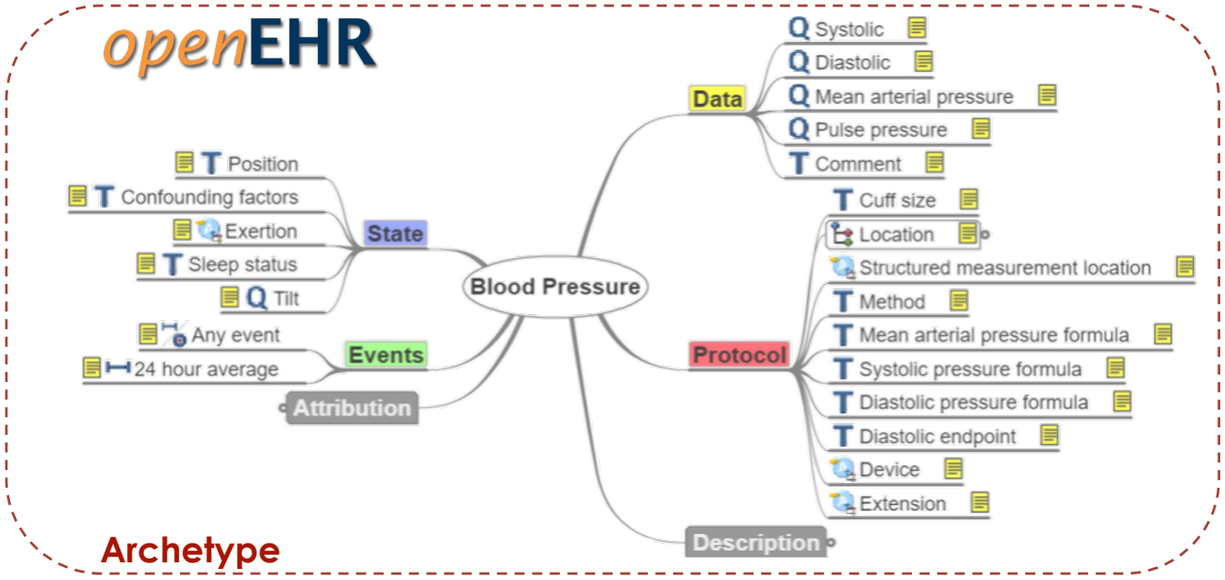
+ Generic
+ Robust
+ Intelligent

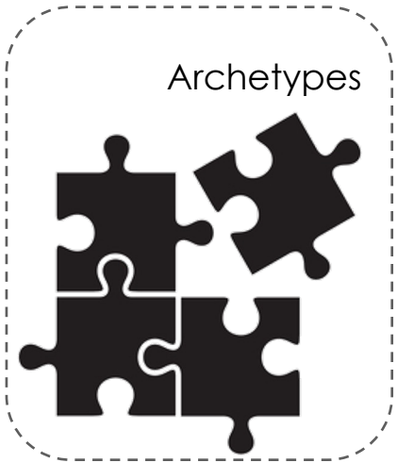
PROBLEM AND SOLUTION

Problem



Solution





WHAT IS THE OpenEHR?

- Non-for-profit organisation since 2001
- An open specification for a Healthcare Information Model
- Promotes an open ecosystem centered on clinical information
- A vendor-neutral and technology-neutral solution
- Dual model to separate clinical and technical terms
- Developed to store and query large clinical datasets
- Clinicians identify new content, which is then automatically submitted to a clinical data repository

WHAT IS THE OpenEHR?

Dual Model Approach

Reference Model

IT Expert

REFERENCE MODEL
Quantity
Text

'Quantity' can have numbers
'Text' can have strings

Layer #1
INFORMATION

Clinical Domain Expert

ARCHETYPE #1
Body Weight
Weight: Quantity
Comment: Text

ARCHETYPE #2
Blood Pressure
Systolic: Quantity
Diastolic: Quantity
Mean Arterial Pressure: Quantity
Pulse Pressure: Quantity
Comment: Text

Layer #2
KNOWLEDGE

Archetype Model

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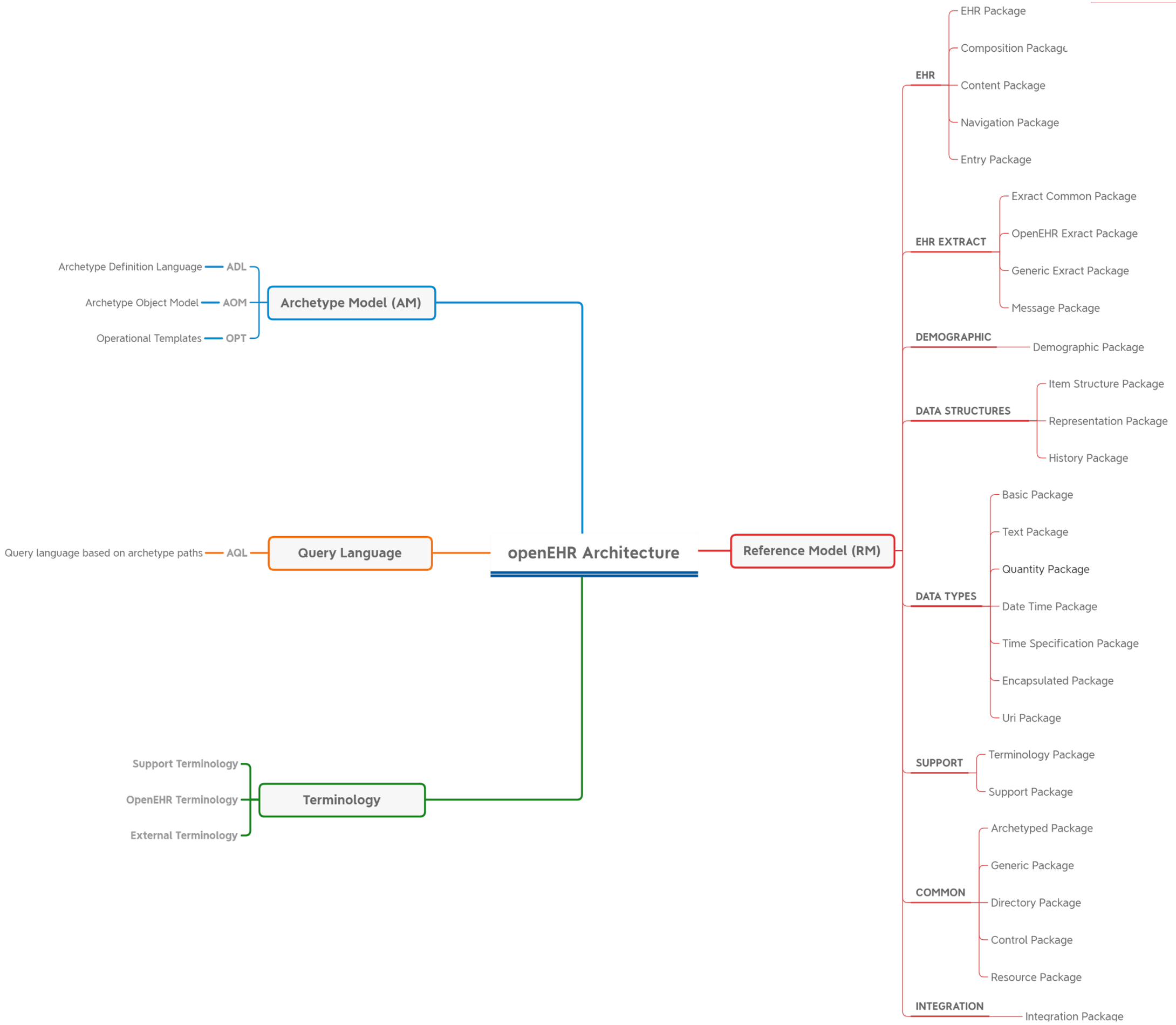


WHAT IS THE OpenEHR?

INTEROPERABILITY

Syntactic	**Structural**	**Semantic**
Reference Model (RM)	Archetypes	Domain Knowledge Governance
Sharing Clinical Information	Reusability	Standardized Terminologies

- ↓ Ambiguity of medical terms
- ↓ Healthcare Costs
- ↓ Complexity of information structure
- ↓ Time taken to provide medical attention

WHAT IS THE OpenEHR?

Classes

- ‘Classes’ are definitions of data structures
  - the ‘assembly instructions’ or ‘recipe’
  - Classes have attributes (properties)

WHAT IS THE OpenEHR?

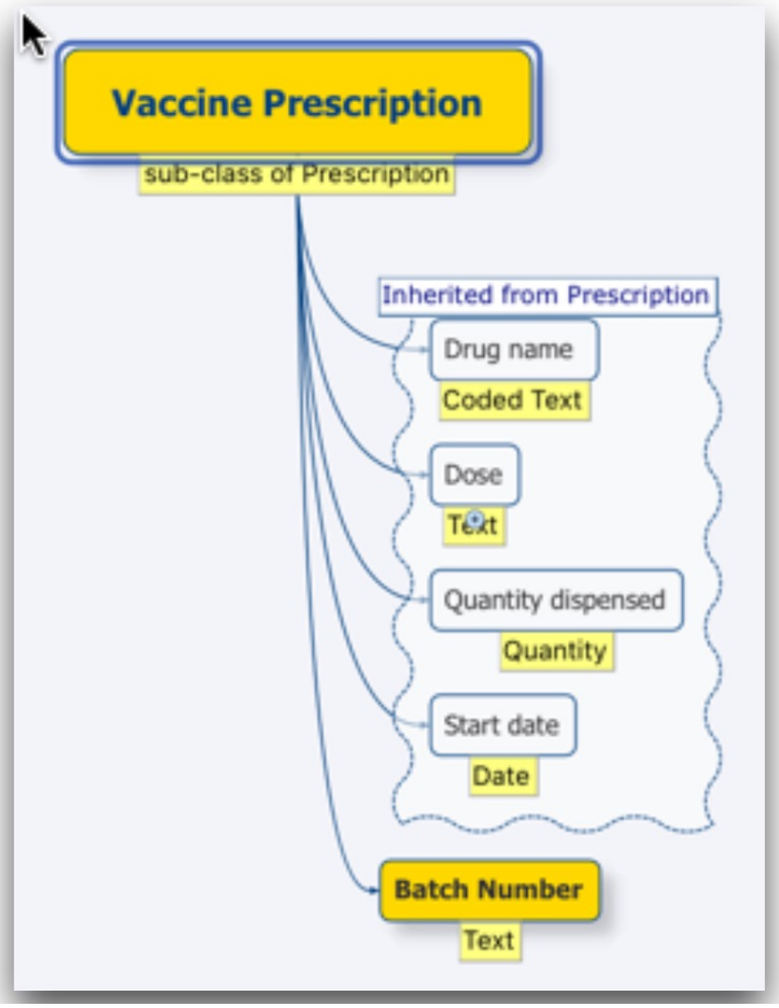
Datatypes

- Datatypes describe the basic **type** of information being carried
  - a piece of text
  - a quantity
  - a date or time duration
  - an image
  - etc, etc

WHAT IS THE OpenEHR?

Inheritance

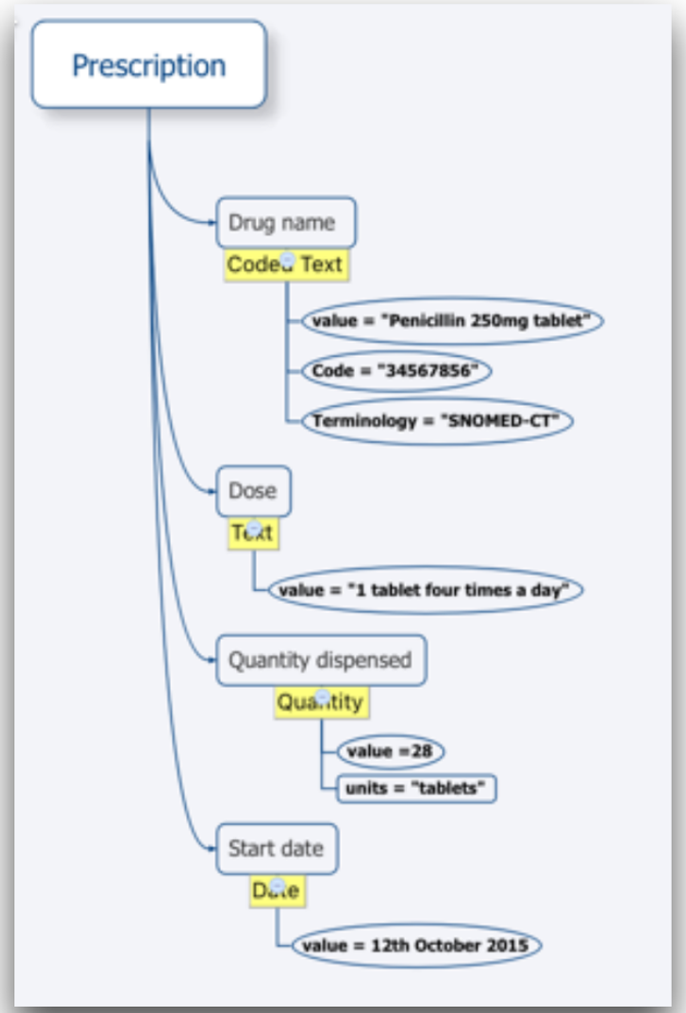
- Classes can based on other ‘parent’ classes
- called inheritance or ‘sub-classing’
- the sub-classes ‘inherit’ all the properties or attributes of the parent
  - Dog is a sub-class of Animal
  - ‘Labrador' is a sub-class of ‘Dog’
  - If ‘Dog’ has an attribute of ‘tail’, The Labrador class will also have ‘Tail’



WHAT IS THE OpenEHR?

Objects

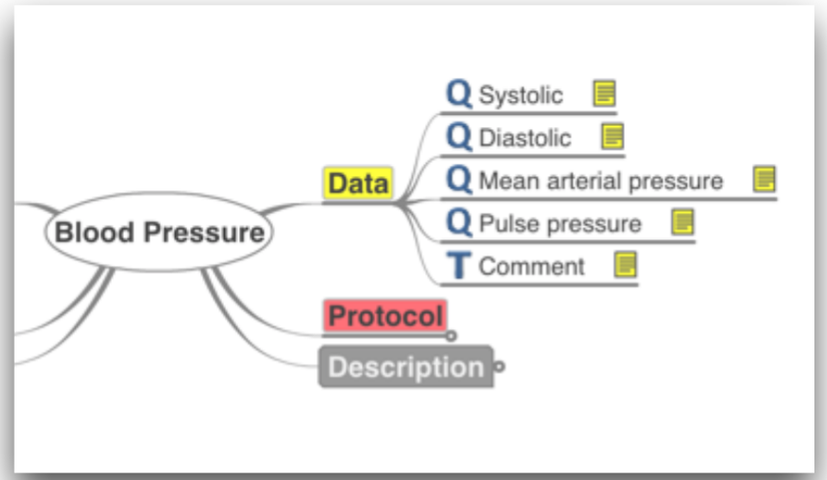
- Objects carry the data specified by the classes
  - Classes are ‘the recipe’
  - Objects are ‘the cake’



WHAT IS THE OpenEHR?

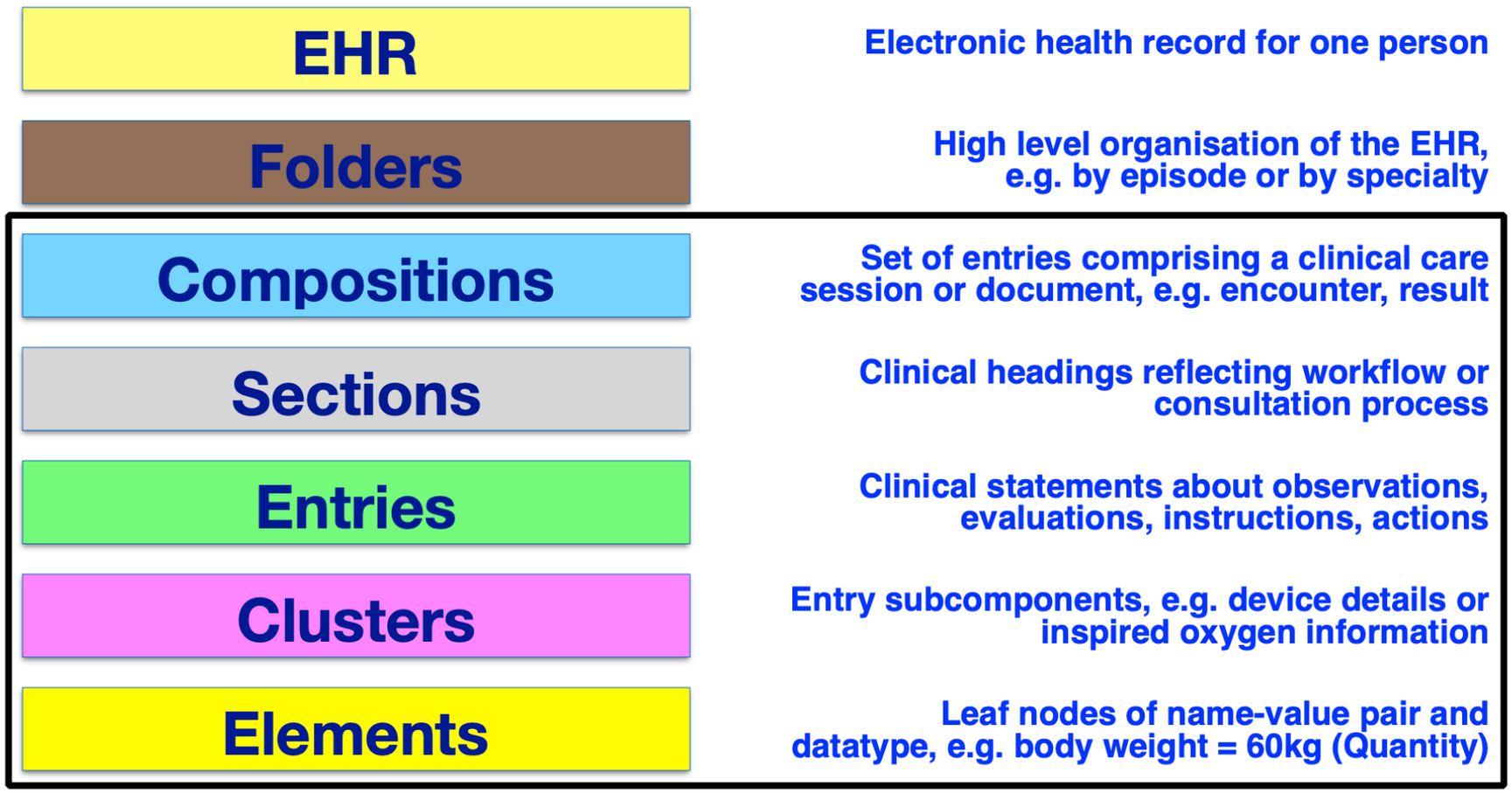
Archetypes and the RM

- Archetypes are built on top of the RM classes and 'inherit' their attributes
  - e.g. An Observation archetype such as Blood pressure inherits the attributes of the RM OBSERVATION class
- Archetypes use the RM datatypes
- Most of these properties are technical but some are important to clinical modellers



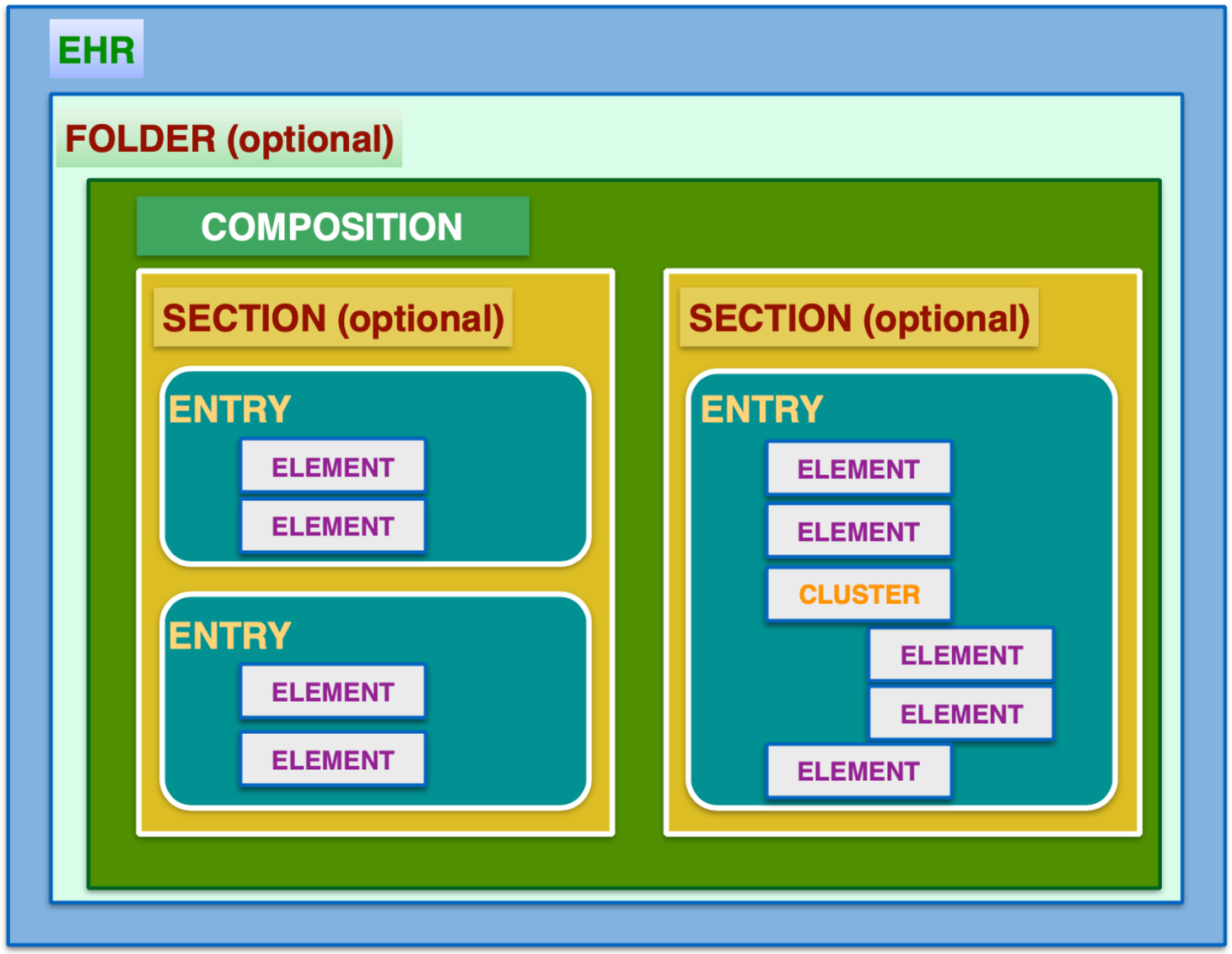
WHAT IS THE OpenEHR?

Archetypes are based on RM 'classes'



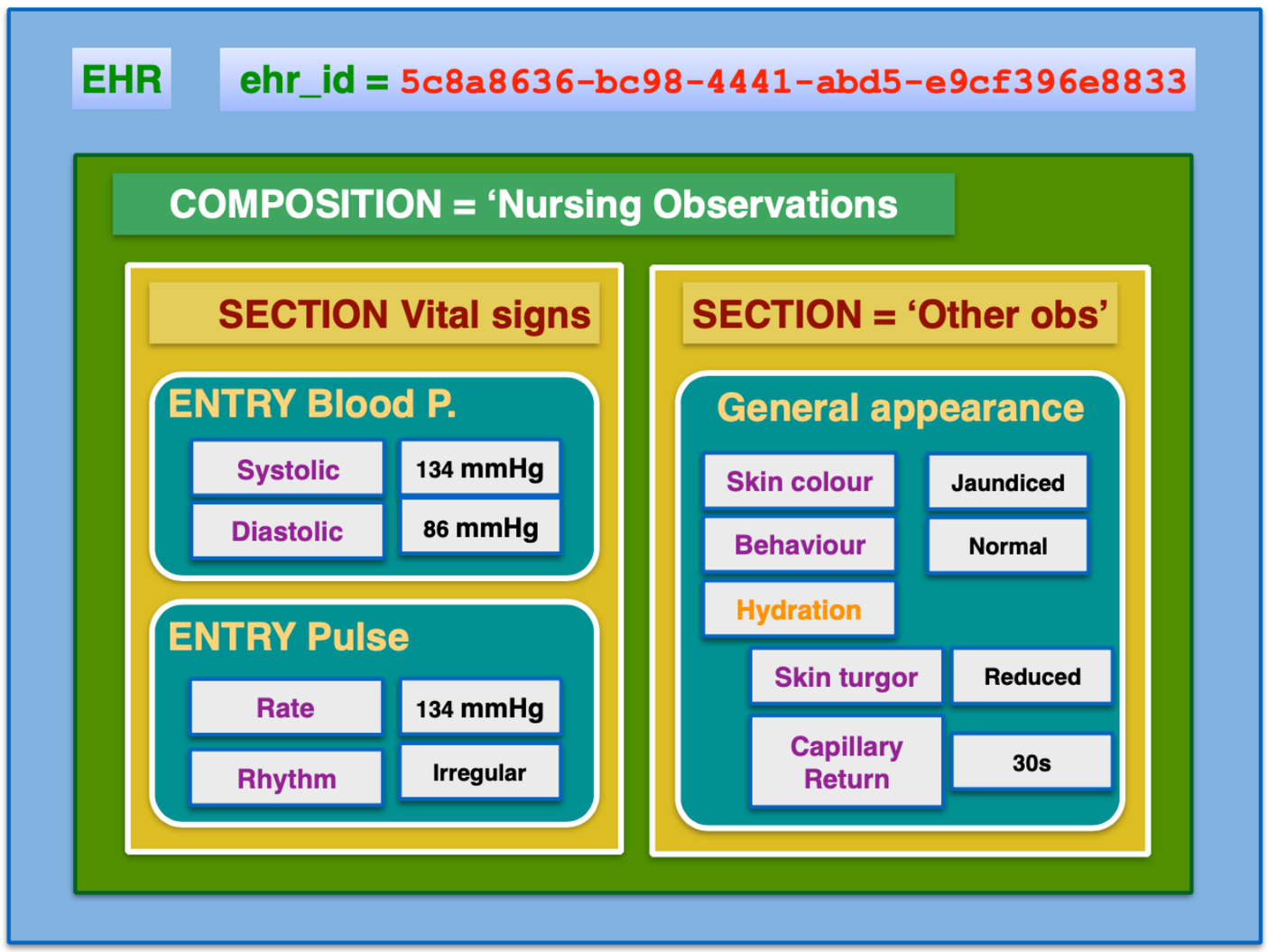
WHAT IS THE OpenEHR?

Key openEHR Classes



WHAT IS THE OpenEHR?

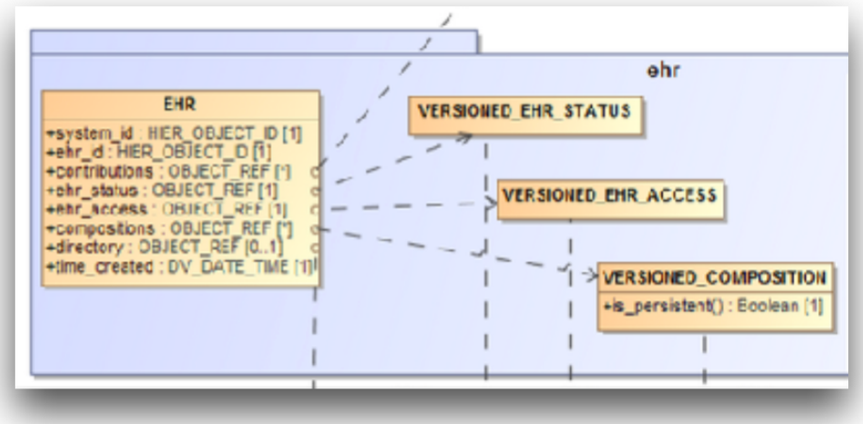
openEHR data objects



WHAT IS THE OpenEHR?

EHR

- Top-level container for all of the data for a **single patient**
- Each EHR has a unique, anonymous ID the ehr_id
- This needs to be associated with a real-world identifier e.g NHS Number to allow the patient to be identified



WHAT IS THE OpenEHR?

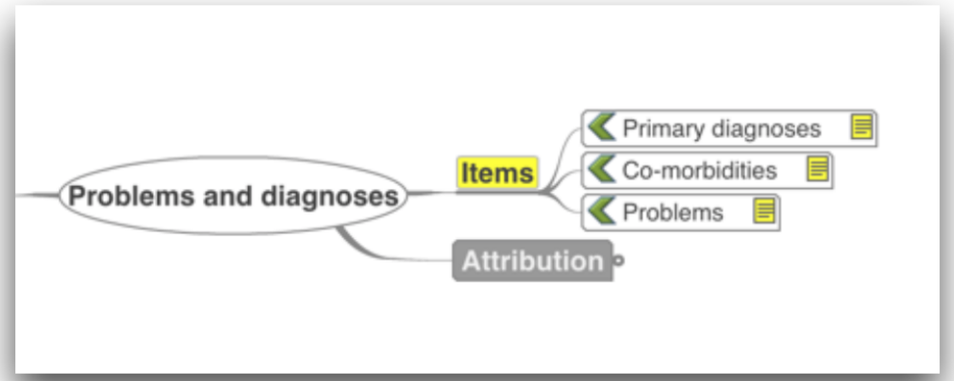
Composition - the document container

- Root ‘document’ for clinical data
- Carries most key medico-legal metadata
  - composer (clinical_author), start_time, end_time
  - organisation, clinical setting
- All recorded patient data saved inside a Composition
- Carries unique ID
  - UID::serverID::Version_Suffix
  - `5c8a8636-bc98-4441-abd5-e9cf396e8833::ripple_osi.ehrscape.c4h::1`
- Versioned
  - All changes will create a new version

WHAT IS THE OpenEHR?

SECTION

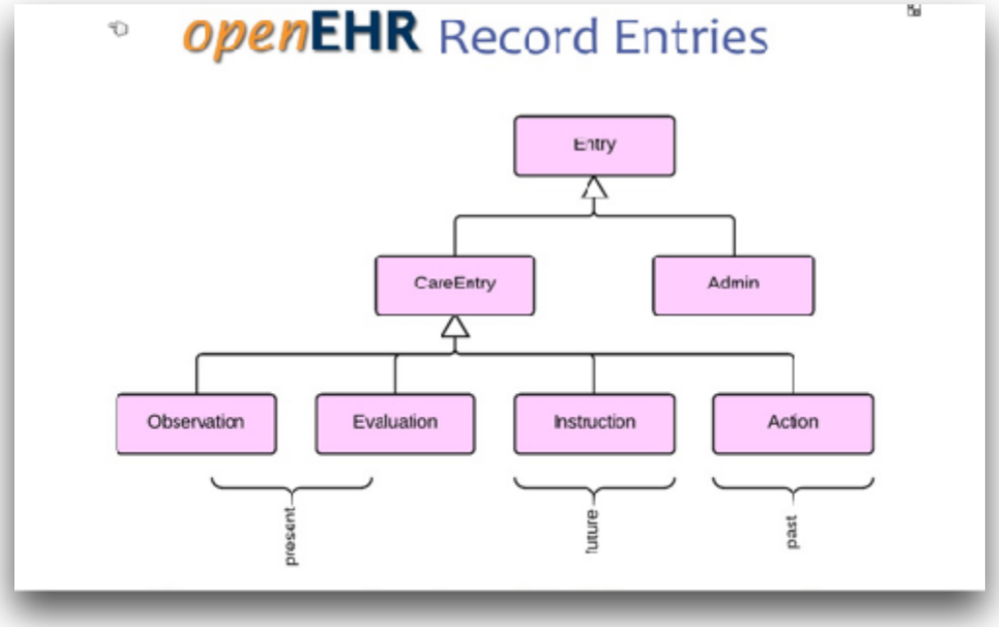
- Used to divide complex compositions into manageable pieces
- Just for human navigation and organisation
- Can be nested
- No important clinical RM attributes



WHAT IS THE OpenEHR?

ENTRY classes

- A set of ENTRY sub-classes **carry all of the clinical payload**
- These are organised to fit the '**Clinical investigator**' cycle
  - OBSERVATION
  - EVALUATION
  - INSTRUCTION
  - ACTION
  - ADMIN ENTRY



WHAT IS THE OpenEHR?

RM attributes for Observations

- **Provider** (optional 'provider of information', where this differs from the Composer)
- **Subject** (optional where record is not about the patient)
- **Participations** (Other people involved)
- **Origin**
  - The start dateTime of the Observation
  - The duration of the observation
- **Event-Time**
  - The start date_Time of an individual event
    - Useful when there are multiple samples for one test
    - e.g pulse / BP monitoring.

WHAT IS THE OpenEHR?

RM attributes for Instructions

- **Provider** (optional 'provider of information', where this differs from the Composer)
- **Subject** (optional where record is not about the patient)
- **Participations** (Other people involved)
- **Activities**
  - allows multiple chained 'sub-instructions'
- **Narrative** (mandatory safety feature)
  - needed in data, to ensure a complex instruction can always be dropped back to simple narrative
- **Timing**
  - Complex timing schedule for the whole instruction (rarely used)

WHAT IS THE OpenEHR?

RM attributes for Actions

- **Provider** (optional 'provider of information', where this differs from the Composer)
- **Participations** (Other people involved)
  - e.g. Operating assistant
- **Time** (the date and time that the action was performed)
  - e.g. date of a procedure or a prescription
- **Current_status and careflow_step**
  - the workflow status of the Action
  - e.g. planned, in-progress, completed, cancelled

WHAT IS THE OpenEHR?

RM attributes for Quantity datatype

- Units
  - e.g.mmHg, mmol/l, /min
- Normal_range
  - For lab or device normal ranges
  - e.g. 20-46 mmol/l
- Other reference ranges
  - For age or sex-specific reference ranges
  - Normal range for children : 18-28 mmol/l
- Magnitude_status
  - To allow numeric to be qualified
    - E.g <= 5 (Less than or equal to 5)
    - ~ 7.3 (approximately 7.3)
- Normal_status
  - High, normal, low based on HL7 lab messages
  - e.g. HHH,HH,H, ,L,LL,LLL

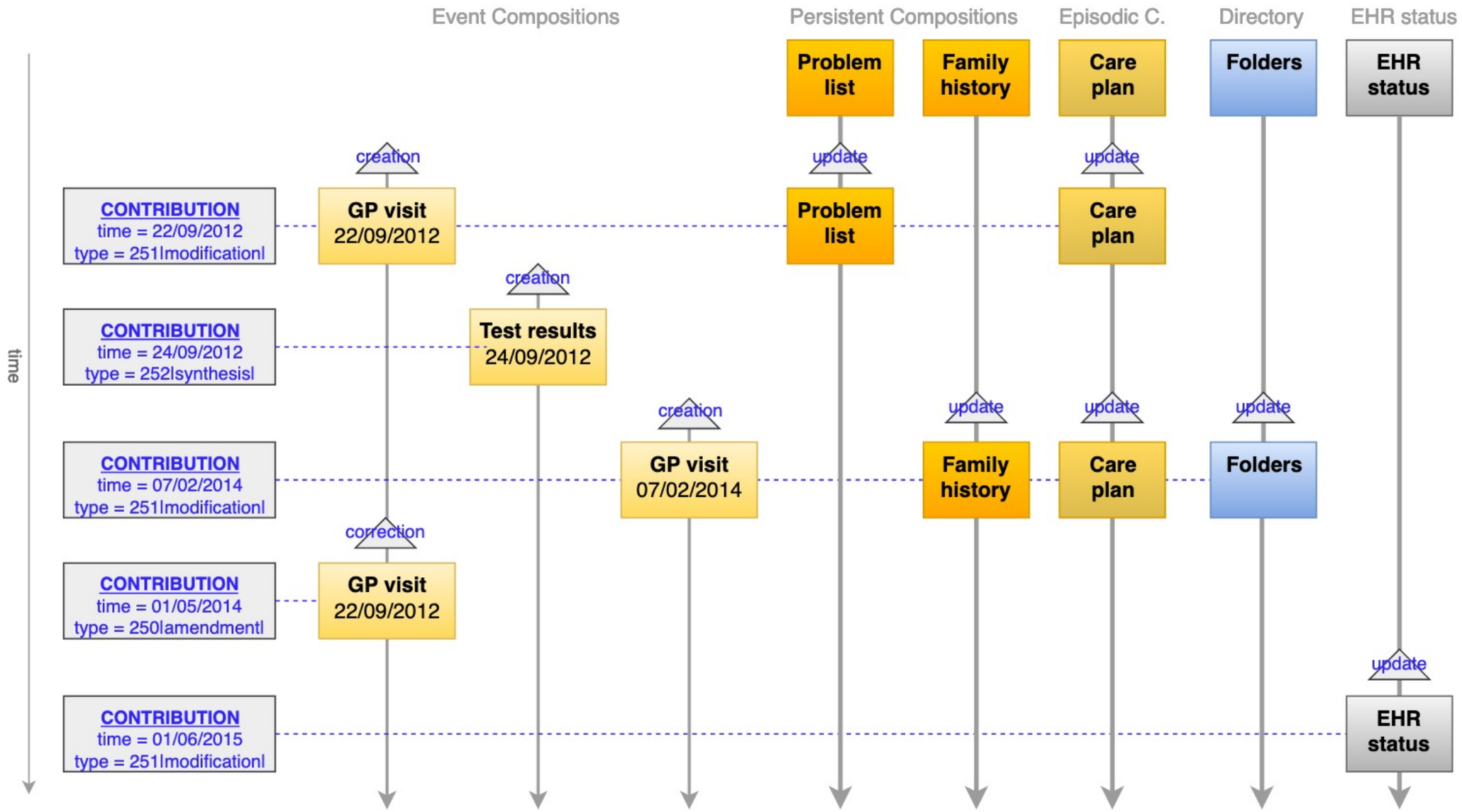
WHAT IS THE OpenEHR?

RM attributes for Text/CodedText datatype

- Any Text datatype can also act as a CodedText datatype
  - if you have defined an element to be Text, it can still carry CodedText
- **Defining_code**
  - The actual code of a CodedText e.g “123478-AS”
  - The terminology/version of the CodedText e.g. “ICD-10”
- **Mappings**
  - to external terminologies
  - e.g. The original code is an internal code “at007::Left” but is mapped to SNOMED code |123456|left|

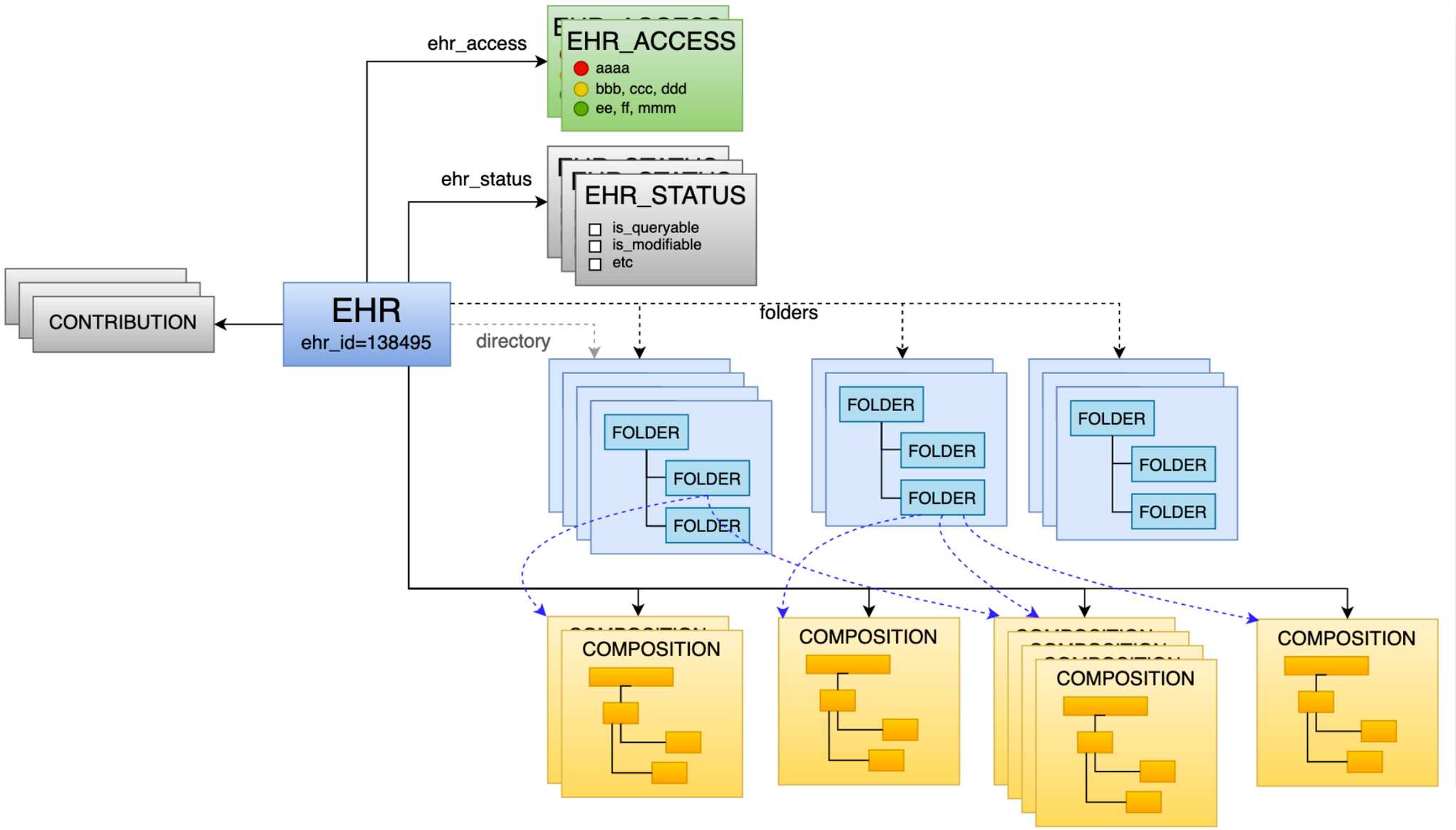
WHAT IS THE OpenEHR?

Contributions / versioning



WHAT IS THE OpenEHR?

Contributions / versioning



WHAT IS THE OpenEHR?

Episode vs Longitudinal persistence

- **Longitudinal Persistence**
  - Some persistent summaries should exist and be updated throughout the patient's lifetime
  - End of Life summary, GP problem list
- **Episodic Persistence**
  - Most outpatient and hospital summaries e.g Allergy lists, Problem lists need to be re-created at admission, then maintained for the period of admission.
  - A new Problem list may need ot be created for each episode of care

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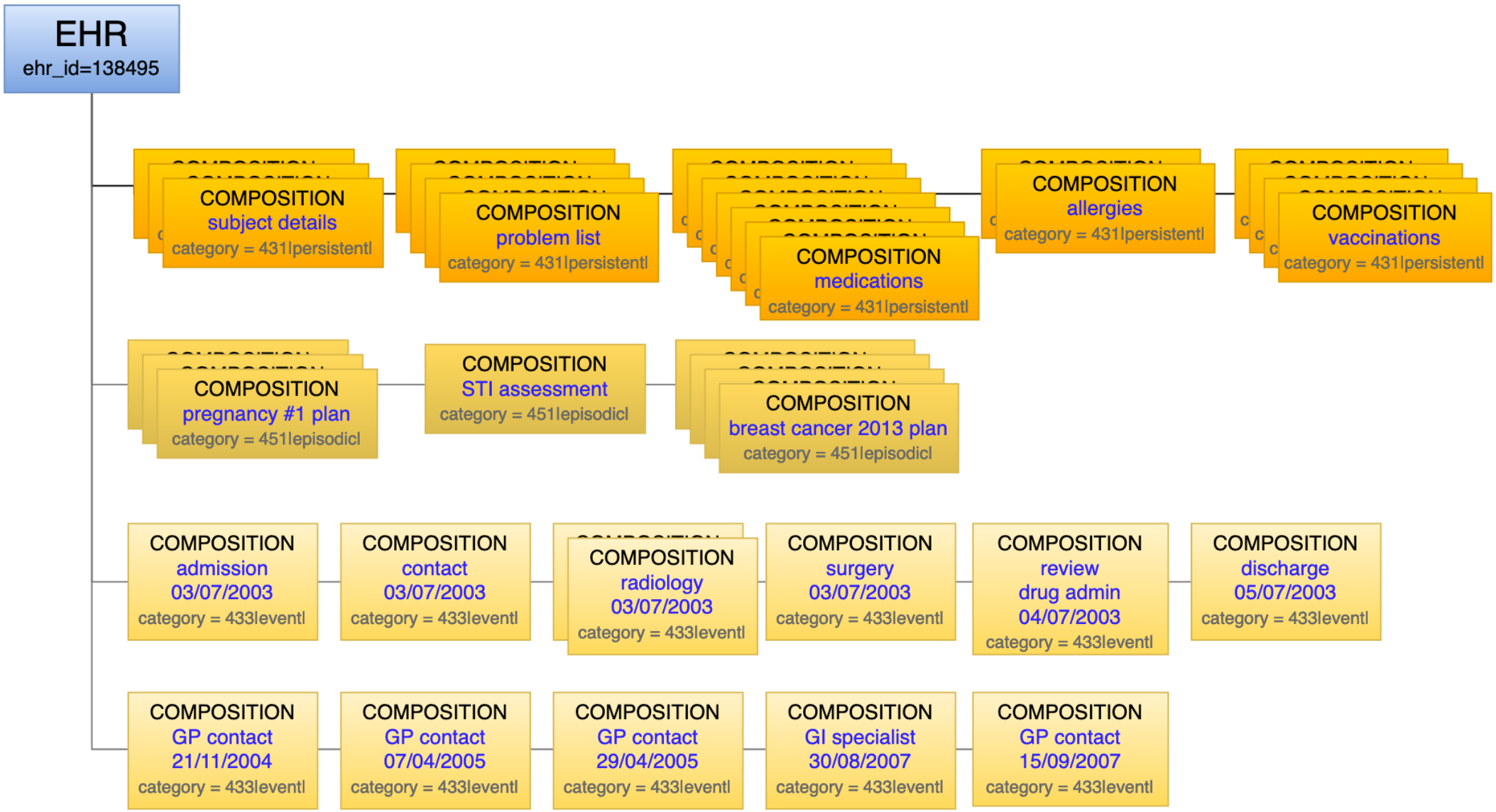
WHAT IS THE OpenEHR?

Episode vs Longitudinal persistence



WHAT IS THE OpenEHR?

Links

- Most of the relationships between different Entries and Elements is defined in archetypes and templates, generally in the same Composition
- Links allow the system developer to connect different Entries which do not have a ‘pre-cooked’ association, and where the Entries live in different Compositions

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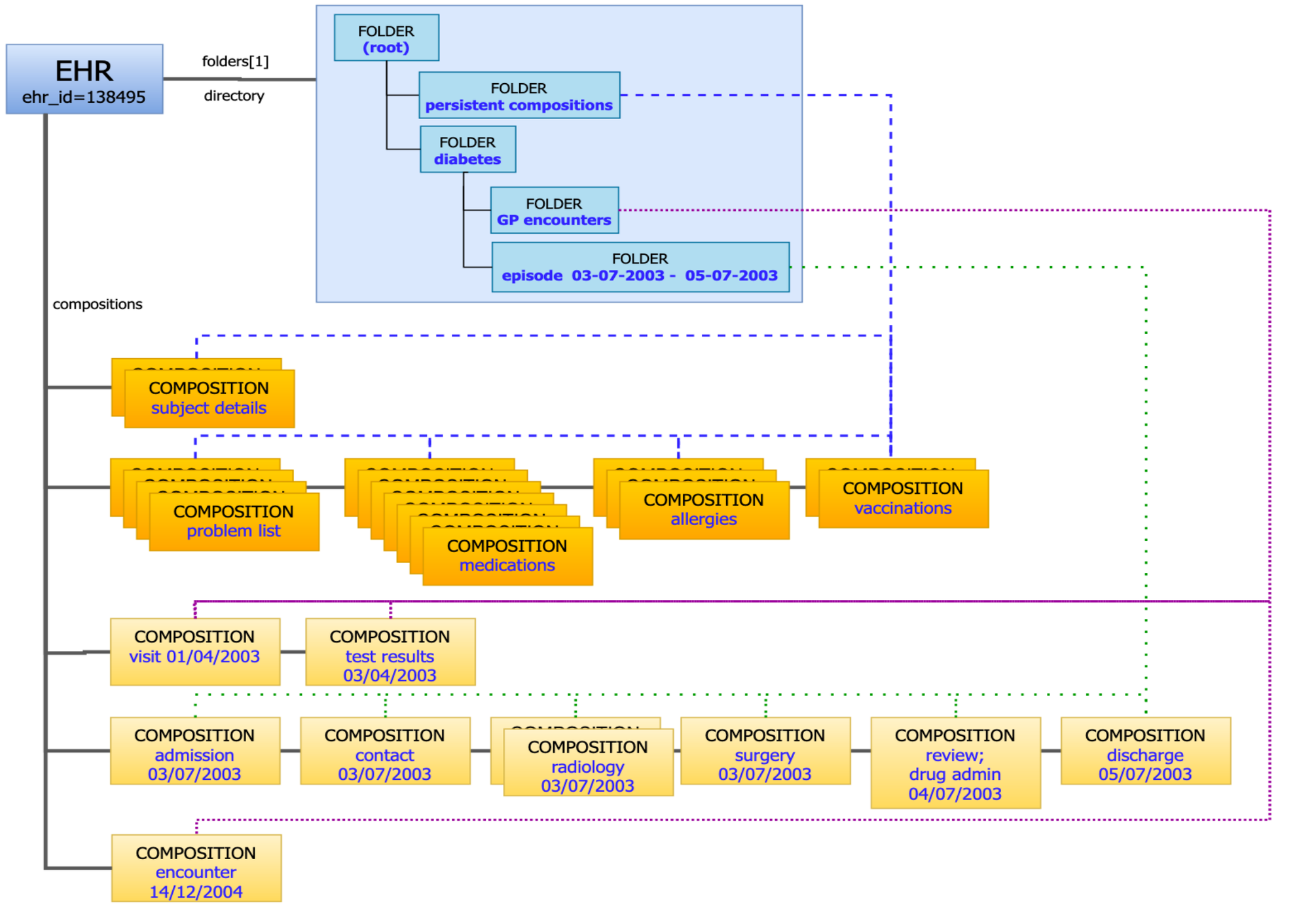
WHAT IS THE OpenEHR?

Links example



WHAT IS THE OpenEHR?

Table 1 – Problems identified with Clinical Data Sets (CDS) and their OpenEHR Solutions

	Problems with CDS	Solutions with OpenEHR
1	Basic Data Types	Reference Model
2	Presentation Formats	Existing tools based on OpenEHR guidelines.
3	Design principles	Archetypes is a predefined structure.
4	Time of data capture	Archetypes have support for defining time-series.
5	Interpretation of data	Relevant archetypes have all relevant information for the interpretation of a measurement.
6	Integrity constraints	Archetypes are used to define integrity constraints in a uniform way.
7	Replication of domain knowledge	Making archetypes freely available at one central place is another mechanism to avoid 'reinventing the wheel'.
8	Multi-language support	Any translation occurs within one archetype only.
9	Non-integrated specialist applications	Archetypes can be shared by multiple HIS and authorities. Information can be exchanged between different systems keeping the semantic meaning.

Source: Expressing clinical data sets with openEHR archetypes: A solid basis for ubiquitous computing - Shelly Sachdeva, Shivani Batra, Subhash Bhalla

OpenEHR as a Solution

Main Goals

- Develop a New Clinical Model to support the EHR
- Ensure Structured Data
- Improve of the information exchange between HIS
- Promote Interoperability at its different levels
- Generate new Relevant Knowledge
- Ensure knowledge-based activities - Decision Support Systems
- Consult the complete EHR of the patient, in real time

Lifelong | Longitudinal | Computable | Secure | Sharable

New Healthcare System Features

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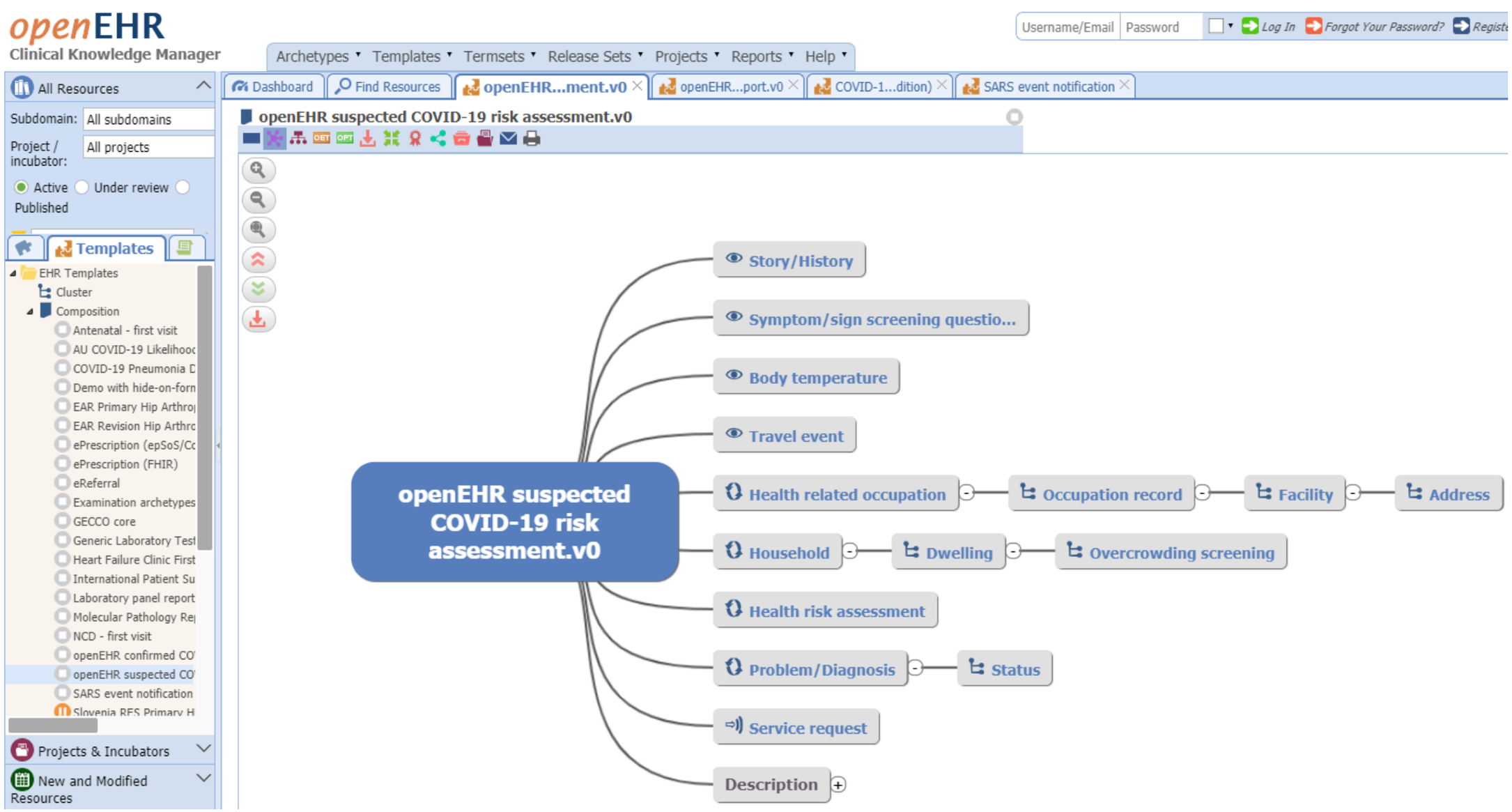
CKM



Source: https://ckm.openehr.org/ckm/

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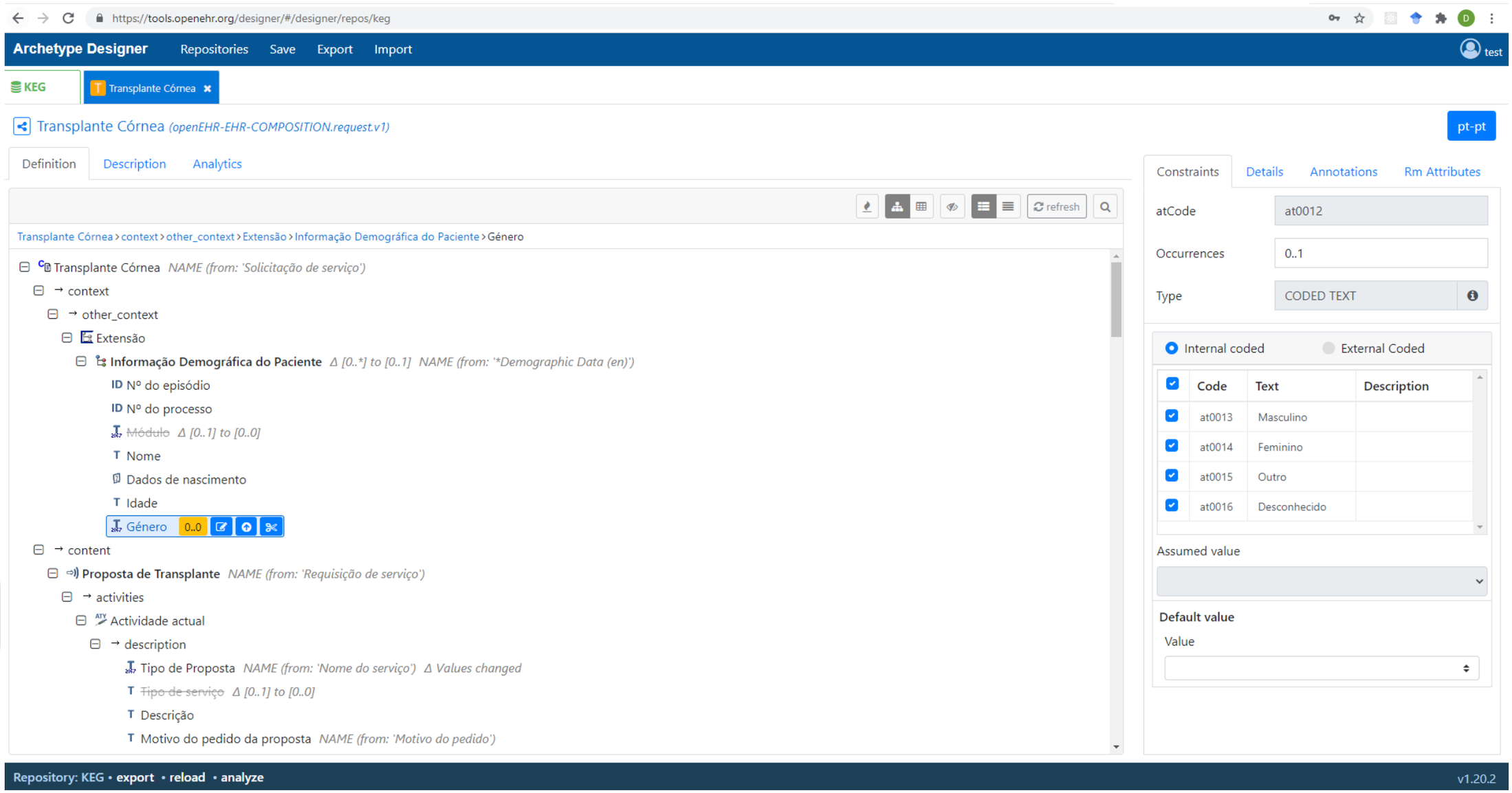
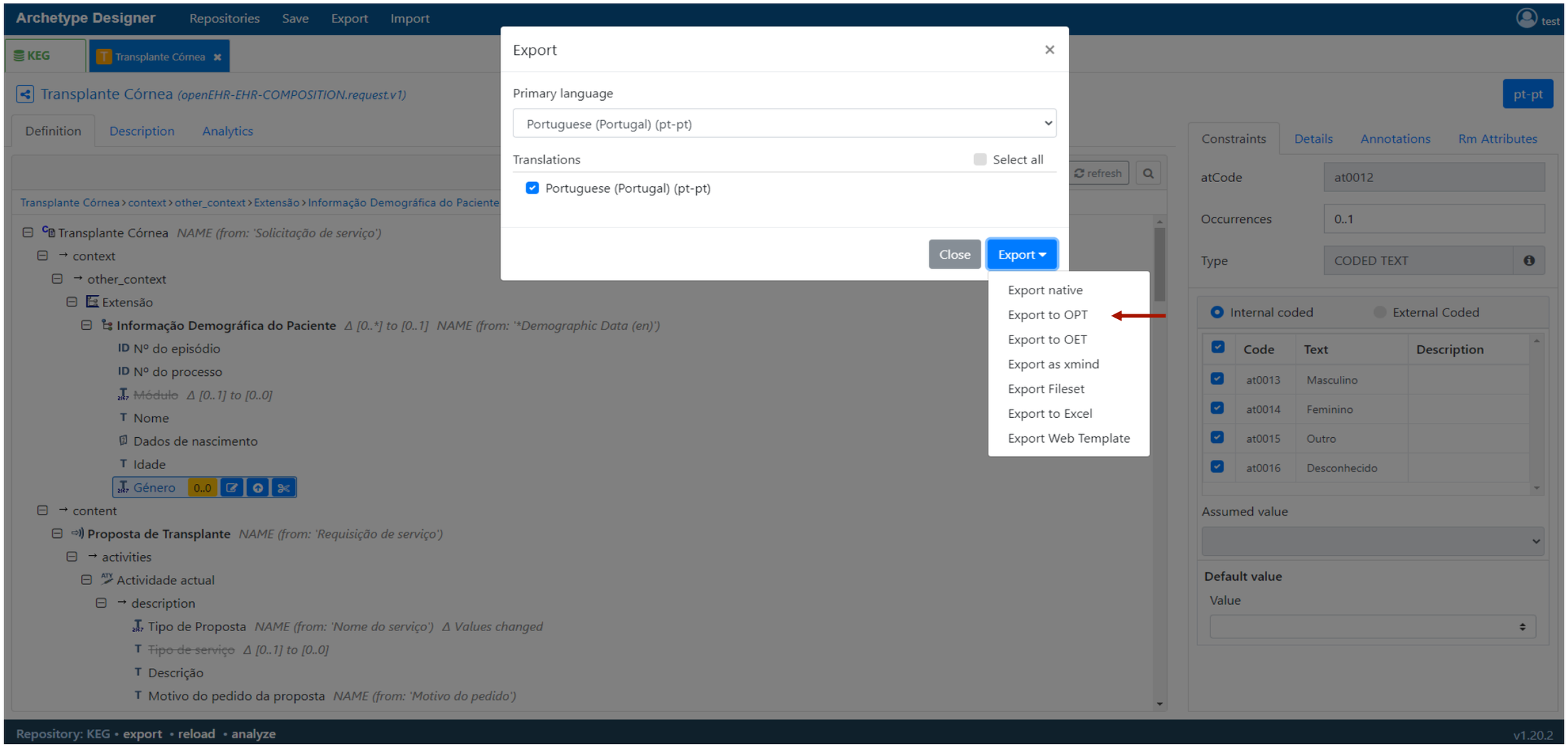
Archetype Designer



Source: https://tools.openehr.org/designer/#/designer/repos/keg

Archetype Designer



Source: https://tools.openehr.org/designer/#/designer/repos/keg

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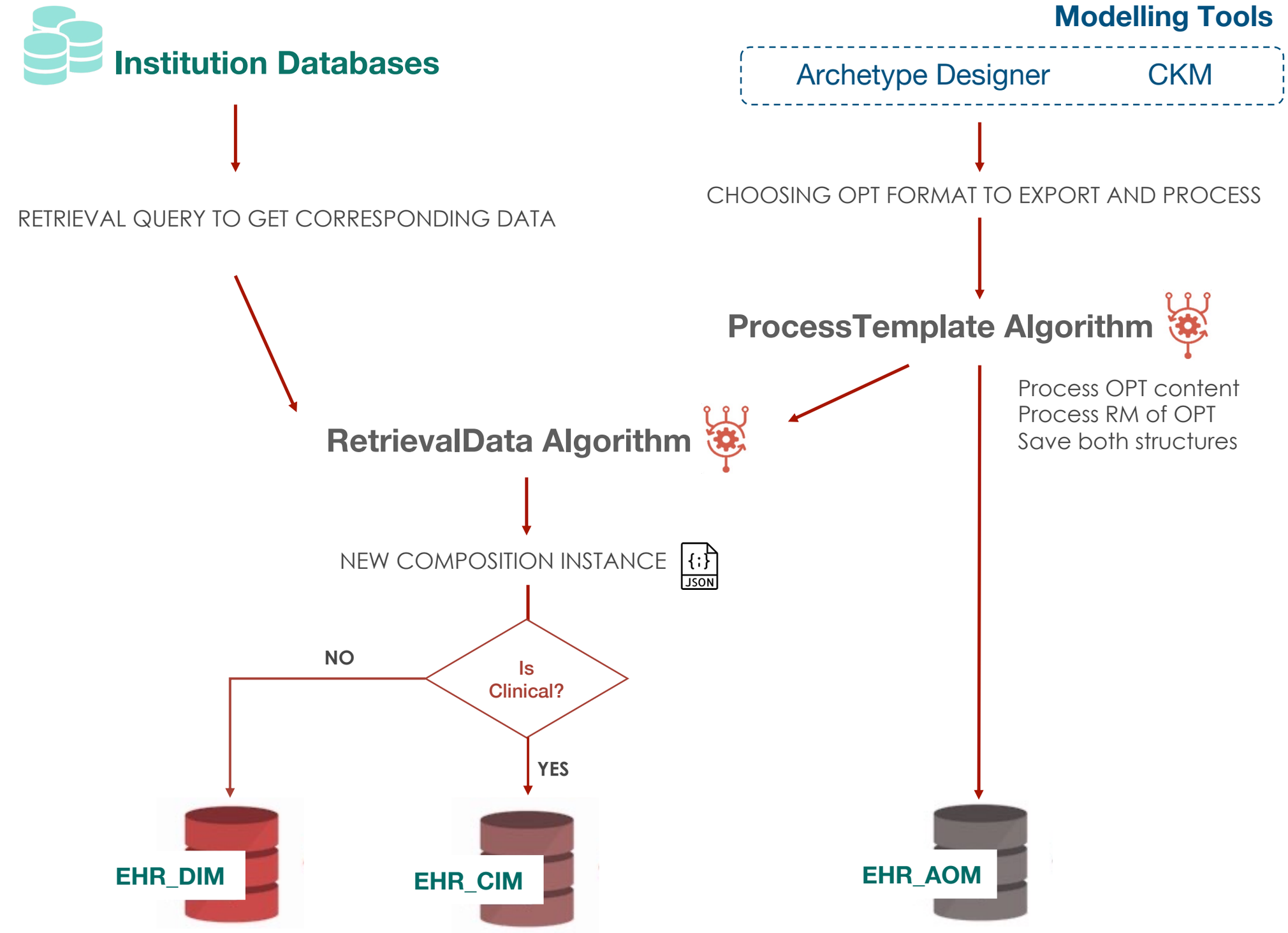
OPT FORMAT

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<template xmlns="http://schemas.openehr.org/v1">
    <language> ...
    </language>
    <description> ...
    </description>
    <uid>
        <value>9a5c8f5b-ebe8-49e6-a272-33625bb2a289</value>
    </uid>
    <template_id>
        <value>Transplante Córnea</value>
    </template_id>
    <concept>Transplante Córnea</concept>
    <definition>
        <rm_type_name>COMPOSITION</rm_type_name>
        <occurrences> ...
        </occurrences>
        <node_id>at0000</node_id>
        <attributes xsi:type="C_SINGLE_ATTRIBUTE" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"> ...
        </attributes>
        <attributes xsi:type="C_SINGLE_ATTRIBUTE" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"> ...
        </attributes>
        <attributes xsi:type="C_MULTIPLE_ATTRIBUTE" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"> ...
        </attributes>
        <archetype_id>
            <value>openEHR-EHR-COMPOSITION.request.v1</value>
        </archetype_id>
        <template_id>
            <value>Transplante Córnea</value>
        </template_id>
        <term_definitions code="at0000">
            <items id="text">Transplante Córnea</items>
            <items id="description">Documento enviado de um prestador de cuidados de saúde ou organização para outro, com a finalidade de solicitar aconselhamento, um serviço ou transferência de
            assistência. </items>
        </term_definitions>
        <term_definitions code="at0001">
            <items id="text">Tree</items>
            <items id="description">@ internal @</items>
        </term_definitions>
        <term_definitions code="at0042">
            <items id="text">Extensão</items>
            <items id="description">Informações adicionais necessárias para obter conteúdo local ou para alinhar com outros modelos / formalismos de referência.</items>
            <items id="comment">*For example: Local hospital departmental information or additional metadata to align with FHIR or CIMI equivalents. (en)</items>
        </term_definitions>
    </definition>
    <constraints>
        <attributes> ...
        </attributes>
    </constraints>
</template>
```

OpenEHR Industry Partners

Source:
https://www.openehr.org/community/industry_partners/

SYSTEM ARCHITECTURE



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CONCLUSION

Archetypes and Templates

Forms to represent the Templates

AQL motor

System Based On OpenEHR

Refsets of Data

Guidelines CDS

Terminologies

Task Planning Processes

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PUBLICATIONS

- Daniela Oliveira. Rui Miranda. Nuno Abreu. Pedro Leuschner. António Abelha. Manuel Santos and José Machado. Management of a Pandemic Based on an openEHR approach. in Procedia Computer Science. Elsevier. 177. 2020
- Daniela Oliveira. Rui Miranda. Nuno Abreu. Pedro Leuschner. António Abelha and José Machado. Steps towards an Healthcare Information Model based on openEHR. In Procedia Computer Science. HODII. Elsevier. 2021 (Accepted)
- Daniela Oliveira. Rui Miranda. Pedro Leuschner. Nuno Abreu. Manuel Filipe Santos. Antonio Abelha and José Machado. OpenEHR modeling: improving clinical records during the COVID-19 pandemic. in Health and Technology. Springer Nature. 2021 (Accepted)
- Francini Hak, Daniela Oliveira, Nuno Abreu, Pedro Leuschner, António Abelha, Manuel Santos, An OpenEHR Adoption in a Portuguese Healthcare Facility, Procedia Computer Science, Volume 170,2020, Pages 1047-1052 (https://doi.org/10.1016/j.procs.2020.03.075)
- Daniela Oliveira, Ana Coimbra, Filipe Miranda, Nuno Abreu, Pedro Leuschner, José Machado and António Abelha, Step Towards OpenEHR in a Portuguese Healthcare facility, in Advances in Intelligent Systems and Computing, Volume 747, Springer, 2018.

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Requisitos para uma implementação

RQ1 – Como modelar/criar estruturas OpenEHR?

1. Open EHR Modelling

- Better Platform
- CKM Repository

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Requisitos para uma implementação

RQ2 – Como utilizar estruturas OpenEHR?

2. Process OPT Algoritm -> nodejs

- Processa o .opt
- Processa todo o RM associado
- Armazena estrutura numa document store database (SODA - Oracle 12c)

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Requisitos para uma implementação

RQ3 – Como reutilizar estruturas OpenEHR?

3. FormBuilder Platform

- A partir de um template permite criar novas estruturas e diferentes formularios

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Requisitos para uma implementação

RQ4 – Como aceder à informação guardada em estruturas OpenEHR?

4. AIDAEHR information Model (API)

- Submição, edição de composições.

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Requisitos para uma implementação

RQ5 – Como migrar sistemas legados para estruturas OpenEHR?

5. RetrievalData Algoritm

-> carregamento de mapeamentos

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Requisitos para uma implementação

RQ6 – Qual a estrutura de dados para estruturas OpenEHR?

6. Separação de modelos de informação

-> DIM – modelo demográfico
-> CIM – EHR modelo

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Requisitos para uma implementação

RQ7 – Qual o paradigma dados para estruturas OpenEHR?

7. Document Store Databse

-> SODA – Oracle 12c
-> SODA – Oracle 19 (Task Plan Engine)

Requisitos para uma implementação

RQ8 – Terminologias e Ontologias vs OpenEHR?

8. Criação de refsets por query ou estáticos para utilização em coded_texts e external codes