



ARCHITECTURE

Architecture Overview

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is an independent, non-profit community, facilitating the creation and sharing of health records by consumers and clinicians via open-source, standards-based implementations.

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Issue	Details	Raiser	Completed
R E L E A S E 1.0			
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1 Introduction

1.1 Purpose

This document provides an overview of the *openEHR* architecture in terms of a model overview, key global semantics, relationship to published standards, and finally the approach to building Implementation Technology Specifications (ITSs). Semantics specific to each information, archetype and service model are described in the relevant model.

The intended audience includes:

- Standards bodies producing health informatics standards
- Software development groups using *openEHR*
- Academic groups using *openEHR*
- The open source healthcare community

1.2 Related Documents

Prerequisite documents for reading this document include:

- The *openEHR* Roadmap document
- The *openEHR* Modelling Guide

Other documents describing related models, include:

- The *openEHR* Information Model documents
- The *openEHR* Archetype Model documents

1.3 Status

This document is under development, and is published as a proposal for input to standards processes and implementation works.

This document is available at <http://svn.openehr.org/specification/TAGS/Release-1.0/publishing/architecture/overview.pdf>.

The latest version of this document can be found at <http://svn.openehr.org/specification/TRUNK/publishing/architecture/overview.pdf>.

New versions are announced on openehr-announce@openehr.org.

Blue text indicates sections under active development.

1.4 Peer review

Areas where more analysis or explanation is required are indicated with “to be continued” paragraphs like the following:

To Be Continued: **more work required**

Reviewers are encouraged to comment on and/or advise on these paragraphs as well as the main content. Please send requests for information to info@openEHR.org. Feedback should preferably be provided on the mailing list openehr-technical@openehr.org, or by private email.

2 Overview

This document provides an overview of the *openEHR* architecture. It commences with a description of the specification project, followed by an overview of the reference model structure and packages. Key global semantics including archotyping, identification, version and paths are then described. The relationship to published standards is indicated, and finally, the approach to building Implementation Technology Specifications (ITSs) is outlined.

2.1 The *openEHR* Specification Project

FIGURE 1 illustrates the *openEHR* Specification Project. The project consists of requirements, architectural specifications, implementation technology specifications (ITSs), and conformance specifications. The focus of this document is the architectural and implementation technology specifications (ITSs).

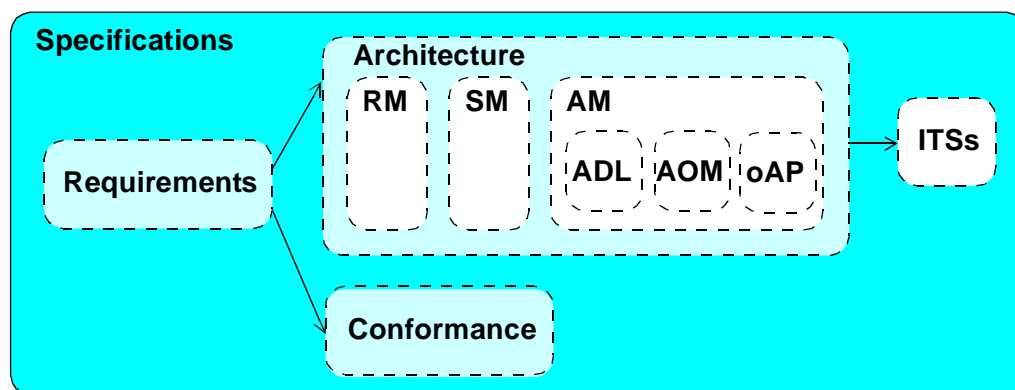


FIGURE 1 *openEHR* Specification project

The architecture specifications consist of the Reference Model (RM), the Service Model (SM) and Archetype Model (AM). The first two correspond to the ISO RM/ODP information and computational viewpoints respectively.

All of the architecture specifications published by *openEHR* are defined as a set of *abstract* models, using the UML notation and formal textual class specifications. These models remain the primary references for all semantics, regardless of what is done in any implementation domain. The *openEHR* Modelling Guide describes the semantics of the models. The presentation style of these abstract specifications is deliberately intended to be clear, and semantically close to the ideas being communicated. Conversely, the abstract specifications do not follow idioms or limitations of particular programming languages, schema languages or other formalisms. All such expressions are treated as ITSs, for which explicit mappings generally have to be developed and described (since almost no formalism natively implements complete UML semantics).

There are numerous implementation technologies, ranging from programming languages, serial formalisms such as XML, to database and distributed object interfaces. Each of these has its own limits and strengths. The approach to implementing any of the *openEHR* abstract models in a given implementation technology is to firstly define an “implementation technology specification” (ITS) for the particular technology, then to use it to formally map the abstract models into expressions in that technology.

2.2 Design Approach

The *openEHR* approach to modelling information, services and domain knowledge is based on a number of design principles, including the following.

“Two-level” modelling

The first paradigm on which *openEHR* models are based is known as “two-level” modelling, described in [2]. The information models constitute a first level of modelling, while formal structured constraint definitions of clinical concepts - *archetypes* - are the second level. Archetypes are themselves instances of an *archetype model*, which defines a language in which to write archetypes. Archetypes are general-purpose, re-usable, and composable. They are used at runtime by building *templates* from them. A template is a tree of archetypes each in turn constraining instances of the coarse-grained parts of the information model, e.g. in the EHR model, Compositions, Section hierarchies, Entries and so on. Thus, while there are likely to be archetypes for such things as “biochemistry results” (an Entry archetype) and “SOAP headings” (a Section archetype), templates are used to put archetypes together to form whole Compositions in the EHR, e.g. for “discharge summary”, “antenatal exam” and so on. Templates correspond closely to screen forms and printed report definitions.

When a template is ready for use, it is used to create default data structures and to validate data input, ensuring that all data in the EHR conform to the constraints defined in the archetypes comprising the template. In particular, it conforms to the *path* structure of the archetypes, as well as their terminological constraints. Which archetypes were used at data creation time is written into the data, in the form of both archetype identifiers at the relevant root nodes, and archetype node identifiers - normative node names, which are the basis for paths; the details of archetype identifiers and paths are given in Archotyping on page 19 and Paths on page 22. When it comes time to modify or query data, these archetype data enable applications to retrieve and use the original archetypes, ensuring modifications respect the original constraints, and allowing queries to be intelligently constructed.

Separation of Responsibilities

A second key design paradigm used in *openEHR* is that of separation of responsibilities within the computing environment. Complex domains are only tractable if the functionality is first partitioned into broad areas of interest, i.e. into a “system of systems” [5]. This principle has been understood in computer science for a long time under the rubrics “low coupling”, “encapsulation” and “componentisation”, and has resulted in highly successful frameworks and standards, including the OMG’s CORBA specifications and the ISO Reference Model for Open Distributed Processing (RM-ODP) [4]. Each area of functionality forms a focal point for a set of models formally describing that area, which, taken together usually describe a distinct information system or service.

FIGURE 2 illustrates a notional health information environment containing numerous services, each denoted by a bubble. Typical connections are indicated by lines, and bubbles closer to the centre correspond to services closer to the core needs of clinical care delivery, such as the EHR, terminology, demographics/identification, medical reference data and so on. Of the services shown on the diagram, *openEHR* currently provides specifications only for the more central ones, including EHR and Demographics.

Since there are standards available for some aspects of many services, such as terminology, image formats, messages, EHR Extracts, service-based interoperation, and numerous standards for details such as date/time formats and string encoding, the *openEHR* specifications often act as a mechanism to create coherent structural definitions in the informational and computational viewpoints that integrate existing standards.

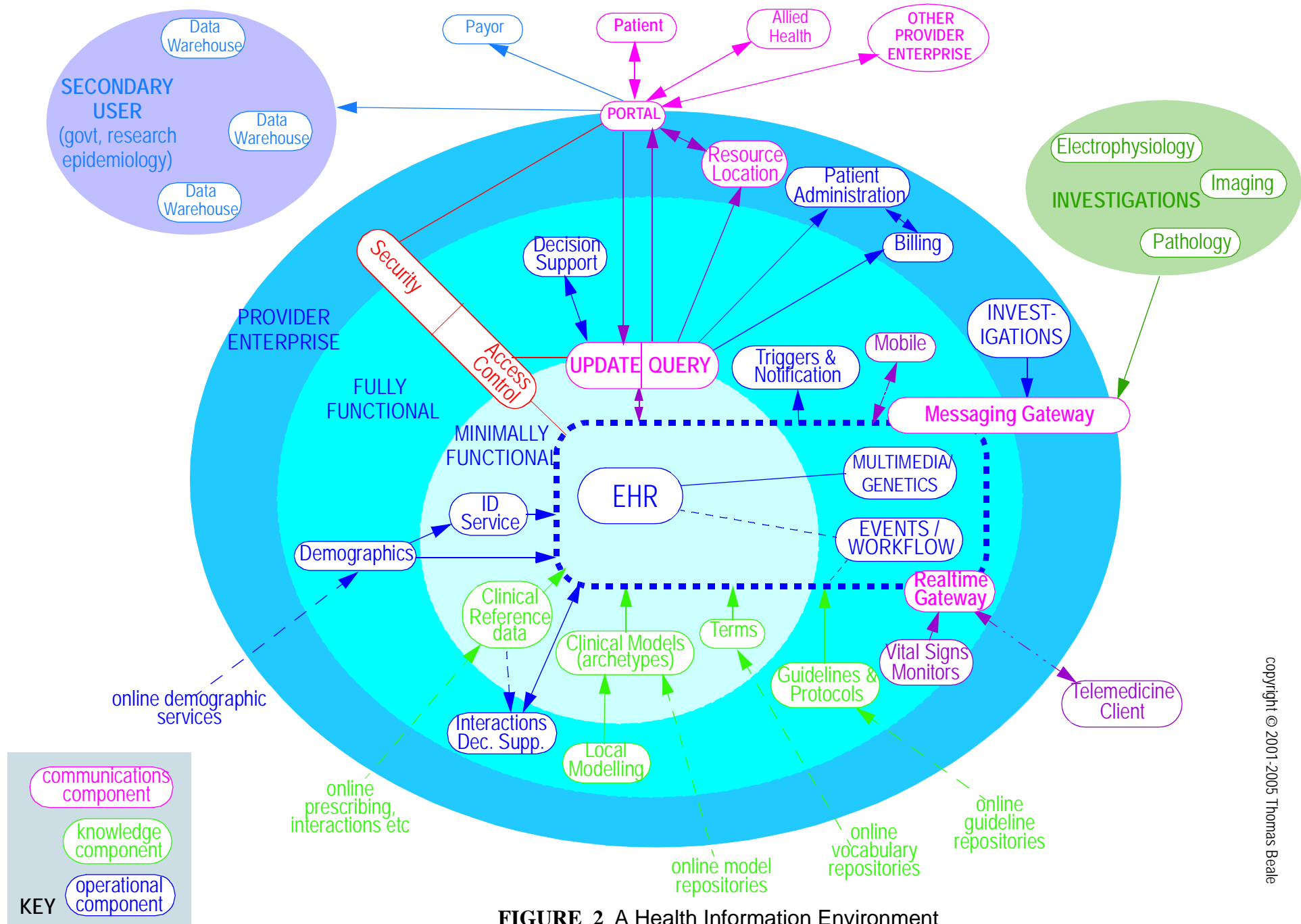


FIGURE 2 A Health Information Environment

Separation of Viewpoints

The third computing paradigm used in *openEHR* is a natural consequence of the separation of responsibilities, namely the *separation of viewpoints*. When responsibilities are divided up among distinct components, it becomes necessary to define a) the information that each processes, and b) how they will communicate. These two aspects of models constitute the two central “viewpoints” of the ISO RM/ODP model [4], which are as follows:

Enterprise: concerned with the business activities, i.e. purpose, scope and policies of the specified system.

Information: concerned with the semantics of information that needs to be stored and processed in the system.

Computational: concerned with the description of the system as a set of objects that interact at interfaces - enabling system distribution.

Engineering: concerned with the mechanisms supporting system distribution.

Technological: concerned with the detail of the components from which the distributed system is constructed.

The *openEHR* specifications accordingly include an information viewpoint - the *openEHR* Reference Model - and a computational viewpoint - the *openEHR* service model. The Engineering and Technological viewpoints are the direct concerns of implementors, and indirectly related to *openEHR* view ITs, and implementation guidelines. An important aspect of the division into viewpoints is that there is generally not a 1:1 relationship between model specifications in each viewpoint. For example, there might be a concept of “health mandate” (a CEN ENV13940 Continuity of Care concept) in the enterprise viewpoint. In the information viewpoint, this might have become a model containing many classes. In the computational viewpoint, the information structures defined in the information viewpoint are likely to recur in multiple services, and there may or may not be a “health mandate” service. The granularity of services defined in the computational viewpoint corresponds most strongly to divisions of function in an enterprise or region, while the granularity of components in the information view points corresponds to the granularity of mental concepts in the problem space, the latter usually being more fine-grained. The *openEHR* archetype model (AM) is in addition to the reference and service models, and provides the knowledge-enabling of the computational environment.

Small, Semantically Powerful Reference Model

The *openEHR* architecture includes a small (around 70 classes) reference model, comprising a set of information models forming well-defined and re-usable layers. The topmost layers define high-level concepts such as the EHR, and demographic entities. Semantics defined in the RM include:

- a generic model of versioning, including change-sets (known as “contributions” in *openEHR*) audit and attestations;
- a generic model of feeder system data and meta-data;
- a clear model of contextual information, i.e. “who, when, where, why” information;
- an ontological model of basic clinical information types in the EHR, including Observation, Evaluation, Instruction, Action, and Admin_entry;
- reusable data structures (History, Item_list, Item_tree etc) and data types (Quantity, Coded text, etc);
- a clear model of identification.

3 openEHR Package Structure

FIGURE 4 illustrates the overall package structure of the *openEHR* formal specifications. Three major packages are defined: *rm*, *am* and *sm*. All packages defining detailed models appear inside one of these outer packages, which may also be thought of as namespaces. They are conceptually defined within the *org.openehr* namespace, which is usually represented in UML as further packages. In some implementation technologies (e.g. java), the *org.openehr* namespace may actually be used within program texts.

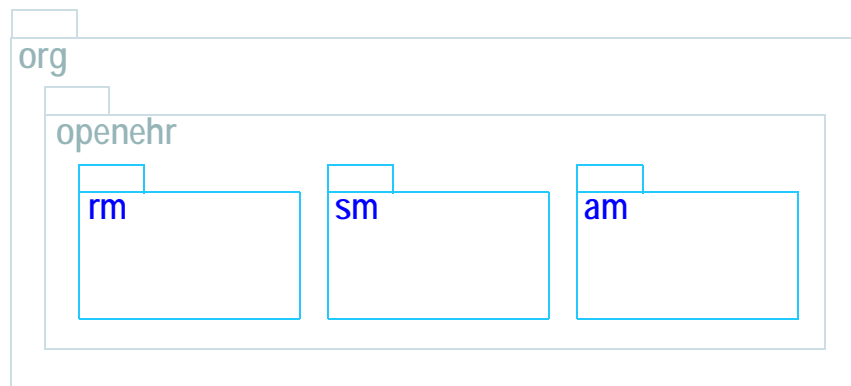


FIGURE 3 Global Package Structure of *openEHR*

3.1 Reference Model (RM)

Within the any given namespace, each package defines a local context for definition of classes. FIGURE 4 illustrates the package structure in the RM namespace. An informal division into “scientific computing” and “health information” is shown. The packages in the latter group are generic, and are used by all *openEHR* models, in all the outer packages. Together, they provide identification, access to knowledge resources, data types and structures, versioning semantics, and support for archotyping. The packages in the former group define the semantics of enterprise level health information types, including the EHR and demographics.

Each outer package in FIGURE 4 corresponds to one *openEHR* specification document¹, documenting an “information model” (IM). Where packages are nested, the inner packages cannot exist outside of their parent package. The package structure will normally be replicated in all ITS expressions, e.g. XML schema, programming languages like Java, C# and Eiffel, and interoperability definitions like IDL and .Net.

3.1.1 Information Overview

In terms of logical information structures, the RM packages define two kinds of things: information “repositories” and “top-level information structures”. Models of “repository” semantics in the RM include the following:

- the EHR itself;
- the generic model of versioned containers, defined by the class `VERSIONED_OBJECT` (Common IM).

1. with the exception of the EHR and Composition packages, which are both described in the EHR Reference Model document; this may change in the future.

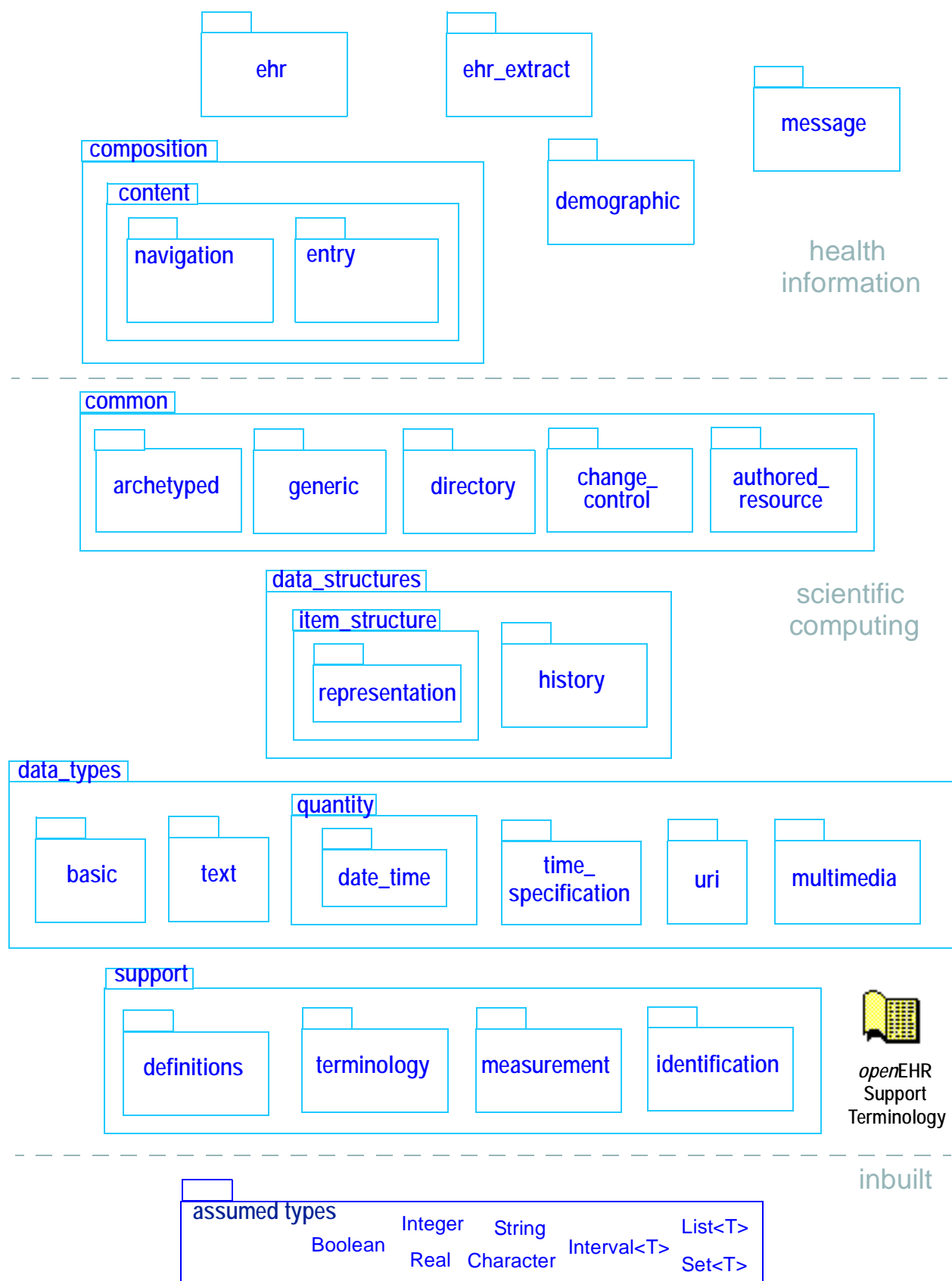


FIGURE 4 Structure of `org.openehr.rm` package

Top-level information structures are those that are self-contained or self-standing, can be sensibly converted into documents, and are stored within repositories. The top-level structures of the *openEHR* RM include:

- the `EHR_STATUS`, an EHR-wide object containing data management information;
- the `COMPOSITION`, the top-level data container in the EHR;
- the `PARTY`, which is the top-level structure in the demographic model;
- the directory, a tree structure of `FOLDERS`, which can be used to classify and cross-reference other top-level information objects in both the EHR and demographic models.

3.1.2 Package Overview

The following sub-sections provide a brief overview of the RM packages.

Support Information Model

This package describes the most basic concepts, required by all other packages, and is comprised of the Definitions, Identification, Terminology and Measurement packages. The semantics defined in these packages allow all other models to use identifiers and to have access to knowledge services like terminology and other reference data. The support package includes the special package *assumed_types*, describing what basic types are assumed by *openEHR* in external type systems; this package is a guide for integrating *openEHR* models proper into the type systems of implementation technologies.

Data Types Information Model

A set of clearly defined data types underlies all other models, and provides a number of general and clinically specific types required for all kinds of health information. The following categories of datatypes are defined in the data types reference model.

Text: plain text, coded text, paragraphs.

Quantities: any ordered type including ordinal values (used for representing symbolic ordered values such as “+”, “++”, “+++”), measured quantities with values and units, and so on.

Date/times: date, time, date-time types, and partial date/time types.

Encapsulated data: multimedia.

Basic types: boolean, state variable.

Data Structures Information Model

In many reference models, generic data structures are available for expressing content whose particular structure will be defined by archetypes. The generic structures are as follows.

Single: single items, used to contain any single value, such as a height or weight.

List: linear lists of named items, such as many pathology test results.

Table: tabular data, including unlimited and limited length tables with named and ordered columns, and potentially named rows.

Tree: tree-shaped data, which may be conceptually a list of lists, or other deep structure.

History: time-series structures, where each time-point can be an entire data structure of any complexity, described by one of the above structure types. Point and interval samples are supported.

Common Information Model

Several semantic concepts are used in common by various models. The classes `LOCATABLE` and `ARCHETYPED` provide the link between information and archetype models. The classes `ATTESTATION` and `PARTICIPATION` are generic domain concepts that appear in various reference models. The last group of concepts consists of a formal model of change management which applies to any service that needs to be able to supply previous states of its information, in particular the demographic and EHR services.

EHR Information Model

The EHR IM defines the containment and context semantics of the concepts `EHR`, `COMPOSITION`, `SECTION`, and `ENTRY`. These classes are the major coarse-grained components of the EHR, and correspond directly to the classes of the same names in CEN EN13606:2005 and fairly closely to the “levels” of the same names in the HL7 Clinical Document Architecture (CDA) release 2.0.

EHR Extract

The EHR Extract IM defines how an EHR extract is built from `COMPOSITIONs`, demographic, and access control information from the EHR.

Demographics

The demographic model defines generic concepts of `PARTY`, `ROLE` and related details such as contact addresses. The archetype model defines the semantics of constraint on `PARTYs`, allowing archetypes for any type of person, organisation, role and role relationship to be described. This approach provides a flexible way of including the arbitrary demographic attributes allowed in the OMG HDTF PIDS standard.

Workflow

Workflow is the dynamic side of clinical care, and consists of models to describe the semantics of processes, such as recalls, as well as any care process resulting from execution of guidelines.

3.2 Archetype Model (AM)

The *openEHR* `am` package contains the models necessary to describe the semantics of archetypes and templates, and their use within *openEHR*. These include `ADL`, the Archetype Definition Language (expressed in the form of a syntax specification), the `archetype` and `template` packages, defining the object-oriented semantics of archetypes and templates, and the `openehr_profile` package, which defines a profile of the generic archetype model defined in the `archetype` package, for use in *openEHR* (and other health computing endeavours). The internal structure of the `am` package is shown in FIGURE 5.

3.3 Service Model (SM)

The *openEHR* service model includes definitions of basic services in the health information environment, centred around the EHR. It is illustrated in FIGURE 6. The set of services actually included will undoubtedly evolve over time, so this diagram should not be seen as definitive.

EHR Client API

The EHR client API defines the fine-grained interface to EHR data, at the level of `Compositions` and below. It allows an application to create new information in an EHR, and to request parts of an existing EHR and modify them. This API enables fine-grained archetype-mediated data manipulation. Changes to the EHR are committed via the EHR service.

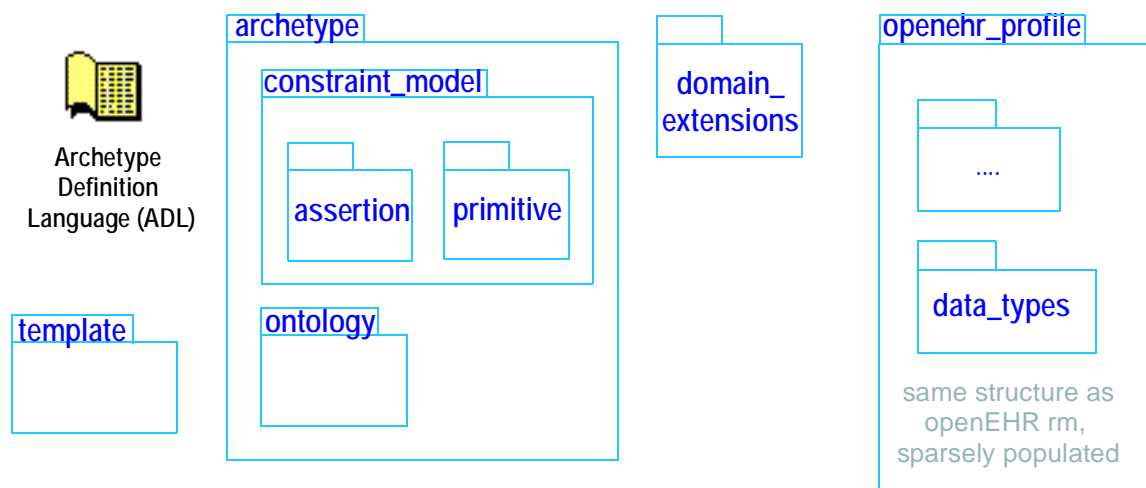


FIGURE 5 Structure of the org.openehr.am package

EHR Service Model

The EHR service model defines the coarse-grained interface to electronic health record service. The level of granularity is *openEHR* Contributions and Compositions, i.e. a version-control / change-set interface. The finest object that can be requested or committed via the EHR service is a single Composition, or the EHR Directory structure.

Part of the model defines the semantics of server-side querying, i.e. queries which cause large amounts of data to be processed, generally returning small aggregated answers, such as averages, or sets of ids of patients matching a particular criterion.

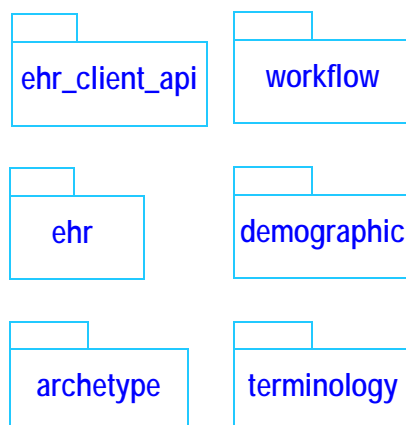


FIGURE 6 Structure of the org.openehr.sm package

Archetype Service Model

The archetype service model defines the interface to online repositories of archetypes, and can be used both by GUI applications designed for human browsing as well as access by other software services such as the EHR.

Terminology Interface Model

The terminology interface service provides the means for all other services to access any terminology available in the health information environment, including basic classification vocabularies such as ICDx and ICPC, as well as more advanced ontology-based terminologies. Following the concept of

division of responsibilities in a system-of-systems context, the terminology interface abstracts the different underlying architectures of each terminology, allowing other services in the environment to access terms in a standard way. The terminology service is thus the gateway to all ontology- and terminology-based knowledge services in the environment, which along with services for accessing guidelines, drug data and other “reference data” enables inferencing and decision support to be carried out in the environment.

4 Archetyping

All information conforming to the *openEHR* Reference Model (RM) - i.e. the collection of Information Models (IMs) is “archetypable”, meaning that it can be controlled by archetypes. Archetypes allow control over creation, modification and querying of data. Archetypes are themselves separate from the data, and are stored in their own repository. The archetype repository at any particular location will usually include archetypes from well-known online archetype libraries. Archetypes are deployed at runtime via templates that specify particular groups of archetypes to use for a particular purpose, often corresponding to a screen form.

4.1 Application of Archetypes and Templates

4.1.1 Scope

All nodes in the top-level information structures (i.e. EHR_STATUS, COMPOSITION, FOLDER structure, PARTY etc) in the RM are “archetypeable”, with certain nodes within those structures being archetype “root points”. Each top-level type is always guaranteed to be an archetype root point. Although it is theoretically possible to use a single archetype for an entire top-level structure, in most cases, particularly for COMPOSITION and PARTY, a hierarchical structure of multiple archetypes will be used. This allows for componentisation and reusability of archetypes. Where hierarchies of archetypes are used for a top-level structure, there will also be archetype root points in the interior of the structure. For example, within a COMPOSITION, ENTRY instances (i.e. OBSERVATIONS, EVALUATIONS etc) are almost always root points. SECTION instances are root points if they are the top instance in a Section structure; similarly for FOLDER instances within a directory structure. Other nodes (e.g. interior SECTIONS, ITEM_STRUCTURE instances) might also be archetype root points, depending on how archetypes are applied at runtime to data. FIGURE 7 illustrates the application of archetypes and templates to data.

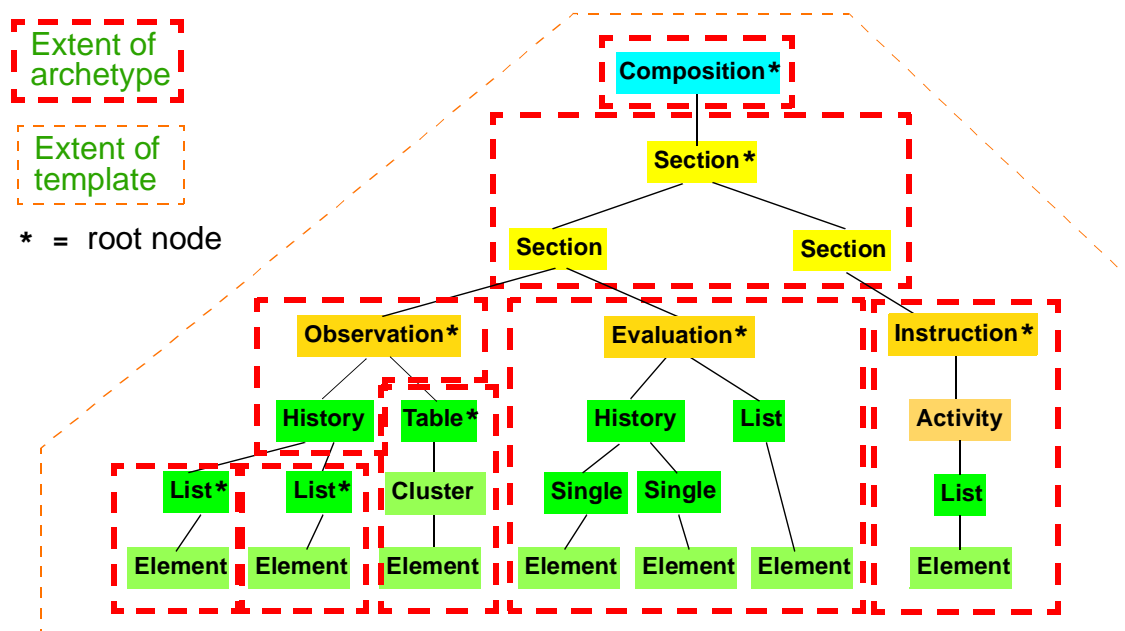


FIGURE 7 How Archetypes apply to Data

4.1.2 Archetype-enabling of Data

Archetype-enabling is achieved via inheritance into all concrete types in the RM of the class `LOCATABLE` from the package `common.archetyped` (see Common IM). The `LOCATABLE` class includes the attributes *archetype_node_id* and *archetype_details*. In the data, the former carries an identifier from the archetype node used to create each data node. If the node in the data is a root point, *archetype_node_id* carries the multipart identifier of the generating archetype, and *archetype_details* carries an `ARCHETYPED` object, containing information pertinent to archetype root points. If it is a non-root node, the *archetype_node_id* attribute carries an interior node identifier (known as an “at”, or “archetype term” code) from the archetype, and the *archetype_details* attribute is empty.

Sibling nodes in data can carry the same archetype node id in some cases, since archetypes provide a pattern for data, rather than an exact template; depending on what the archetype allows, a single node may be replicated in the data.

In this way, each *archetyped data composition*¹ in EHR data has a generating archetype which defines the particular configuration of instances to create the desired composition. An archetype for “biochemistry results” is an `OBSERVATION` archetype, and constrains the particular arrangement of instances beneath an `OBSERVATION` object; a “problem/SOAP headings” archetype constrains `SECTION` objects forming a SOAP headings structure. In general, an archetyped data composition is any composition of data starting at a root node and continuing to its leaf nodes, at which point lower-level compositions, if they exist begin. Section trees and Entry structures are thus archetyped data compositions.

The result of the use of archetypes to create data in the EHR (and other systems) is that the structure of data in any particular top-level structure conforms to the constraints defined in a particular composition of archetypes chosen by a template. In particular, it conforms to the path structure of the archetypes, as well as their terminological constraints.

1. Note: care must be taken not to confuse the general term “composition” with the specific use of this word in *openEHR* and CEN EN 13606, defined by the `COMPOSITION` class; the specific use is always indicated by using the term “Composition”.

5 Identification and Versioning

In order to make data items locatable from the outside, identification is needed at 3 levels in *openEHR*:

- *repository structures*: such as the EHR (EHR IM) and `VERSIONED_OBJECTs` (Common IM);
- *versions of top-level structures*: `VERSIONs` of `VERSIONED_OBJECTs` (such as `VERSIONED_COMPOSITION`, `VERSIONED_PARTY` etc) must be identifiable; since all top-level content structures are versioned, the identifier of a `VERSION` identifies a top-level structure as well;
- *internal nodes*: nodes within top-level structures need to be identified.

Three kinds of identification are used respectively in these contexts. For repository structures, meaningless unique identifiers (“uids”), defined by the abstract type `OBJECT_ID` are used. In most cases, the subtype `HIER_OBJECT_ID` will be used, which contains either an ISO OID or an ECMA GUID. In general GUIDs are favoured since they require no central assignment and can be generated on the spot.

Versions of top-level structures are identified in a way that is guaranteed to work even in distributed environments where copying, merging and subsequent modification occur. The full identification of a version of a top-level structure is the globally unique tuple consisting of the *uid* of the owning `VERSIONED_OBJECT`, and the two `VERSION` attributes *version_id* and *system_id_chain*. The *version_id* is a typical numeric 2-part number string, such as “1.2” or for branching, a 4-part number string “1.2.1.3”. The *system_id_chain* attribute carries a concatenation of system identifiers, starting with the id of the system most recently adding versions, and ending with the id of the system where the original version was created. A typical version identification tuple is as follows:

F7C5C7B7-75DB-4b39-9A1E-C0BA9BFDBDEC	-- id of <code>VERSIONED_COMPOSITION</code>
au.gov.health.rdh.ehr1	-- id of creating system
1.4	-- current version

The *openEHR* version identification scheme is described in detail in the `change_control` package section of the Common IM.

The last component of identification is the path, used to refer to an interior node of a top-level structure. Paths in *openEHR* follow an X-path style syntax, with slight abbreviations to shorten paths in the most common cases. Paths are described in detail in the next section.

With the combination of these identifiers, any *openEHR* information entity can be reached. Usually the requirement is to point to a top-level structure, and optionally within that, an interior data node. The various identifiers can be combined in a URI to make a single string reference for use across the internet; as described below.

6 Paths

6.1 Overview

The *openEHR* architecture includes a “runtime” path mechanism that enables any node or leaf item of EHR data to be referred to using a string locator. The locator includes a path expression that uses an Xpath¹-like syntax and is a superset of the path syntax described in the Archetype Definition Language (ADL) specification. The syntax is designed to be easily mappable to Xpath expressions, for use with *openEHR*-based XML².

6.2 Runtime Path Syntax

The runtime path syntax used in locator expressions follows the general pattern of a path consisting of segments each consisting of an attribute name, and separated by the slash (‘/’) character, i.e.:

```
attribute_name / attribute_name / ... / attribute_name
```

Paths select the object which is the value of the final attribute name in the path, when going from some starting point in the tree and following attribute names given in the path. The starting point is indicated by the initial part of the path, and can be specified in three ways:

relative path: path starts with an attribute name, and the starting point is the current point in the tree (given by some previous operation or knowledge);

absolute path: path starts with a ‘/’; the starting point is the top of the structure;

movable path: path starts with a movable path leader ‘//’ and is taken to be a pattern which can start anywhere in the data; the pattern is matched if an actual path can be found anywhere in the structure that matches the path given after the ‘//’ leader.

6.2.1 Predicate Expressions

Paths specified solely with attribute names are limited in two ways. Firstly, they can only locate objects in structures in where there are no containers, such as lists or sets. However, in any realistic data, including most *openEHR* data, list, set and hash structures are common. Additional syntax is needed to match a particular object from among the siblings referred to by a container attribute. This takes the form of a predicate expression enclosed in brackets (‘[]’) after the relevant attribute in a segment, i.e.:

```
attribute_name [predicate expression]
```

The general form of a path then resembles the following:

```
attribute_name / attribute_name [predicate expression] / ...
```

Here, predicate expressions are used optionally on those attributes defined in the reference model to be of a container type (i.e. having a cardinality of > 1). If a predicate expression is not used on a container attribute, the whole container is selected.

The second limitation of basic paths is that they cannot locate objects based on other conditions, such as the object having a child node with a particular value. To address this, predicate expressions can

1. See W3C Xpath 1.0 specification, 1999. Available at <http://www.w3.org/TR/xpath>.

2. In all *openEHR* documentation, the term “attribute” is used in the object-oriented sense of “property of an object”, not in the XML sense of named values appearing within a tag. The syntax described here should not be considered to necessarily have a literal mapping to XML instance, but rather to have a logical mapping to object-oriented data structures.

also be used to select an object on the basis of other conditions relative to the object, by including boolean expressions including paths, operators, values and parentheses.

The syntax of predicate expressions is a subset of the Xpath syntax for predicates with a small number of shortcuts. The general form of a predicate statement is a boolean-returning expression consisting of paths, values, operators and parentheses. In the current release of *openEHR*, it is expected that only very simple expressions will be used. The simplest such expression is to identify an object by its *archetype_node_id* value, which will be an ‘at’ code from an archetype; in other words, just to use the ADL archetype path against the runtime data. A typical ADL path is the following (applied to an Observation instance):

```
/data/events[at0003]/data/items[at0025]/value/magnitude
```

This path refers to the magnitude of a 1-minute Apgar total in an Observation containing a full Apgar result structure. In this path, the [atNNNN] predicates correspond to [@archetype_node_id = "atNNNN"] in standard Xpath, however, the shorthand form is used in *openEHR* as it is the only kind of predicate used in archetype paths. In *openEHR* runtime paths, archetype code predicates are also commonly used, and the same shortcut is allowed. However, runtime path predicates can also include other expressions (including the orthodox Xpath equivalent expression for the archetype node id shortcut), typically based on the value of some other attribute such as *ELEMENT.name* or *EVENT.time*. Combinations of the *archetype_node_id* and other such values are likely to be commonly used in querying, such as the following path fragment (applied to an OBSERVATION instance):

```
/data/events[at0007 AND time >= "24-06-2005 09:30:00"]
```

This path would choose Events in Observation.data whose *archetype_node_id* meaning is “summary event” (at0007 in some archetype) and which occurred after the given time. The following example would choose an Evaluation containing a diagnosis (at0002.1) of “other bacterial intestinal infections” (ICD10 code A04):

```
/data/items[at0002.1
AND value/defining_code/terminology_id/value = "ICD10AM"
AND value/defining_code/code_string = "A04"]
```

6.3 URIs, Locators and Paths in the *openEHR* EHR

In real systems, paths will usually need to be constructable from the “top” of independent structures, such as Compositions, the Folder structure, Party objects and so on. Such objects can be thought of as somewhat equivalent to self-standing documents (e.g. in the XML sense). However, there is also a need to construct locator expressions to objects from the outside of the EHR, or the EHR system, which requires a way of locating the EHR for a subject of care, and then locating any particular top-level object within it (similarly for locating the Party object for a patient in the demographic repository).

The current *openEHR* approach is to treat paths *within* top-level structures, and locators *to* top-level structures as distinct things, and to allow them to be combined to form URIs (uniform resource locators) in an “ehr” scheme-space. The overall pattern for an EHR URI to refer to a low-level object within some top-level object within an EHR is as follows:

```
ehr://top_level_object_locator/path_inside_top_level_object
```

Under this scheme, any object in an *openEHR* EHR is addressable via a URI. This enables DV_EHR_URIs to be constructed for use within LINKs and elsewhere in the *openEHR* EHR. (URIs of course are only one method of addressing or querying data in the EHR. Other querying syntaxes and functional interfaces will be developed and used over time.)

6.3.1 Locating Top-Level Structures

Semantically speaking, any locator for a top-level structure needs to specify the following things:

- EHR id
- potentially, EHR system id
- optionally, version epoch, i.e. time baseline for retrieving versions, defaults to “now”;
- identifier of particular top-level object, typically its Uid

Currently there is no standard syntax for encapsulating these parameters, for a number of reasons. Firstly, there is an issue to do with how EHRs will be identified in *openEHR* systems. Identifiers may be required to conform to local health jurisdiction requirements, or may not. If EHR identifiers are globally unique, or even nationally unique, then in theory, system identifiers can be dispensed with. However in a practical sense the identifier of the EHR system can only be dispensed with if there is a health information location service operating in the environment that can perform EHR id -> system id mappings, in much the same way as the internet DNS converts logical domain names to IP addresses.

Another issue is whether it can be assumed that the version epoch has already been established in some earlier call or service invocation, and that no version time information is needed.

Various syntax possibilities include:

- an Xpath-style syntax; this does not seem desirable as it implies hierarchical data containment structures that don't exist;
- a web-services inspired functional syntax;
- a database-inspired query syntax.

Currently, an orthodox URI query style of syntax is used, as shown in the following examples. This path matches a specified `Versioned_composition`:

```
ehr://rdh.health.gov.au?ehr=1234567&versioned_composition=87284370-2D4B-4e3d-A3F3-F303D2F4F34B
```

The following path matches the Version containing the latest Composition from a specified `Versioned_composition`:

```
ehr://rdh.health.gov.au?ehr=1234567&versioned_composition=0892BF98-910D-4df9-BF7E-F10D72C1C81A&composition.version_id=latest
```

The following path matches a Composition within the latest version committed to a `Versioned_composition`

```
ehr://rdh.health.gov.au?ehr=1234567&versioned_composition=F7C5C7B7-75DB-4b39-9A1E-C0BA9BFDBDEC&composition.version_id=latest/data
```

In these paths, the following pseudo-identifiers are used:

- `versioned_composition`: to indicate an instance of `VERSIONED_COMPOSITION`;
- `latest_version`: to indicate a `VERSION` instance being the result of the call `VERSIONED_COMPOSITION.latest_version`;
- `composition`: to indicate an instance of `COMPOSITION`.

Implementors and users of the current release of *openEHR* are encouraged to experiment and/or propose improved solutions to the locator requirement described in this section.

6.3.2 Paths within Top-level Structures

In *openEHR*, objects within the following top-level structures are queryable by Xpath-style paths:

- Compositions;
- the Folder structure;
- the Ehr_status object;
- descendants of Party.

Paths within these structures strictly adhere to attribute and function names in the relevant parts of the reference model. Predicate expressions are needed to distinguish multiple siblings in various points in paths into these structures, but particularly at archetype “chaining” points. A chaining point is where one archetype takes over from another, and are illustrated in FIGURE 7. Chaining points in Compositions occur between the Composition and a Section structure, potentially between a Section structure and other sub-Section structures (constrained by a different Section archetype), and between either Compositions or Section structures, and Entries. Chaining might also occur inside an Entry, if archetyping is used on lower level structures such as Item_lists etc. Most chaining points correspond to container types such as List<T> etc, e.g. COMPOSITION.content is defined to be a List<CONTENT_ITEM>, meaning that in real data, the content of a Composition could be a List of Section structures. To distinguish between such sibling structures, predicate expressions are used, based on the *archetype_id*. At the root point of an archetype in data (e.g. top of a Section structure), the *archetype_id* carries the identifier of the archetype used to create that structure, in the same manner as any interior point in an archetyped structure has an *archetype_node_id* attribute carrying archetype *node_id* values. The chaining point between Sections and Entries works in the same manner, and since multiple Entries can occur under a single Section, *archetype_id* predicates are also used to distinguish them. The same shorthand is used for *archetype_id* predicate expressions as for *archetype_node_ids*, i.e. instead of using [*@archetype_id* = “xxxxx”], [xxxx] can be used instead.

The following paths are examples of referring to items within a Composition:

```
/content[openEHR-EHR-SECTION.vital_signs.v1]/
  items[openEHR-EHR-OBSERVATION.heart_rate-pulse.v1]/data/
  items[at0003 AND time='2006-01-25T08:42:20']/data/items[at0004]
/content[openEHR-EHR-SECTION.vital_signs.v1]/
  items[openEHR-EHR-OBSERVATION.blood_pressure.v1]/data/
  items[at0006 AND time='2006-01-25T08:42:20']/data/items[at0004]
/content[openEHR-EHR-SECTION.vital_signs.v1]/
  items[openEHR-EHR-OBSERVATION.blood_pressure.v1]/data/
  items[at0006 AND time='2006-01-25T08:42:20']/data/items[at0005]
```

Paths within the other top level types follow the same general approach, i.e. are created by following the required attributes down the hierarchy.

7 Relationship to Standards

The *openEHR* specifications make use of available standards where relevant, and as far as possible in a compatible way. However, for the many standards have never been validated in their published form (i.e. the form published is not tested in implementations, and may contain errors), *openEHR* makes adjustments so as to ensure quality and coherence of the *openEHR* models. In general, “using” a standard in *openEHR* may mean defining a set of classes which map it into the *openEHR* type system, or wrap it or express it in some other compatible way, allowing developers to build completely coherent *openEHR* systems, while retaining compliance or compatibility with standards. The standards relevant to *openEHR* fall into a number of categories as follows.

Standards by which *openEHR* can be evaluated

These standards define high-level requirements or compliance criteria which can be used to provide a means of normative comparison of *openEHR* with other related specifications or systems. The following ones have been used for this purpose so far:

- ISO TC 251 TS 18308 - Technical Specification for Requirements for an EHR Architecture.

Standards which have influenced the design of *openEHR* specifications

The following standards have influenced the design of the *openEHR* specifications:

- **OMG HDTF** Standards - general design
- **CEN EN 13606:2006**: Electronic Health Record Communication
- **CEN HISA 12967-3**: Health Informatics Service Architecture - Computational viewpoint

Standards which have influenced the design of *openEHR* archetypes

The following standards are mainly domain-level models of clinical practice or concepts, and are being used to design *openEHR* archetypes and templates.

- **CEN HISA 12967-2**: Health Informatics Service Architecture - Information viewpoint
- **CEN ENV 13940**: Continuity of Care.

Standards which are used “inside” *openEHR*

The following standards are used or referenced at a fine-grained level in *openEHR*:

- **ISO 8601**: Syntax for expressing dates and times (used in *openEHR* Quantity package)
- **ISO 11404**: General Purpose Datatypes (mapped to in *openEHR* `assumed_types` package in Support Information Model)
- **HL7 UCUM**: Unified Coding for Units of Measure (used by *openEHR* Data types)
- **HL7v3 GTS**: General Timing Specification syntax (used by *openEHR* Data types).
- some HL7v3 domain vocabularies are mapped to from the *openEHR* terminology.

Standards which require a conversion gateway

The following standards are in use and require data conversion for use with *openEHR*:

- **CEN EN 13606:2005**: Electronic Health Record Communication - near-direct conversion possible, as *openEHR* and CEN EN 13606 are actively maintained to be compatible.
- **HL7v3 CDA**: Clinical Document Architecture (CDA) release 2.0 - fairly close conversion may be possible.
- **HL7v3 messages**. Quality of conversion currently unknown due to flux in HL7v3 messaging specifications.

- **HL7v2 messages.** Experience in Australia indicates that importing of HL7v2 message information is relatively easy. Export from *openEHR* may also be possible.

Generic Technology Standards

The following standards are used or referenced in *openEHR*:

- ISO RM/ODP
- OMG UML 2.0
- W3C XML schema 1.0
- W3C Xpath 1.0

8 Implementation Technology Specifications

8.1 Overview

ITSs are created by the application of transformation rules from the “full-strength” semantics of the abstract models to equivalents in a particular technology. Transformation rules usually include mappings of:

- names of classes and attributes;
- property and function signature mapping;
- mapping of basic types e.g. strings, numerics;
- how to handle multiple inheritance;
- how to handle generic (template) types;
- how to handle covariant and contravariant redefinition semantics;
- the choice of mapping properties with signature $xxxx:T$ (i.e. properties with no arguments) to stored attributes ($xxxx:T$) or functions ($xxxx():T$);
- how to express preconditions, postconditions and class invariants;
- mappings between assumed types such as `List<>`, `Set<>` and inbuilt types.

ITSs are being developed for a number of major implementation technologies, as summarised below. Implementors should always look for an ITS for the technology in question before proceeding. If none exists, it will need to be defined. A methodology to do this is being developed.

FIGURE 8 illustrates the implementation technology specification space. Each specification documents the mapping from the standard object-oriented semantics used in the *openEHR* abstract models, and also provides an expression of each of the abstract models in the ITS formalism.

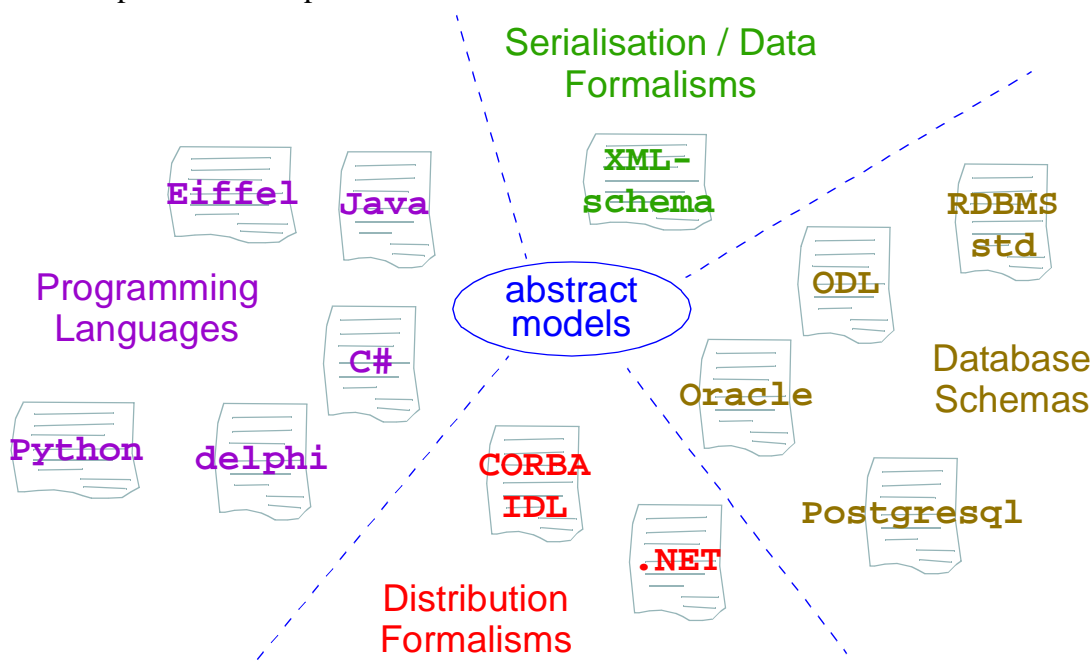


FIGURE 8 Implementation Technologies

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