*open*EHR Release 1.1

The *open*EHR Archetype Model

*open*EHR Templates

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a. Ocean Informatics

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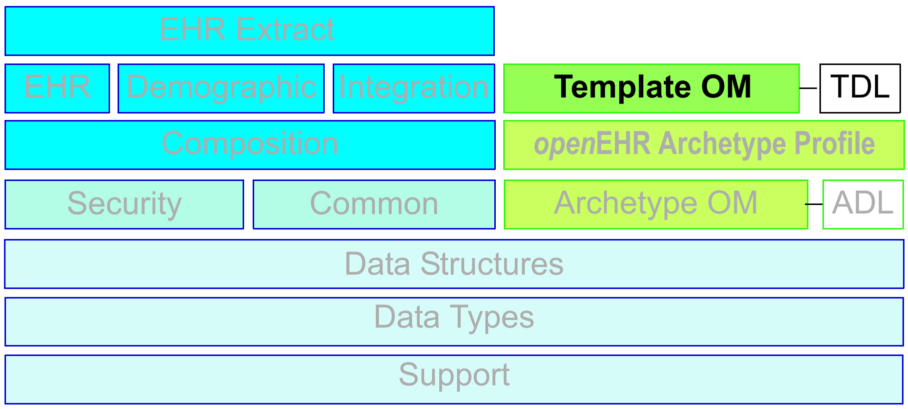

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1 Introduction

1.1 Purpose

This document describes the semantics of *open*EHR templates. Source templates are defined as technically normal archetypes, with the only differences being to do with identification rules. The ADL and AOM 1.5 models support all aspects of template definition. A very small additional model is required to formally define the *operational* template, which is the result generated from a source templates and archetypes.

The intended audience includes:

- Standards bodies producing health informatics standards;
- Software development organisations using *open*EHR;
- Academic groups using *open*EHR;
- Medical informaticians and clinicians interested in health information;
- Health data managers.

1.2 Related Documents

Prerequisite documents for reading this document include:

- The *open*EHR Architecture Overview

Related documents include:

- The *open*EHR Archetype Definition Language (ADL)
- The *open*EHR Archetype Object Model (AOM)

1.3 Nomenclature

In this document, the term 'attribute' denotes any stored property of a type defined in an object model, including primitive attributes and any kind of relationship such as an association or aggregation. XML 'attributes' are always referred to explicitly as 'XML attributes'.

The term 'template' used on its own always means an *open*EHR template definition, i.e. an instance of the AOM used for templating purposes. An operational template is always denoted as such in *open*EHR.

1.4 Status

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

The latest version of this document can be found in PDF format at http://www.openehr.org/svn/specification/TRUNK/publishing/architecture/am/tom.pdf. New versions are announced on openehr-announce@openehr.org.

Blue text indicates sections under active development.

2 Overview

2.1 Context

Templates constitute a third layer above archetypes and the reference model in the *open*EHR application architecture shown in FIGURE 1, and provide the means of defining groupings of archetype-defined data points for particular business purposes. They support bindings to terminology subsets specific to their intended use, and can be used to generate or partly generate a number of other artefact types including screen forms and message schemas.

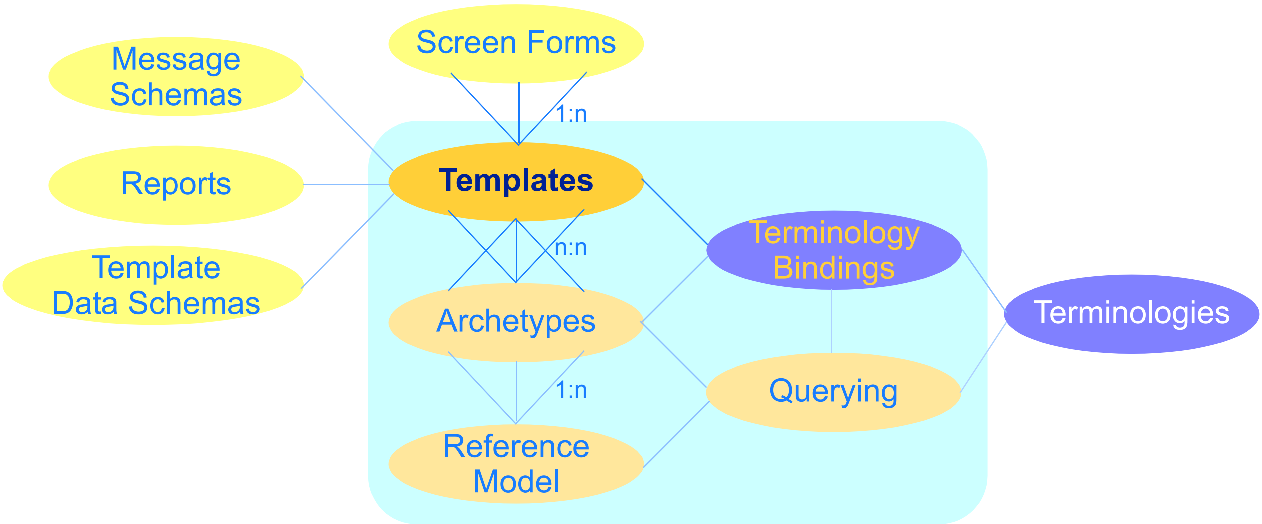

FIGURE 1 The *open*EHR Semantic Architecture

Templates are formally expressed in terms of ADL/AOM 1.5. The operational form of a template is defined by the `template` package described in this specification, which is a slight variant of the flat archetype from the AOM.

2.2 Basic Semantics

2.2.1 Purpose

An *open*EHR template is an artefact that enables the content defined in published archetypes to be used for a particular use case or business event. In health this is normally a 'health service event' such as a particular kind of encounter between a patient and a provider. Archetypes define content on the basis of topic or theme e.g. blood pressure, physical exam, report, independently of particular business events. Templates provide the way of using a particular set of archetypes, choosing a particular (often quite limited) set of nodes from each and then limiting values and/or terminology in a way specific to a particular kind of event, such as 'diabetic patient admission', 'ED discharge' and so on. Such events in an ICT environment nearly always have a logical 'form' (which may have one or more 'pages' or subforms and some workflow logic) associated with them; as a result, an *open*EHR template is often a direct precursor to a form in the presentation layer of application software. Templates are the technical means of using archetypes in runtime systems.

This job of a template is as follows:

- aggregate archetypes into larger structures by indicating which archetypes should fill the slots of higher-level archetypes;
- remove archetype elements ('data points') not needed for the purpose of the template;
- narrow existing constraints on archetypes or on the reference model (i.e. on parts of the RM not yet constrained by the archetypes referenced in the template);
- set default values if required.

A template may aggregate any number of archetypes, but choose very few data points from each, thus having the effect of defining a small data set from a very large number of data points defined in the original archetypes.

2.2.2 Formal Definition

Formally, an *open*EHR template source is a collection of one or more specialised archetypes, managed in a template repository. Each such archetype is either a 'template', i.e. an explicitly published artefact, or a 'template-component', which is a specialised archetype used as a private component of a template. The template root is thus just a specialisation of some published archetype, as are any further constraints on referenced archetypes. The *artefact_type* attribute in the `ARCHETYPE` class is used to distinguish between these types, although there is no formal difference between them. Instead, tools control how the underlying formalism is used, with templates and their components typically being managed in the following way:

- templates are managed in a workspace separate to that of published archetypes, normally local to the organisation defining the templates;
- template identifiers, while legal archetype identifiers, follow certain patterns that make them easier to identify as templates, including by tools;
- templates tend to exclusively use the slot-filling semantic, even though it is technically valid in any archetype;
- default values, while technically possible in published archetypes are typically only stated in templates.

TBD_1: `whether templates can add extra nodes like archetypes can`

When a template is successfully compiled, it produces an *operational template* which is a flat-form archetype, containing the ontologies of all the constituent archetypes in addition to its own.

The fact that templates are implemented as normal specialised archetypes means that they cannot change the semantics of archetypes they use. Accordingly, *all data created due to the use of templates are guaranteed to conform to the referenced archetypes and the underlying reference model*.

2.3 Computational Environment

FIGURE 2 shows how a logical template, consisting of local archetypes, and referencing published archetypes, is used to create an operational template. The template refers to one or more archetypes and usually imposes further constraints (contained in component archetypes). A template parser converts a template into an in-memory object form described by the Template Object Model. The document form template may be expressed in TDL, or in any XML or other equivalent derived from the Template Object Model. An operational template builder generates an in-memory Operational Template which is a standalone artefact (contains all relevant parts of its template, referenced archetypes and terminology) that can be used to generate other computational artefacts including screen forms. The builder takes a palette as an input, which has the effect of removing other languages and terminologies when generating the operational template, ensuring that each resulting artefact only contains what is needed for local use.

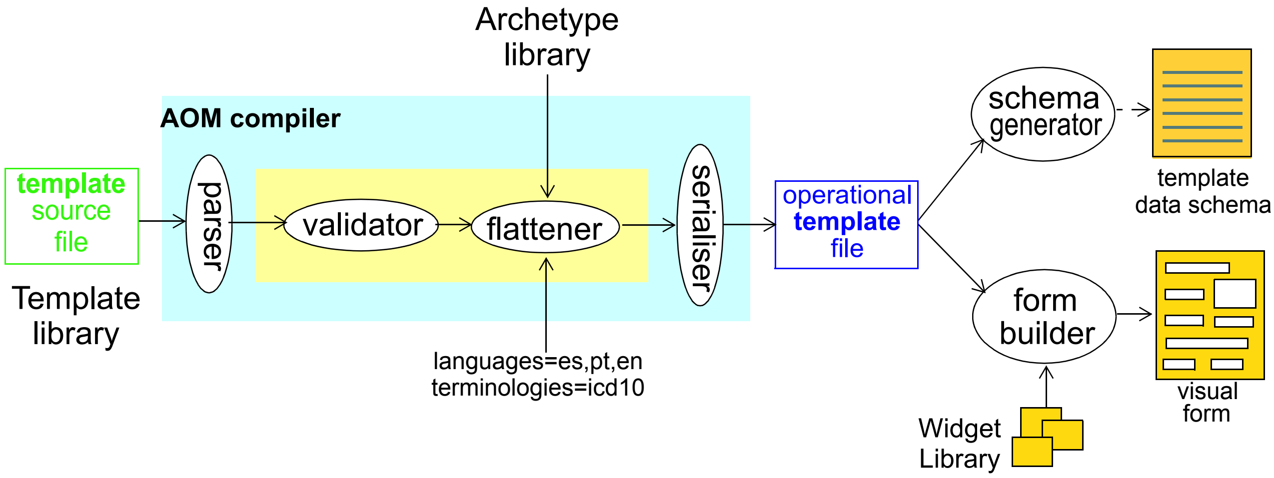

FIGURE 2 Template Tool Chain

3 Requirements

3.1 Overview

Templates need to be able to perform four main functions as follows.

Aggregation: the first is to combine archetypes into larger structures by filling archetype slots with archetypes or previously defined templates.

Element choice: the second is to choose which parts of the chosen archetypes should remain in the final structure, by removing unneeded elements, and indeed whole parts of structures specified in an archetype or the underlying reference model (where not constrained by the archetypes being used)

Further constraining: the third is to optionally add further constraints to the chosen archetypes or reference model, specific to the needs of the template. This may include narrowing of value ranges, and refined constraints on terminology.

Default values: the fourth function is to define default values of leaf or near-leaf structures. Default values will usually be used to pre-populate fields on a screen form, or within a template-based message.

A further general requirement on templates is of a documentary nature: how are they described, and how are they linked to existing resources to do with defining data, records and user interfaces.

The following sections describe the requirements for *open*EHR templates. Most of the requirements described here have been determined by real world use of prototype models of *open*EHR templates in health.

3.2 Governance Requirements

TBD_2: Need to be able to unambiguously distinguish archetype from template from t-archetype.

3.3 Documentary Requirements

3.3.1 Descriptive Meta-data

A similar set of meta-data as supported by archetypes should also be supported by templates, including items such as:

- purpose;
- use;
- misuse;
- audit details of creation and modification;
- references to resources used in the authoring process;
- copyright status.

Descriptive meta-data should be limited to items that directly help explain the template, rather than cross-references to every possible related item in an enterprise, which should be dealt with by other means.

3.3.2 Author Annotations

It should be possible for a template author via the use of a tool to create annotations per node of the template definition structure. Note that such annotations only apply to nodes mentioned in the template, i.e. nodes further constrained in the template. At each node, it should be possible to create one or more annotations, each with a unique tag with respect to other annotations on the same node. Annotation content is required to be normal text.

Annotations should be modifiable over time by authors. It is expected that many annotations will be meaningful only during the authoring period, but not at the time of release. A way is needed to easily remove or ignore some or all node-level annotations in the production form of a template.

3.3.3 Institutional Meta-data and Links

There is a need to be able to create links between new artefacts like archetypes and templates, and institutional or external resources, typically documentary or design artefacts about the same topic expressed in natural language or older technologies. Within the template building environment the need is to be able to assert and persist links between such resources and templates, or parts of templates, which requires a means of referencing individual nodes in a template. It is not expected that templates themselves need to support such linking internally, rather they would be represented in an artefact external to templates.

3.4 Application Requirements

Ideally, a template can be used to generate artefacts that can be used directly in the building of applications, including forms. The main requirement is to ensure that the connection between application form elements and controls and the underlying template (archetype) element is maintained.

Some specific requirements for templates relating to end user applications include:

- a way of specifying that a template node is not displayed on the screen;
- a way of specifying help text for a template node, accessible by the application.

It is recognised that many aspects of form appearance will not be included in templates and will need to be supplied in other artefacts, most likely using template paths to refer to specific elements within a template.

3.5 Semantic Requirements

3.5.1 Relationship to Archetypes

A template is required to constrain one ‘root’ archetype, including any constraint redefinition and slot-filling possible within the root archetype.

3.5.2 Slot Filling

The most basic requirement is to be able to define larger structures composed from archetypes, by choosing filler archetypes for the slots defined in ‘higher’ (in the aggregation sense) archetypes. There are three possibilities that have to be supported:

- completely specifying the fillers for a slot;
- specifying some fillers for a slot, where remaining slot fillers may be decided at runtime;
- leaving the slot as defined by the archetype, leaving all slot fillers to be decided at runtime.

In addition, existing templates should be allowed to be used in a slot in place of an archetype. Experience with prototype templates in *open*EHR has shown the need to be able to define a template for a subtree of content that will always be constrained in the same way in all top-level objects in which it is used in the institution. Rather than redefine the same constraints in each top-level template, it is clearly preferable to be able to reuse a single definition of such content.

Typical examples are the Oximetry, Blood Pressure and Heartrate templates of the *open*EHR `OBSERVATION` class, which are reused in a number of `SECTION` and `COMPOSITION` templates.

Template reuse needs to work in such a way that if the referenced template is changed, it is changed in all templates using it, i.e. a true reference. It also needs to function such a way that the referencing template can define additional constraints over and above what the referenced section defines.

3.5.3 Constraint Refinement

Templates should be able to refine the constraints defined in any included archetypes, or create new constraints on the parts of the reference model relevant to those archetypes, in the same was as for archetypes. In particular, terminology constraints need to be redefinable as in specialised archetypes, i.e. any of the following:

- redefine open constraint on text to be set of coded terms;
- narrow coded term constraint to a subset;
- redefine an external subset (defined using an ac-code in an archetype) to a narrower external subset;
- redefine an external subset to an internal subset.

3.5.4 Default Values

Template authors need to be able to define default values for nodes defined in the template, or in an underlying archetype, even if the template does not change the node in question, and similarly for elements in the reference model for which there may or may not be constraints in the archetypes or template. A ‘default’ value is one which will be usually be displayed and will be used at runtime unless the user or application actively supplies something different.

Experience has shown that defaults need to be settable on primitive leaf types, i.e. String, Integer, Real, Boolean, the date/time types, and also the *open*EHR `DATA_VALUE` descendants, such as `DV_QUANTITY` and `DV_CODED_TEXT`.

3.5.5 Conditional Constraints

In some cases it is needed to be able to state a constraint that is applied only if a condition is true. A typical situation is to make the existence of a subtree dependent on the existence or runtime values of data found in other subtrees. A condition is an expression combining variables and constants with boolean, arithmetic and relational operators, to generate a boolean result that can be used to decide whether to apply a constraint.

The following types of condition variables need to be supported:

- *external variable*: variables such as ‘today’s date’;
- *EHR variable*: variables such as ‘date of birth’, ‘gender’ from the EHR;
- *existence of another path*: the existence of a path in the data, which implies that at runtime an optional node was included;
- *value on other path*: the value of a leaf object in the data on a particular path.

Constants that can be used in condition expressions include the primitive types, and dates and times.

Conditions should include the facility for a natural language description of the condition so that the intent is recorded.

3.6 Optimisations

In some cases it is desirable to be able to pre-populate some terminology subsets, particularly those that are small, change rarely, or for situations where the relevant terminologies will not be available in the deployment environment at runtime. For large subsets, e.g. the set corresponding to Snomed-ct 'bacteria' (numbering in the 10s of thousands of terms), prepopulation is not desirable.

It should be possible to state within a template whether a particular subset of a specific terminology should be pre-populated.

TBD_3: if the subset was defined in the archetype, we really want to specify that a particular *binding* should be prepopulated, but if it was specified in the template, then we are choosing the binding directly?

For subsets that would normally have internal structure intact at runtime, the pre-populated version should also retain this structure, allowing the subset to be treated at runtime in the same way as if it had been available from an online terminology service. For example, a Snomed-CT subset that contains IS-A links should retain these when pre-populated.

Pre-population of templates is effected in operational templates. Consequently, when a terminology is updated, affected operational templates need to be regenerated. This requires a way of recording which templates need to be accessed in order to regenerate the corresponding operational template when changes occur in terminologies.

3.7 Tooling Requirements

For purposes of clarity in the authoring process, it is suggested that the following features are supported in template editing tools:

- included templates shown in a different way, e.g. a different colour;

TBD_4: Nested templates in a different colour

TBD_5: cut and paste of a template, template section

4 Template Definition and Development

4.1 Overview

Templates are defined in the form of specialised archetypes. This means that all the formal characteristics of a template are defined by the *open*EHR Archetype Object Model (AOM) and Archetype Definition Language (ADL) specifications. However, the mode of use of the AOM and ADL are slightly different from the typical archetype in two ways. Firstly, the following formal features are used in templates but not generally archetypes:

- slot-filling - note that specifying a slot-filler is achieved by specialisation, because a legal specialisation of a slot can be a redefinition of the slot with or without fillers;
- specifying 0..0 constraints to remove elements not needed from the referenced archetypes;
- setting default values.

Secondly, because a logical template generally implicates a number of archetypes - i.e. the root archetype plus component archetypes mentioned as slot-fillers - and also usually defines further constraints on the root and component archetypes, the typical template is expressed in the form of a *group of specialised archetypes*, with specific identifiers.

In order to better explain the template artefact structure, an example is shown in FIGURE 3. The archetype `org.openehr::openEHR-EHR-COMPOSITION.encounter_report.v1` is shown at the top left. This is templated by the template `uk.nhs.clinical::openEHR-EHR-COMPOSITION.t_encounter_report.v1`. The template performs the job of filling the at0004 slot in the root archetype by specialising it: the specialised version adds a filler object (the `C_ARCHETYPE_ROOT` instance) and also overrides the original `ARCHETYPE_SLOT` instance to close the slot to any further filling, either by further templating or at runtime. The filler object specifies in its *node_id* attribute the archetype artefact being used to fill the slot, whose identifier is `uk.nhs.clinical::openEHR-EHR-SECTION.t_encounter_report-vital_signs_headings-0001.v1`. Note that this artefact is a result of the templating process, and has a generated identifier.

The same kind of redefinition occurs within the `SECTION` t-archetype, which is a specialisation of the archetype `org.openehr::openEHR-EHR-SECTION.vital_signs_headings.v1`. The at0001 slot node in this archetype is redefined by the `C_ARCHETYPE_ROOT` object in the t-archetype, which in the same way specifies the filler archetype as yet another t-archetype, this time `uk.nhs.clinical::openEHR-EHR-EVALUATION.t_encounter_report-problem_description-0004.v1`. Both of the component archetypes - the t-archetypes - also add other constraints of their own, typically removing unwanted items from the specialisation parent archetypes.

The logical template is thus constructed of three archetype artefacts, which we denote for convenience as:

- the ‘template’, or ‘template root’;
- two internal components, which we denote as ‘template-components’.

It is not always the case that the components of a template must be internal; within the template environment, lower level reference model concepts such as `EVALUATION` may be templated in their own right. In this case, the outer template may contain both t-archetypes and other templates.

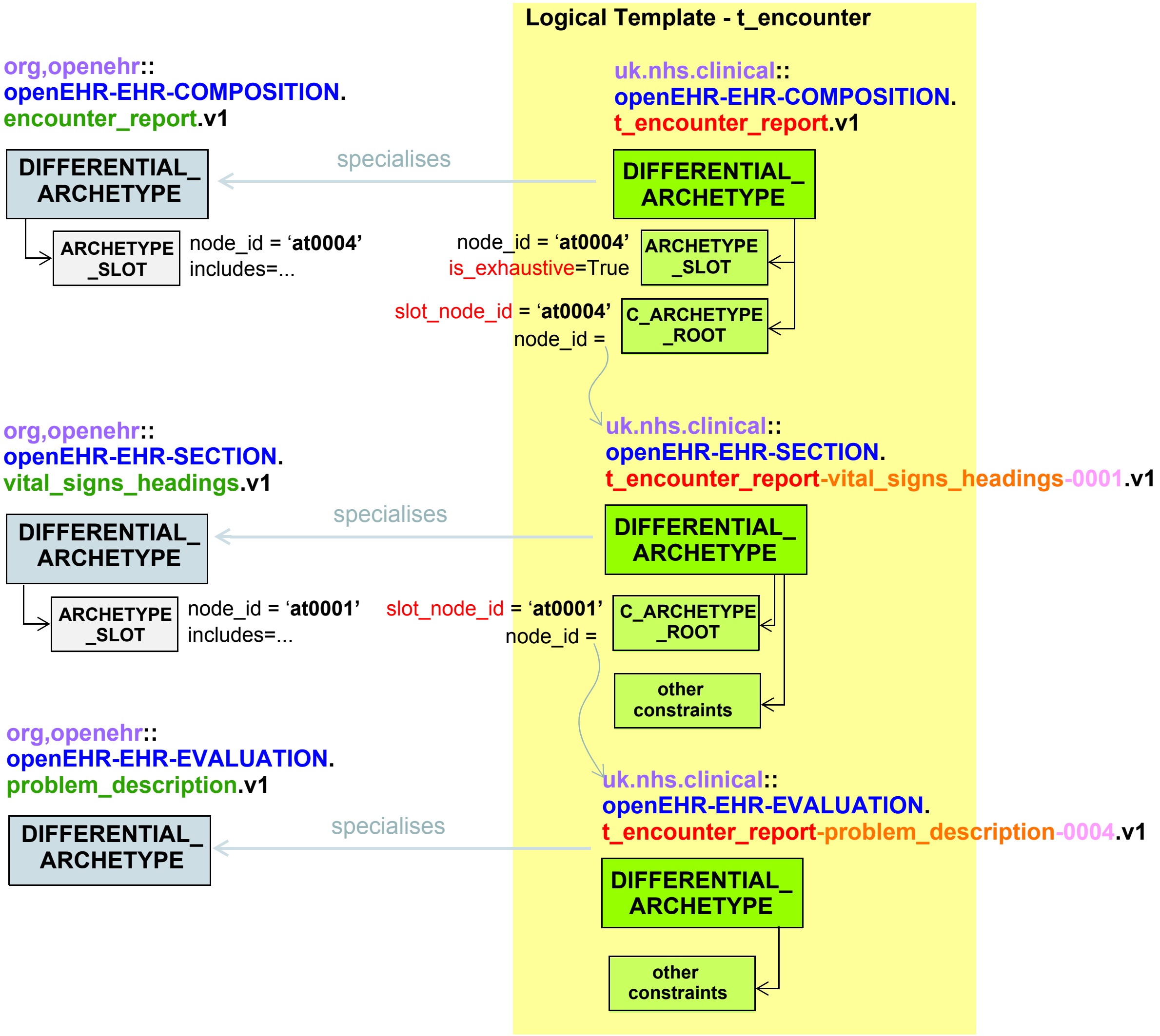

FIGURE 3 Typical template artefact structure

4.2 Design

4.2.1 Template Identification

Identification of templates is the same as for archetypes. There are two possible identifiers: the structured multi-axial form defined by the ARCHEYTPE_ID class, and a Guid form. These identifiers are found at the attributes ARCHETYPE.*archetype_id* and *uid* respectively. The structural identifier is for human readability and use in ontological classifications. Two rules, currently not formalised are strongly recommended for template identifiers. The first is to include a 't_' prefix as shown in the example. This simply enables human readers to easily spot an archetype whose design intention and use is as a template. The second is the sub-structuring of the concept_id part of the identifier of internal component t-archetypes. The recommended structure for a template-component ta, specialising an archetype A within a template T is as follows:

```
T:  tpl_namespace::tpl_rm_concept.tpl_domain_concept.v_tpl
A:  arch_namespace::arch_rm_concept.arch_domain_concept.v_arch
```

```
ta: template_namespace::archetype_rm_concept.
      template_domain_concept-archetype_domain_concept-counter.v_ta
```

For example:

```
Root template:
    uk.nhs.clinical::openEHR-EHR-COMPOSITION.t_encounter_report.v1
t-archetype component:
    uk.nhs.clinical::openEHR-EHR-EVALUATION.
                                        t_encounter_report-problem_description-0001.v1
```

This approach defines a concept identifier which obeys the formal rule (that concept identifiers must be unique within a namespace), is human-readable, and most importantly, is tool-generatable.

Where the Guid identifier is in use, a new identifier can be immediately generated by tooling without reference to a central identification service. Each published revision of a template is assigned a new Guid, ensuring that revisions of the same logical template are distinguished. Note that the multi-axial identifier in its standard form (including only a version identifier, e.g. 'v2') does not do this, but does in its long form (including a full 3-part identifier '.v2.5.1').

This specification uses only the multi-axial form.

4.2.2 Meta-data

Templates support the same global and node-level meta-data as archetypes, defined by the `openehr.rm.common.resource` package. The actual content will of course be oriented toward describing local template-related concerns. The language used must be one of the languages of the underlying archetypes.

4.2.3 Definition section

The definition part of a template or t-archetype is formally expressed in the same way as an archetype. In a template, the definition part has the following functions:

1. to declare archetype slot fillers;
2. to redefine or close slots;
3. to remove unwanted attributes and object nodes;
4. to specify local terminology use, which can be done in two ways:
    a) explicit inclusion of codes within the template;
    b) the use of a subset / ref-set binding to a place-holder reference (ac-code);
5. to create template-specific 'clones' of existing generic nodes;
6. any other narrowing/specialisation of constraints present in the flattened parent archetype, or on otherwise unconstrained underlying reference model attributes;
7. setting template-wide rules such as conditional existence;
8. add default values, usually on leaf or near-leaf nodes.

All of these functions are performed with archetype semantics defined in the AOM, and are described below.

4.2.4 Slot-filling

A template is created as a specialisation of an archetype, usually one based on a top-level reference model concept like `COMPOSITION` or `PARTY`, but this need not be the case. Within such archetypes there are usually slots, i.e. `ARCHETYPE_SLOT` nodes (although this is not mandatory). Where there are slots within the archetype, the template can do two things in terms of filling the slots:

- fill the slots with appropriate archetypes;
- ‘close’ the slot for further filling at runtime.

It does this by defining a specialisation of the `ARCHETYPE_SLOT` found in the underlying archetype, which is in the form of any of the following:

- slot fillers in the form of one or more `C_ARCHETYPE_ROOT` nodes;
- a redefined version of the `ARCHETYPE_SLOT` object itself, either to narrow its defnition, or to ‘close’ it.

`C_ARCHETYPE_ROOT` nodes do not have sub-structure within a template source - they are a single node acting as a reference to the archetype to be used at that point in the operational template. This may be one of:

- a t-archetype, i.e. a redefinition of an archetype used privately by the current template, with an identifier like:
  `uk.nhs.clinical::openEHR-EHR-EVALUATION.`**`t_xxx-aaa-0001`**`.v1`
- a locally pubished template, designed to be reused in other higher-level templates, with an identifier like:
  `uk.nhs.clinical::openEHR-EHR-EVALUATION.`**`t_xxx`**`.v1`
- a normal published archetype, with no further constraints imposed on it by the template, like **`org.openehr`**`::openEHR-EHR-EVALUATION.aaa.v1`

In all cases, the identifier is a legal archetype identifier, and is stored in the *node_id* attribute, normally used for storing at-codes on all other object node types. This *node_id* is what will be used in both the operational template, and in data, at any archetype root point. In order for the `C_ARCHETYPE_ROOT` node to be associated with the original slot, a second attribute *slot_node_id* is used to record the at-code of that slot. The use of these two attributes can be seen in the template in FIGURE 3.

A `C_ARCHETYPE_ROOT` node, like any other object node, can redefine the occurrences constraint as long as:

- it is within the occurrences of the underlying slot;
- it is compatible to the cardinality constraint of the parent attribute.

4.2.5 Slot Redefinition and Closing

The ability to redefine a slot by specifying fillers, and/or redefining the slot itself, gives rise to the a number of variations in a template, including:

- it may specify the archetypes filling a slot and close the slot;
- it may specify the archetypes filling a slot and leave the slot open, possibly narrowed;
- it may specify no fillers, but redefine the slot itself, narrowing the set of archetypes that could match it;
- it may simply close the slot - this only makes sense if there are already slot fillers defined;
- it may make no statements about a slot, leaving things as they were before.

Closing a slot, is achieved by including an `ARCHETYPE_SLOT` node within the template, which sets the the *is_exhaustive* attribute to `True`. In the variants where the slot remains open, the runtime system will be able to add further t-archetypes to a slot. Such t-archetypes are either constructed on the fly, or may exist in a store of pre-validated and flattened template components, but in any case the end result must validate for the template to function properly.

4.2.6 Removal of Archetype Nodes

The most common kind of 'redefinition' specified within a template on an archetype used within the template is the removal of unwanted nodes and sub-trees. This is because most archetypes are designed as 'maximal data sets', and include a large superset of data point definitions that would ever be used in a particular context. Two types of removal are required:

- removal of one or more object children of a container attribute;
- removal of the entirety of an attribute (container or single-valued).

A simple example of the first situation is the `OBSERVATION`.blood_pressure archetype, which defines the following data points:

- systolic blood pressure;
- diastolic blood pressure;
- mean arterial pressure (MAP);
- pulse pressure.

In any particular clinical context, the only meaningful combinations that can be used are: systolic & diastolic (typical general practice, hospital use) OR mean arterial pressure (used as the perfusion pressure by anaesthetists) OR pulse pressure (difference between systolic and diastolic, used in many modern monitoring machines). Thus, one job of the template is to choose which of the above combinations is to be used in the template. This is done by the use of exclusion constraints on the unwanted nodes, i.e. setting of the occurrences constraint to {0}, as illustrated in the top half of FIGURE 4.

An example of the second situation is the removal of the `OBSERVATION`.*protocol* attribute from the blood pressure archetype by a template for which no protocol information (instrument type, measurement location on body etc) is needed. This is shown in the lower half of FIGURE 4.

4.2.7 Node cloning

The concept of creating a number of more specialised variants of a container attribute child object node within a template is exactly as for any normal archetype. The node in question is redefined by one or more 'clones' whose at-codes are specialisations of the at-code of the original node. The term 'clone' is actually a misnomer, because as soon as any cloning operation is performed, the resultant nodes or subtrees are independent, and can be further specialised separately.

Optionally, the occurrences of the original node may be reduced to {0}, meaning that no occurrences of data matching only the generic node may be created, i.e. all data instances must match one of the specialised nodes. FIGURE 5 illustrates the cloning of the at0013 ('panel item') node from a generic 'lab result' archetype into a number of specific types of children, namely LDL, HDL and total cholesteral.

Because node specialisation in templates is performed in the same way as for an archetype, the effect on querying is the same: all cloned (specialised) nodes carry a specialised version of the parent at-code, and will match a query containing the any parent at-code in a path or expression. Thus, a query including the archetype path `.../data/events[at0006]/items[at0013]` will match the at0013.1, at0013.2 and at0013.3 items above, and if at0013 instances had been allowed, these would be matched as well.

Cloning of Whole Trees

In many cases, a node being 'cloned' is the parent of a further subtree of child attributes and object nodes, at least some of which have their own at-codes. If an entire subtree were cloned by a tool, the only node that must have a redefined node identifier is the root node, i.e. the node which is now

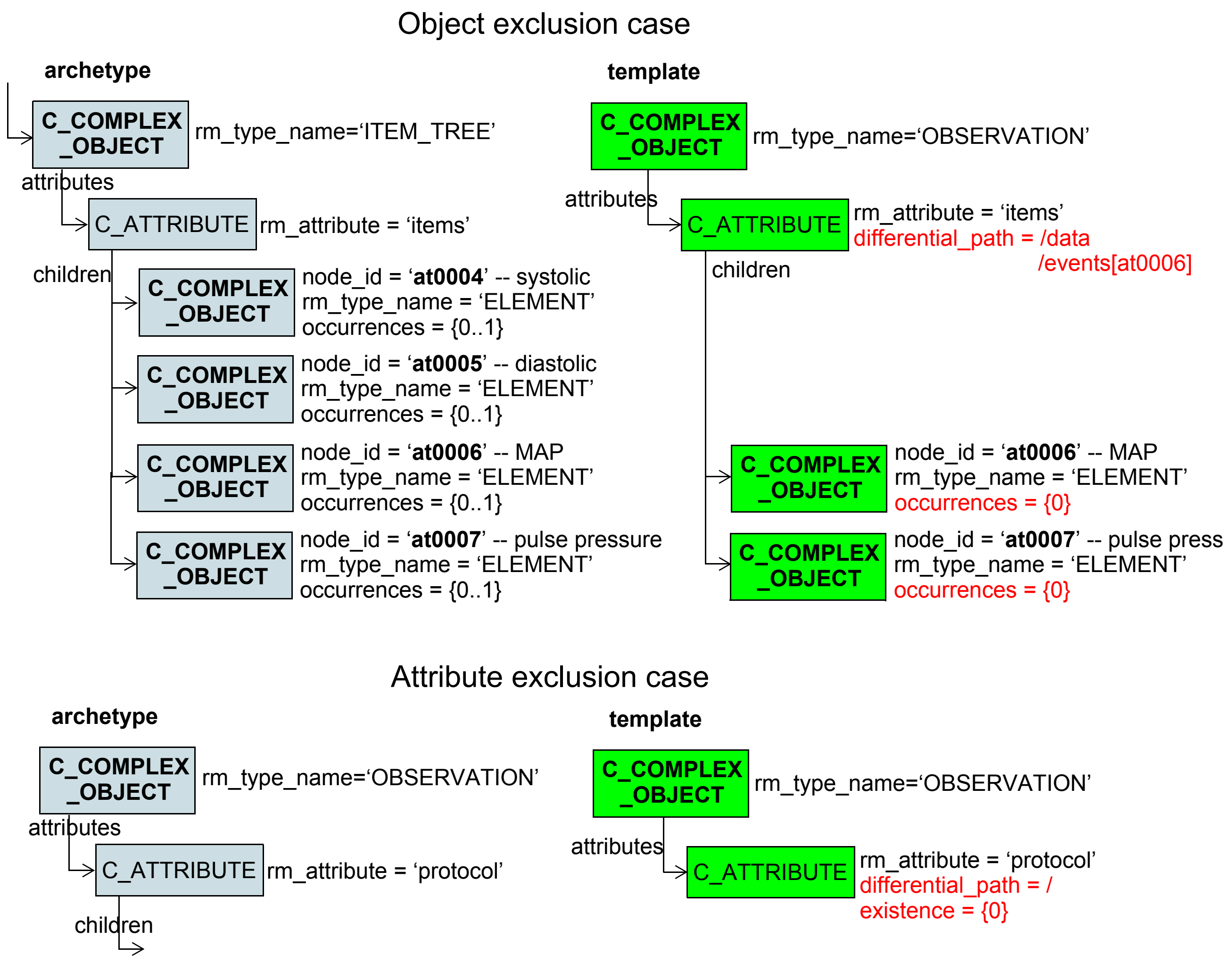

FIGURE 4 Exclusion of unwanted nodes

replaced by multiple duplicates at under some container attribute. Once the cloning operation is complete, further constraining of each copy can take place independently.

Repeated use of Same Archetype

Another frequent scenario is for the same archetype to be required more than once at the same slot, usually for very generic archetypes that will be specialised in some way each time they are used. At an archetype root point, the node identifier is an archetype identifier, not an at-code, so initially it may not seem clear how multiple copies of the same archetype could be used in a template. In fact, each such copy has to be locally specialised into a t-archetype, which will carry its own redefinitions, at a minimum, for the 'name' attribute in the case of *open*EHR reference model `LOCATABLE` descendants.

4.2.8 Terminology Subset Redefinition

The use of more constrained terminology subsets can be achieved in a template in the same way as within a specialised archetype. Various types of redefinition are possible, which can be distinguished by whether the resulting constraint is a `CONSTRAINT_REF` or not (marked with '*' below), as follows:

- a node whose values are defined by local at-codes can be redefined to be a subset of the same codes:
  - either by redefinition into a reference to an external ref-set, or *

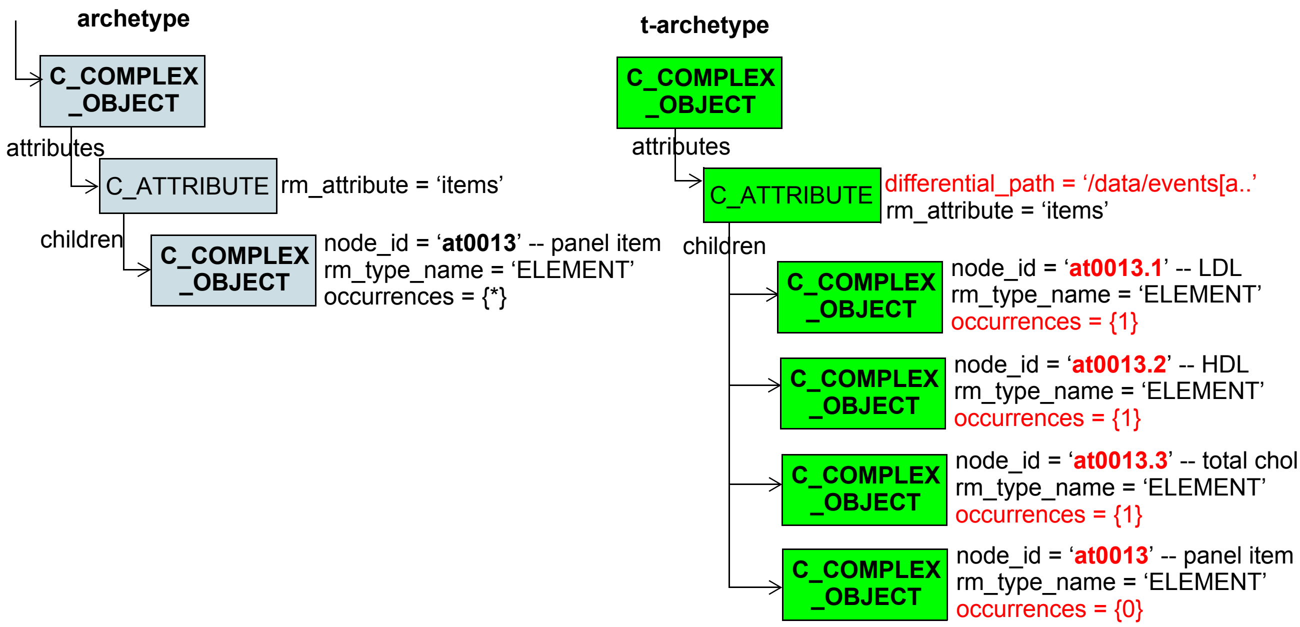

FIGURE 5 Template node cloning

  - by redefinition into a smaller subset, using the `!matches` operator to remove undesired codes;
- a node whose values are defined by an external terminology ref-set, referenced by an ac-code can be redefined to refer to a narrower ref-set; *
- a node whose values are defined by an external terminology subset, referenced by an ac-code can have the reference set redefined into a set of local codes whose values are a semantic subset of those of the originally referenced external subset;
- a node can be defined to have a set of values from an external terminology, declared inline in the template (i.e. in the same was as for local at-codes).

The two cases above in which a `CONSTRAINT_REF` (ac-code) node remains in the template are resolvable if there is a binding for the relevant ac-code to an external reference. During the generation of the operational template, the `CONSTRAINT_REF` node will be replaced by....

TBD_6: this has yet to be decided. It could be a new AOM class like REF_SET, or some variant of CONSTRAINT_REF, or else an augmented version of C_CODE_PHRASE.

The semantics of these redefinitions are identical with those allowed in specialised archetypes, although the use of terminology-specific constraints is generally rare in archetypes but quite common in templates.

4.2.9 Default Values

Default values are defined on the `C_DEFINED_OBJECT` in the AOM, and instances can be defined within a template on any descendant of this class. In practice, the use of default values in templates is normally limited to primitive types and other near-leaf complex types, including descendants of the `C_DOMAIN_TYPE` class. Default values are always of the reference model type constrained by the archetype object node to which they are attached.

In a template, the default value may be the only override set on a node. In terms of object structure, this will result in an empty C_COMPLEX_OBJECT or C_PRIMITIVE_OBJECT, to which the default value object is attached.

FIGURE 6 illustrates the use of a default value in a template.

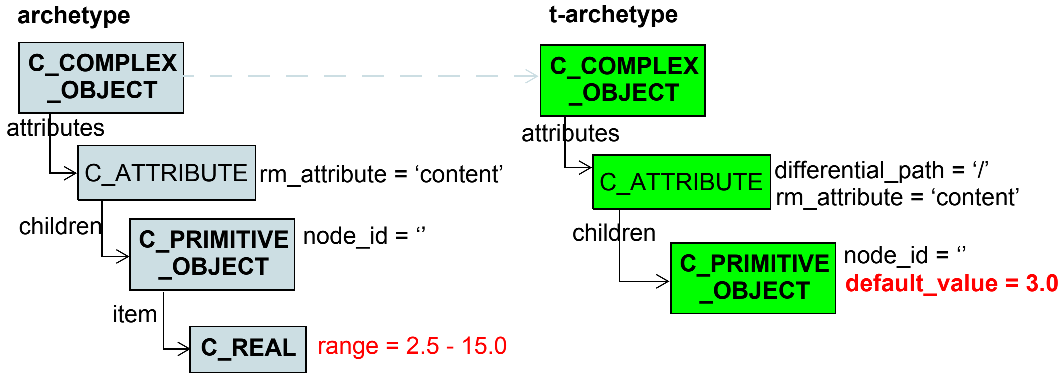

FIGURE 6 Default values in a template

4.2.10 Rules

Template rules are expressed in the form of logic statements, using the RULE_STATEMENT classes defined in the Archetype Object Model, and are attached to the template in the same way as for archetypes, i.e. via the *rules* attribute. The meaning of any such condition is that if present, and evaluated to True at runtime, the constraint to which it is attached will be considered to apply. Absence of a condition means that the constraint will always apply.

The only difference between rules expressed in a template - either in the root template or in any component t-archetype - and rules within a normal archetype is that template rules may contain paths that cross archetype boundaries. Such paths contain the archetype (i.e. sub-template or t-archetype) identifier in the place of an at-code at the archetype root point, but are otherwise the same as any other path.

4.3 Template Validity

5 Examples

5.1 Constrain *open*EHR name attribute to Text

5.2 Template adds terminology subset to DV_TEXT

Original ADL:

DV_TEXT matches {}

want to add coding constraint like

DV_CODED_TEXT matches {[ac0003]} -- but do we want to require acnnnn + binding approach

plus may want to allow default to coding with any code, i.e.

DV_CODED_TEXT matches {[snomed::]}

5.3 No coding allowed on DV_TEXT constraint

how to remove the ability to allow a DV_CODED_TEXT on a DV_TEXT constraint in the archetype - just detect in the application, since there will be no details of subset or terminology set;

TBD_7: Q how to disinquish from the case where free coding allowed?

5.4 Override EVENT with INTERNAL_EVENT

Override with INTERNAL_EVENT that has width set and limited set of codes on math_function

5.5 Condition on Age or Sex

To Be Continued:

6 Serialisation

6.1 dADL

To Be Continued:

6.2 XML

To Be Continued:

7 The Template Package

7.1 Overview

The `template` package is the third package within the archetype model package, as shown in FIGURE 7.

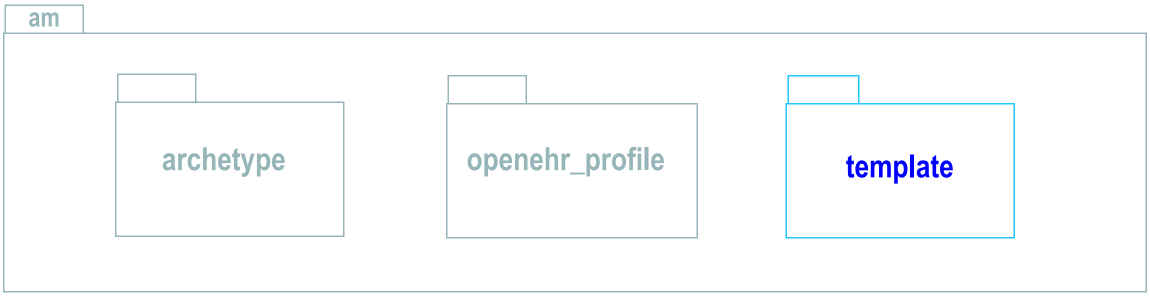

FIGURE 7 openehr.am.template Package in context

FIGURE 8 illustrates the `template` package. As can be seen from the model, an operational template has only two differences from a flat archetype definition. The first is that the root object is a `C_ARCHETYPE_ROOT` rather than a `C_COMPLEX_OBJECT`, and the second is the addition of the ontology structures from the constituent archetypes. The first difference is due to the fact that in a flattened archetype all archetype root points (including the top one) are replaced by `C_ARCHETYPE_ROOT` objects, which carry the relevant archetype identifiers.

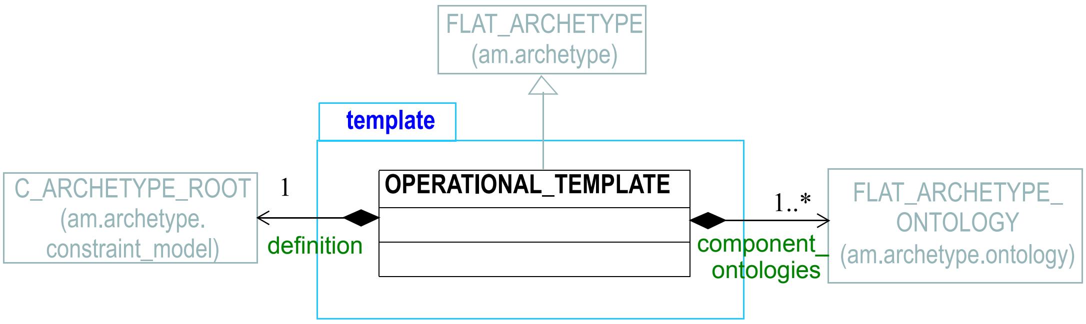

FIGURE 8 The openehr.am.template Package

The second difference is due to the fact that the flattening process usually involves more than one archetype, due to slot filling, meaning that the operational template has to explicitly include the flattened ontologies of all component archetypes in addition to its own ontology (which is that of the template root).

7.2 Design

The design intention of the operational template is to function as a self-standing computable structure, containing all archetype and reference model elements relevant to runtime use, while resolving or removing design-time elements such as internal references and so on. The resulting structure is essentially like a single large archetype, containing individual archetype identifiers at all the archetype root points, and also carrying the sum of all the archetype ontologies, enabling the at-codes from each source archetype to be resolved at runtime. FIGURE 9 illustrates the operational archetype structure.

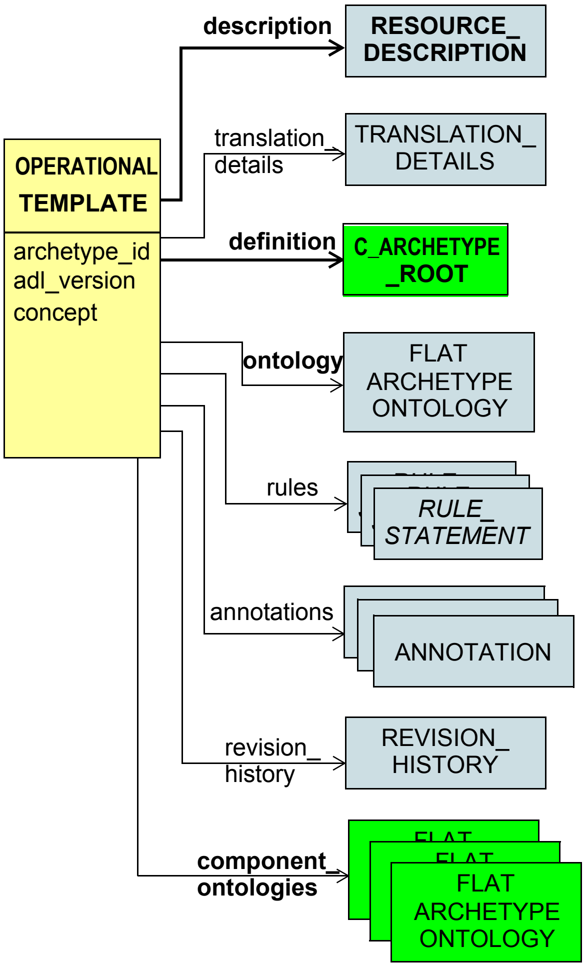

FIGURE 9 Typical Operational Template Object Structure

7.2.1 Operational Template (OPT) Generation

The process used to generate the operational template is done in two logical steps:

template flattening: convert the template and all its constituent template-components and/or archetypes to a single flattened structure denoted as a ‘flat template’;

compression: remove unwanted languages, terminologies and annotations, depending on final intended use, producing the final ‘operational template’.

These operations are illustrated in FIGURE 10. Parameters to each sub-process are shown in magenta. The details of each sub-process are described below.

Template flattening

The initial flattening process performs the following transformations on the set of validated template / template-components / archetypes making up the source template:

- use_nodes (internal references) are expanded out to copies of the referenced nodes;
- open slots (*is_exhaustive* = False): the ARCHETYPE_SLOT object is retained;

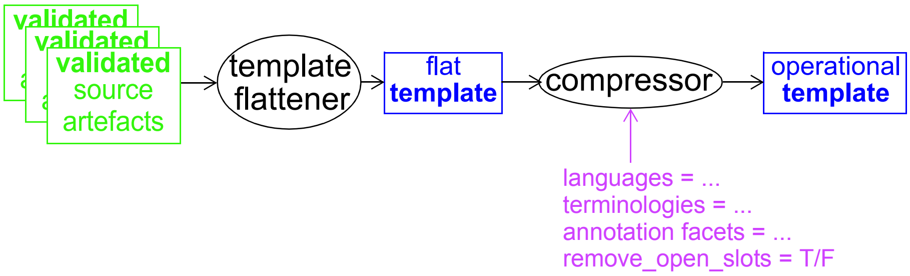

FIGURE 10 Operational template generation process

- the ontology of each component template / archetype is added, indexed by archetype id, and filtered as follows:
  - remove all `term_definitions`, `constraint_definitions`, `term_bindings` and `constraint_bindings` for at-codes and ac-codes no longer present in the template due to element removal.
- ac_code nodes (i.e. `CONSTRAINT_REF` nodes) are replaced by

TBD_8: not yet determined - need a new or modified class in AOM.

After this step, and unresolvable `CONSTRAINT_REF` nodes should be flagged with an error or a warning.

The resulting flat template can be thought of as the effective 'difference' between the template structure and the reference model, i.e. the sum total effect of all the constraints in the template over and above the RM. This form of the template is an appropriate form for publishing with an authoring context for review purposes.

Compression

The compression step is designed to reduce the operational template to its minimal or optimum size and contents, depending on the required use. A number of paramaters can be used to control the operation, which involves the following:

- removal of unneeded languages according to an input parameter;
- removal of unneeded terminologies according to an input parameter;
- optional removal of annotations, either completely, or certain facets according to an input parameter;
- amalgamation of all individual terminology extracts into the terminology extract of the root ontology.

Depending on the settings of these parameters, the resulting operational template will be smaller or larger, and will be suitable for different types of further transformation. For example, annotations could be completely removed for most software purposes, but would usually be retained in part or full for publishing purposes.

7.3 Class Definitions

7.3.1 OPERATIONAL_TEMPLATE Class

CLASS	**OPERATIONAL_TEMPLATE**	
Purpose	Root object of an operational template. An operational template is derived from a template definition and the archetypes mentioned by that template by a process of flattening, and potentially removal of unneeded languages and terminologies.	
Use		
Inherit	`FLAT_ARCHETYPE`	
Attributes	**Signature**	**Meaning**
1 (redefined)	**definition**: `C_ARCHETYPE_ROOT`	
1	**component_ontologies**: `Hash <FLAT_ARCHETYPE_ONTOLOGY, String>`	Compendium of flattened ontologies of all archetypes and component templates used in template, keyed by identifier.
Functions	**Signature**	**Meaning**
	component_ontology (an_id: `String`): `FLAT_ARCHETYPE_ONTOLOGY`	Ontology for archetype or template component with identifier *an_id*.
Invariant	***definition_valid***: definition /= Void ***component_ontologies_valid***: component_ontologies /= Void	

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5 Heard S, Beale T. *The openEHR Archetype System*. See http://www.openehr.org/repositories/spec-dev/latest/publishing/architecture/archetypes/system/REV_HIST.html.

Resources

6 *open*EHR. EHR Reference Model. See http://www.openehr.org/repositories/spec-dev/latest/publishing/architecture/top.html.

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