The openEHR Archetype Model

openEHR Archetype Profile

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\(^a\) Ocean Informatics

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## Amendment Record

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<td>1.0.0</td>
<td><strong>CR-000200</strong>: Correct Release 1.0 typographical errors. Global changes to this document. Fix invariants in C_QUANTITY classes. Correct C_QUANTITY_property to CODE_PHRASE. Correct invariants for C_CODED_TEXT; correct inheritance for C_DV_ORDERED. Corrected C_QUANTITY_ITEM class. Corrected errors in DV_STATE model by adding 2 new classes.</td>
<td>T Beale, D Lloyd, R Chen, A Patterson, M Forss</td>
<td>08 Apr 2007</td>
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<td><strong>CR-000219</strong>: Use constants instead of literals to refer to terminology in RM.</td>
<td>R Chen</td>
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<td><strong>CR-000224</strong>: Relax semantics of C_QUANTITY etc to allow no constraint.</td>
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<td>T Beale</td>
<td>05 Feb 2005</td>
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<td>Original modelling work.</td>
<td>T Beale, A Goodchild, Z Tun, D Kalra, D Lloyd, N Lea, T Austin</td>
<td>June 2004</td>
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1 Introduction

1.1 Purpose
This document describes the openEHR Archetype Profile (AP), which defines custom constraint classes for use with the generic archetype object model (AOM). The intended audience includes:

- Standards bodies producing health informatics standards
- Software development organisations using openEHR
- Academic groups using openEHR
- The open source healthcare community
- Clinical and domain modelling specialists.

1.2 Related Documents
Prerequisite documents for reading this document include:

- The openEHR Architecture Overview

Prerequisite documents for reading this document include:

- The openEHR Archetype Definition Language (ADL)
- The openEHR Archetype Object Model (AOM)

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-1.0.1/publishing/architecture/am/openehr_archetype_profile.pdf.

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

1.4 Peer review
Known omissions or questions are indicated in the text with a “to be determined” paragraph, as follows:

TBD_1:  (example To Be Determined paragraph)

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

2.1 Background

An underpinning architectural feature of openEHR is the use of archetypes and templates, which are formal models of domain content, and are used to control data structure and content during creation, modification and querying. The elements of this architecture are twofold.

- The openEHR Reference Model (RM), defining the structure and semantics of information in terms of information models (IMs). The RM models correspond to the ISP RM/ODP information viewpoint, and define the data of openEHR EHR systems. The information model is designed to be invariant in the long term, to minimise the need for software and schema updates.

- The openEHR Archetype Model (AM), defining the structure and semantics of archetypes and templates. The AM consists of the archetype language definition language (ADL), the Archetype Object Model (AOM) and the openEHR Archetype profile (oAP).

The purpose of the ADL is to provide an abstract syntax for textually expressing archetypes and templates. The AOM defines the object model equivalent of ADL. It is reference model-neutral, meaning that it can be used to express archetypes for any reference model in a standard syntax. ADL and the AOM are brought together in an ADL parser, i.e. any tool which can read ADL archetype texts, and whose parse-tree (resulting in-memory object representation) is instances of the AOM.

The purpose of the openEHR Archetype Profile, the subject of this document, is to define custom archetype classes and in some cases, custom syntax equivalents (essentially shorthands) that can be used instead of the AOM generic classes for archetyping certain RM classes.

2.2 Package Structure

The openEHR Archetype Profile model is defined in the package `am.openehr_profile`, illustrated in FIGURE 1. It is shown in the context of the openEHR `am` and `am.archetype` packages. The internal structure of the package mimics the structure of the reference model it profiles, i.e. the openEHR reference model. This is done to make software development easier, even though the package structure may be sparsely populated. Packages need only be defined where there are custom types to be defined; the only ones currently defined are in the `data_types` package.
FIGURE 1 openehr.am.openehr_profile Package
3 Data_types.basic Package

The am.openehr_profile.basic package, illustrated in FIGURE 2, defines custom types for constraining the RM type DV_STATE.

A example of a state machine to model the state of a medication order is illustrated in FIGURE 3. This state machine is defined by an instance of the class STATE_MACHINE. (Note that for general modelling of states of medications and other interventions, the standard state machine defined in the EHR IM should normally be used).

3.1 Class Descriptions

3.1.1 C_DV_STATE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>C_DV_STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Constrainer type for DV_STATE instances. The attribute c_value defines a state/event table which constrains the allowed values of the attribute value in a DV_STATE instance, as well as the order of transitions between values.</td>
</tr>
</tbody>
</table>
### 3.1.2 STATE_MACHINE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>STATE_MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Definition of a state machine in terms of states, transition events and outputs, and next states.</td>
</tr>
<tr>
<td>Attributes</td>
<td>Signature</td>
</tr>
<tr>
<td>1..1</td>
<td>states: Set &lt;STATE&gt;</td>
</tr>
<tr>
<td>Invariants</td>
<td>States_valid: states /= Void and then not states.is_empty</td>
</tr>
</tbody>
</table>

### 3.1.3 STATE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>STATE (abstract)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Abstract definition of one state in a state machine.</td>
</tr>
<tr>
<td>Attributes</td>
<td>Signature</td>
</tr>
<tr>
<td>1..1</td>
<td>name: String</td>
</tr>
<tr>
<td>Invariants</td>
<td>Name_valid: name /= Void and then not name.is_empty</td>
</tr>
</tbody>
</table>

### 3.1.4 NON_TERMINAL_STATE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>NON_TERMINAL_STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Definition of a non-terminal state in a state machine, i.e. one that has transitions.</td>
</tr>
<tr>
<td>Inherit</td>
<td>STATE</td>
</tr>
<tr>
<td>Attributes</td>
<td>Signature</td>
</tr>
<tr>
<td>1..1</td>
<td>transitions: Set &lt;TRANSITION&gt;</td>
</tr>
<tr>
<td>Invariants</td>
<td>Transitions_valid: transitions /= Void and then not transitions.is_empty</td>
</tr>
</tbody>
</table>
### 3.1.5 TERMINAL_STATE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>TERMINAL_STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Definition of a terminal state in a state machine, i.e. a state with no exit transitions.</td>
</tr>
<tr>
<td>Inherit</td>
<td>STATE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Signature</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invariants</td>
<td>Event_valid: event /= Void and then not event.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Action_valid: action /= Void implies not action.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guard_valid: guard /= Void implies not guard.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Next_state_valid: next_state /= Void</td>
<td></td>
</tr>
</tbody>
</table>

### 3.1.6 TRANSITION Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>TRANSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Definition of a state machine transition.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Signature</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1..1 event: String</td>
<td>Event which fires this transition</td>
<td></td>
</tr>
<tr>
<td>0..1 guard: String</td>
<td>Guard condition which must be true for this transition to fire</td>
<td></td>
</tr>
<tr>
<td>0..1 action: String</td>
<td>Side-effect action to execute during the firing of this transition</td>
<td></td>
</tr>
<tr>
<td>1..1 next_state: STATE</td>
<td>Target state of transition</td>
<td></td>
</tr>
<tr>
<td>Invariants</td>
<td>Event_valid: event /= Void and then not event.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Action_valid: action /= Void implies not action.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guard_valid: guard /= Void implies not guard.is_empty</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Next_state_valid: next_state /= Void</td>
<td></td>
</tr>
</tbody>
</table>
4 Data_types.text Package

4.1 Overview

The am.openehr_profile.data_types.text package contains custom classes for expressing constraints on instances of the types defined in the rm.data_types.text package. Only one type is currently defined, enabling the constraining of CODE_PHRASE instances. It is illustrated in FIGURE 4.

![Diagram of am.openehr_profile.data_types.text Package](image)

FIGURE 4 am.openehr_profile.data_types.text Package

4.2 Design

4.2.1 Standard ADL Approach

The generic kind of constraint that can be expressed for the DV_CODED_TEXT type can, like all standard archetype constraints, only include constraints on the attributes defined in the reference model type. This is illustrated by the following fragment of ADL:

```
DV_CODED_TEXT matches {
    defining_code matches {
        CODE_PHRASE matches {
            terminology_id matches {"xxxx"}
            code_string matches {"cccc"}
        }
    }
}
```

The standard approach allows the attributes terminology_id and code_string to be constrained independently, and would for example, allow terminology_id to be constrained to ICD10|Snomed-ct|LOINC, while code_string could be constrained to some particular fixed values. However, this makes no sense; codes only make sense within a given terminology, not across them. It also makes no sense to allow codes from more than one terminology, as terminologies generally have quite different designs - LOINC and Snomed-CT are completely different in their conception and realisation.

A more appropriate kind of constraint for CODE_PHRASE instances is for terminology_id to be fixed to one particular terminology, and for code_string to be constrained to a set of allowed codes; an empty list indicates that any code is allowed. These semantics are formalised in the class definition, shown below.

4.2.2 Inline dADL form

In an archetype, an instance of C_CODE_PHRASE can be included as inline dADL, as in the following example:

```
defining_code matches {
```

4.2.3 Custom Syntax Form

The same constraint as above can be expressed used a custom syntax extension to ADL. This form is most usually used for expressing value-set constraints within an archetype.

```adl
defining_code matches {
    [icd10::
        F43.00, -- acute stress reaction, mild
        F43.01, -- acute stress reaction, moderate
        F32.02] -- acute stress reaction, severe
}
```

4.2.4 Archetype-local Codes

In either of the constraint forms above, the special terminology name “local” is recognised. This is used to indicate that the listed terms come from the ontology section of the archetype itself, rather than an external terminology, as in the following example:

```adl
defining_code matches {
    [local::
        at1311, -- Colo-colonic anastomosis
        at1312, -- Ileo-colonic anastomosis
        at1313, -- Colo-anal anastomosis
        at1314, -- Ileo-anal anastomosis
        at1315] -- Colostomy
}
```

4.2.5 Assumed value

The custom code syntax provides an equivalent of the assumed value notion from standard ADL by repeating the assumed value separated by the semi-colon (;) character, as in the following example:

```adl
defining_code matches {
    [local::
        at1311, -- Colo-colonic anastomosis
        at1312, -- Ileo-colonic anastomosis
        at1313, -- Colo-anal anastomosis
        at1314, -- Ileo-anal anastomosis
        at1315; -- Colostomy
        at1312] -- (assumed value)
}
```
4.3 Class Descriptions

4.3.1 C_CODE_PHRASE Class

<table>
<thead>
<tr>
<th>CLASS</th>
<th>C_CODE_PHRASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Express constraints on instances of CODE_PHRASE. The terminology_id attribute may be specified on its own to indicate any term from a specified terminology; the code_list attribute may be used to limit the codes to a specific list.</td>
</tr>
<tr>
<td>Inherit</td>
<td>C_DOMAIN_TYPE</td>
</tr>
<tr>
<td>Attributes</td>
<td>Signature</td>
</tr>
<tr>
<td>0..1 (cond)</td>
<td>terminology_id: TERMINOLOGY_ID</td>
</tr>
<tr>
<td>0..1 (cond)</td>
<td>code_list: List&lt;String&gt;</td>
</tr>
<tr>
<td>Functions</td>
<td>Signature</td>
</tr>
<tr>
<td>(effected)</td>
<td>any_allowed: Boolean ensure Result = terminology_id = Void and code_list = Void</td>
</tr>
<tr>
<td>Invariants</td>
<td>List_validity: code_list /= Void implies (not code_list.is_empty and terminology_id /= Void) Any_allowed_validity: any_allowed xor terminology_id /= Void</td>
</tr>
</tbody>
</table>
5 Data_types.quantity Package

5.1 Overview

The `am.openehr_profile.data_types.quantity` package is illustrated in FIGURE 5. Two custom types are defined: `C_DV_QUANTITY` and `C_DV_ORDINAL`.

![FIGURE 5 am.openehr_profile.data_types.quantity Package](image)

5.2 Design - Ordinals

5.2.1 Standard ADL

An ordinal value is defined as one which is ordered without being quantified, and is represented by a symbol and an integer number. The `DV_ORDINAL` class can be constrained in a generic way in ADL as follows:

```adl
item matches {
    DV_ORDINAL matches {
        value matches {0}
        symbol matches {
            DV_CODED_TEXT matches {
                defining_code matches [{local::at0014}] -- no heartbeat
            }
        }
    }
    DV_ORDINAL matches {
        value matches {1}
        symbol matches {
            DV_CODED_TEXT matches {
                defining_code matches [{local::at0015}] -- less than 100 bpm
            }
        }
    }
    DV_ORDINAL matches {
        value matches {2}
        symbol matches {
            DV_CODED_TEXT matches {
            }
        }
    }
}
```
The above says that the allowed values of the attribute value is the set of **ORDINALs** represented by three alternative constraints, each indicating what the numeric value of the ordinal in the series, as well as its symbol, which is a **CODED_TEXT**.

### 5.2.2 Inline dADL Section

The above constraint can be represented as an inline instance of the **openEHR type** `C_ORDINAL`, as follows:

```adl
defining_code matches {
    C_DV_ORDINAL <
    list = <
        "1" = <
            value = <0>
            symbol = <
                defining_code = <[local::at0014]> -- no heartbeat
        >
        "2" = <
            value = <1>
            symbol = <
                defining_code = <[local::at0015]> -- less than 100 bpm
        >
        "3" = <
            value = <2>
            symbol = <
                defining_code = <[local::at0016]> -- greater than 100 bpm
        >
    >
}
```

### 5.2.3 Custom Syntax

A more efficient way of representing the same constraint is using the following ADL syntax:

```adl
item matches {
    0|[local::at0014], -- no heartbeat
    1|[local::at0015], -- less than 100 bpm
    2|[local::at0016]; -- greater than 100 bpm
}
```

### 5.2.4 Assumed Value

Assumed value is represented in the same way as in the custom code syntax, i.e. by adding a semi-colon demarcated value at the end of the list, as follows:

```adl
item matches {
    0|[local::at0014], -- no heartbeat
    1|[local::at0015], -- less than 100 bpm
    2|[local::at0016]; -- greater than 100 bpm
    0|[local::at0014] -- (assumed value)
}```
5.3 Design - Quantities

5.3.1 Standard ADL
A typical need in clinical and demographic data containing an age attribute is to be able to constrain it to different ranges depending on whether it is expressed in months (as is normally the case with infants) or years (for adults). If the age value is expressed using the openEHR DV_QUANTITY, this constraint can be expressed as follows:

```daml
age matches {
  DV_QUANTITY matches {
    property matches "time"
    units matches "yr"
    magnitude matches {0.0..200.0}
  }
  DV_QUANTITY matches {
    property matches "time"
    units matches "mth"
    magnitude matches {3.0..12.0}
  }
}
```

The above says that if units matches “years”, the constraint on DV_QUANTITY:magnitude is 0 - 200, while if units is “months” then the magnitude constraint is 3 - 12. This approach is not particularly efficient or clear, since it allows multiple instances of the constraint on the property attribute, when in fact property can only sensibly be the same for all branches of the constraint.

5.3.2 Inline dADL Section
The above constraint can be represented as an inline instance of the type C_QUANTITY, as below. Note that an assumed value has been included as well, just using normal dADL.

```daml
age matches {
  C_DV_QUANTITY <
  property = <[openehr::128]> -- time
  list = <
    ["1"] = <
      units = "yr"
      magnitude = |0.0..200.0|
      precision = |2|
    >
    ["2"] = <
      units = "mth"
      magnitude = |1.0..36.0|
      precision = |2|
    >
    >
    assumed_value = <
      magnitude = <1.0>
      units = "yr"
    >
  >
}
```

5.4 Class Definitions
### 5.4.1 C_DV_ORDINAL Class Definition

<table>
<thead>
<tr>
<th>CLASS</th>
<th>C_DV_ORDINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Class specifying constraints on instances of DV_ORDINAL. Custom constrainer type for instances of DV_ORDINAL.</td>
</tr>
<tr>
<td>Inherit</td>
<td>C_DOMAIN_TYPE</td>
</tr>
<tr>
<td>Attributes</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>Meaning</td>
</tr>
<tr>
<td>1..1</td>
<td>list: Set&lt;DV_ORDINAL&gt;</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>Meaning</td>
</tr>
<tr>
<td>(effected)</td>
<td>any_allowed: Boolean</td>
</tr>
<tr>
<td></td>
<td>ensure</td>
</tr>
<tr>
<td>Invariants</td>
<td>Ordinals_valid: items /= Void xor any_allowed</td>
</tr>
<tr>
<td></td>
<td>Items_valid: items /= Void implies not items.is_empty</td>
</tr>
</tbody>
</table>

### 5.4.2 C_DV_QUANTITY Class Definition

<table>
<thead>
<tr>
<th>CLASS</th>
<th>C_DV_QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Constrain instances of DV_QUANTITY.</td>
</tr>
<tr>
<td>Inherit</td>
<td>C_DOMAIN_TYPE</td>
</tr>
<tr>
<td>Attributes</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>Meaning</td>
</tr>
<tr>
<td>0..1</td>
<td>list: List&lt;C_QUANTITY_ITEM&gt;</td>
</tr>
<tr>
<td>0..1</td>
<td>property: CODE_PHRASE</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td>Meaning</td>
</tr>
<tr>
<td>(effected)</td>
<td>any_allowed: Boolean</td>
</tr>
<tr>
<td></td>
<td>ensure</td>
</tr>
<tr>
<td>Invariants</td>
<td>List_valid: list /= Void implies not list.is_empty</td>
</tr>
<tr>
<td></td>
<td>Property_valid: property /= Void implies terminology(Terminology_id_openehr).has_code_for_group_id (Group_id_property, property)</td>
</tr>
<tr>
<td></td>
<td>Overall_validity: (list /= Void or property /= Void) xor any_allowed</td>
</tr>
</tbody>
</table>
## 5.4.3 C_QUANTITY_ITEM Class Definition

<table>
<thead>
<tr>
<th>CLASS</th>
<th>C_QUANTITY_ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Constrain instances of DV_QUANTITY.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Signature</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0..1</td>
<td>magnitude: Interval&lt;Real&gt;</td>
<td>Constraint on the magnitude of the DV_QUANTITY.</td>
</tr>
<tr>
<td>0..1</td>
<td>precision: Interval&lt;Integer&gt;</td>
<td>Constraint on the precision of the DV_QUANTITY. A value of -1 means that precision is unconstrained.</td>
</tr>
<tr>
<td>1..1</td>
<td>units: STRING</td>
<td>Constraint on units of the DV_QUANTITY.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functions</th>
<th>Signature</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision_unconstrained:</td>
<td>Boolean</td>
<td>True if no constraint on precision; True if precision = -1.</td>
</tr>
<tr>
<td>ensure</td>
<td>precision = -1 implies Result</td>
<td></td>
</tr>
</tbody>
</table>

| Invariants | units_valid: units /= Void and not units.is_empty |
6 Syntax Specification

The syntax described in this specification require some additions to the standard cADL grammar described in the openEHR ADL specification.

The additions to the grammar and lexical specificatoin for the standard cADL syntax are shown below. The actual grammar and lexical files used in the openEHR reference ADL parser (written in Eiffel) are available at http://my.openehr.org/wsvn/ref_impl_eiffel/TRUNK/components/adl_parser/src/syntax/cadl/parser/?rev=0&sc=0. The .l and .y files can be converted for use in other yacc/lex-based programming environments. The production rules of the .y file are available as an HTML document.

6.1 Grammar

The following shows additions to the standard cADL parser production rules (yacc specification) as of revision 158 of the Eiffel reference implementation repository (http://svn.openehr.org/ref_impl_eiffel).

```
c_object:
    c_complex_object
    | archetype_internal_ref
    | archetype_slot
    | constraint_ref
    | c_code_phrase -- added
    | c_ordinal -- added
    | c_primitive_object
    | V_C_DOMAIN_TYPE
    | ERR_C_DOMAIN_TYPE
    | error

c_ordinal:
    c_ordinal_spec
    | c_ordinal_spec ; integer_value
    | c_ordinal_spec ; error

c_ordinal_spec:
    ordinal
    | c_ordinal_spec , ordinal

ordinal:
    integer_value SYM_INTERVAL_DELIM V_QUALIFIED_TERM_CODE_REF

c_code_phrase:
    V_TERM_CODE_CONSTRAINT
    | V_QUALIFIED_TERM_CODE_REF
```

6.2 Symbols

The following patterns are added to the lexical specification for the standard cADL grammar.

```
---------/* V_TERM_CODE_CONSTRAINT of form */ ------------------------
-- [terminology_id::code, -- comment
--    code, -- comment
--    code] -- comment
```
-- Form with assumed value
-- [terminology_id::code, -- comment
--     code; -- comment
--     code] -- an optional assumed value
--
\[[a-zA-Z0-9.\-\_]+::[ \t\n]* -- pick up [ line

<IN_TERM_CONSTRAINT> {
    [ \t]*[a-zA-Z0-9.\-\_]+[ \t\n]*[ \t\n]* -- pick up , line
    [ \t]*[a-zA-Z0-9.\-\_]+[ \t\n]*[ \t\n]* -- pick up ; line
    \-\-[^\],\n]*\n    [ \t]*[a-zA-Z0-9.\-\_]+[ \t\n]*\} -- pick up ] line
END OF DOCUMENT