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## **Language resource management—Lexical markup framework (LMF)**

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## Table of contents

Warning .....	1
Copyright notice .....	2
Foreword .....	4
1 Scope .....	7
2 Normative references .....	7
3 Terms and definitions .....	8
4 Key standards used by LMF .....	13
5 The LMF Model .....	14
Annex A (normative) Morphology extension .....	21
Annex B (informative) Morphology examples .....	24
Annex C (normative) Machine Readable Dictionary extension .....	30
Annex D (informative) Machine Readable Dictionary examples .....	32
Annex E (normative) NLP syntax extension .....	33
Annex F (informative) NLP syntax examples .....	36
Annex G (normative) NLP semantics extension .....	39
Annex H (informative) NLP semantic examples .....	42
Annex I (normative) NLP multilingual notations extension .....	49
Annex J (informative) NLP multilingual notations examples .....	52
Annex K (normative) NLP paradigm pattern extension .....	55
Annex L (informative) NLP paradigm Pattern examples .....	59
Annex M (normative) NLP multiword expression patterns extension .....	72
Annex N (informative) NLP multiword expression patterns examples .....	74
Annex O (normative) Constraint expression extension .....	76
Annex P (informative) Constraint expression example .....	78
Annex Q (informative) Connection with Terminological Markup Framework (TMF) and other concept based representation systems .....	80
Annex R (informative) LMF DTD .....	81

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard 24613 was prepared by Technical Committee ISO/TC 37, *Terminology and other language resources*, Subcommittee SC 4, *Language resource management*.

ISO 24613 is designed to coordinate closely with ISO Draft Revision 12620, *Computer applications in terminology – Data categories – Data category registry*, and ISO DIS 16642, *Computer applications in terminology – TMF (Terminological Markup Framework)*.

Annexes A, C, E, G, I, K, M, O form an integral part of this International Standard.

## Introduction

Optimizing the production, maintenance and extension of electronic lexical resources is one of the crucial aspects impacting human language technologies (HLT) in general and natural language processing (NLP) in particular, as well as human-oriented translation technologies. A second crucial aspect involves optimizing the process leading to their integration in applications. Lexical Markup Framework (LMF) is an abstract metamodel that provides a common, standardized framework for the construction of computational lexicons. LMF ensures the encoding of linguistic information in a way that enables reusability in different applications and for different tasks. LMF provides a common, shared representation of lexical objects, including morphological, syntactic, and semantic aspects.

The goals of LMF are to provide a common model for the creation and use of electronic lexical resources ranging from small to large in scale, to manage the exchange of data between and among these resources, and to facilitate the merging of large numbers of different individual electronic resources to form extensive global electronic resources. The ultimate goal of LMF is to create a modular structure that will facilitate true content interoperability across all aspects of electronic lexical resources.

The LMF core package describes the basic hierarchy of information of a lexical entry, including information on the form. The core package is supplemented by various resources that are part of the definition of LMF. These resources include:

- Specific data categories used by the variety of resource types associated with LMF, both those data categories relevant to the metamodel itself, and those associated with the extensions to the core package;
- The constraints governing the relationship of these data categories to the metamodel and to its extensions;
- Standard procedures for expressing these categories and thus for anchoring them on the structural skeleton of LMF and relating them to the respective extension models;
- The vocabularies used by LMF to express related informational objects for describing how to extend LMF through linkage to a variety of specific resources (extensions) and methods for analyzing and designing such linked systems.

Extensions of the core package which are documented in this standard in annexes include:

- Machine Readable Dictionaries
- Natural Language Processing lexical resources

LMF extensions are expressed in a framework that describes the reuse of the LMF core components (such as structures, data categories, and vocabularies) in conjunction with the additional components required for a specific resource.

Types of individual instantiations of LMF can include such electronic lexical resources as fairly simple lexical databases, NLP and machine-translation lexicons, as well as electronic monolingual, bilingual and multilingual lexical databases. LMF provides general structures and mechanisms for analyzing and designing new electronic lexical resources, but LMF does not specify the structures, data constraints, and vocabularies to be used in the design of specific electronic lexical resources. LMF also provides mechanisms for analyzing and

## **ISO 24613:2007**

describing existing resources using a common descriptive framework. For the purpose of both designing new lexical resources and describing existing lexical resources, LMF defines the conditions that allow the data expressed in any one lexical resource to be mapped to the LMF framework, and thus provides an intermediate format for lexical data exchange.

## 1 Scope

This International Standard describes the Lexical Markup Framework (LMF), a metamodel for representing data in lexical databases used with monolingual and multilingual computer applications.

LMF provides mechanisms that allow the development and integration of a variety of electronic lexical resource types<sup>1</sup>. These mechanisms will present existing lexicons as far as possible. If this is impossible, problematic information will be identified and isolated.

## 2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of ISO 24613. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on ISO 24613 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 639-1:2002, Codes for the representation of names of languages – Part 1: Alpha-2 Code.

ISO 639-2:1998, Code for the representation of languages – Part 2: Alpha-3 Code.

ISO DIS 639-3:2005, Codes for the representation of languages – Part 3: Alpha-3 Code for comprehensive coverage of languages.

ISO 1087-1:2000, Terminology – Vocabulary – Part 1: Theory and application.

ISO 1087-2:1999, Terminology – Vocabulary – Part 2: Computer application.

ISO/IEC 10646-1:2003, Information technology – Universal Multiple-Octet Coded Character Set (UCS).

ISO/IEC 11179-3:2003, Information Technology – Data management and interchange – Metadata Registries (MDR) – Part 3: Registry Metamodel (MDR3)

ISO 15924:2004, Information and documentation – Code for the representation of names of scripts.

ISO 16642:2003, Computer applications in terminology – TMF (Terminological Markup Framework).

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<sup>1</sup> It supports existing lexical resource models such as the Genelex [9], the EAGLES International Standards for Language Engineering (ISLE) [5] and Multilingual ISLE Lexical Entry (MILE) models [6].

## ISO 24613:2007

ISO 12620:2007, Terminology and other language and content resources – Data Categories – Specification of data categories and management of a data category registry for language resources.

ISO 24610-1:2006, Language resources management – Features structures – Part 1: Feature structure representation.

### 3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 1087-1, ISO 1087-2, ISO 12620:2007 and the following apply<sup>2</sup>:

#### 3.1 abbreviated form

**form** resulting from the omission of any part of the **full form** of the same **lexeme**

#### 3.2 adjunct

non-essential element associated with a verb as opposed to **syntactic arguments**

EXAMPLE Alfred (syntactic argument) reads a book (syntactic argument) today (adjunct).

NOTE Adverbs are possible adjuncts for a sentence.

#### 3.3 affix

**bound morph** that may contribute to a **form** and participates in the process of **inflection**, **agglutination**, **derivation** or **composition**

NOTE Affixes function as prefixes (pre-positioned), suffixes (post-positioned), infixes (inserted) and circumfixes (combination of prefix and suffix).

#### 3.4 affixation

process in which an **affix** is added to a **lemma** or a **stem**

#### 3.5 agglutination

process in which an **agglutinated form** is made up

#### 3.6 agglutinated form

**word form** that a **lexeme** can take when used in a sentence or a phrase within an **agglutinating language**

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<sup>2</sup> It is worth noting that, on purpose, we avoid to define and use highly controversial terms like "word", "morpheme", "base", "fusion", "ergative", and "collocation".

### 3.7 agglutinating language

language where a **word form** may consist of more than one **morph** but the boundaries between **morphs** are always clear-cut [16]

EXAMPLE Korean, Japanese, Hungarian and Turkish are agglutinating languages.

### 3.8 bound morph

**morph** that appears only together with one or several other **morphs**

### 3.9 composition compounding

**lexeme** formation in which a new **lexeme** (associated with its **part of speech** information) is formed by adjoining at least two **lexemes**, in their original **forms** or with slight transformations

NOTE Composition should not be confused with agglutination and derivation, where bound morphs are added to free ones.

### 3.10 compound

**lexeme** associated with **part of speech** information that is built from two or more **lexemes**

### 3.11 compound form

**form** resulting from a **composition**

### 3.12 derivation

change in the **forms** of a **lexeme** to create a new **lexeme**, usually by modifying the **stem** or by **affixation**

NOTE Sometimes derivation signals a change in part of speech, such as *nation* to *nationalize*. Sometimes the part of speech remains the same as in *nationalization* vs. *denationalization*.

### 3.13 derived form

**form** resulting from a **derivation**

### 3.14 form

sequence of **morphs**

### 3.15 free morph

**morph** that may stand by itself

EXAMPLE The English noun *boy*.

### 3.16 full form

complete representation of a **lexeme** for which there is an **abbreviated form**

## ISO 24613:2007

### 3.17 grammatical feature

property associated to the **inflected, agglutinated, compound** or **derived form**

NOTE An example of a grammatical feature is: /grammatical gender/<sup>3</sup>.

### 3.18 graph

minimal unit in a written language including letters, pictograms, ideograms, numerals and punctuations

### 3.19 inflected form

**word form** that a **lexeme** can take when used in a sentence or a phrase within an **inflectional language**

### 3.20 inflection

process in which an **inflected form** is made up

### 3.21 inflectional language inflecting language

language where there is no clear-cut boundary between **morphs** in that **morphs** are generally fused together to yield a single, non-segmentable **form** [16]

EXAMPLE Spanish, Italian, French and English are inflectional languages.

### 3.22 interlingua

abstract intermediary language used in the machine translation of human languages

### 3.23 lemma lemmatised form canonical form

conventional **form** chosen to represent a **lexeme**

EXAMPLE In European languages, the lemma is usually the /singular/ if there is a variation in /number/, the /masculine/ form if there is a variation in /gender/ and the /infinitive/ for all verbs. In some languages, certain nouns are defective in the singular form, in which case, the /plural/ is chosen. In Arabic, for a verb, the lemma is usually considered as being the third person singular with the accomplished aspect.

### 3.24 lexeme

abstract unit generally associated with a set of **forms** sharing a common meaning

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<sup>3</sup> Following, the convention adopted in the revision of ISO 12620, the slashes are used in order to delimit data category values.

### 3.25 lexical entry

container for managing one or several **forms** and possibly one or several meanings in order to describe a **lexeme**

### 3.26 lexical resource lexical database

database consisting of one or several **lexicons**

### 3.27 lexicon

resource comprising **lexical entries** for a given language

NOTE A special language lexicon or a lexicon prepared for a specific NLP application can comprise a specific subset of language.

### 3.28 machine readable dictionary MRD

electronic **lexical resource** designed to be consulted by human beings

NOTE Historically, MRDs were first computer representations of 'printed' dictionaries, that's why they are called *machine readable* now.

### 3.29 machine translation lexicon

electronic **lexical resource** in which the individual **lexical entries** contain equivalents in two or more languages together with morphological, syntactic and/or semantic information to facilitate automatic or semi-automatic processing of **lexemes** during machine translation

### 3.30 morph

sequence of **graphs** or sequence of **phones**

EXAMPLE The word *boys* consists of two morphs: *boy* and *s*.

### 3.31 morphology

description of the structure and formation of **forms**

### 3.32 multiword expression MWE

**lexeme** made up of a sequence of two or more **lexemes** that has properties that are not predictable from the properties of the individual **lexemes** or their normal mode of combination

NOTE An MWE can be a compound, a fragment of a sentence, or a sentence. The group of lexemes making up an MWE can be continuous or discontinuous. It is not always possible to mark an MWE with a part of speech.

EXAMPLE *to kick the bucket*, which means *to die* rather than *to hit a bucket with one's foot*.

## ISO 24613:2007

### 3.33 natural language processing NLP

field covering knowledge and techniques involved in the processing of linguistic data by a computer

### 3.34 orthography

way of spelling or writing **lexemes** that conforms to a conventionalized use

NOTE Aside from standardized spellings of alphabetical languages, such as standard UK or US English, or reformed German spelling, there can be variations such as transliterations of languages in non-native scripts, stenographic renderings, or representations in the International Phonetic Alphabet. In this regard, orthographic information in a lexical entry can describe a kind of transformation applied to the form that is the object of the entry.

### 3.35 paradigm pattern

set of **form** operations that build the various forms of a **lexeme**, possibly by **inflection**, **agglutination**, **composition** or **derivation**

NOTE An inflectional paradigm pattern is not the explicit list of inflected forms. It usually references a prototypical class of inflectional forms, e.g., *ring*, as per *sing*.

### 3.36 part of speech lexical category word class

category assigned to a **lexeme** based on its grammatical properties

NOTE Typical parts of speech for European languages include: *noun*, *verb*, *adjective*, *adverb*, *preposition*, etc.

### 3.37 phone

minimal unit in the sound system of a language

### 3.38 script

set of graphic characters used for the written **form** of one or more language (ISO/IEC 10646-1, definition 4.14)

NOTE The description of scripts ranges from a high level classification such as hieroglyphic or syllabic writing systems vs. alphabets to a more precise classification like Roman vs. Cyrillic. Scripts are defined by a list of values taken from ISO-15924. Examples are: Hiragana, Katakana, Latin and Cyrillic.

### 3.39 stem

sequence of **morphs** that is smaller than or equal to the **form** of a single **lexeme** and that may be affected by an **inflectional**, **agglutinative**, **compositional** or **derivation** process

## ISO 24613:2007

### 3.40 subcategorization frame

**valence**

**valency**

set of restrictions on a **lexeme** indicating the properties of the **syntactic arguments** that can or must occur with this given **lexeme**

### 3.41 support verb

verb that makes a generic semantic contribution to the context and that combines with a noun to form a **lexeme**

EXAMPLE *take an exam* or *give an exam*. In these examples, *take* and *give* have only limited inherent meaning based on their semantics, but rather are used in a conventional, generic way to express a collocational conceptualization.

### 3.42 syntactic argument

one of the essential and functional elements in a clause that identifies the participants in the process referred to by a verb

Example: Alfred (syntactic argument) reads a book (syntactic argument) today (adjunct).

### 3.43 transcription

**form** resulting from a coherent method of writing down speech sounds, to include converting speech sounds described in one writing system to an equivalent representation of the same speech sounds described in another writing system

### 3.44 transliteration

**form** resulting from the conversion of one writing system into another

### 3.45 variant

one of the alternative **forms** of a **lexeme**

### 3.46 word form

**form** that a **lexeme** takes when used in a sentence or a phrase

## 4 Key standards used by LMF

### 4.1 Unicode

LMF is Unicode compliant and presumes that all data are represented using Unicode character encodings.

### 4.2 ISO 12620 Data Category Registry (DCR)

The designers of an LMF conformant lexicon shall use data categories from the ISO 12620 Data Category Registry (DCR).

### 4.3 Unified Modeling Language (UML)

LMF complies with the specifications and modeling principles of UML as defined by the Object Management Group (OMG) [2]. LMF uses a subset of UML that is relevant for linguistic description.

## 5 The LMF Model

### 5.1 Introduction

LMF models are represented by UML classes, associations among the classes, and a set of ISO 12620 data categories that function as UML attribute-value pairs. The data categories are used to adorn the UML diagrams that provide a high level view of the model. LMF specifications in the form of textual descriptions that describe the semantics of the modeling elements provide more complete information about classes, relationships, and extensions than can be included in UML diagrams.

In this process, lexicon developers shall use the classes that are specified in the **LMF core package** (section 5.2). Additionally, developers can optionally use classes that are defined in the **LMF extensions** (relevant annexes). Developers shall define a data category selection (DCS) as specified for **LMF data category selection procedures** (section 5.4).

### 5.2 LMF Core Package

The LMF core package is a metamodel that provides a flexible basis for building LMF models and extensions.

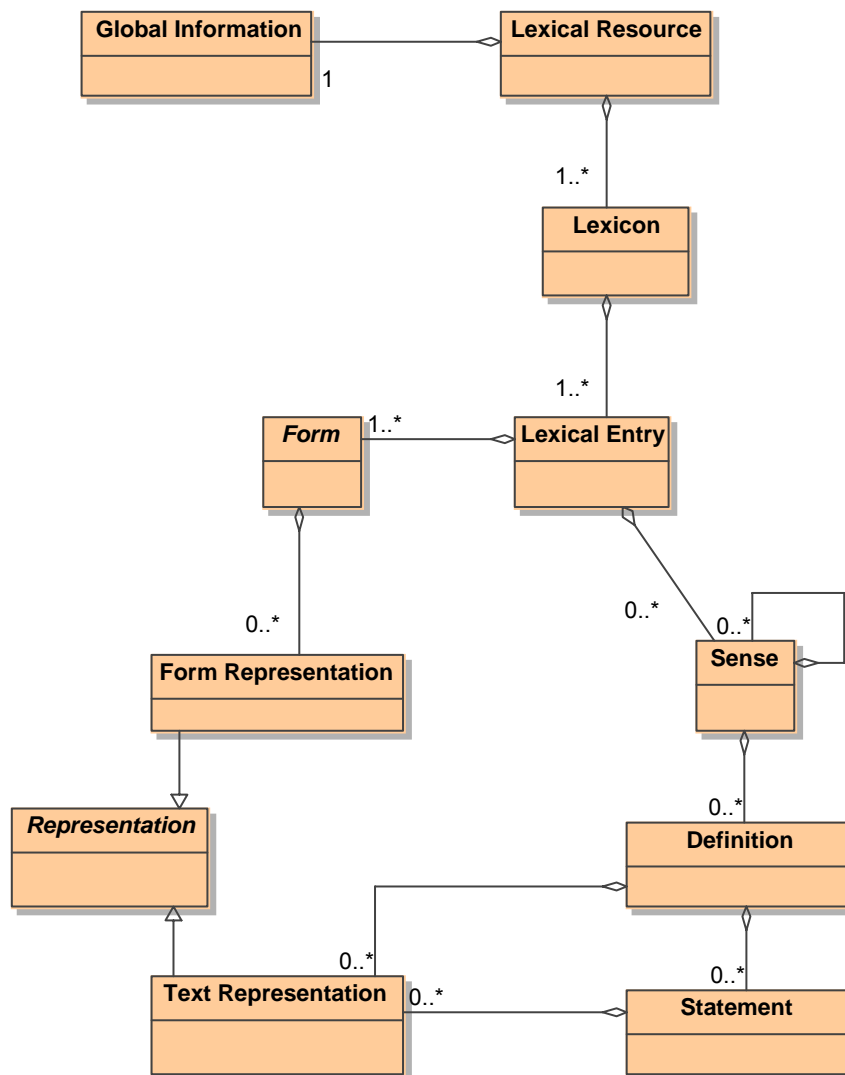


Figure 1: LMF core package

**5.2.1 Lexical Resource class**

*Lexical Resource* is a class representing the entire resource. *Lexical Resource* occurs once and only once. The *Lexical Resource* instance is a container for one or more lexicons.

**5.2.2 Global Information class**

*Global Information* is a class representing administrative information and other general attributes. There is an aggregation relationship between the *Lexical Resource* class and the *Global Information* class in that the latter describes the administrative information and general attributes of the entire resource. The *Global Information* class does not allow subclasses.

*Global Information* instance must contain at least the following attribute:

- /language coding/ Language identifiers used in LMF-compliant resources shall conform to criteria specified in the ISO 639 family of standards. Some issues involving the combination of language and country codes, as well as the coordination of different parts of the ISO 639 standard have been addressed in external standards

## ISO 24613:2007

supported by the technology community. It is recommended that users should consult the current edition of IETF Best Common Practices (BCP) 47, *Tags for the Identification of Languages* in order to resolve issues involving choice and match of identifiers for use in electronic environments [1]. This attribute specifies which standard is used in order to code the language names within the whole *Lexical Resource* instance.

*Global Information* instance may contain the following attributes:

- */script coding/* When the script code is not part of the language identifier, script identifiers shall conform to criteria specified in the ISO 15924 Codes for Script Identification. This attribute specifies which standard is used in order to code the script names within the whole *Lexical Resource* instance.
- */character coding/* This attribute specifies which Unicode version is used within the whole *Lexical Resource* instance.

NOTE Other standard related precisions may be specified on the *Global Information* instance.

### 5.2.3 Lexicon class

*Lexicon* is a class containing all the lexical entries of a given language within the entire resource. A *Lexicon* instance must contain at least one lexical entry. The *Lexicon* class does not allow subclasses.

### 5.2.4 Lexical Entry class

*Lexical Entry* is a class representing a lexeme in a given language. The *Lexical Entry* is a container for managing the *Form* and *Sense* classes. Therefore, the *Lexical Entry* manages the relationship between the forms and their related senses. A *Lexical Entry* instance can contain one to many different forms, and can have from zero to many different senses. The *Lexical Entry* class does not allow subclasses.

### 5.2.5 Form class

*Form* class is an abstract class representing a lexeme, a morphological variant of a lexeme or a morph. The *Form* class manages one or more orthographical variants of the abstract *Form* as well as data categories that describe the attributes of the word form (e.g. lemma, pronunciation, syllabification). The *Form* class allows subclasses.

### 5.2.6 Form Representation class

*Form Representation* is a class representing one variant orthography of a *Form*. When there is more than one variant orthography, the *Form Representation* class contains a Unicode string representing the *Form* as well as the unique attribute-value pairs that describe the specific orthography (e.g. canonical form, transliteration, pronunciation, or variant spelling).

### 5.2.7 Representation class

*Representation* is an abstract class representing a Unicode string as well as, if needed, the unique attribute-value pairs that describe the specific orthography. The *Representation* class allows subclasses.

### 5.2.8 Sense Class

*Sense* is a class representing one meaning of a lexical entry. The *Sense* class allows subclasses. The *Sense* class allows for hierarchical senses in that a sense may be more specific than another sense of the same lexical entry.

### 5.2.9 Definition Class

*Definition* is a class representing a narrative description of a sense. It is displayed for human users to facilitate their understanding of the meaning of a *Lexical Entry* and is not meant to be processable by computer programs. A *Sense* instance can have zero to many definitions. Each *Definition* instance may be associated with zero to many *Text Representation* instances in order to manage the text definition in more than one language or script. The narrative description can be expressed in a different language and/or script than the one of the *Lexical Entry* instance.

EXAMPLE: In a *Lexical Entry* for *abbess* the narrative description may be *woman who is in charge of a convent*.

### 5.2.10 Statement Class

*Statement* is a class representing a narrative description and refines or complements *Definition*. A *Definition* instance can have zero to many *Statement* instances.

NOTE: A full example is given in WordNet context in NLP semantic annex.

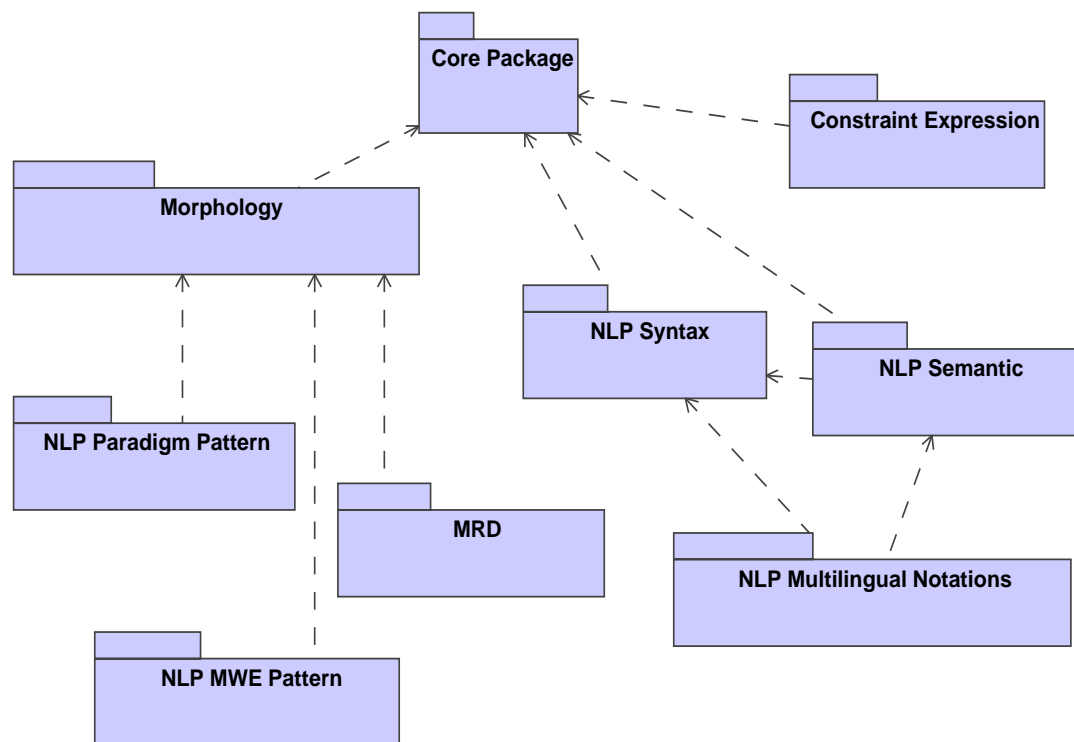
### 5.2.11 Text Representation Class

*Text Representation* is a class representing one textual content of *Definition* or *Statement*. When there is more than one variant orthography, the *Text Representation* class contains a Unicode string representing the textual content as well as the unique attribute-value pairs that describe the specific orthography.

EXAMPLE: In a Bambara lexicon, a given lexical entry may be associated with one definition that is expressed in Bambara for native speakers and in French for French speakers that learn Bambara. The *Definition* instance will thus have two *Text Representation* instances, each with a specific narrative content and an attribute-value pair for the language information.

## 5.3 LMF extension use

All extensions conform to the LMF core package in the sense that each extension is anchored in a subset of the core package classes. An extension cannot be used to represent lexical data independently of the core package. Depending on the kind of linguistic data involved, an extension can depend on another extension. From the point of view of UML, an extension is a UML package. The dependencies of the various extensions are specified in the following diagram.



**Figure 2: Dependencies between the LMF core and extension packages**

Additional extensions may be developed over time. A new extension may either be based on the LMF core package itself or on an existing extension to the core package, or may be a combination of extension mechanisms from the core package and existing extensions.

The extension mechanisms include:

- the creation of subclasses based on UML modeling principles
- the addition of new classes
- constraints on the cardinality and type of associations
- specification of different anchor points for associations
- data category selections (DCSs)

The current LMF extensions are described in the annexes of this International Standard. Creators of lexicons should select the subsets of these possible extensions that are relevant to their needs.

## 5.4 LMF data category selection procedures

### 5.4.1 LMF Attributes

UML models such as LMF are adorned or further described by UML attributes, which provide information about specific properties or characteristics associated with the model. All LMF attributes are complex data categories. For a given class, all attributes are different. Each value of an attribute is either a simple data category or a Unicode string. Each attribute has only one value.

#### **5.4.2 Data Category Registry (DCR)**

The Data Category Registry (DCR) is a set of data category specifications defined by ISO 12620 [18] [19] [20]. The designers of any specific LMF lexicon shall rely on the DCR when creating their own data category selection.

#### **5.4.3 Data Category Selection (DCS)**

In the broadest sense, a data category selection can comprise all the data categories used by a given domain in the field of language resources. A DCS can also list and describe the set of data categories that can be used in a given LMF lexicon. The DCS also describes constraints on how the data categories are mapped to specific classes.

#### **5.4.4 User-defined data categories**

Lexicon creators can define a set of new data categories to cover data category concepts that are needed and that are not available in the DCR. This supplemental set of data categories shall be registered with the DCR Registration Authority and managed in conformance with ISO 12620.

#### **5.4.5 Lexicon comparison**

When two LMF conformant lexicons are based on two different DCSs, comparison of the DCS in each lexicon provides a framework for identifying what information can be exchanged between one format and the other, or what will be lost during a conversion. When LMF is used to describe an existing resource, it will be necessary to map the existing resource to corresponding data categories in the DCR.

### **5.5 LMF process**

LMF shall be used according to the following steps.

Step 1: Define an LMF conformant lexicon

Step 2: Populate this lexicon

An LMF conformant lexicon is defined as the combination of an LMF core package, zero to many lexical extensions and a set of data categories. The combination of all these elements is described in the following UML activity diagram:

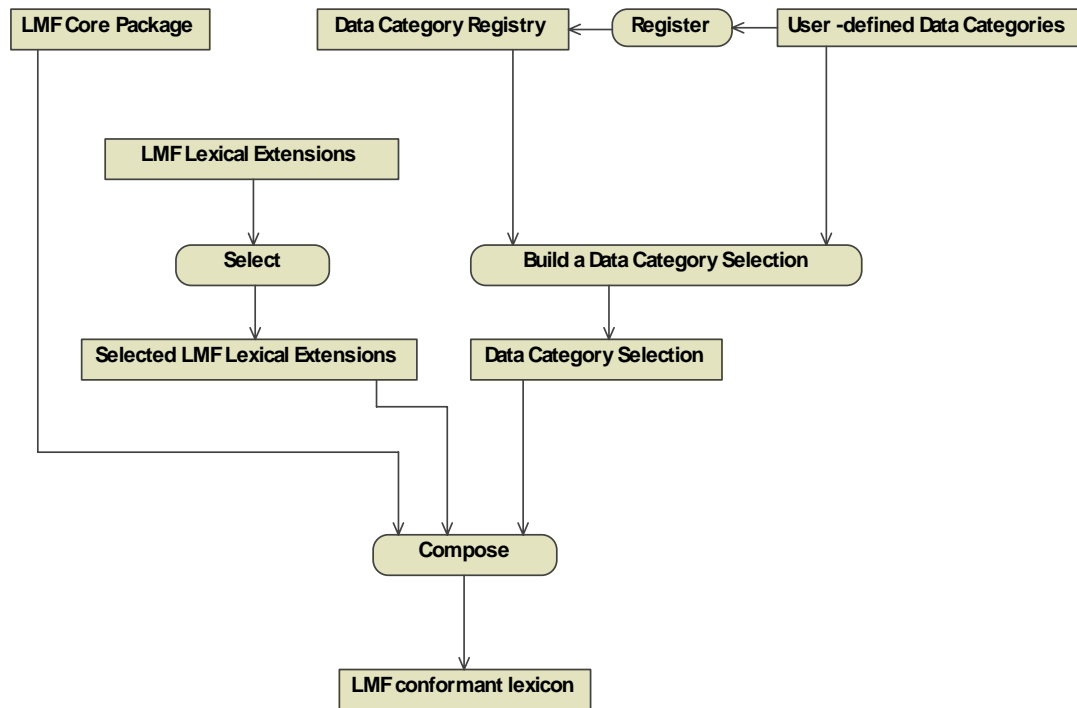


Figure 3: LMF Process

## Annex A (normative) Morphology extension

### A.1 Objectives

The purpose is to provide the mechanisms to support the development of lexicons that have an **extensional** description of the morphology of lexical entries.

EXAMPLE: when applied to an inflectional language, "extensional" means that all inflected forms will be explicitly described within one *Lexicon* instance.

NOTE: the mechanisms for an **intensional** description of the morphology are specified in the Paradigm Pattern annex.

### A.2 Class diagram

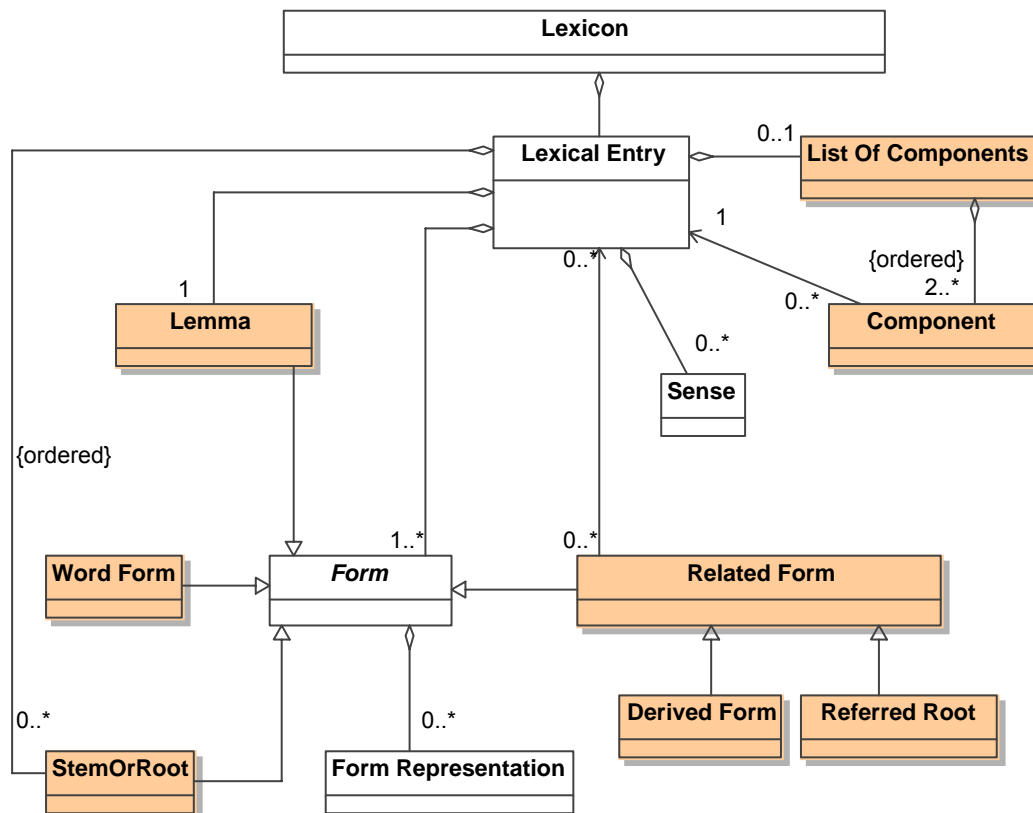


Figure A.1: Morphology class model

### A.3 Description of morphology model

The morphology model manages two categories of *Form* subclasses: *Form* subclasses that represent sets of grammatical variants that make up the abstract lexeme, and *Form* subclasses that can be related to a form in another *Lexical Entry* instance. The former classes

## ISO 24613:2007

include the *Lemma*, *Word Form*, and *StemOrRoot*. The latter classes include the *Related Form* and its subclasses. The *Lexical Entry* is constrained on the Part of Speech.

### A.3.1 Form subclasses

#### A.3.1.1 Lemma Class

*Lemma* is a *Form* subclass representing a word form chosen by convention to designate the *Lexical Entry*. The *Lemma* class is in a one to one aggregate association with the *Lexical Entry* that overrides the multiplicity inherited from the *Form* class. The lemma is usually equivalent to one of the inflected forms, the root or stem, or MWE, e.g. compound, idiomatic phrase. The convention for selecting the lemma can vary by language, language family, or editorial choice.

#### A.3.1.2 Word Form Class

*Word Form* is a *Form* subclass representing a form that a lexeme can take when used in a sentence or a phrase. So, *Word Form* class can manage simple lexemes, compounds and multi-word expressions.

#### A.3.1.3 StemOrRoot Class

*StemOrRoot* is a *Form* subclass representing a morph. The aggregation association between a *Lexical Entry* and a *StemOrRoot* is ordered. So, *StemOrRoot* class manages the sub-lexeme parts.

#### A.3.1.4 Related Form Class

*Related Form* is a *Form* subclass representing a word form or a morph that can be related to the *Lexical Entry* in one of a variety of ways (e.g. derivation, root). The *Related Form* can be typed and has the following subclasses: *Derived Form* class and *Referred Root* class. There is no assumption that the *Related Form* is associated with the *Sense* class in the *Lexical Entry*.

#### A.3.1.5 Derived Form Class

*Derived Form* is a *Related Form* subclass representing a word form of type derivation.

#### A.3.1.6 Referred Root Class

*Referred Root* is a *Related Form* subclass representing a morph of type root. The *Referred Root* class specifically represents a root that is managed by a different *Lexical Entry* instance and is shared by two or more other *Lexical Entry* instances.

### A.3.2 List Of Components Class

*List Of Component* is a class representing the aggregative aspect of a multiword expression. The *List Of Components* class is in a zero or one aggregate relationship with the *Lexical Entry* class. Each *List Of Component* instance should have at least two components.

The mechanism can also be applied recursively, that is a multiword expression may be comprised of components that are themselves multiword expressions. *List Of Components* class is used in Paradigm Pattern and MWE Pattern packages.

**A.3.3 Component class**

*Component* is a class representing a reference to a lexical entry when the latest one is an element of *List Of Component* class.

## Annex B (informative) Morphology examples

### B.1 Introduction

This extension provides examples of how to develop models for MRD and NLP Morphology lexicons.

### B.2 Example of class adornment

Classes may be adorned with the following attributes:

Class name	Example of attributes	Comment
<i>Lemma</i>	writtenForm phoneticForm geographicalVariant scheme	/writtenForm/ and /phoneticForm/ take Unicode strings as values.
<i>Word Form</i>	writtenForm phoneticForm hyphenation grammaticalNumber grammaticalGender grammaticalTense person	When /writtenForm/ is valued as "kitten", /hyphenation/ will be valued as "kit ten".  /grammaticalNumber may be valued by /plural/ for instance.
<i>StemOrRoot</i>	writtenForm phoneticForm	
<i>Derived Form</i>	writtenForm phoneticForm	
<i>Referred Root</i>	writtenForm	
<i>Component Form</i>		
<i>List Of Components</i>		

## B.3 Example of lexeme description

### B.3.1 Example of a simple morphology

In the following example, the lexical entry is associated with a lemma *clergyman* and two inflected forms *clergyman* and *clergymen*. The language coding is set for the whole lexical resource. The language value is set for the whole lexicon<sup>4</sup>.

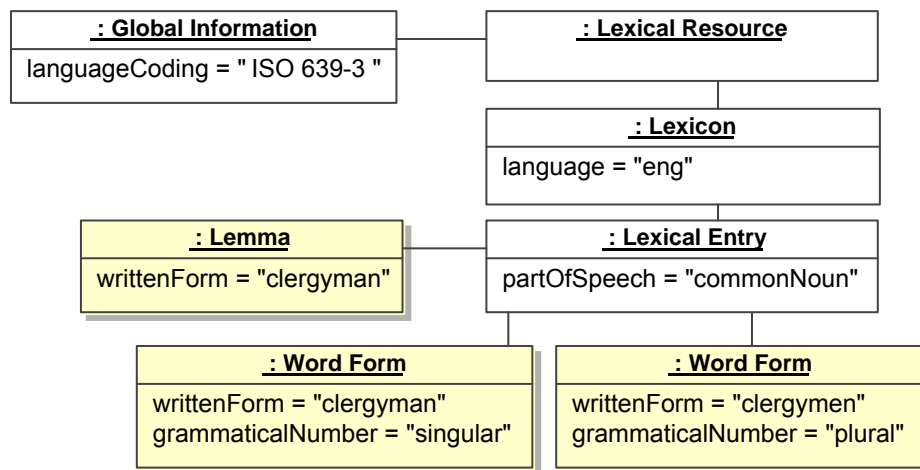


Figure B.1: Instance diagram for a simple example

The same data can be expressed by the following XML fragment:

```

<LexicalResource dtdVersion="14">
  <GlobalInformation
    <feat att="languageCoding" val="ISO 639-3"/>
  </GlobalInformation>
  <Lexicon>
    <feat att="language" val="eng"/>
    <LexicalEntry>
      <feat att="partOfSpeech" val="commonNoun"/>
      <Lemma>
        <feat att="writtenForm" val="clergyman"/>
      </Lemma>
      <WordForm>
        <feat att="writtenForm" val="clergyman"/>
        <feat att="grammaticalNumber" val="singular"/>
      </WordForm>
      <WordForm>
        <feat att="writtenForm" val="clergymen"/>
        <feat att="grammaticalNumber" val="plural"/>
      </WordForm>
    </LexicalEntry>
  </Lexicon>
</LexicalResource>
  
```

<sup>4</sup> In order to ease the reading, the instances whose class is defined in the current package, are coloured. And the instances whose class is defined in another package, are presented in white.

It is also possible to precise the type of *Word Form* by adding a specific attribute *lexicalType* as in the following instance diagram:

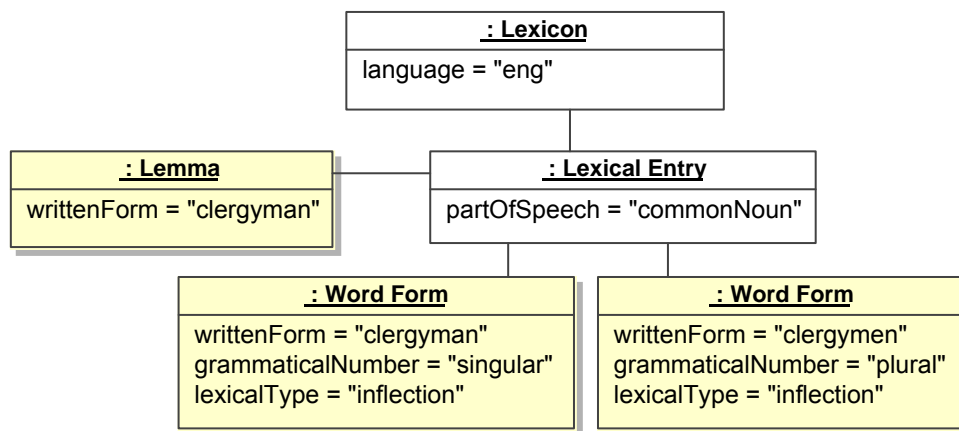


Figure B.2: highly specified Word Form example

### B.3.2 Example of Regional Variants

Regional variants can be modeled using the *Form Representation* class, with a shared *phonetic form* attribute, as follows:

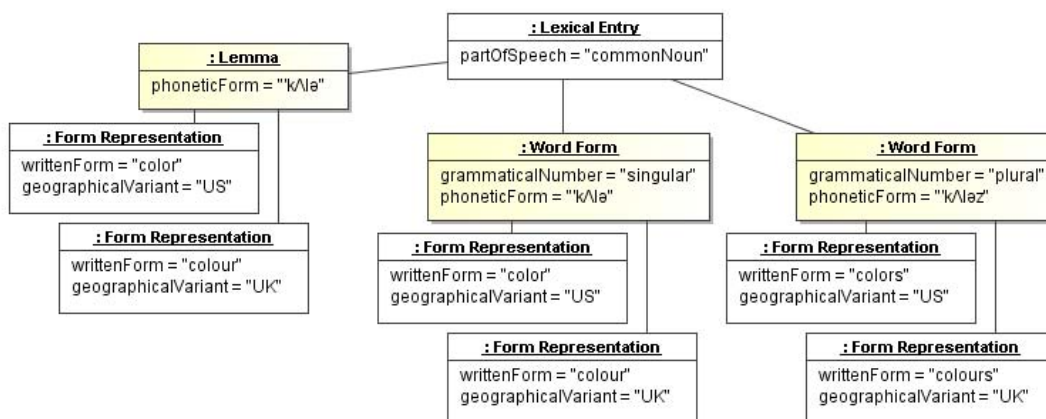


Figure B.3: example of regional variants using Form Representation

### B.3.3 Example of multiple scripts and orthographies

In the following example, the lexical entry is associated with a lemma with three different ways to express the word form [22]. The lexical entry is associated with an inflected form with also three different ways to express the word form.

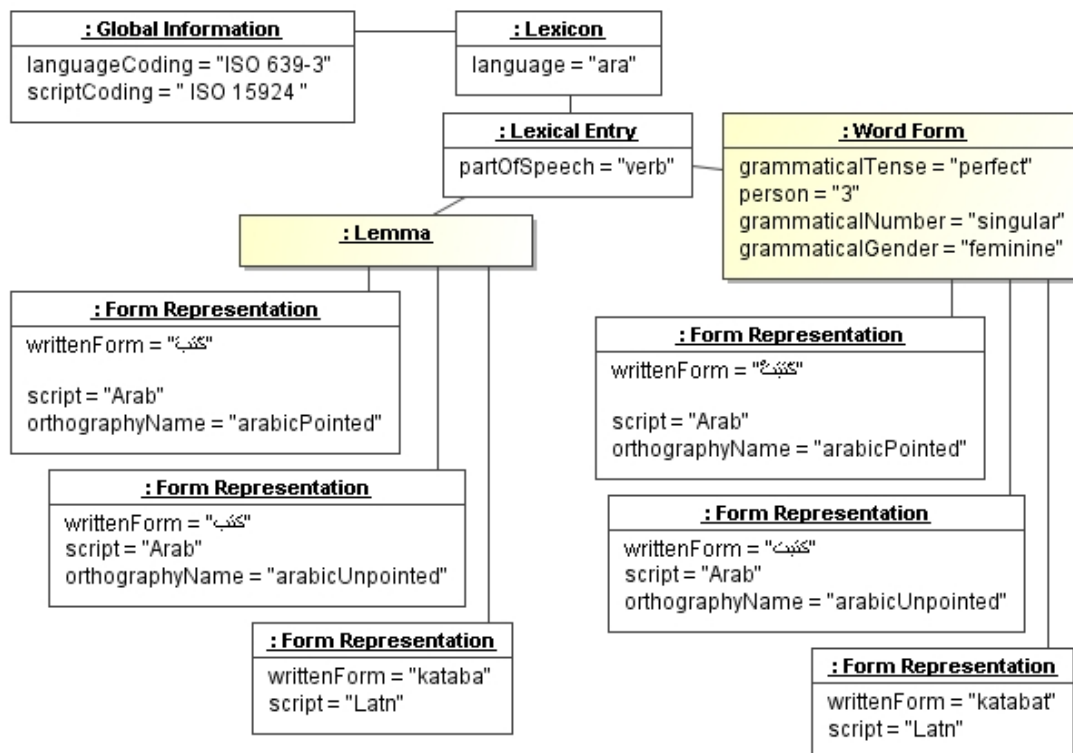


Figure B.4: example of multiple scripts and orthographies

It's worth noting that this strategy is not the only possible option in Arabic. Another strategy is to describe the Arabic pointed script forms in the lexicon and to provide an external mechanism to compute automatically the Arabic unpointed script forms and transliterations. In this case, *Form Representation* instances are not needed.

### B.3.4 Example of multiple scripts, orthographies and variants

The number of *Form Representation* instances may be more important as in Japanese where four kinds of writing systems co-exist and combine: hiragana, katakana, kanji and their romanisation. A set of variants with the same script name may be combined as in the following example representing *curly hair*.

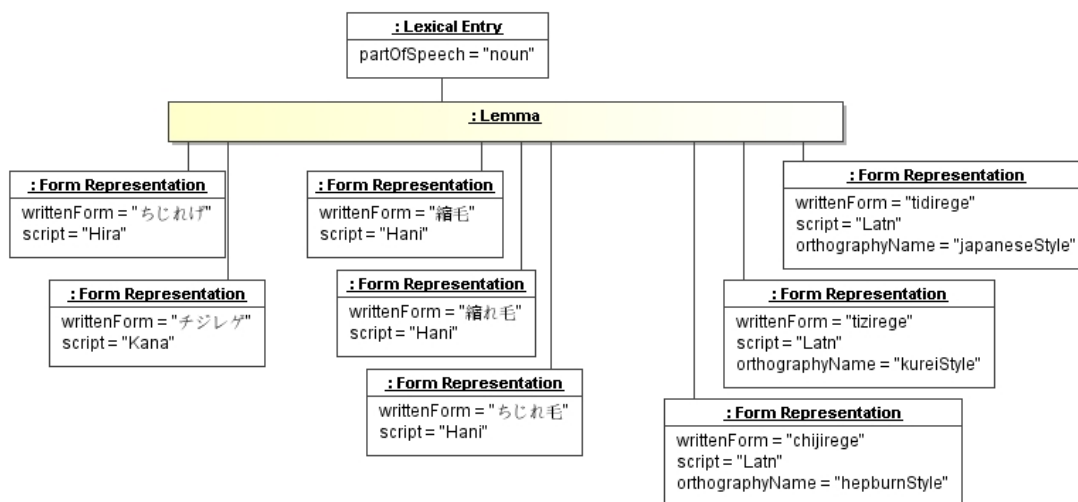


Figure B.5: example of multiple scripts orthographies and variants

### B.3.5 Example in Chinese

Over the years, the Chinese writing system changed. The movement to simplify the Chinese writing system originated in the 1890s and was extended in the 1950s. The strategy of simplification involves a reduction in the number of strokes of commonly used characters. And at the moment, the two variants are in use. According to ISO-15924, the script code is *Hans* for simplified variant and *Hant* for traditional variant.

The following example shows a situation where two different traditional forms are equivalent to one unique simplified form. If the user wants to restrict the description to simplified forms, a single lemma is sufficient, for *behavior on the stage* and *typhoon*, as in the following diagram. The language and script information are global to all lexical entries, thus these attributes are located on the *Lexicon* instance.

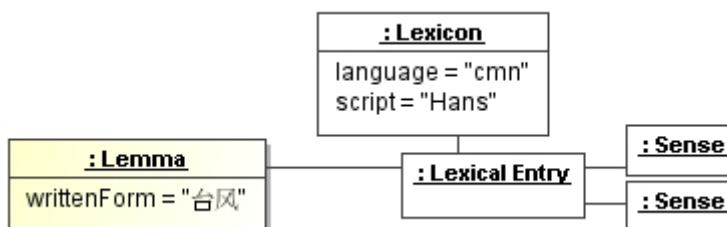


Figure B.6 example in simplified Chinese writing system

But if the user wants to describe traditional forms, two *Lexical Entry* instances are required because there are two distinct traditional forms and the meaning of each of these lexemes is different.

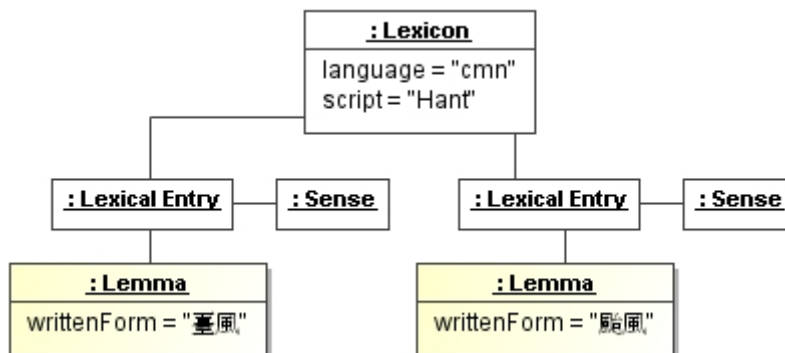


Figure B.7 example in traditional Chinese writing system

It is worth noting that if the user wants to mix simplified and traditional forms in the same lexicon, the script attribute cannot be set to the *Lexicon* instance but must be set to each *Form Representation* instance, as in the previous Japanese example.

### B.3.6 Example of Arabic root management

Arabic root is represented by a shared *Referred Root* instance. In the following instance diagram, the verb *kataba* and the noun *maktabatun* are both associated with the *Referred Root* instance *ktb*. It's worth noting that due to the fact that *Referred Root* class is a subclass of *Form*, a set of multiple representations may be recorded as in the previous Arabic example by means of *Form Representation* instances.

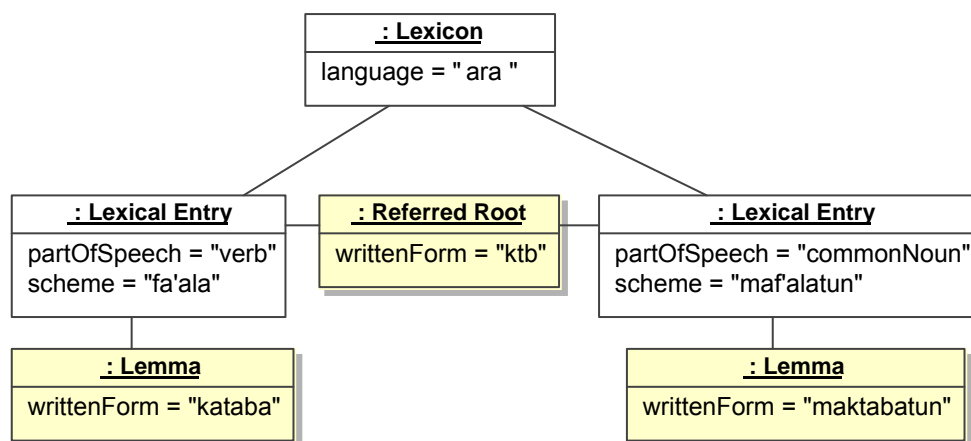


Figure B.8: example of Arabic root management

## Annex C (normative) Machine Readable Dictionary extension

### C.1 General Objectives

The Machine Readable Dictionary (MRD) extension provides metamodel packages for representing data stored in machine readable dictionaries. The extension supports electronic machine readable dictionary access for both human use and machine processing. Since the MRD extension is based on the LMF core package, it is designed to interchange data with other LMF extensions where applicable.

### C.2 MRD Package

#### C.2.1 Objectives

The objectives of the MRD Package are to provide monolingual and bi-lingual dictionary support for human translators, support enterprise systems covering multiple languages and language families, support the preparation of lexical data for use in NLP systems, and directly support NLP systems (e.g. lexical data for named entity extraction).

#### C.2.2 Class Diagram

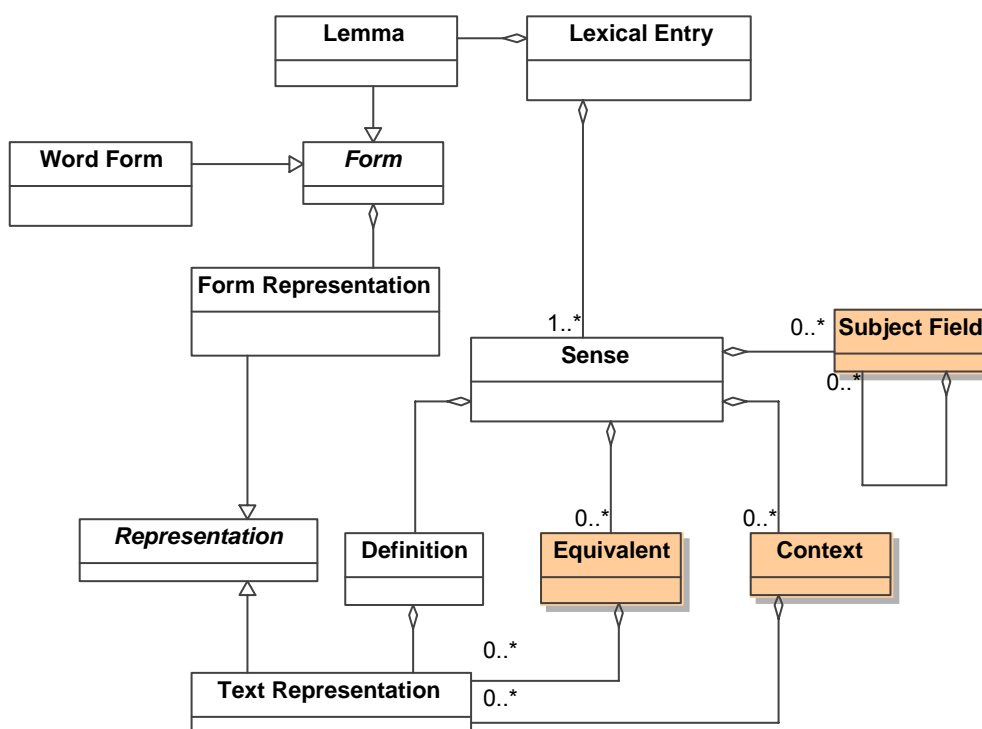


Figure C: MRD class model

### C.2.3 Description of the MRD Metamodel

The MRD metamodel is based on the NLP Morphological Extension with the following modifications:

- The MRD package relaxes all constraints on the *Related Form* class. [NOTE: For example, the Related Form class can be typed or admit subclasses for the full range of word forms related to the Lexical Entry, e.g. synonym, antonym, abbreviation].
- The package requires a *Sense* class (1 to 1...\* multiplicity).
- The package provides additional classes for the *Sense* class

### C.2.4 Equivalent Class

In a bilingual MRD, the *Equivalent* class represents the translation equivalent of the word form managed by the *Lemma* class. The *Equivalent* class is in a zero to many aggregate association with the *Sense* class, which allows the lexicon developer to omit the *Equivalent* class from a monolingual dictionary.

### C.2.5 Context Class

The *Context* class represents a text string that provides authentic context for the use of the word form managed by the *Lemma*. The *Context* class is in a zero to many aggregate association with the *Sense* class and may be associated with zero to many *Text Representation* classes which manage the representation of the translation equivalent in more than one script or orthography.

NOTE: The context may use an inflected form of the *Lemma*.

### C.2.6 Subject Field Class

*Subject Field* is a class representing a text string that provides domain or status information. *Subject Field* class is in a zero to many aggregate association with the *Sense* class. The *Subject Field* class allows for hierarchical senses in that a *Subject Field* instance may be more specific than another *Subject Field* instance of the same lexical entry.

### C.2.7 Text Representation Class

*Text Representation* is a subclass of the *Form Representation* class. A *Text Representation* class is associated with the child classes of the *Sense* class, not the *Lexical Entry*. A *Text Representation* class instance contains a specific orthography and one to many data categories that describe the attributes of that orthography. [Note: A lexicon developer is more likely to allocate language and script attributes to a *Text Representation* class than to a *Form Representation* class.]

## Annex D (informative) Machine Readable Dictionary examples

### D.1 MRD Example

#### D.1.1 Example of a Bilingual MRD with Multiple Representations

The example of a bilingual MRD in Figure D.1 shows an entry containing the Arabic word 'kitaab' and two equivalents in English, 'book' (the most common meaning) and 'credentials'. The transcriptions provide users more information about the pronunciation of the words and context than can be derived from the Arabic script. In this example, the *Word Form* class provides information about the form and pronunciation of the Arabic broken plural, which is an irregular inflection. The decision to include the *Form Representation* class is an editorial choice determined by the goals of the lexicon developer. If the goal were to produce an Arabic-English MRD that contained only Arabic script for the Arabic word forms, the inclusion of *Form Representation* class would not be necessary.

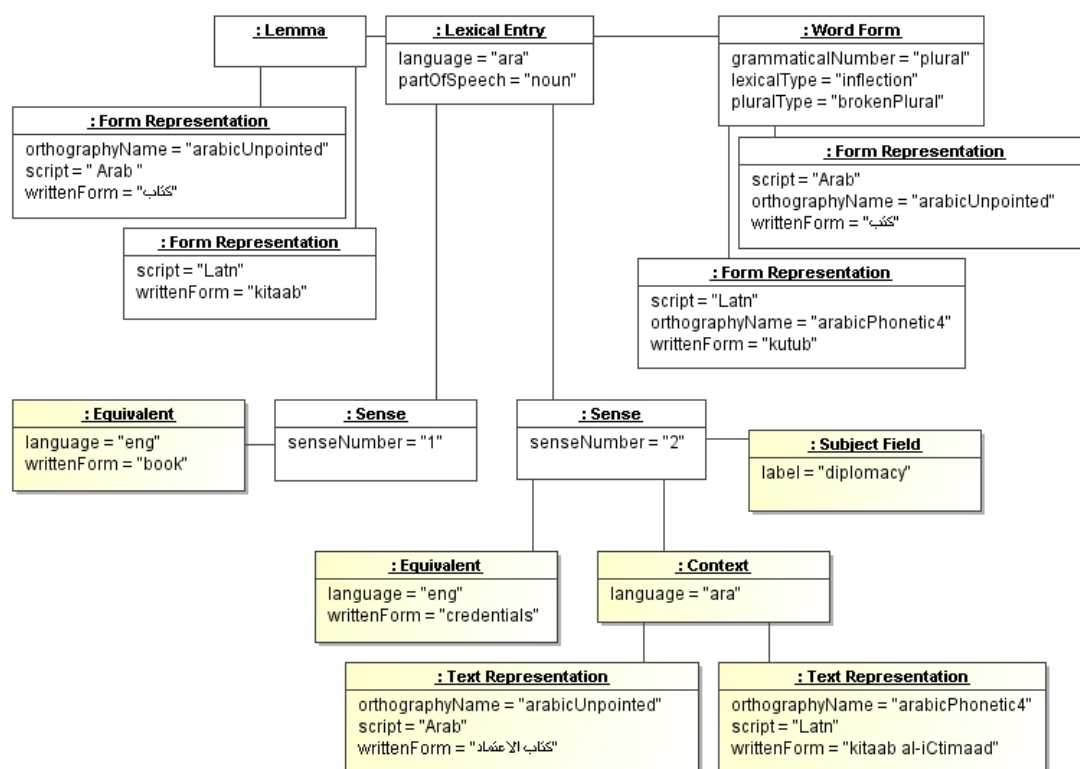


Figure D.1: Instantiation example for a bilingual MRD

## Annex E (normative) NLP syntax extension

### E.1 Objectives

The purpose of this annex is to describe the properties of a lexeme when combined with other lexemes in a sentence. When recorded in a lexicon, the syntactic properties make up the syntactic description of a Lexical Entry instance.

This annex permits the description of specific syntactic properties of lexemes and does not express the general grammar of a language.

### E.2 Class diagram

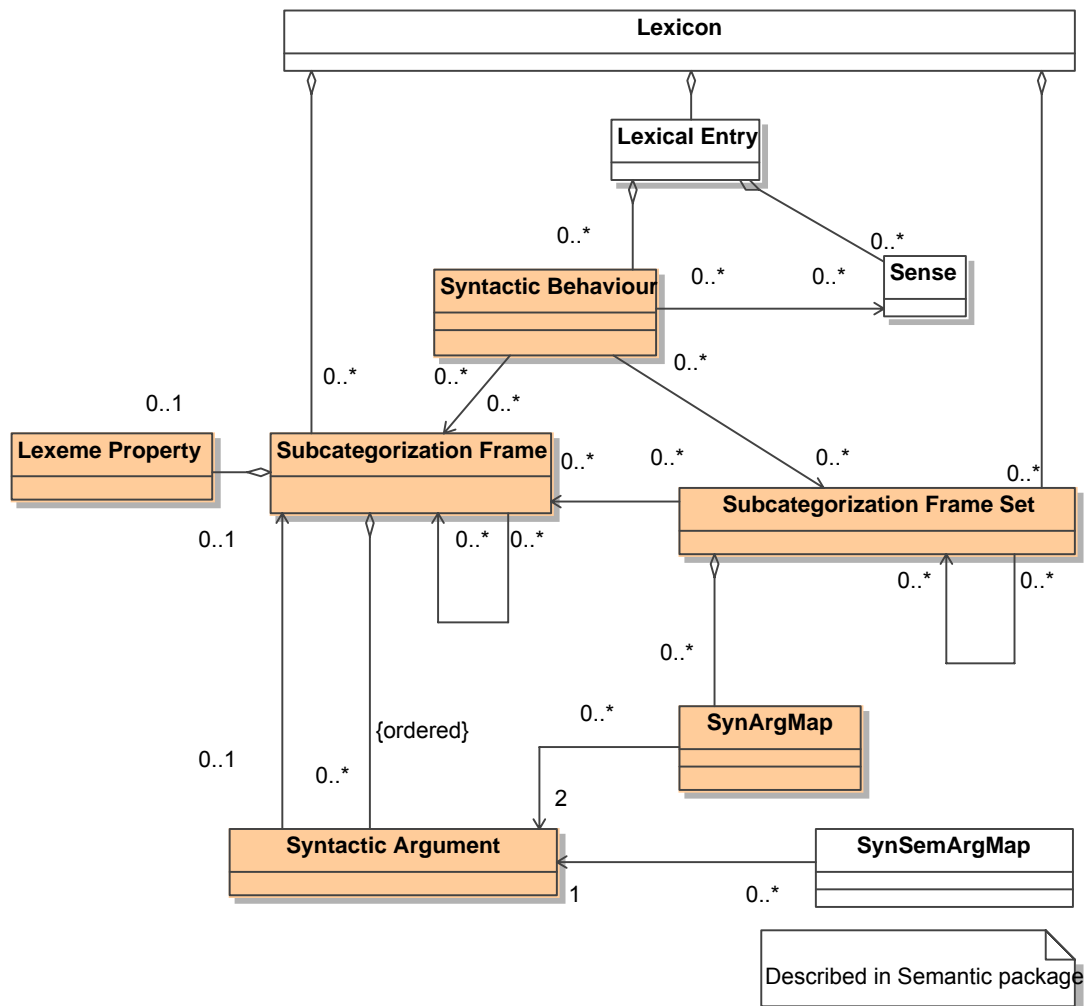


Figure E.1: Syntactic model

## E.3 Description of the syntactic model

### E.3.1 Syntactic Behaviour class

*Syntactic Behaviour* is a class representing one of the possible behaviours of a lexeme. The *Syntactic Behaviour* instance is attached to the *Lexical Entry* instance and optionally to the *Sense* instance. The presence in a given lexicon of one *Syntactic Behaviour* instance for a lexical entry means that this lexeme can have this behaviour in the language of the lexicon.

Syntactic description is optional, so it is possible to describe morphology and semantics without any syntactic description. *Lexical Entry*, *Syntactic Behaviour* and *Sense* instances form a triangle representing Morphology, Syntax and Semantics.

Detailed description of the syntactic behaviour of a lexical entry is defined by the *Subcategorization Frame* instance.

### E.3.2 Subcategorization Frame class

*Subcategorization Frame* is a class representing one syntactic construction. A *Subcategorization Frame* instance is shared by all *Lexical Entry* instances that have the same syntactic behaviour in the same language. A *Subcategorization Frame* can inherit relationships and attributes from another more generic *Subcategorization Frame* by means of a reflexive link. Therefore, it is possible to integrate a hierarchical structure of *Subcategorization Frame* instances.

Example: In a *Lexical Entry* for the Italian verb *amare*, a *Syntactic Behaviour* instance may be created and associated with a *Subcategorization Frame* instance called *regularSVOAvere*. This latter instance describes the regular subject, verb, object structure with a verb using the auxiliary *avere*.

### E.3.3 Lexeme Property class

*Lexeme Property* is a class representing the central node of the *Subcategorization Frame* and is the class that refers to the current *Lexical Entry* instance. A *Lexeme Property* instance connected to a *Subcategorization Frame* instance is shared by all the lexemes that have the same syntactic behaviour.

Example: In the Italian example, the attribute auxiliary on the *Lexeme Property* instance may be set to *avere*.

### E.3.4 Syntactic Argument class

*Syntactic Argument* is a class representing an argument of a given *Subcategorization Frame*. A *Syntactic Argument* can be linked recursively to a *Subcategorization Frame* instance in order to describe deeply complex arguments. *Syntactic Argument* allows the connection with a semantic argument by means of a *SynSemArgMap* instance.

### E.3.5 Subcategorization Frame Set class

*Subcategorization Frame Set* is a class representing a set of syntactic constructions and possibly the relationship between these constructions. A *Subcategorization Frame Set* can inherit relationships and attributes from another more generic *Subcategorization Frame Set* by means of a reflexive link. Therefore, it is possible to integrate a hierarchical structure of *Subcategorization Frame Set* instances.

## ISO 24613:2007

A *Subcategorization Frame Set* groups various syntactic constructions that appear frequently for certain sets of lexemes. The objective is to factorize syntactic descriptions and to maintain a minimum of syntactic behaviour instances in the lexicon.

### E.3.6 SynArgMap class

The *SynArgMap* is a class representing the relationship that maps various *Syntactic Argument* instances of the same *Subcategorization Frame Set* instance.

## Annex F (informative) NLP syntax examples

### F.1.1 Example of class adornment

Classes may be adorned with the following attributes:

Class name	Example of attributes	Comment
Syntactic Behaviour	id label	
Subcategorization Frame	id label comment	
Lexeme Property	partOfSpeech mood voice auxiliary position	The /position/ data category may specify the relative position of the lexeme in the sentence with respect to the syntactic arguments.
Syntactic Argument	function syntacticConstituent introducer label restriction	The /function/ data category may have values like /subject/ or /object/. The /syntacticConstituent/ may have values like /NP/ or /PP/ for <i>Noun Phrase</i> and <i>Prepositional Phrase</i> respectively. The /introducer/ may specify the preposition that is required to introduce the /syntacticConstituent/.
Subcategorization Frame Set	id label example comment	
SynArgMap	comment	

### F.1.2 Examples of lexeme description

#### F.1.2.1 Example in Italian

The example shown in Figure F.1 is taken from the Parole/CLIPS lexicon [3]. In this example, only syntactic structures are used, and no semantic information is described. The syntactic construction being described is a rather simple construction in Italian, where both the subject and the direct object have the simple data category property /nounPhrase/. The *Lexeme Property* instance describes a verb that takes the auxiliary *avere*. A typical example of such a construction is *Gianni ama Maria*.

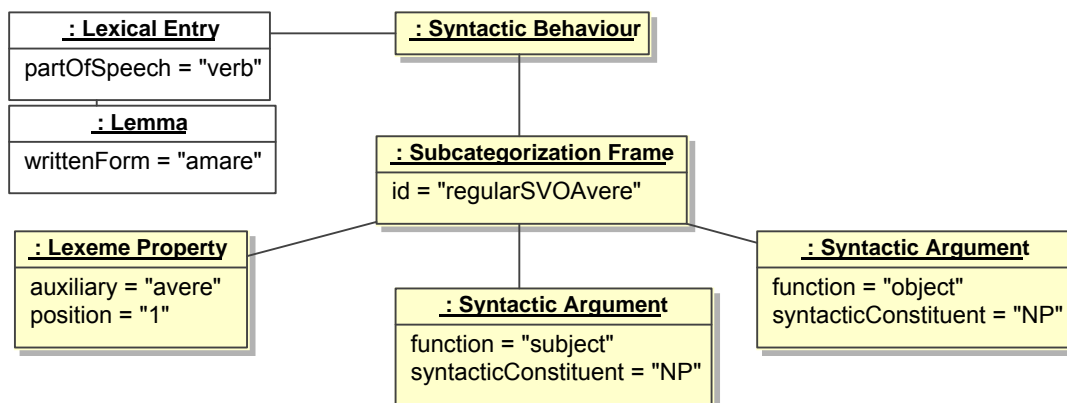


Figure F.1: Instance diagram in Italian

The same data can be expressed by the following XML fragment:

```

<LexicalEntry>
  <feat att="partOfSpeech" val="verb"/>
  <Lemma>
    <feat att="writtenForm" val="amare"/>
  </Lemma>
  <SyntacticBehaviour subcategorizationFrames="regularSVOAvere"/>
</LexicalEntry>
<SubcategorizationFrame id="regularSVOAvere">
  <LexemeProperty>
    <feat att="auxiliary" val="avere"/>
    <feat att="position" val="1"/>
  </LexemeProperty>
  <SyntacticArgument>
    <feat att="function" val="subject"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
  <SyntacticArgument>
    <feat att="function" val="object"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
</SubcategorizationFrame>

```

### F.1.2.2 Example in English

In English, it is possible to use just one *Subcategorization Frame Set* for certain anticausative verbs. For example, *boil* in *he boils a kettle of water* and *the kettle boils*, thus this verb may be described by means of only one syntactic behaviour, instead of two. So, only one *Subcategorization Frame Set* instance is required as shown in the following figure.

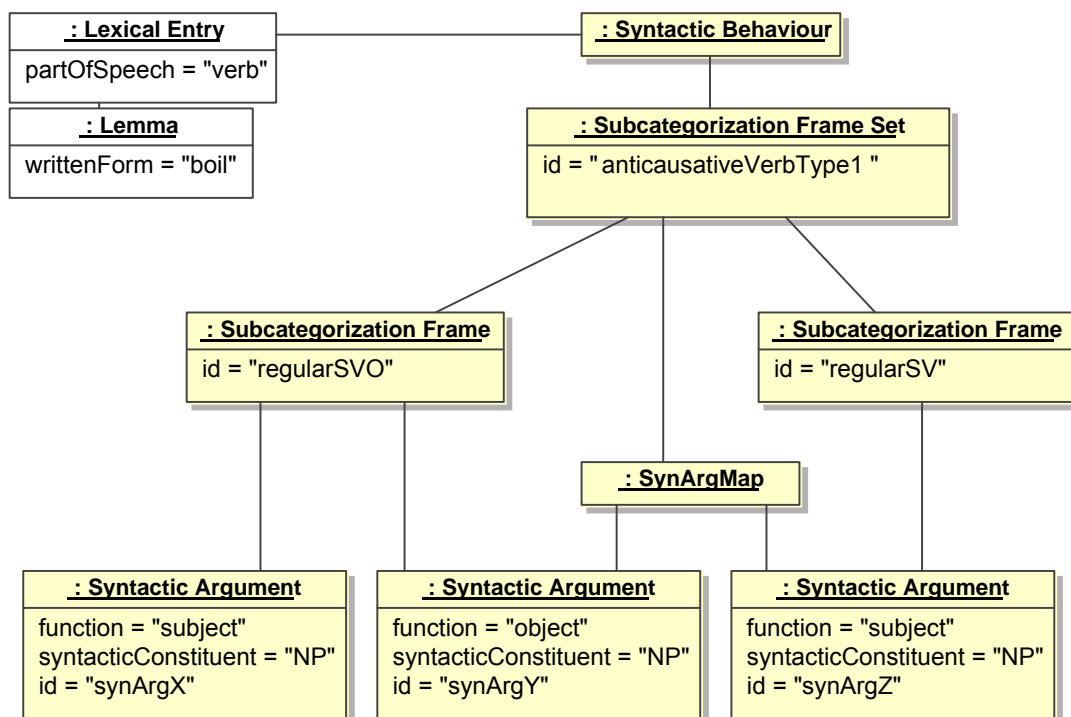


Figure F.2: Instance diagram in English

The same data can be expressed by the following XML fragment:

```

<LexicalEntry>
  <feat att="partOfSpeech" val="verb"/>
  <Lemma>
    <feat att="writtenForm" val="boil"/>
  </Lemma>
  <SyntacticBehaviour subcategorizationFrameSets="anticausativeVerbType1"/>
</LexicalEntry>
<SubcategorizationFrameSet id= "anticausativeVerbType1"
  subcategorizationFrames= "regularSVO regularSV"/>
  <SynArgMap arg1="synArgY" arg2="synArgZ"/>
</SubcategorizationFrameSet>
<SubcategorizationFrame id="regularSVO">
  <SyntacticArgument id="synArgX">
    <feat att="function" val="subject"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
  <SyntacticArgument id="synArgY">
    <feat att="function" val="object"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
</SubcategorizationFrame>
<SubcategorizationFrame id="regularSV">
  <SyntacticArgument id="synArgZ">
    <feat att="function" val="subject"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
</SubcategorizationFrame>
  
```

## Annex G (normative) NLP semantics extension

### G.1 Objectives

The purpose of this section is to describe one sense and its relationship with other senses belonging to the same language. Due to the intricate interactions between syntax and semantics in most languages, this section also provides the connection to syntax. The linkage of senses belonging to different languages will be described using the multilingual notations annex.

### G.2 Class diagram

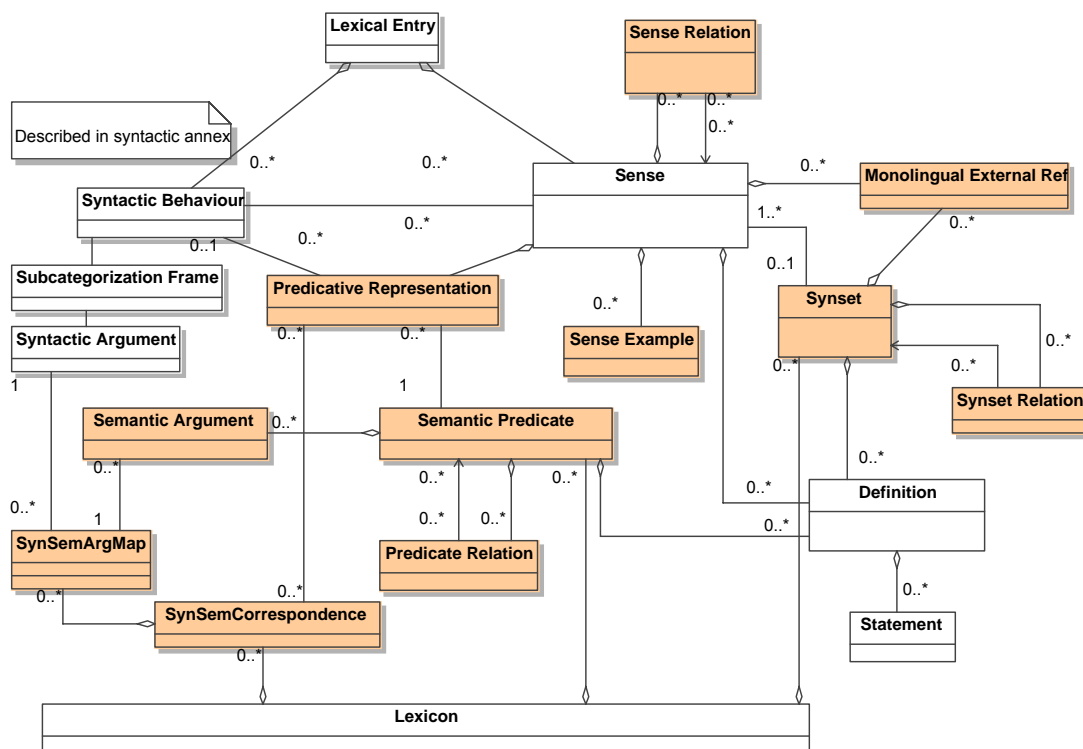


Figure G.1: Semantic model

### G.3 Connection with the core package

The *Sense* class is specified in the core package. The *Sense* class is aggregated in the *Lexical Entry* class. Therefore, a *Sense* instance is not shared among two different *Lexical Entry* instances.

## G.4 Description of the semantic model

### G.4.1 Synset class

*Synset* is a class representing a common and shared meaning within the same language. *Synset* links synonyms forming a synonym set [8]. A *Synset* instance can link senses of different *Lexical Entry* instances with the same part of speech.

Example: In WordNet 2.1 [7], the synset "12100067" groups together the meanings of *oak* and *oak tree* that are considered as synonymous.

### G.4.2 Synset Relation class

*Synset Relation* is a class representing the oriented relationship between *Synset* instances.

### G.4.3 Sense Relation class

*Sense Relation* is a class representing the oriented relationship between *Senses* instances.

### G.4.4 Sense Example class

*Sense Example* is a class used to illustrate the particular meaning of a *Sense* instance. A *Sense* can have zero to many examples.

Example: In a *Lexical Entry* for the MWE *non-governmental organization (NGO)*, a *Sense Example* might be *Amnesty International*.

### G.4.5 Semantic Predicate class

*Semantic Predicate* is a class representing an abstract meaning together with its association with the *Semantic Argument* class. A *Semantic Predicate* instance may be used to represent the common meaning between different senses that are not necessarily fully synonymous. These senses may be linked to *Lexical Entry* instances whose parts of speech are different. A *Semantic Predicate* instance pertains to a given *Lexicon* instance.

Example: In a *Lexical Entry* instance for *to buy* in the sense of "to get something by paying money for it", a *Semantic Predicate* instance might be defined with two semantic arguments: one for the person who buys and one for what is bought. Another *Lexical Entry* instance could be recorded for *buyer* and linked to the same predicate [29], [30].

### G.4.6 Predicative Representation class

*Predicative Representation* class is a class representing the link between the *Sense* and the *Semantic Predicate* classes.

Example: In the example given in the *Semantic Predicate* class section, the link between the sense of the verb (i.e. *to buy*) and the predicate might be marked as *master*. The link between the sense of the noun (i.e. *buyer*) and the predicate might be marked for instance as *agentiveNominalization*.

### G.4.7 Semantic Argument class

*Semantic Argument* is a class representing an argument of a given *Semantic Predicate*.

## ISO 24613:2007

Example: In the example given in the *Semantic Predicate* class section, the predicate might have two *Semantic Argument* instances: one for the person who buys and one for what is bought.

### G.4.8 SynSemArgMap class

*SynSemArgMap* is a class representing the links between a semantic argument and a syntactic argument.

### G.4.9 SynSemCorrespondence class

*SynSemCorrespondence* is a class representing a set of *SynSemArgMap* instances for a given *Subcategorization Frame* instance.

### G.4.10 Predicate Relation class

*Predicate Relation* is a class representing the oriented relationship between instances of *Semantic Predicate*.

### G.4.11 Monolingual External Ref class

*Monolingual External Ref* is a class representing the relationship between a *Sense* or a *Synset* instance and an external system.

Note: guidelines for this class are given in annex Q and [24]

## Annex H (informative) NLP semantic examples

### H.1.1 Example of class adornment

Classes may be adorned with the following attributes:

Class name	Example of attributes	Comment
<i>Sense</i>	dating style frequency geography animacy	
<i>Sense Relation</i>	label	Sense Relation class is a multipurpose class that can be used to represent antonymy, generic/specific or part of relationship.
<i>Sense Example</i>	text source language	For instance a lexicon in the Bambara language (Bamanankan, bam), can contain examples expressed with standard orthography and examples with tones added in order to permit beginners to understand and pronounce the example.
<i>Semantic Predicate</i>	label definition	
<i>Predicative Representation</i>	type comment	For instance, a semantic derivation between a sense of a noun and a sense of a verb can be linked to a shared predicate. In such a situation, the <i>Predicative Representation</i> of the sense of the noun can be typed as <i>/verbNominalization/</i> .
<i>Semantic Argument</i>	semanticRole restriction	
<i>SynSemArgMap</i>		
<i>SynSemCorrespondence</i>		
<i>Predicate Relation</i>	label type	
<i>Synset</i>	label source	
<i>Synset Relation</i>	label type	
<i>Monolingual External Ref</i>	externalSystem	It is not the purpose of the semantic extension to provide a complex know-

Class name	Example of attributes	Comment
	externalReference	ledge organization system, which ideally should be structured as one or several external systems designed specifically for that purpose. However, <i>/externalSystem/</i> and <i>/externalReference/</i> are provided to refer respectively to the name(s) of the external system and to the specific relevant node in this given external system.

## H.1.2 Examples of lexeme description

### H.1.2.1 Simple example

The following English example presents two adjectives: *visible* and *invisible* that are considered to be monosemous lexical entries for the purpose of the explanation. These two lexemes are linked at semantic level by means of a *Sense Relation* instance in order to represent that *visible* is the contrary of *invisible*.

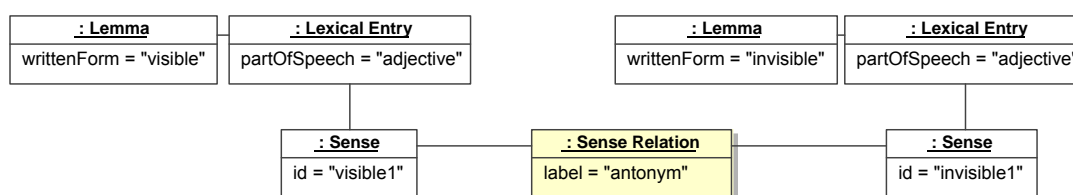


Figure H.1: instance diagram for a simple example

The same data can be expressed by the following XML fragment:

```
<LexicalEntry>
  <feat att="partOfSpeech" val="adjective"/>
  <Lemma>
    <feat att="writtenForm" val="visible"/>
  </Lemma>
  <Sense id="visible1">
    <SenseRelation targets="invisible1">
      <feat att="label" val="antonym"/>
    </SenseRelation>
  </Sense>
</LexicalEntry>
<LexicalEntry>
  <feat att="partOfSpeech" val="adjective"/>
  <Lemma>
    <feat att="writtenForm" val="invisible"/>
  </Lemma>
  <Sense id="invisible1"/>
</LexicalEntry>
```

It is worth noting that there is no need for an XML tag in the reverse direction, that is from "invisible1" to "visible1" because this information is already specified from "visible1".

## H.1.2.2 Example from Princeton WordNet 2.1

The following English example focuses on *Synset* instances. This example is taken from WordNet version 2.1 [7] and presents two *Synset* instances: one for *oak* as a tree and one for *oak* as the wood of the tree. Each WordNet's *lex\_id* is used to identify a *Sense* instance. Each synset contains a narrative description made of several parts. The first part is always a definition and the other parts are statements, often of heterogeneous content. For instance, the synset "12100067" for *oak* has the definition "a deciduous tree of the genus Quercus". The second part is a narrative describing the properties of the oak: "has acorns and lobed leaves". The third part is a proverb "great oaks grow from little acorns". Within the current International Standard, the first part may give a *Definition* instance and the two last parts may give two *Statement* instances. The two *Synset* instances are linked by a *Synset Relation* instance that is marked as *substanceHolonym*.

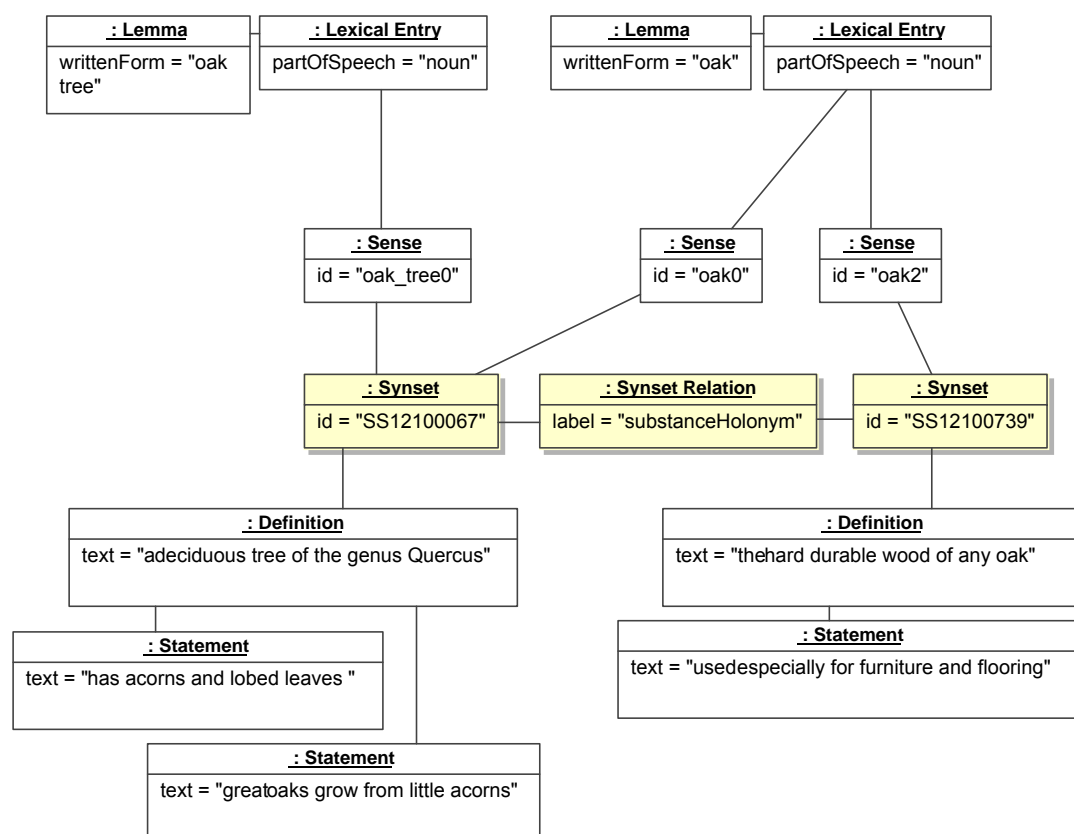


Figure H.2: Instance diagram for the example taken from WordNet

The same data can be expressed by the following XML fragment:

```

<LexicalEntry>
  <feat att="partOfSpeech" val="noun"/>
  <Lemma>
    <feat att="writtenForm" val="oak tree"/>
  </Lemma>
  <Sense id="oak_tree0" synset="SS12100067"/>
</LexicalEntry>
<LexicalEntry>
  <feat att="partOfSpeech" val="noun"/>
  <Lemma>
    <feat att="writtenForm" val="oak"/>
  </Lemma>

```

## ISO 24613:2007

```
<Sense id="oak0" synset="SS12100067"/>
<Sense id="oak2" synset="SS12100739"/>
</LexicalEntry>
<Synset id="12100067">
  <Definition>
    <feat att="text" val="a deciduous tree of the genus Quercus"/>
    <Statement>
      <feat att="text" val="has acorns and lobed leaves"/>
    </Statement>
    <Statement>
      <feat att="text" val="great oaks grow from little acorns"/>
    </Statement>
  </Definition>
  <SynsetRelation targets="SS12100739"
    <feat att="label" val="substanceHolonym"/>
  </SynsetRelation>
</Synset>
<Synset id="SS12100739">
  <Definition>
    <feat att="text" val="the hard durable wood of any oak"/>
    <Statement>
      <feat att="text" val="used especially for furniture and flooring"/>
    </Statement>
  </Definition>
</Synset>
```

### H.1.2.3 Example from *Dictionnaire Explicatif et Combinatoire*

The following French example focuses on *Semantic Predicate* instances and connection between syntactic and semantic representations. This example presents the syntax of the sense *Aider1* taken from *Dictionnaire Explicatif et Combinatoire* [4] [21]. "Aider1" is linked to the semantic argument: "X aide Y à Z-er par W" as in "il vous aidera par son intervention à surmonter cette épreuve" (Literally: "X helps Y to Z by W" i.e., "He will help you to overcome this ordeal by intervening."). This *Lexical Entry* instance yields eight different *Subcategorization Frame instances*, but the following figure supplies the representation for only the first two examples: "La Grande-Bretagne aide ses voisins" ("Great Britain helps its neighbors) and "La Grande-Bretagne a aidé à créer l'ONU" ("Great Britain helped create the UN"), with a special focus on links between syntactic and semantic representations. The two *Subcategorization Frame instances* are related to a common semantic predicate, which has its semantic arguments (X, Y, Z and W). They are shown to be related to particular *Syntactic Argument instances* in the different constructions of the verb. That is, the *Subcategorizations Frame instances* are not linked directly to the predicate, but a particular *Syntactic Argument* in each *Subcategorization Frame instance* is linked to a particular *Semantic Argument instance*.

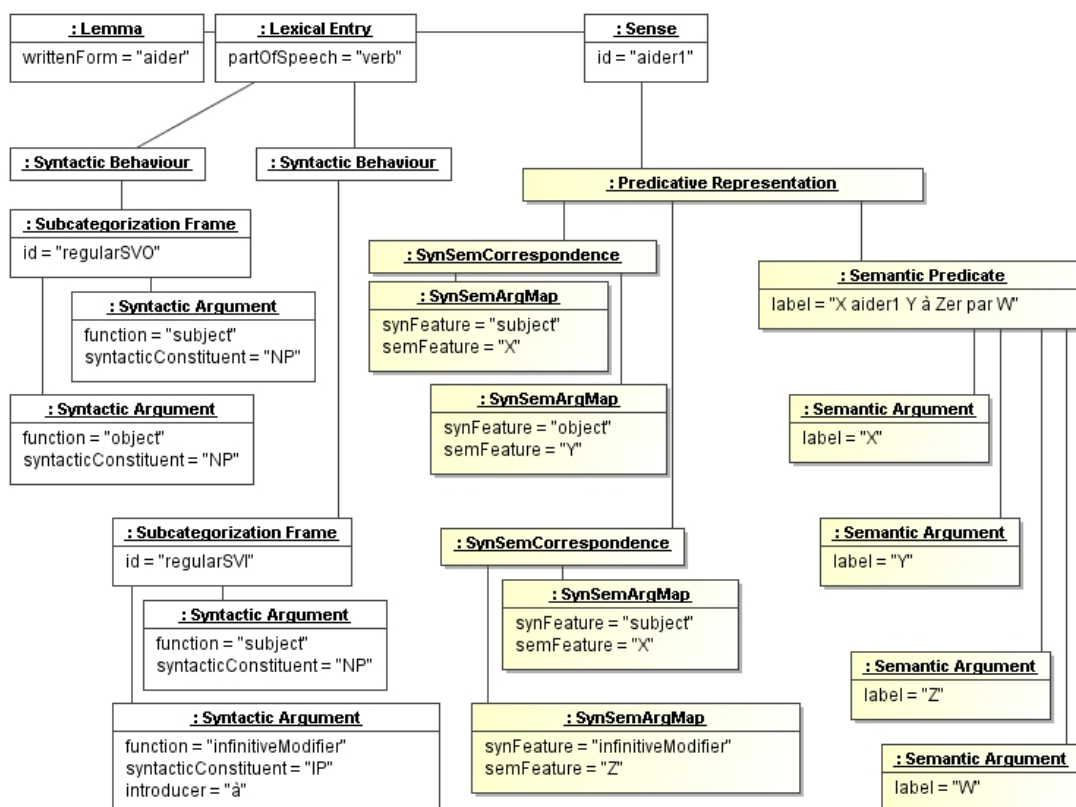


Figure H.3: Instance diagram for the example taken from the DEC

The same data can be expressed by the following XML fragment:

```

<LexicalEntry>
  <feat att="partOfSpeech" val="verb"/>
  <Lemma>
    <feat att="writtenForm" val="aider"/>
  </Lemma>
  <Sense id="aider1">
    <PredicativeRepresentation predicate="P1"
      correspondences="SVO_XY SVI_XZ"/>
  </PredicativeRepresentation>
</Sense>
<SyntacticBehaviour subcategorizationFrames="regularSVO"/>
<SyntacticBehaviour subcategorizationFrames="regularSVI"/>
</LexicalEntry>
<SynSemCorrespondence id="SVO_XY">
  <SynSemArgMap synFeature="subject" semFeature="X"/>
  <SynSemArgMap synFeature="object" semFeature="Y"/>
</SynSemCorrespondence>
<SynSemCorrespondence id="SVI_XZ">
  <SynSemArgMap synFeature="subject" semFeature="X"/>
  <SynSemArgMap synFeature="infinitiveModifier" semFeature="Z"/>
</SynSemCorrespondence>
<SubcategorizationFrame id="regularSVO">
  <SyntacticArgument>
    <feat att="function" val="subject"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
  < SyntacticArgument>

```

```

    <feat att="function" val="object"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
</SubcategorizationFrame>
<SubcategorizationFrame id="regularSVI">
  <SyntacticArgument>
    <feat att="function" val="subject"/>
    <feat att="syntacticConstituent" val="NP"/>
  </SyntacticArgument>
  </SyntacticArgument>
  <feat att="function" val="infinitiveModifier"/>
  <feat att="syntacticConstituent" val="IP"/>
  <feat att="introducer" val="à"/>
</SyntacticArgument>
</SubcategorizationFrame>
<SemanticPredicate id="P1">
  <feat att="label" val="X aider1 Y à Z par W"/>
  <SemanticArgument>
    <feat att="label" val="X"/>
  </SemanticArgument>
  <SemanticArgument>
    <feat att="label" val="Y"/>
  </SemanticArgument>
  <SemanticArgument>
    <feat att="label" val="Z"/>
  </SemanticArgument>
  <SemanticArgument>
    <feat att="label" val="W"/>
  </SemanticArgument>
</SemanticPredicate>

```

#### H.1.2.4 Example of homonymy

The following example presents two different lexical entries with the same written form.

Two *Lexical Entry* instances are created: one for the verb *to book* and one for the noun *book*. Each of them is associated with a distinct *Lemma* instance. Each *Lexical Entry* instance may be completed by descriptors related to the morphology of the lexemes, and these descriptors are completely different from each other. The two *Lexical Entry* instances are linked at semantic level by means of a *Sense Relation* instance that is labelled *homonymy*.

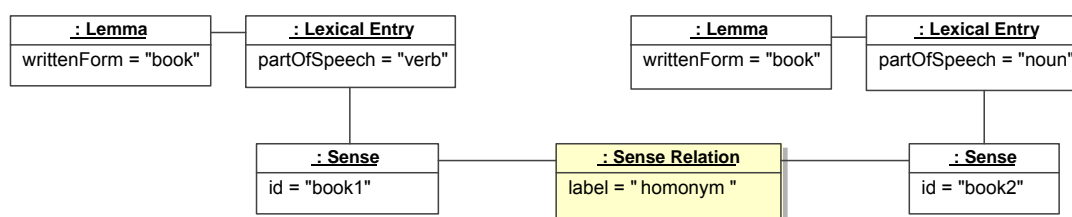


Figure H.4: example of homonymy

The notion of homonymy is represented as a relation, not as a structure. In other terms, the *Lemma* instance is not conceptually shared between lexical entries. This does not imply that a physical implementation will necessarily duplicate the character strings in the database but this mechanism is considered as a data compression mechanism, not as a conceptual consideration.

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It is worth noting that the criterion that rules the decision about having one or two lexemes is not specified in this current standard: it is up to the lexicon manager to decide to split or to share the lexical information.

## Annex I (normative) NLP multilingual notations extension

### I.1 Objectives

The purpose of this section is to describe the representation of equivalents for Sense or SyntacticBehaviour instances between or among two or more languages.

### I.2 Absence versus presence of multilingual notations in a lexicon

The multilingual model can be used for lexical databases describing two or more languages (i.e., bilingual vs. multilingual resources). There is no need to use the multilingual notations in a monolingual database.

### I.3 Class diagram

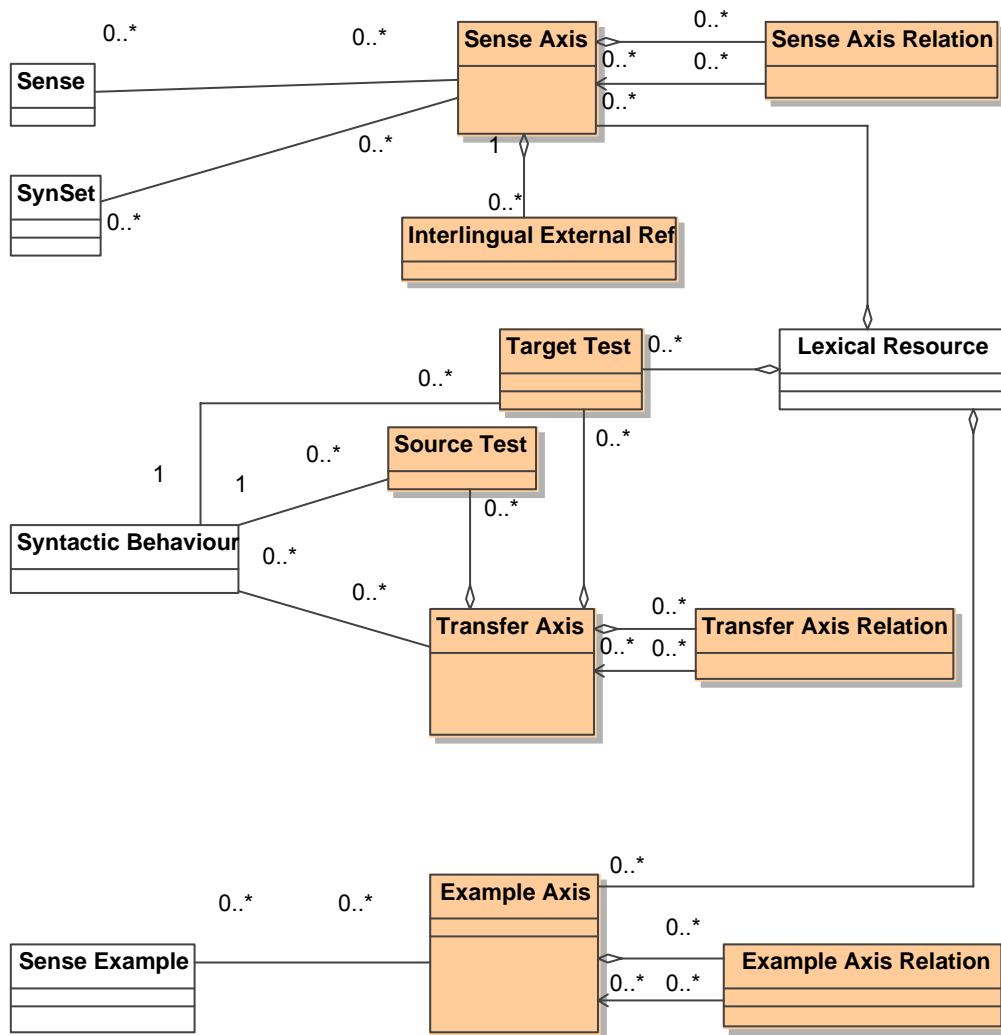


Figure I.1: Multilingual notations model

## I.4 Options

The simplest configuration is the bilingual lexicon where a single link is used to represent the equivalent of a given sense from one language into another, but actual practice reveals at least five more complex configurations:

### I.4.1 diversification and neutralization

In certain circumstances, simple one-to-one mapping between apparent equivalents in two or more languages does not work very well because the conceptual scope represented by lexemes and expressions in the different languages is frequently not the same.

Example: German *Lack* covers a wide range of concepts expressed in English with very specific lexemes: *paint*, *lacquer*, *varnish*, *shellac*, etc. In this case the German to English direction involves diversification and the English to German direction involves neutralization.

### I.4.2 number of links

Although the strategy of one-to-one equivalence is viable for two languages, it becomes untenable for a more extensive number of languages because the number of links explodes to unmanageable proportions. Furthermore, it cannot necessarily be assumed that if under certain conditions, sense  $L_1-A$  equals  $L_2-A$ , and  $L_1-A = L_3-A$ , that  $L_2-A = L_3-A$ , despite the fact that common logic would imply that this is the case. The larger the number languages and the number of links, the greater the chance that lateral links between the various languages can prove faulty.

### I.4.3 transfer or interlingual pivot

NLP-oriented translation is based on two approaches: the use of an *interlingual pivot*, which operates on the basis of semantic analysis and *transfer*, which is based on machine parsing of source text syntax. The pivot approach is implemented via the *SenseAxis* class, and the transfer approach via the *TransferAxis* class.

### I.4.4 representation of similar languages

Very closely related languages that share significant patterns can be efficiently represented using shared *Sense Axis* instances (resp. *Transfer Axis* instances), together with a limited number of specific *Sense Axis* instances (resp. *Transfer Axis* instances) for representing variations between the languages.

### I.4.5 direction and tests

Some multilingual lexicons are very declarative in that every translation is represented by an interlingual object. Others are very procedural in that they restrict the translation by logical tests applied at the source or target language levels.

## I.5 Description of multilingual notations model

The model is based on the notion of Axes that link *Sense*, *Syntactic Behaviour* and *Sense Example* instances pertaining to different languages. Lexicon designers can freely structure the various axes directly or indirectly between and among different languages. A direct link is implemented by a single axis. An indirect link is implemented using several axes and one or more relations.

The model is based on three main classes:

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- Sense Axis
- Transfer Axis
- Example Axis

### I.5.1 Sense Axis class

*Sense Axis* is a class representing the relationship between different closely related senses in different languages and implements approach based on the interlingual pivot. The purpose is to describe the translation of lexemes from one language to another. Optionally, a *Sense Axis* may refer to an external knowledge representation system where the appropriate equivalent can be found.

### I.5.2 Sense Axis Relation class

*Sense Axis Relation* is a class representing the relationship between two different *Sense Axis* instances.

### I.5.3 Interlingual External Ref class

*Interlingual External Ref* is a class representing the relationship between a *Sense Axis* instance and an external system.

Note Guidelines are given in [24].

### I.5.4 Transfer Axis class

*Transfer Axis* is a class representing multilingual transfer. A *Transfer Axis* instance links several *Syntactic Behaviour* instances pertaining to different languages.

### I.5.5 Transfer Axis Relation class

*Transfer Axis Relation* is a class representing the relationship between two *Transfer Axis* instances.

### I.5.6 Source Test class

*Source Test* is a class representing a condition that affects the translation with respect to the usage on the source language side.

### I.5.7 Target Test class

*Target Test* is a class representing a condition that affects the translation with respect to the usage on the target language side.

### I.5.8 Example Axis class

*Example Axis* is a class representing previously translated translation examples that meet matching or fuzzy matching criteria for a given text chunk.

### I.5.9 Example Axis Relation class

*Example Axis Relation* is a class representing the relationship between two *Example Axis* instances.

## Annex J (informative) NLP multilingual notations examples

### J.1 Example of class adornment

Classes may be adorned with the following attributes:

Class name	Example of attributes	Comment
<i>Sense Axis</i>	label id	It's worth noting that there is no constraint on the types of lexeme that are linked by a <i>Sense Axis</i> instance. For instance, a single lexeme in one language can have as its equivalent a compound in another language.
<i>Sense Axis Relation</i>	label view	The label enables the coding of simple interlingual relations like the specialization of <i>fleuve</i> compared to <i>rivière</i> and <i>river</i> . It is not, however, the goal of this strategy to code a complex knowledge organization system.
<i>Interlingual External Ref</i>	externalSystem externalReference	It is not the purpose of the multilingual extension to provide a complex knowledge organization system, which ideally should be structured as one or several external systems designed specifically for that purpose. However, <i>/externalSystem/</i> and <i>/externalReference/</i> are provided to refer respectively to the name(s) of the external system and to the specific relevant node in this given external system.
<i>Transfer Axis</i>	label id	This approach enables the translation of syntactic arguments involving inversion, such as: fra: "elle me manque" => eng: "I miss her".  Due to the fact that a <i>LexicalEntry</i> can contain as its form a support verb, it is possible to represent equivalents between a simple verb in one language and a more complex verb structure in another language, involving, e.g. a support verb or other supplemental elements, such as in the equivalence relation between French: "Marie rêve" and Japanese: "Marie wa yume wo miru".
<i>Transfer Axis Relation</i>	label variation	The <i>Transfer Axis Relation</i> class may be used to represent slight variations between closely related languages. For instance, in order to represent slight variations between European and

Class name	Example of attributes	Comment
		Brazilian Portuguese, different intermediate <i>Transfer Axis</i> instances can be created. The <i>Transfer Axis Relation</i> class holds a label to distinguish which of the <i>Transfer Axis</i> instances to use depending on the object language.
<i>Source Test</i>	text comment	
<i>Target Test</i>	text comment	
<i>Example Axis</i>	comment source id	The purpose of this class is not to record large scale multilingual corpora; the goal is to link a <i>Lexical Entry</i> instance with a typical sample translation.

## J.2 Examples of lexeme description

### J.2.1 Example of equivalence at sense level

The example shown in figure J.1 illustrates how to use two intermediate *Sense Axis* instances in order represent a near match between *fleuve* in French and *river* in English. This phenomenon is usually called diversification and neutralization. The *Sense Axis* instance on the bottom is not linked directly to any English sense because this notion does not exist in English.

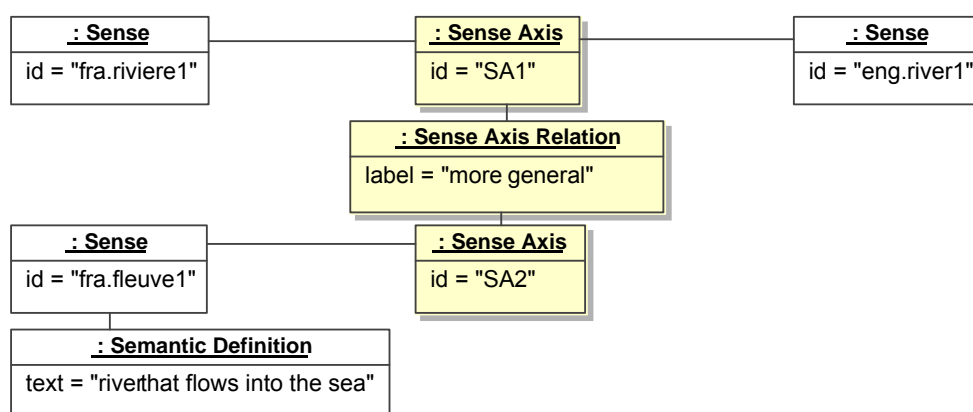


Figure J.1: Instance diagram for "river"

The instances modeled in the multilingual notation annex can be expressed by the following XML fragment, with the assumption that the *Sense* and *Semantic Definition* instances are defined elsewhere:

```

<SenseAxis id="SA1" senses="fra.riviere1 eng.river1">
  <SenseAxisRelation targets="SA2">

```

```

    <feat att="label" val="more general"/>
  </SenseAxisRelation>
</SenseAxis>
<SenseAxis id="SA1" senses="fra.fleuve1"/>

```

## J.2.2 Example of equivalence at transfer level

This example shows how to use the *Transfer Axis Relation* instance to relate different information in a multilingual transfer lexicon. It represents the translation of the English *develop* into Italian and Spanish. Recall that the more general sense links *develop* in English and *desarrollar* in Spanish. Both Spanish and Italian have restrictions that should be tested in the source language: if the second argument of the *Subcategorization Frame* instance refers to certain elements like *building*, it should be translated into specific verbs.

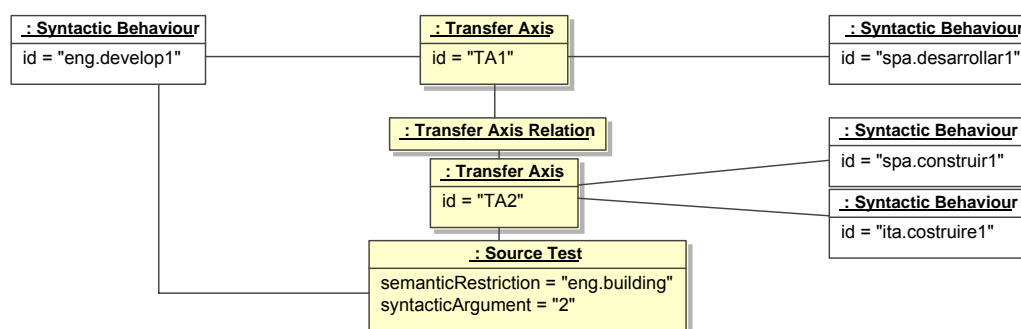


Figure J.2: Instance diagram for "develop"

The instances modeled in the multilingual notation annex can be expressed by the following XML fragment, with the assumption that the *Syntactic Behaviour* instances are defined elsewhere:

```

<TransferAxis id="TA1" syntacticBehaviours="eng.develop1 esp.desarrollar1">
  <TransferAxisRelation targets="TA2"/>
</TransferAxis>
<TransferAxis id="TA2" syntacticBehaviours="esp.construir1 ita.costruire1">
  <SourceTest>
    <feat att="semanticRestriction" att="eng.building"/>
    <feat att="syntacticArgument" att="2"/>
  </SourceTest>
</TransferAxis>

```

## Annex K (normative) NLP paradigm pattern extension

### K.1 Objectives

The objective of this extension is to provide the description in intension of the morphology of a given language. The aim is to support the organization and storage of lexical information needed for the analysis and generation of inflected, agglutinated, derived, or compound word forms. These forms are not explicitly listed but the *Lexical Entry* instance is associated with a shared *Paradigm Pattern* instance. The forms documented in the lexical entry may include the root, stem, or stem allomorphs. And these forms are unique to a specific lexical entry.

The lexical information documented in the paradigm structure may include shared forms (e.g. affixes) and associated rules intended to support the design of morphological lexicons that are process independent. That is, algorithms used to analyze and generate the forms. This extension is not intended to meet all the needs for morphological lexicons; however, LMF core package and this extension provide the basis for developing additional morphology extensions.

## K.2 Class diagram

The following diagram specifies the classes of the Paradigm Pattern model:

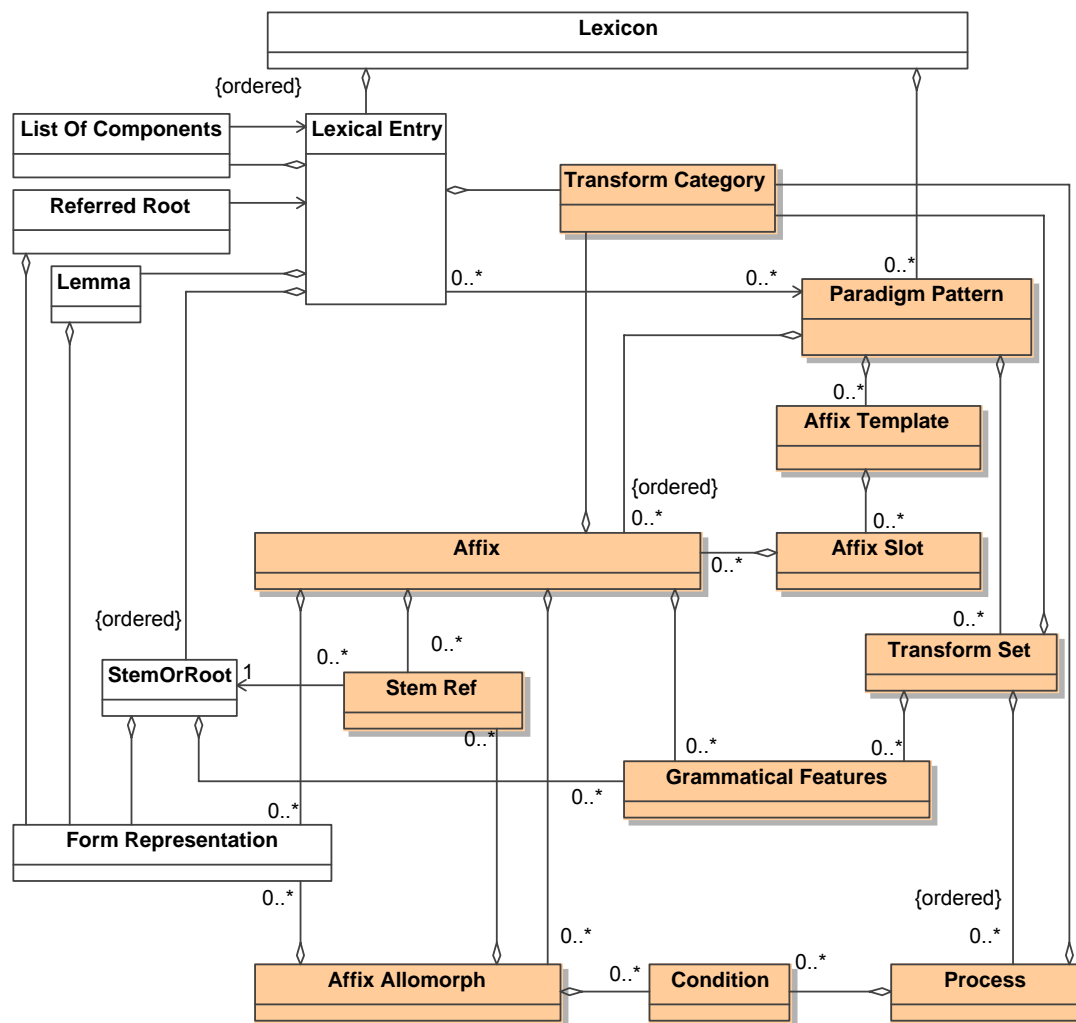


Figure K.1: Paradigm Pattern model

## K.3 Description of the paradigm pattern model

### K.3.1 Introduction

*Lexical Entry* and *Paradigm Pattern* are in aggregate association with the *Lexicon* class. The *Lexical Entry* class manages the word forms and morphs that are unique to a specific lexical entry. In contrast, the *Paradigm Pattern* manages the classes that constitute a paradigm schema shared by several lexical entries.

### K.3.2 Paradigm Pattern class

*Paradigm Pattern* is a class representing the structure of affixes and/or a set of processes that describe a pattern of morphological changes for a given language. *Paradigm Pattern* supports the modelling of inflectional, derivational, agglutinative and compounding patterns and may be subtyped accordingly, e.g. `paradigmType='inflectional'`. Class constraints, associated types of morphological features, and specific pattern choices enable the *Paradigm*

## ISO 24613:2007

*Pattern* class to describe a variety of different methods used by diverse language groups for encoding morphological changes. For example, a *Paradigm Pattern* may be constrained on part of speech to manage inflectional patterns for Indo-European languages, or to be used to manage a reduplication process modelling verb intensification for Thai with no need to constrain on part of speech. A *Paradigm Pattern* can manage an *Affix* class indirectly through the *Affix Slot* class, or can manage the *Affix* class directly, but not both. The *Paradigm Pattern* also manages a *Transform Set* class that supports the modelling of linguistic rules and processes. The *Transform Set* class association and *Affix Slot/Affix* association are not mutually exclusive.

### K.3.3 Transform Set class

*Transform Set* is a class representing the association between *Process* class and *Grammatical Features* class that further define the scope or range of the managed paradigm. *Transform Set* is in a zero to many aggregation with the *Paradigm Pattern*.

### K.3.4 Process class

*Process* is a class representing the rules or linguistic operations applied to one word form or combination of word forms. A *Process* instance can be subtyped, e.g. `processType='phonologicalOperation'` and is in ordered aggregation with the *Transform Set* class.

### K.3.5 Grammatical Features class

*Grammatical Features* is a class representing an unordered combination of grammatical features.

### K.3.6 Condition class

*Condition* is a class representing the conditions that determine or constrain the usage of a *Process* or an *Affix Allomorph* instance.

EXAMPLE: A *Condition* instance may describe the phonetic environments that determine the choice of affix allomorphs.

### K.3.7 Affix class

*Affix* is a class representing an affix, that is a word form or morpheme that is required for analyzing or generating word forms. An *Affix* instance may be refined by several *Form Representation* instances in situations where multiple orthographies are required.

### K.3.8 Affix template class

*Affix Template* is a class managing an *Affix Slot* pattern for inflectional, derivational, and agglutinative morphology. *Affix Template* attributes may describe the type of affix (e.g. suffix, circumfix), the directionality of the affixes, the number of affixes in an ordered set, and any special conditions applicable to the affix pattern (e.g. optionality for specific slots).

NOTE: The direction of the ordered constraint is dependent on the subclass and language. Right-to-left and left-to-right languages would have different orders; also, suffix slots and prefix slots would have different orders.

### **K.3.9 Affix Slot class**

*Affix Slot* is a class managing a set of mutually exclusive affixes that attach to the same position relative to a stem. *Affix Slot* may contain attributes that describe the morphological functions shared by the affixes that occupy the slot.

### **K.3.10 Affix Allomorph class**

*Affix Allomorph* is a class representing allomorphs of the canonical affix form in all scripts and representations. An *Affix Allomorph* may be refined by several *Form Representation* instances in situations where multiple orthographies are required. An *Affix Allomorph* may be associated to *Condition* instances in order to constraint the application of such or such *Affix Allomorph* instance.

### **K.3.11 Transform Category class**

*Transform Category* is a class representing attributes that constrain or describe sets of features needed to manage morphological change.

EXAMPLE: conjugation classes in Spanish or stem groups in Arabic.

### **K.3.12 Stem Ref class**

*Stem Ref* is a class representing a reference to a stem. The stem is referred by a numerical rank and may contain additional attributes such as stem group names. *Stem Ref* class is in a zero to many aggregation with *Affix* or *Affix Allomorph* classes.

## Annex L (informative) NLP paradigm Pattern examples

### L.1.1 Absence versus presence of paradigm patterns in a lexicon

Not all lexicons utilize the paradigm pattern approach. Theoretically, it would be possible to list all forms in a lexicon, but the use of paradigm patterns has the following important advantages:

- Description of languages with complex morphology is possible without resorting to voluminous, unmanageable documentation.
- The linguistic knowledge describing how to associate a lemma with an inflected, agglutinated, compound, derived form is focused on a specific exemplary element instead of being spread throughout a great number of elements.

### L.1.2 Example of class adornment

Classes may be adorned with the following attributes:

Class name	Example of attributes	Comment
Paradigm Pattern	id comment example partOfSpeech paradigmType	A <i>Paradigm Pattern</i> instance is designed to be shared and referred, thus it holds an identifier. A <i>Paradigm Pattern</i> instance cannot be used for two different parts of speech (section K.3.2), so it's important to record the part of speech mark.
Transform Set	comment	This class is designed to link instances, thus, aside from a comment, the class is not intended to be marked with any linguistic information.
Process	operator affixRank componentRank stemRank rule stringValue	The values for /operator/ may be for instance, /addLemma/, /addAffix/, or /addComponentStem/.  The values for rules are string values that can represent a wide range of linguistic rules, for instance, a pattern such as /CVx/ or a formalism such as /[X]n -> [1 u]v/.
Condition	id location agreement affix transformType	
Affix	writtenForm type	The type may be specified for instance with values like /prefix/ or /suffix/.
Affix Template	type	The type may be specified for instance with values like /prefix/ or /suffix/.

Class name	Example of attributes	Comment
Affix Slot	label position	The /position/ specifies where the affix is to be set in the word form.
Affix Allomorph	writtenForm	
Transform Category	id comment	A <i>Transform Category</i> instance is designed to be shared and referred, thus it holds an identifier.
Grammatical Features	grammaticalNumber grammaticalGender grammaticalTense person	

### L.1.3 Examples of lexeme description

#### L.1.3.1 Introduction

The model allows the development of implementation to support different modeling goals, e.g. Item-and-Arrangement model, Item-and-Process model, lemma based approach [11], [12], [13], [14], [15], [17].

The examples are presented in the following order:

- examples of inflection, beginning with simple phenomena and ending with more complex ones
- examples of agglutination
- example of derivation
- examples of composition

*StemOrRoot*, *Affix*, *Lexical Entry* (in *List Of Components* association) and *Process* instances are ordered. In the following diagrams, the order is not mentioned. The assumption is made that the instances are to be read from left to right and top to bottom.

#### L.1.3.2 Inflection using an underspecified paradigm pattern instance

In this example, the lemma *clergyman* is declared as conforming to the *Paradigm Pattern* "asMan". This *Paradigm Pattern* instance has a name but is not analytically described within the lexicon. For instance, the *Paradigm Pattern* may be implemented by an external opaque algorithm.

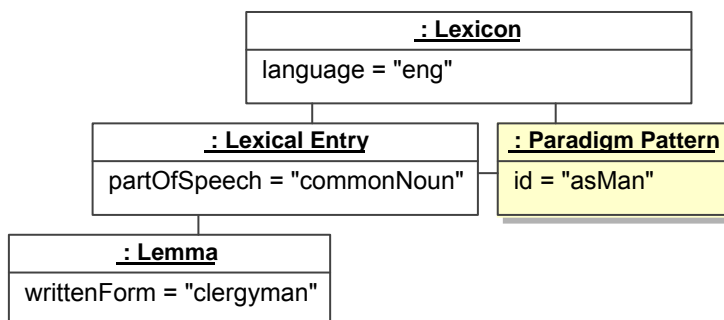


Figure L.1 inflection using an underspecified paradigm pattern

### L.1.3.3 Inflection using the Transform Set Class

This example implements a traditional lemma based inflection using the English noun "table". This lexeme is considered as inflected according to the paradigm pattern "regularNoun". The strategy used in this example is based on the lemma. The singular form is set as the lemma, that is "table". The plural form is set as the lemma plus the affix "s". In the diagram, there is only one affix, but more complex situations may contain more than one affix, thus, in order to adopt a generic strategy, these affixes are numbered. In the example, the affix number is one.

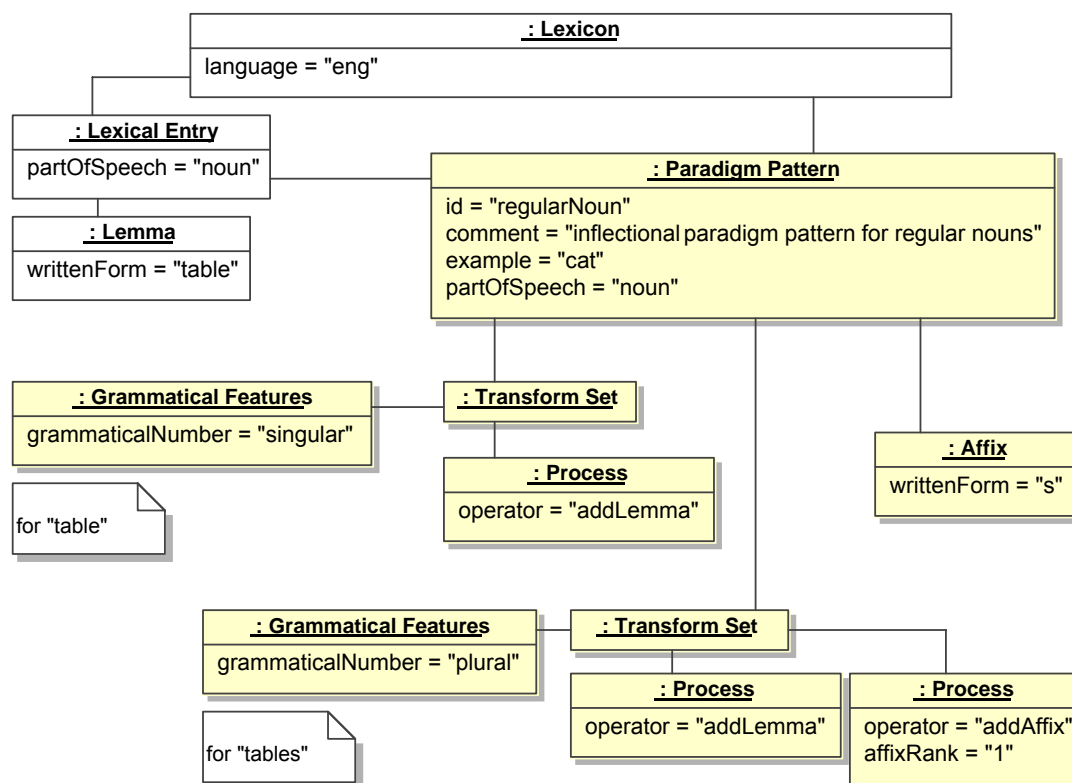


Figure L.2: Inflection using Transform Set and Affix classes

It is possible to adopt a more procedural approach in using an operation that codes the addition of "s" [28]. In this case, the use of an *Affix* instance is not needed, as in the following diagram:

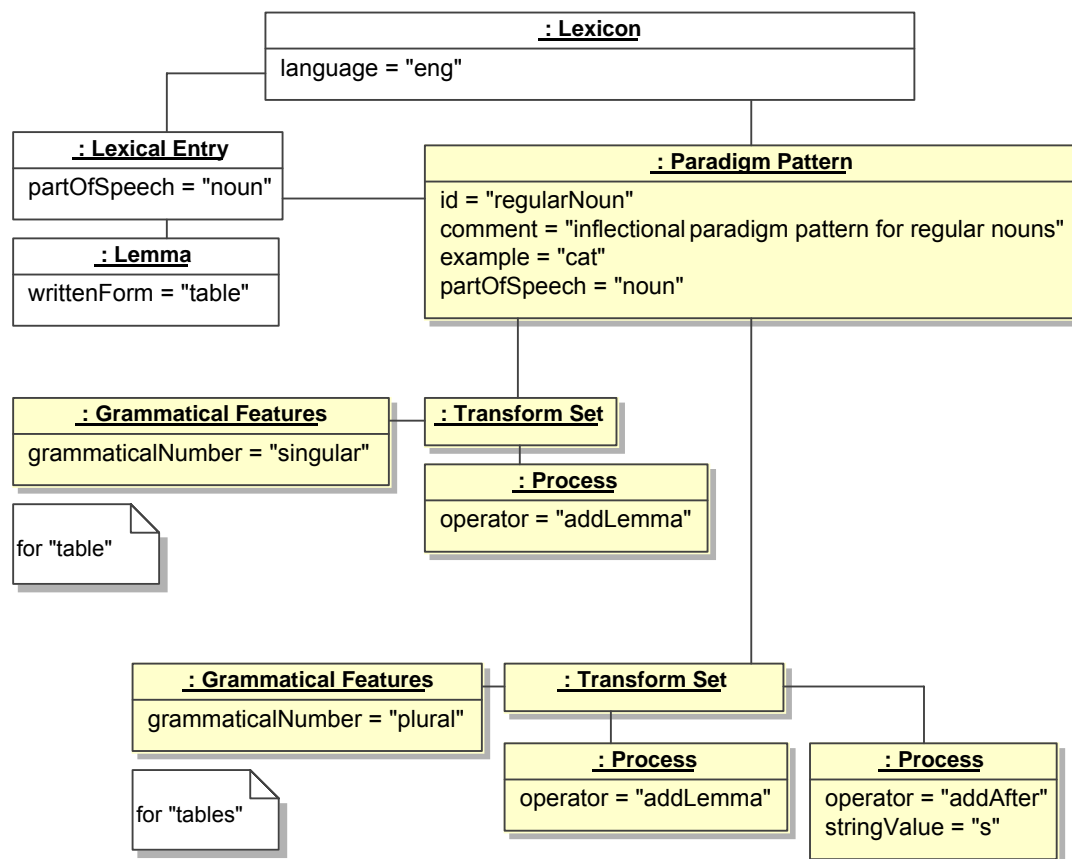


Figure L.3: Inflection using a Transform Set class

#### L.1.3.4 Inflection based on an item and arrangement approach

This example implements an item and arrangement approach. On the lexical entry side, stems are represented and associated with a *Grammatical Features* instance. On the *Paradigm Pattern* side, affixes are associated with *Grammatical Features* instances. Stem and affix combination are correlated through the grammatical features. In other terms, the *Grammatical Features* class functions as a pivot. The first and third person will be associated to "pesqu" + "e" to give "pesque". And the second person will be associated to "pesqu" + "es" to give "pesques".

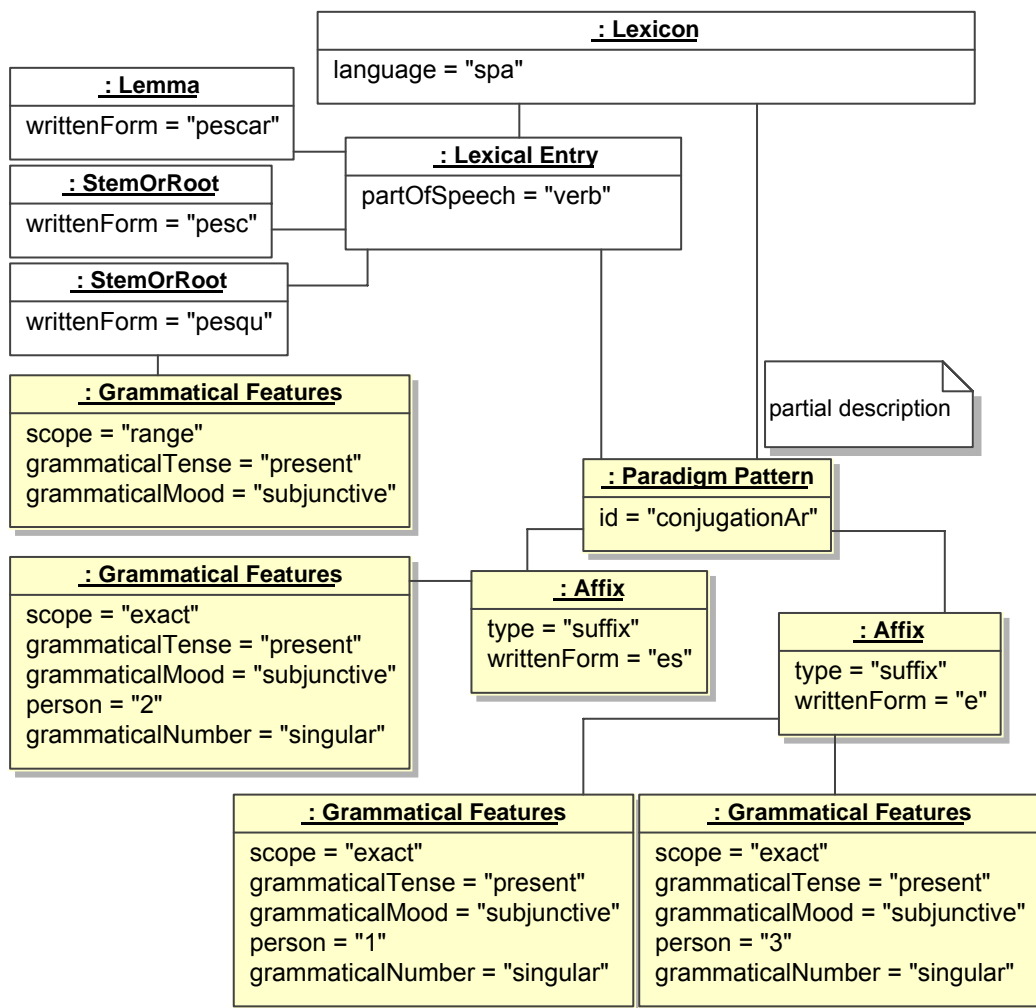


Figure L.4: Inflection using item and arrangement approach (first strategy)

Another item and arrangement strategy is to define a common *Paradigm Pattern* instance for a given part of speech. The lexical entry is associated to a certain number of references to *Transform Category* instances that function as markers. And instead of using a grammatical feature as a pivot, as in the last diagram, different *Transform Category* instances are used to combine stems and affixes.

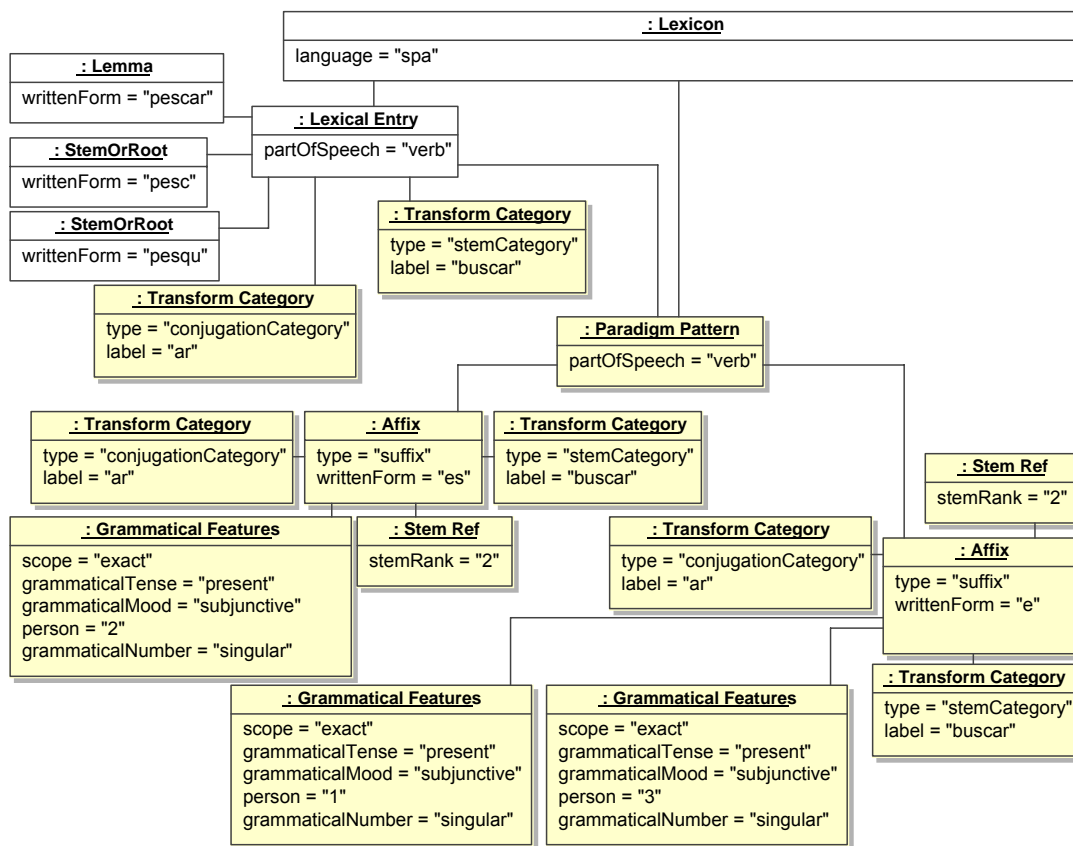


Figure L.5: Inflection using item and arrangement approach (second strategy)

L.1.3.5 Complex inflection: verbal forms in Tagalog

Verbs in Tagalog are difficult to describe by means of a pure item and arrangement approach. This particular example shows how to form the future tense by taking the first consonant, adding the first vowel and adding these letters to the left side of the lemma.

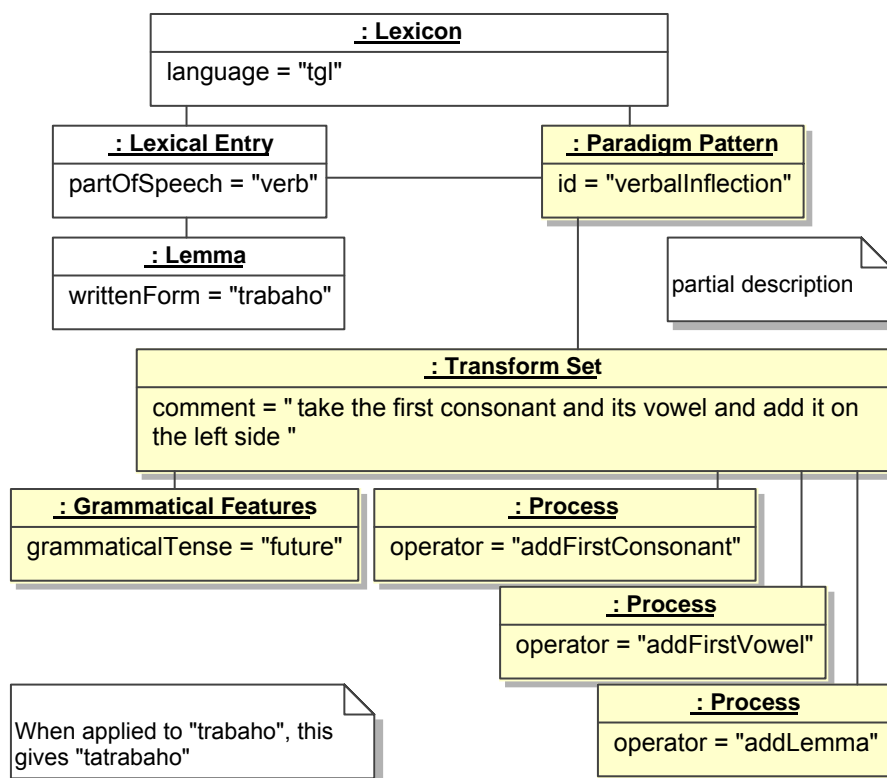


Figure L.6: verbal forms in Tagalog

### L.1.3.6 Lemma based agglutination

This example implements a lemma based strategy with a multiple underlying form (MUF) model for the allomorphs. The examples shown in the previous sections deal with inflectional languages. On the contrary, the following example is about Hungarian that is an agglutinative language. In Hungarian, agglutination is ruled by two interrelated mechanisms that are repeated many times: a suffixation mechanism, where a stem is associated with a suffix, and a vowel harmony mechanism that selects an affix depending on vowel agreement [27].

For instance: "ház" (house) gives "ház+ak" (houses) because of "á", but "szék" (chair) gives "szék+ek" (chairs) because of "é". The system is rather general but cannot be associated with the whole lexicon because there are exceptions. And these exceptions must be recorded in *Paradigm Pattern* instances. For example, imported lexemes that have variants like "hotelban" vs "hotelben" (at the hotel) do not respect the general rule.

Vowel harmony is represented by a *Condition* instance associated with an *Affix Allomorph* instance.

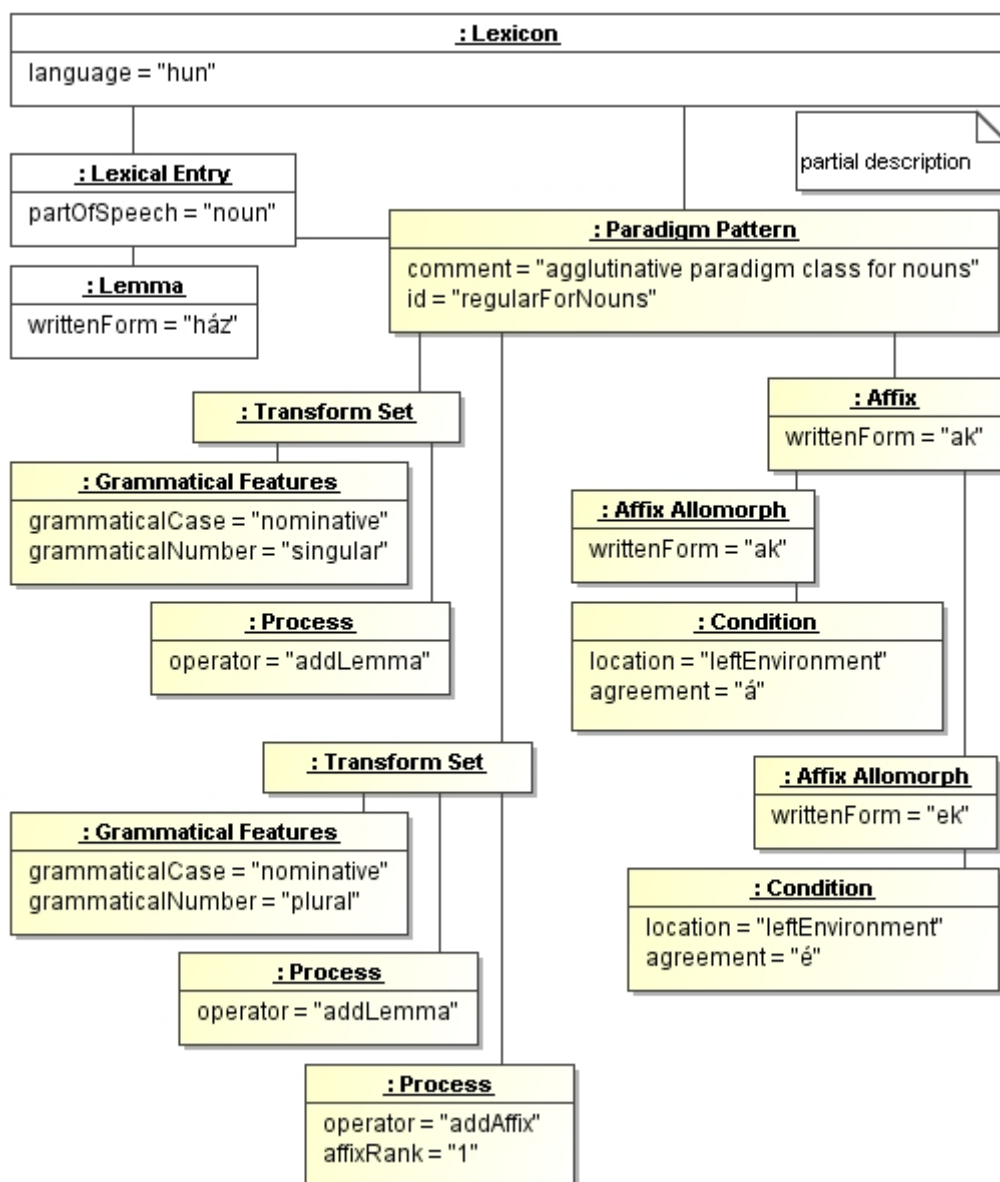


Figure L.7: Lemma based agglutination

It is worth noting that due to the fact that in Hungarian the number of forms for a noun, for instance, is more than two hundred, the strategy of listing all the agglutinated forms explicitly in the lexicon (like in Annex A) produces unmanageable documentation. Usually, a strategy based on paradigm patterns is preferred.

### L.1.3.7 Agglutination using the Suffix Slot class

This example implements an item and arrangement approach. The following diagram shows a simplified Turkish verb conjugation. To support the agglutinative process, each *Affix Slot* instance represents a different verbal aspect. This example shows the suffix for the past tense, using the *Affix Slot* to indicate a tense affix and a *Grammatical Features* instance to indicate past tense. This model differs significantly from the model for Spanish conjugation (as presented previously) where tense and person are both managed through a *Grammatical Features* instance.

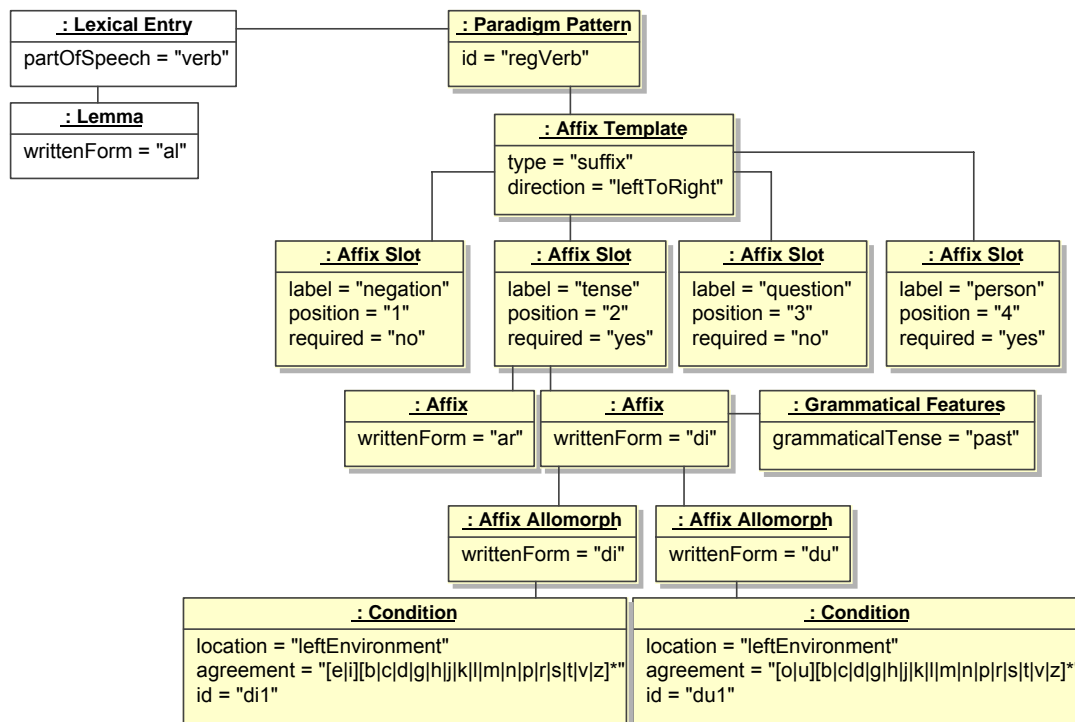


Figure L.8: Agglutination using the Affix slots class

### L.1.3.8 Inflection based on an item and process approach

This example implements an Item and Process approach applied to an Arabic scheme and paradigm pattern description. In the following diagram, 'C' stands for consonant and 'V' stands for vowel. The *Process* class is used to implement rules that may have conditions. The first rule states that "a" is added to the stem for third person singular perfect. The second rule covers phonological changes under certain conditions: if the transform category is C2=C3 and the affix consists of a consonant-vowel-anything combination, then the stem is used. Otherwise, the format is consonant-vowel-consonant-consonant. This approach represents stems, rules and conditions within the lexicon but an external parser is needed to fully interpret the rules.

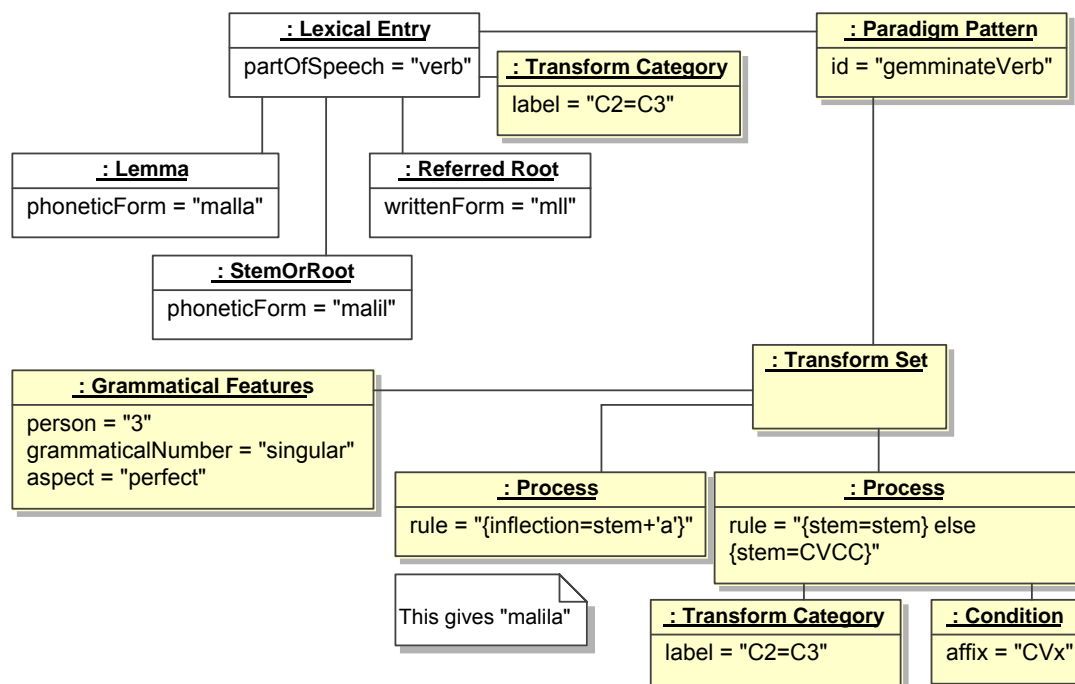


Figure L.9 Arabic dialect scheme

### L.1.3.9 Derivation using reduplication

In Thai, the derivation is a frequent mechanism, thus it is time consuming to record a separate entry for the derived form. Reduplication is used to modify the sense of a lexeme by some operation to repeat the sound of the lemma [25], [26].

The types of derivation using reduplication are:

- AA type. The form of reduplication is generated by attaching a character symbol 'Mai Yamok' (๑ ) to produce a reduplicated sound of the lemma. For instance, the lemma "ดำ" (to be pronounced "dam" and that means "black") can be modified to give "ดำ๑" (to be pronounced "dam-dam" and that means "blackish") in order to express a generalization.
- A'A type (tone change in the first syllable), for instance, "ด้าดำ" (to be pronounced "da:m3-dam0" and that means "extremely black") for intensification.
- AA'A type (triplication), for instance, "กินกินกิน" (to be pronounced "kin-kin4-kin" and that means "eat like a horse") for intensification.
- More complex mechanisms like AABB or AB'AB types.

The two following diagrams show different options for representing derivation. It is worth noting that in these examples, and on the contrary of the other examples, two different *Paradigm Pattern* instances are attached to the given *Lexical Entry* instance.

A first approach is simply to mark the *Paradigm Pattern* instance. In the particular example of "black", two *Paradigm Pattern* instances are linked to one unique and shared *Lexical Entry* instance, as follows:

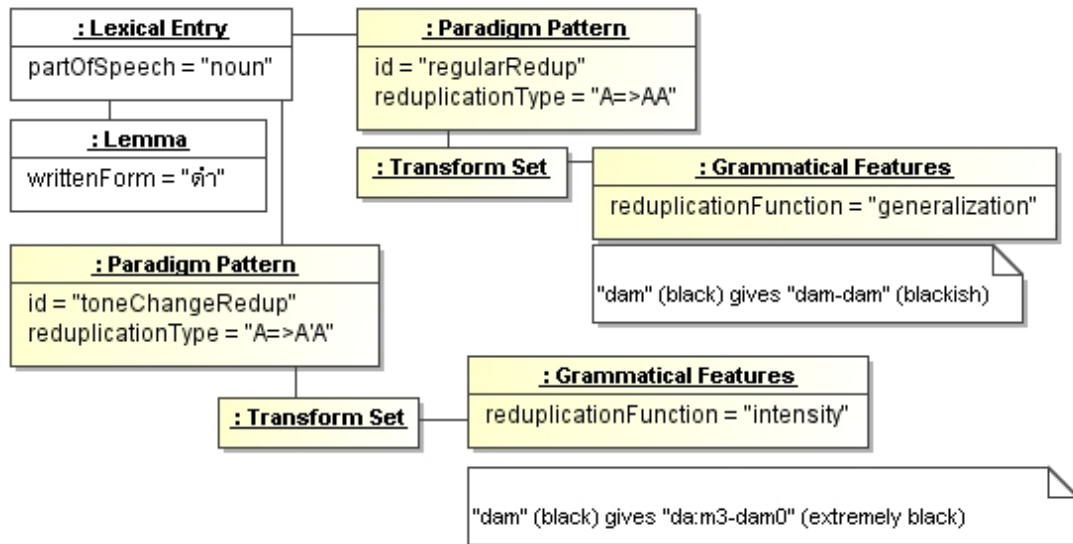


Figure L.10 Derivation using reduplication (simple approach)

A more complex and detailed approach is to describe the reduplication type by means of *Process* instances:

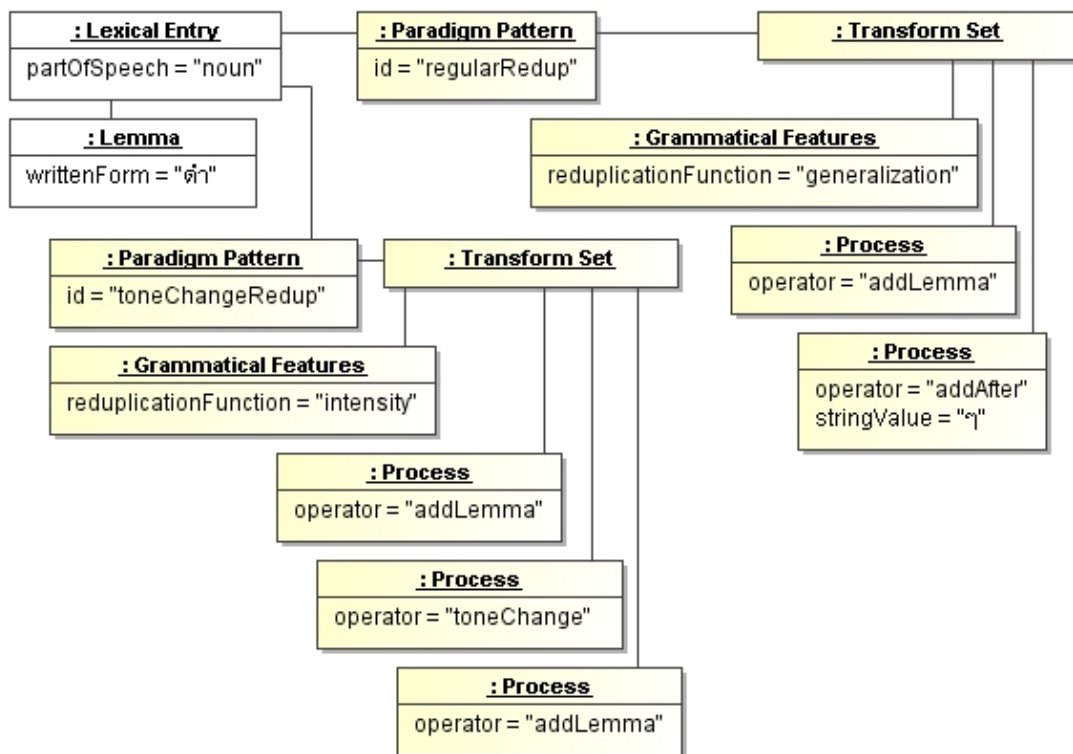


Figure L.11 Derivation using reduplication (complex approach)

It's worth noting that reduplication is not specific to derivation but appears also in languages like Indonesian in order to express plural forms [23].

### L.1.3.10 Lemma based composition: Anwendungsprogramm

Composition is a bit different from inflection, agglutination and derivation. In these latest examples, each form is defined from the lemma (or one stem) of the entry with various operations like adding affixes. And only one entry is concerned by the description.

In the composition process, there is a compound entry whose each form is defined from the *List of Component* instance and thus relies on the morphological behaviour of each component.

The following diagram illustrates a German example of an inflectional paradigm pattern applied to a compound involving the use of an orthographic separator. The compound forms are deduced from the two components presented in the *List Of Components* instance. The lemma is associated with a paradigm pattern that describes how to build the compound. The first component is selected, then an "s" is added and the second component is added with the initial letter transformed into a lowercase letter.

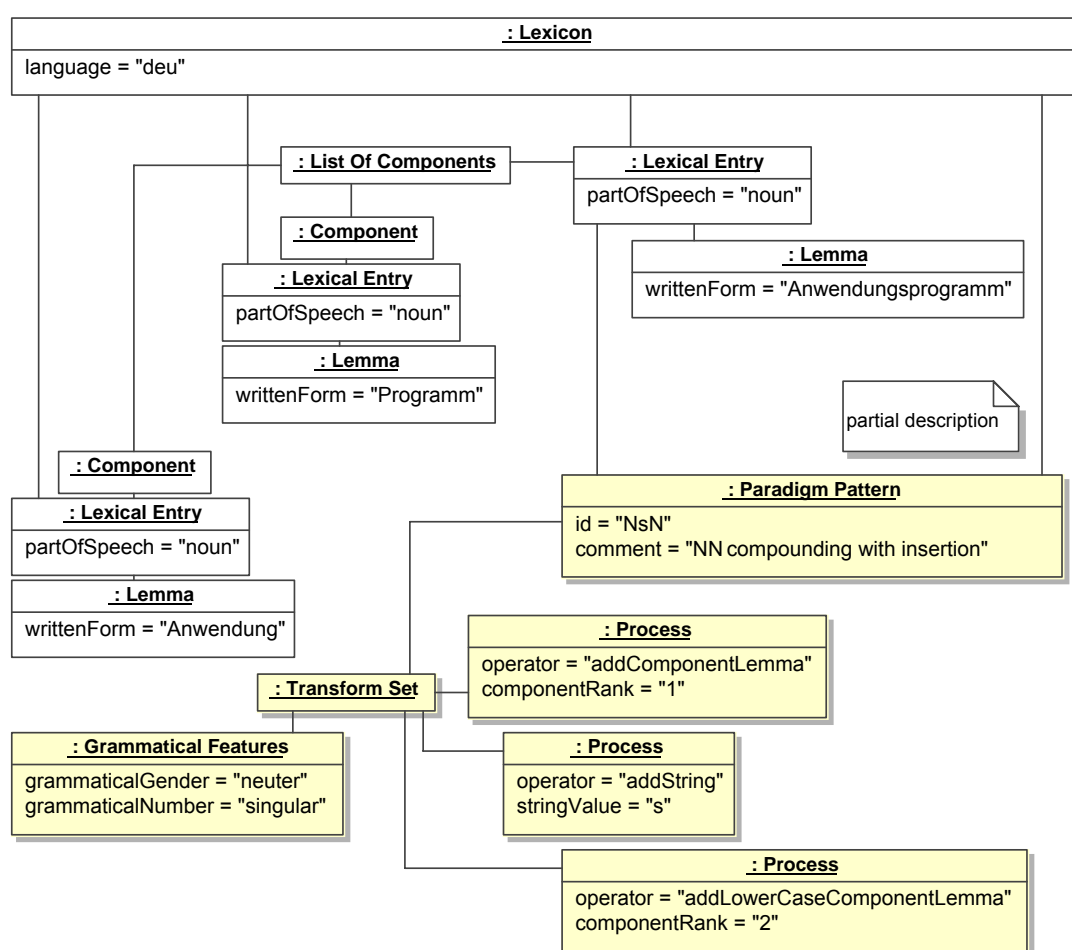


Figure L.12: example of a lemma based composition

### L.1.3.11 Stem based composition: Schulkind

The following figure illustrates a second German example of a paradigm pattern applied to noun-noun compounds involving the use of a stem. In cases where the lemma ends in "e" or "en", there is a truncation of letters from the end during compounding. In this example, "Shule+Kind" produces "Shulkind". Instead of using a "delete" operation on "Schule", this example illustrates an approach which treats "schul" as the stem of the noun "Schule", with the assumption that internal additions transform the initial letter into lowercase.

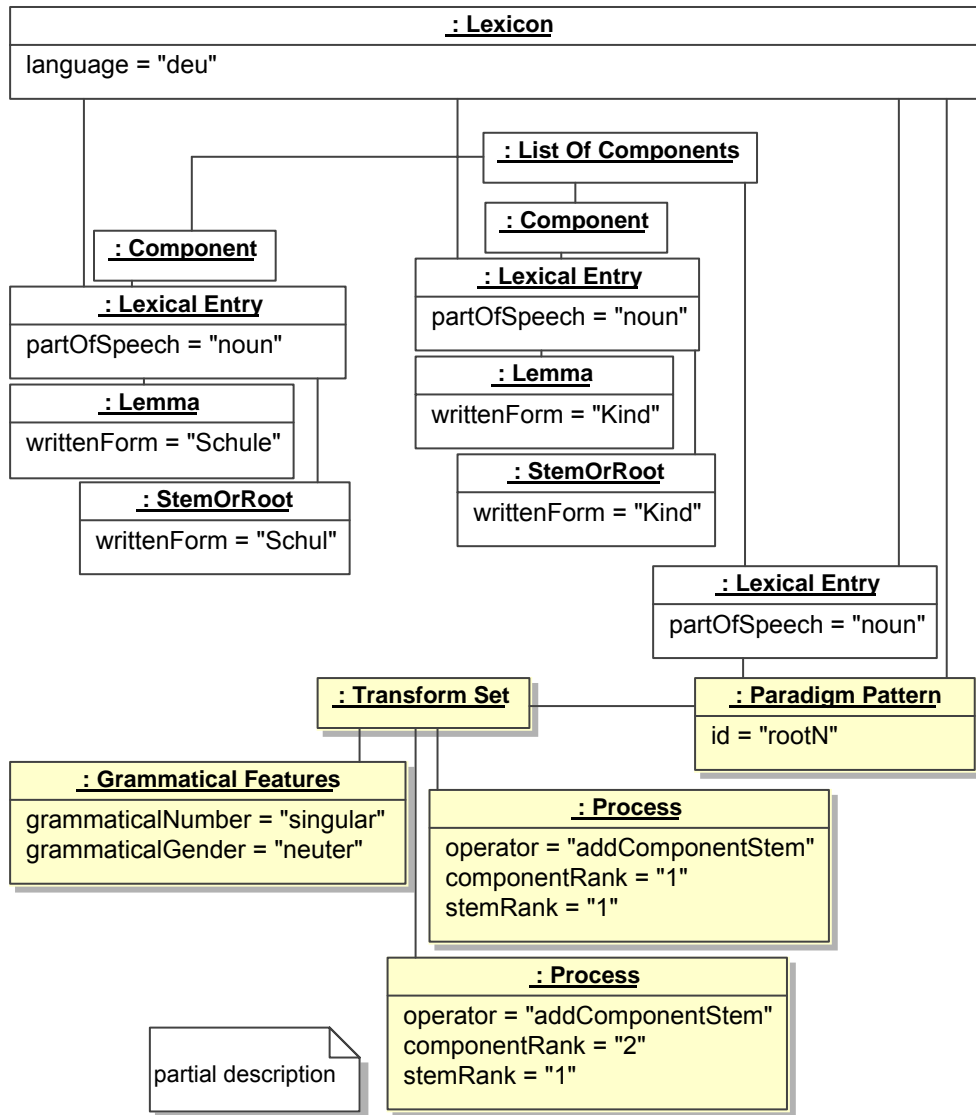


Figure L.13: Example of a stem based composition

## Annex M (normative) NLP multiword expression patterns extension

### M.1 Objectives

The purpose of this section is to allow a representation of the internal (semi-fixed or flexible) structure of MWEs in a given language.

In all languages, MWEs comprise a wide-range of distinct but related phenomena such as collocations, phrasal verbs, noun-noun compounds and many others. Some systems or linguistic traditions also treat shorter idioms as MWEs. Even though some MWEs are fixed, and do not present internal variation such as *ad hoc*, others are much more flexible and allow different degrees of internal variation and modification.

### M.2 Absence versus presence of MWE patterns

It is also possible to describe some MWEs using the Paradigm Class extension, but such cases are limited to simple MWEs without any variation. In contrast, this annex allows for the analysis of the entire MWE based on the grammar of the language.

### M.3 Class diagram

Essentially, the *MWE Pattern* class is a phrase structure grammar.

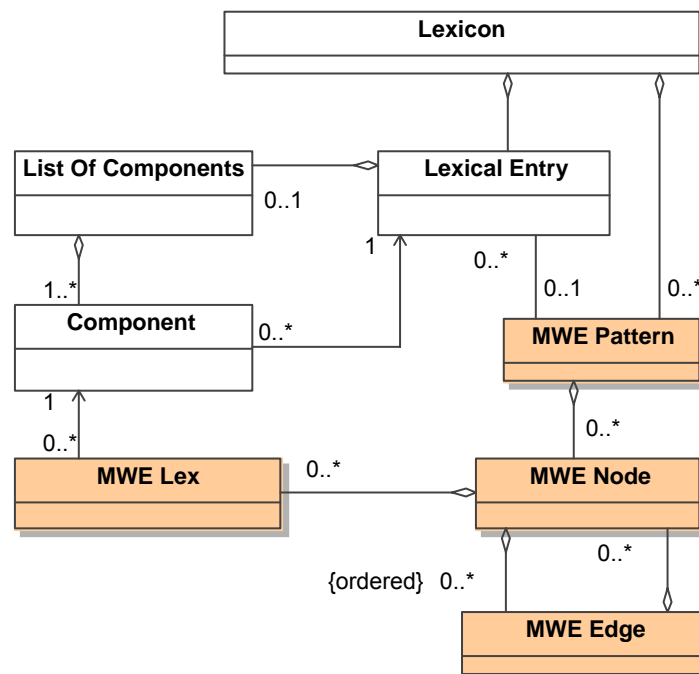


Figure M.1: MWE pattern class model

## **M.4 Description of MWE pattern model**

### **M.4.1 MWE Pattern class**

*MWE Pattern* is a class representing a certain type of lexical combination phenomena. A pattern always refers to the *List Of Components* instances of the *Lexical Entry* instance. *MWE Pattern* shall not to be used for a *Lexical Entry* instance that is not associated with a *List Of Components* instance. An *MWE Pattern* instance is described using *MWE Node* instances.

### **M.4.2 MWE Node class**

*MWE Node* is a class representing the details about the structure of the MWE. A *Combiner* instance can be linked with zero to many *MWE Edge* instances.

### **M.4.3 MWE Edge class**

*MWE Edge* is a class representing a smaller element of information as the *MWE Node* class. A *MWE Edge* instance may itself be associated recursively to a *MWE Node* instance.

### **M.4.4 MWE Lex class**

*MWE Lex* is a class representing a reference to a lexical component. The objective of the whole package being to provide a generic representation of MWE combinations within a given language, the components are not referenced directly but on the contrary, they are referenced by their respective ordering as specified in the *List Of Component* instance.

## Annex N (informative) NLP multiword expression patterns examples

### N.1.1 Example of class adornment

Classes may be adorned with the following attributes:

**Table N.1: Class adornment for NLP Multiword expression patterns**

Class name	Example of attributes	Comment
<i>MWE Pattern</i>	id comment	The purpose of an <i>MWE Pattern</i> instance is to be shared by all the forms that have this structure.  <i>MWE Pattern</i> instances are shared resources and therefore are associated with an <i>id</i> so that they can be targeted by cross-reference links.
<i>MWE Node</i>	syntacticConstituent semanticRestriction grammaticalNumber	
<i>MWE Edge</i>	function	
<i>MWE Lex</i>	structureHead rank graphicalSeparator	

### N.1.2 Example of word description

The example is "to throw somebody to the lions".

The structure contains three sub-structures:

- A fully specified verb: *throw*, referenced by rank one within the *List Of Components* instance;
- A noun phrase: *somebody*, that is not fully specified in the sense that the only restriction that is expressed is that the nucleus of the phrase must be of type */human/*.
- A fully specified second noun phrase *to the lions* referenced by ranks two, three and four within the *List Of Components* instances. This prepositional phrase is labelled as */plural/*.

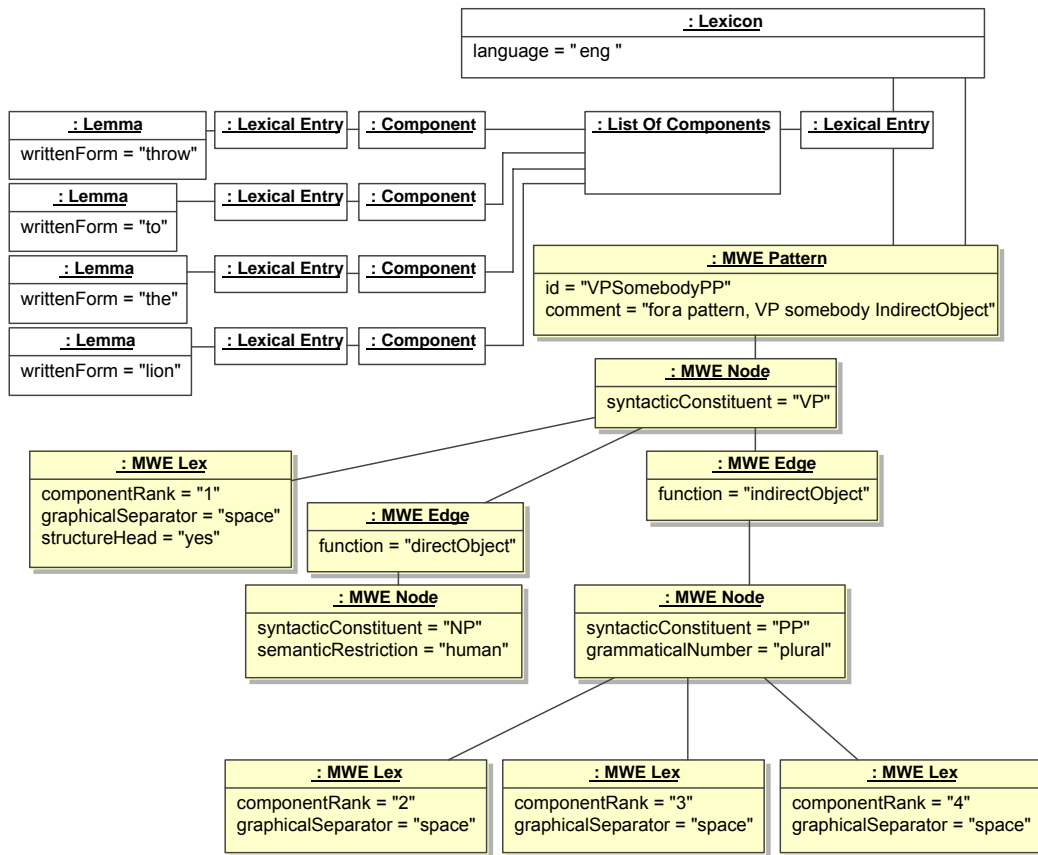


Figure N.1: MWE pattern example

## Annex O (normative) Constraint expression extension

### O.1 Objectives

The aim is to allow the description of constraints on pairs of attribute-values. The scope of the constraints is the *Lexicon* instance.

#### O.1.1 Class diagram

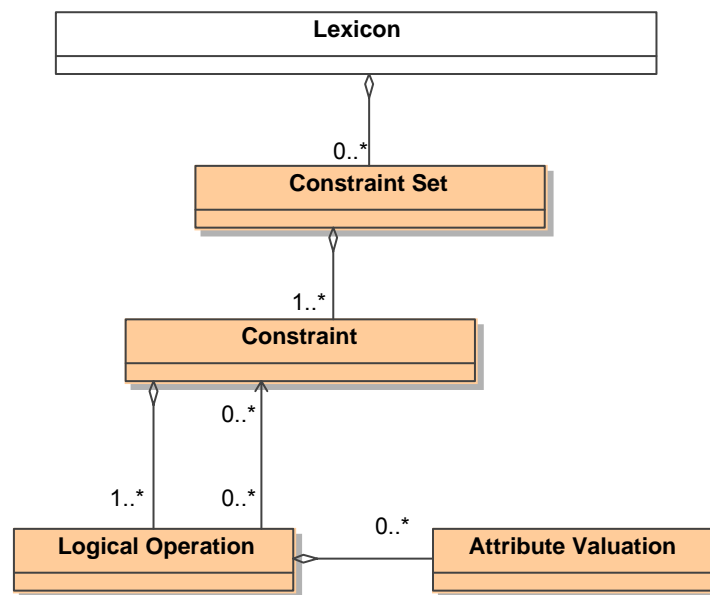


Figure O.1 Constraint Expression model

#### O.1.2 Description of the constraint expression model

##### Constraint Set

*Constraint Set* is a class representing a group of constraints. *Constraint Set* class is associated to *Lexicon* class with a zero to many cardinality.

EXAMPLE: a constraint set defining how to combine every part of speech value of a given language with the grammatical features of this language.

NOTE: it is possible to define a *Constraint Set* instance for the morphological representations of a *Lexicon* instance and a *Constraint Set* instance for the syntactic representations of this given lexicon.

##### Constraint

*Constraint* is a class representing one or several boolean expressions that must be respected in a given *Lexicon* instance.

## ISO 24613:2007

### Logical Operation

*Logical Operation* is a class representing a boolean expression between *Attribute Valuation* instances and *Constraint* instances.

EXAMPLE: A *Logical Operation* instance may represent a conjunction (e.g. a logical and) or a disjunctive conjunction (e.g. a logical or).

NOTE: it is possible to define recursively a *Constraint* instance as a logical combination of other *Constraint* instances.

### Attribute Valuation

*Attribute Valuation* is a class representing a pair between an attribute name of an LMF class and a value of this particular attribute.

EXAMPLE: An *attribute Valuation* instance may be the pair *partOfSpeech* and *adjective*.

## Annex P (informative) Constraint expression example

### P.1 Example of class adornment

Table O.1: Class adornment for constraint expression

Class name	Example of attributes	Comment
<i>Constraint Set</i>	label comment	
<i>Constraint</i>	label	
<i>Logical Operation</i>	operator	The values for the operator attribute may be /logicalAnd/, /logicalOr/, /logicalNot/.
<i>Attribute Valuation</i>	partOfSpeech grammaticalNumber grammaticalGender	A special value /any/ may be used to specify that the attribute is mandatory but that any value may be used.  The class name of this attribute is not specified.

### P.2 Example of constraint expression

In this French example, the *Constraint Set* instance represents a constraint to make explicit that the part of speech adjective varies only according to grammatical number and grammatical gender for a defined set of values. The acceptable values for grammatical gender are *masculine* and *feminine*, that is *neuter* is not allowed, for instance. The acceptable values for grammatical number are *singular* and *plural*, that is *dual* is not allowed, for instance.

More precisely, the *Attribute Valuation* instance for the part of speech is set to a particular value, that is *adjective*. The valid attributes and values are given explicitly fixing the allowed combinations by means of a logical disjunctive conjunction.

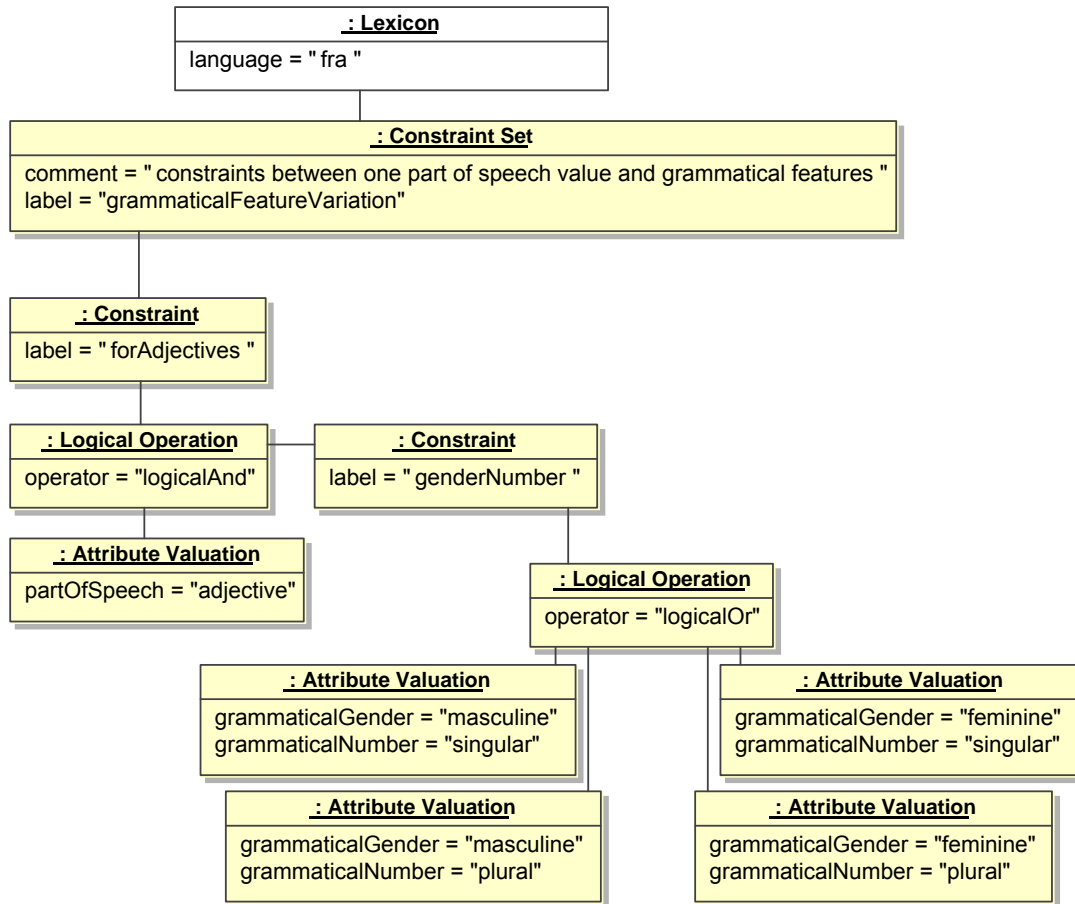


Figure P.1: example of constraint expression

## Annex Q (informative) Connection with Terminological Markup Framework (TMF) and other concept based representation systems

### Q.1 Introduction

The aim of this annex is to provide some guidelines on how to link an LMF compliant lexicon with external systems like Terminological Markup Framework (TMF) resources and other concept based representation systems.

LMF is focused on linguistics properties of words. It is not the purpose of a lexicon to provide a complex knowledge organization system.

### Q.2 Configurations

There are two main different types of lexical resources:

- Configuration 1: *Lexical Resource* instance is monolingual, thus, only one *Lexicon* instance is aggregated in the *Lexical Resource* instance. In this situation, the external linking is attached to a *Sense* instance.
- Configuration 2: *Lexical Resource* instance is multilingual, thus, more than one *Lexicon* instance is aggregated in the *Lexical Resource* instance and *Sense Axis* instances are recorded in order to link *Sense* instances belonging to different languages. In this situation, the external linking is attached to a *Sense Axis* instance.

As defined in Core Package, an attribute is unique, but a *Sense* instance (respectively *Sense Axis* instance) may need to be associated to more than one node of an external system. Thus, the linking is not represented by an attribute-value pair but by the means of a specific class.

In a monolingual configuration, the external linking is represented by a *Monolingual External Ref* instance, as specified in NLP semantic package. The attributes */externalSystem/* and */externalReference/* are provided to refer respectively to the name(s) of the external system and to the specific relevant node in this given external system.

In a multilingual configuration, the external linking is represented by a *Multilingual External Ref* instance, as specified in the NLP multilingual notation package. The attributes */externalSystem/* and */externalReference/* are provided to refer respectively to the name(s) of the external system and to the specific relevant node in this given external system.

## Annex R (informative) LMF DTD

### R.1 Foreword

The following material is provided for information only and covers core package and annexes. XML elements are transcoded from the UML class diagrams [10] with the same name. The class adornment is implemented as a set of *feat* elements.

A user can decide to define another DTD or schema to implement LMF. It is also possible to use the XML structures that are defined in the Feature Structure Representation standard (i.e. ISO 24610-1).

### R.2 LMF DTD

```
<?xml version='1.0' encoding="UTF-8"?>
  <!-- LMF DTD -->
  <!-- ##### Core package -->
<!ELEMENT LexicalResource (feat*, GlobalInformation, Lexicon+, SenseAxis*, TransferAxis*, ExampleAxis*)>
<!ATTLIST LexicalResource
  dtdVersion CDATA #FIXED "14">
<!ELEMENT GlobalInformation (feat*)>
<!ELEMENT Lexicon (feat*, LexicalEntry+, SubcategorizationFrame*, SubcategorizationFrameSet*, SemanticPredicate*, Synset*,
  SynSemCorrespondence*, ParadigmPattern*, MWEPattern*, ConstraintSet*)>
<!ELEMENT LexicalEntry (feat*, Lemma, WordForm*, StemOrRoot*, DerivedForm*, ReferredRoot*, ListOfComponents?,
  TransformCategory*, Sense*, SyntacticBehaviour*)>
<!ATTLIST LexicalEntry
  id ID #IMPLIED
  paradigmPatterns IDREFS #IMPLIED
  mwePattern IDREF #IMPLIED>
<!ELEMENT Sense (feat*, Sense*, Equivalent*, Context*, SubjectField*, PredicativeRepresentation*, SenseExample*,
  Definition*, SenseRelation*, MonolingualExternalRef*)>
<!ATTLIST Sense
  id ID #IMPLIED
  synset IDREF #IMPLIED>
<!ELEMENT Definition (feat*, Statement*, TextRepresentation*)>
<!ELEMENT Statement (feat*, TextRepresentation*)>
<!ELEMENT TextRepresentation (feat*)>
  <!-- ##### Package for Morphology -->
<!ELEMENT Lemma (feat*, FormRepresentation*)>
<!ELEMENT WordForm (feat*, FormRepresentation*)>
<!ELEMENT StemOrRoot (feat*, FormRepresentation*, GrammaticalFeatures*)>
<!ELEMENT FormRepresentation (feat*)>
<!ELEMENT DerivedForm (feat*, FormRepresentation*)>
<!ATTLIST DerivedForm
  targets IDREFS #IMPLIED>
```

## ISO 24613:2007

```
<!ELEMENT ReferredRoot (feat*, FormRepresentation*)>
<!ATTLIST ReferredRoot
  targets IDREFS #IMPLIED>
<ELEMENT ListOfComponents (feat*, Component+)>
<ELEMENT Component (feat*)>
<!ATTLIST Component
  entry IDREF #REQUIRED>
  <!--##### Package for MRD -->
<ELEMENT Equivalent (feat*, TextRepresentation*)>
<ELEMENT Context (feat*, TextRepresentation*)>
<ELEMENT SubjectField (feat*, SubjectField*)>
  <!--##### Package for Syntax -->
<ELEMENT SyntacticBehaviour (feat*)>
<!ATTLIST SyntacticBehaviour
  id ID #IMPLIED
  senses IDREFS #IMPLIED
  subcategorizationFrames IDREFS #IMPLIED
  subcategorizationFrameSets IDREFS #IMPLIED>
<ELEMENT SubcategorizationFrame (feat*, LexemeProperty?, SyntacticArgument*)>
<!ATTLIST SubcategorizationFrame
  id ID #IMPLIED
  inherit IDREFS #IMPLIED>
<ELEMENT LexemeProperty (feat*)>
<ELEMENT SyntacticArgument (feat*)>
<!ATTLIST SyntacticArgument
  id ID #IMPLIED
  target IDREF #IMPLIED>
<ELEMENT SubcategorizationFrameSet (feat*, SynArgMap*)>
<!ATTLIST SubcategorizationFrameSet
  id ID #IMPLIED
  subcategorizationFrames IDREFS #IMPLIED
  inherit IDREFS #IMPLIED>
<ELEMENT SynArgMap (feat*)>
<!ATTLIST SynArgMap
  arg1 IDREF #REQUIRED
  arg2 IDREF #REQUIRED>
  <!--##### Package for Semantics -->
<ELEMENT PredicativeRepresentation (feat*)>
<!ATTLIST PredicativeRepresentation
  predicate IDREF #REQUIRED
  correspondences IDREFS #REQUIRED>
<ELEMENT SemanticPredicate (feat*, Definition*, SemanticArgument*, PredicateRelation*)>
<!ATTLIST SemanticPredicate
  id ID #REQUIRED>
<ELEMENT SemanticArgument (feat*)>
<!ATTLIST SemanticArgument
  id ID #IMPLIED>
```

## ISO 24613:2007

```
<!ELEMENT SynSemCorrespondence (feat*,SynSemArgMap*)>
<!ATTLIST SynSemCorrespondence
  id      ID #REQUIRED>
<!ELEMENT SynSemArgMap (feat*)>
<!ATTLIST SynSemArgMap
  synFeature  CDATA #REQUIRED
  semFeature  CDATA #REQUIRED>
<!ELEMENT PredicateRelation (feat*)>
<!ATTLIST PredicateRelation
  targets    IDREFS #IMPLIED>
<!ELEMENT SenseExample (feat*)>
<!ATTLIST SenseExample
  id        ID #IMPLIED>
<!ELEMENT Synset (feat*, Definition*, SynsetRelation*, MonolingualExternalRef*)>
<!ATTLIST Synset
  id        ID #IMPLIED>
<!ELEMENT SynsetRelation (feat*)>
<!ATTLIST SynsetRelation
  targets    IDREFS #IMPLIED>
<!ELEMENT MonolingualExternalRef (feat*)>
<!ELEMENT SenseRelation (feat*)>
<!ATTLIST SenseRelation
  targets    IDREFS #REQUIRED>
  <!--##### Package for Multilingual notations -->
<!ELEMENT SenseAxis (feat*, SenseAxisRelation*, InterlingualExternalRef*)>
<!ATTLIST SenseAxis
  id        ID #IMPLIED
  senses    IDREFS #IMPLIED
  synsets   IDREFS #IMPLIED>
<!ELEMENT InterlingualExternalRef (feat*)>
<!ELEMENT SenseAxisRelation (feat*)>
<!ATTLIST SenseAxisRelation
  targets    IDREFS #REQUIRED>
<!ELEMENT TransferAxis (feat*, TransferAxisRelation*, SourceTest*, TargetTest*)>
<!ATTLIST TransferAxis
  id        ID #IMPLIED
  syntacticBehaviours IDREFS #IMPLIED>
<!ELEMENT TransferAxisRelation (feat*)>
<!ATTLIST TransferAxisRelation
  targets    IDREFS #REQUIRED>
<!ELEMENT SourceTest (feat*)>
<!ATTLIST SourceTest
  syntacticBehaviours IDREFS #REQUIRED>
<!ELEMENT TargetTest (feat*)>
<!ATTLIST TargetTest
  syntacticBehaviours IDREFS #REQUIRED>
<!ELEMENT ExampleAxis (feat*, ExampleAxisRelation*)>
```

## ISO 24613:2007

```
<!ATTLIST ExampleAxis
  id      ID #IMPLIED
  examples IDREFS #IMPLIED>
<ELEMENT ExampleAxisRelation (feat*)>
<!ATTLIST ExampleAxisRelation
  targets IDREFS #REQUIRED>
  <!--##### Package for paradigm patterns -->
<ELEMENT ParadigmPattern (feat*, TransformSet*, Affix*, AffixTemplate*)>
<!ATTLIST ParadigmPattern
  id      ID #IMPLIED>
<ELEMENT TransformSet (feat*, Process*, GrammaticalFeatures*, TransformCategory*)>
<ELEMENT GrammaticalFeatures (feat*)>
<ELEMENT Process (feat*, Condition*, TransformCategory*)>
<ELEMENT Condition (feat*)>
<ELEMENT Affix (feat*, FormRepresentation*, AffixAllomorph*, StemRef*, GrammaticalFeatures*, TransformCategory*)>
<ELEMENT AffixAllomorph (feat*, FormRepresentation*, StemRef*, Condition*)>
<ELEMENT AffixTemplate (feat*, AffixSlot*)>
<ELEMENT AffixSlot (feat*, Affix*)>
<ELEMENT TransformCategory (feat*)>
  <!--##### Package for MWE patterns -->
<ELEMENT MWEPattern (feat*, MWENode*)>
<!ATTLIST MWEPattern
  id      ID #REQUIRED>
<ELEMENT MWENode (feat*, MWEdge*, MWELex)>
<ELEMENT MWEdge (feat*, MWENode*)>
<ELEMENT MWELex (feat*)>
  <!--##### Package for Constraint expression -->
<ELEMENT ConstraintSet (feat*, Constraint*)>
<ELEMENT Constraint (feat*, LogicalOperation*)>
<!ATTLIST Constraint
  id      ID #IMPLIED>
<ELEMENT LogicalOperation (feat*, AttributeValuation*)>
<!ATTLIST LogicalOperation
  constraints IDREFS #IMPLIED>
<ELEMENT AttributeValuation (feat*)>
  <!--##### for data category adornment: feat stands for feature-->
<ELEMENT feat EMPTY>
  <!-- att=constant to be taken from the DataCategoryRegistry -->
  <!-- val=free string or constant to be taken from the DCR-->
<!ATTLIST feat
  att      CDATA #REQUIRED
  val      CDATA #REQUIRED>
```

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