BRITISH STANDARD

BS ISO/IEC 24707:2007

Information technology — Common Logic (CL): a framework for a family of logic-based languages

ICS 35.060

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee IST/40, Data management and interchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

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Information technology — Common Logic (CL): a framework for a family of logic-based languages

Technologies de l'information — Logique commune (CL): un cadre pour une famille de langages basés sur la logique

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 24707 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 32, *Data management and interchange*.

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Introduction

Common Logic is a logic framework intended for information exchange and transmission. The framework allows for a variety of different syntactic forms, called dialects, all expressible within a common XML-based syntax and all sharing a single semantics.

Common Logic has some novel features, chief among them being a syntax which is signature-free and permits 'higher-order' constructions such as quantification over classes or relations while preserving a first-order model theory, and a semantics which allows theories to describe intensional entities such as classes or properties. It also fixes the meanings of a few conventions in widespread use, such as numerals to denote integers and quotation marks to denote character strings, and has provision for the use of datatypes and for naming, importing and transmitting content on the World Wide Web using XML.

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Information technology — Common Logic (CL): a framework for a family of logic-based languages

1 Scope

This International Standard specifies a family of logic languages designed for use in the representation and interchange of information and data among disparate computer systems.

The following features are essential to the design of this International Standard:

- Languages in the family have declarative semantics. It is possible to understand the meaning of expressions in these languages without appeal to an interpreter for manipulating those expressions.
- Languages in the family are logically comprehensive — at its most general, they provide for the expression of arbitrary first-order logical sentences.
- Interchange of information among heterogeneous computer systems.

The following are within the scope of this International Standard:

- representation of information in ontologies and knowledge bases;
- specification of expressions that are the input or output of inference engines;
- formal interpretations of the symbols in the language.

The following are outside the scope of this International Standard:

- the specification of proof theory or inference rules;
- specification of translators between the notations of heterogeneous computer systems;
- computer-based operational methods of providing relationships between symbols in the logical “universe of discourse” and individuals in the “real world”.

This International Standard describes Common Logic’s syntax and semantics.

It defines an abstract syntax and an associated model-theoretic semantics for a specific extension of first-order logic. The intent is that the content of any system using first-order logic can be represented in this International Standard. The purpose is to facilitate interchange of first-order logic-based information between systems.

Issues relating to computability using this International Standard (efficiency, optimization, etc.) are not addressed.

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2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 2382-15:1999, *Information technology — Vocabulary — Part 15: Programming languages*

ISO/IEC 10646:2003, *Information technology — Universal Multiple-Octet Coded Character Set (UCS)*

ISO/IEC 14977:1996, *Information technology — Syntactic metalanguage — Extended BNF*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
atom
sentence form which has no subsentences as syntactic components

NOTE Can be either an equation, or an atomic sentence consisting of a predicate applied to an argument sequence.

3.2
axiom
any sentence which is assumed to be true, from which others are derived, or by which they are entailed

NOTE In a computational setting, an axiom is a sentence which is never posed as a goal to be proved, but only used to prove other sentences.

3.3
Common Logic Interchange Format
CLIF
KIF-based syntax that is used for illustration purposes in this International Standard

NOTE It is one of the concrete syntaxes as described in Annex A. The name “KIF” is not used for this syntax in order to distinguish it from the commonly used KIF dialects. No assumptions are made in this International Standard with respect to KIF semantics; in particular, no equivalence between CLIF and KIF is intended.

3.4
conceptual graph
CG
graphical or textual display of symbols arranged according to the style of conceptual graph theory

3.5
Conceptual Graph Interchange Format
CGIF
text version of conceptual graphs whose rules of formation conform to Annex B of this International Standard

NOTE Sometimes may refer to an example of a character string that conforms to Annex B. Intended to convey exactly the same structure and semantics as an equivalent conceptual graph.

3.6
conceptual graph theory
form of first-order logic which represents existential quantification and conjunction via the assertion of logical constructs called concepts and relations, which are arranged in an abstract or visually displayed graph

NOTE Conceptual graph theory was introduced by John Sowa [1].

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3.7
denotation
relationship holding between a name or expression and the thing to which it refers

NOTE Also used, with "of," to mean the entity being named, i.e. the referent of a name or expression.

3.8 dialect
concrete instance of Common Logic syntax that shares (at least some of) the uniform semantics of Common Logic

NOTE A dialect may be textual or graphical or possibly some other form. A dialect by definition is also a conforming language (see 7.1 for further details).

3.9
discourse name
name whose interpretation is in the universe of discourse

NOTE There is no assumption that different names are interpreted as different individuals. A single individual in the universe of discourse may be denoted by two or more distinct names.

3.10
domain of discourse
See universe of discourse.

3.11
eXtensible Common Logic Markup Language
XCL
XML-based syntax for Common Logic

3.12
individual
one element of the universe of discourse

NOTE The universe of discourse is the set of all individuals.

3.13
Internationalized Resource Identifier
IRI
string of Unicode characters conforming to the syntax described in [2] and intended for use as an Internet network identifier syntax which can accommodate a wide variety of international character forms

NOTE Intended to replace **Uniform Resource Identifier** as an Internet standard for network identifiers.

3.14
interpretation
formal specification of the meanings of the names in a vocabulary of a Common Logic dialect in terms of a universe of reference.

NOTE 1 An interpretation in turn determines the semantic values of all complex expressions of the dialect, in particular the truth values of its sentences.

NOTE 2 See 6.2 for a more precise description of how an interpretation is defined.

3.15
Knowledge Interchange Format
KIF
text-based first order formalism, using a LISP-like list notation

NOTE 1 KIF, introduced by Mike Genesereth [3], originated with the Knowledge Sharing Effort sponsored by the US DARPA.

NOTE 2 KIF forms the basis for one of the three Common Logic dialects included in this International Standard.

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3.16
operator
distinguished syntactic role played by a specified component within a functional term

NOTE The denotation of a functional term in an interpretation is determined by the functional extension of the denotation of the operator together with the denotations of the remaining components.

3.17
predicate
⟨Common Logic⟩ distinguished syntactic role played by exactly one component within an atomic sentence

NOTE The truth value of an atomic sentence in an interpretation is determined by the relational extension of the denotation of the predicate together with the denotations of the remaining components.

3.18
segregated dialect
dialect in which some names are non-discourse names

NOTE In an interpretation of a segregated dialect, the denotations of the non-discourse names are in the universe of reference, but not in the universe of discourse.

3.19
sentence
⟨Common Logic⟩ unit of logical text which is true or false, i.e. which is assigned a truth-value in an interpretation

3.20
sort
any subset of the universe of discourse over which some quantifier is allowed to range

NOTE Related to the definition of “type” (see 3.24). Generally used to mean a proper subset of the individuals in the universe of discourse.

3.21
sorted logic
logic system (whether first-order or not) which requires that all nonlogical symbols be assigned to a sort

3.22
term
⟨Common Logic⟩ expression which denotes an individual, consisting of either a name or, recursively, a function term applied to a sequence of arguments, which are themselves terms

3.23
traditional first-order logic
TFOL
traditional mathematical formulations of logic as introduced chiefly by Russell, Whitehead, Peano, Frege, Peirce and Tarski dealing with *n*-ary predication, the Boolean operators (including negation) and quantification, and in which every proposition is either determinately true or determinately false

NOTE Languages for traditional first-order logic specifically exclude predicate quantifiers and the use of the same name in both predicate and argument position in atomic sentences, both of which are permitted (though not required) in Common Logic. Languages for traditional first-order logic fall within the category of segregated dialects in CL (see 6.1.3).

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3.24
type
logical framework in which expressions in the logic are classified into syntactic or lexical categories (types) and restricted to apply only to arguments of a fixed type

NOTE 1 In practice, a type represents a class of individuals."Type theory" usually refers to a particular class of such logics in which relation symbols are separated into orders, with relations of order n applying only to those of lower orders.

NOTE 2 A type is more restricted than a sort in that a type imposes intensional or categorical constraints on which individuals are members of the type category, whereas a sort refers only to any subset of individuals in the domain over which some quantifier is presumed to operate.

3.25
universe of discourse
domain of discourse
set of all the individuals in an interpretation, i.e. the set over which the quantifiers range

NOTE Required to be a subset of the universe of reference, and may be identical to it.

3.26
universe of reference
set of all the entities needed to define the meanings of logical expressions in an interpretation

NOTE 1 Required to be a superset of the universe of discourse, and may be identical to it.

NOTE 2 Segregated dialects are commonly described to have a universe of discourse, without mentioning the universe of reference; and for non-segregated dialects the universes of discourse and of reference are identical. The distinction makes it possible to provide a single semantics which can cover both styles of dialect. Non-segregated dialects which treat the universes of discourse and of reference as identical may simply refer to 'the universe' of an interpretation.

3.27
Uniform Resource Identifier
URI
sequence of ASCII characters conforming to the syntax forms defined in [4]

NOTE At the time of writing, the Internet standard syntax for network identifiers. It is likely to be obsoleted by **Internationalized Resource Identifier**.

4 Symbols and abbreviations

These symbols and abbreviations are generally for the main clauses of the standard. Some annexes may introduce their own symbols and abbreviations which will be grouped together within that annex.

4.1 Symbols

Some of these symbols represent terms which are defined in clause 3.

fun_I a mapping from UR_I to functions from UD_I* to UD_I

I an interpretation, in the model-theoretic sense

int_I a mapping from names in a vocabulary V to UR_I; informally, a means of associating names in V to referents in UR_I

rel_I a mapping from UR_I to subsets of UD_I*

seq_I a mapping from sequence markers in V to UD_I*

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V a vocabulary, which is a set of names and sequence markers

UD_I the universe of discourse; a non-empty set of individuals that an interpretation I is "about" and over which the quantifiers are understood to range

UR_I the universe of reference, i.e. the set of all referents of names in an interpretation I

X* the set of finite sequences of the elements of X, for any set X

4.2 Abbreviations

These abbreviations are used in this International Standard. See clause 3 for definitions or further elaboration on these terms.

CG Conceptual graph

CGIF Conceptual Graph Interchange Format

CL Common Logic

CLIF Common Logic Interchange Format

DF Display form (used in Annex B)

EBNF Extended Backus-Naur Format, as in ISO/IEC 14977:1996.

FO First-order

IRI Internationalized Resource Identifier

KIF Knowledge Interchange Format

OWL Web Ontology Language

RDF Resource Definition Framework

RDFS Resource Definition Framework Schema

TFOL traditional first order logic

URI Uniform Resource Identifier

XCL eXtensible Common Logic Markup Language

XML eXtensible Markup Language

5 Requirements and design overview

This clause is informative. Its purpose is to briefly describe the purposes of Common Logic and the overall guiding principles and constraints on its content.

5.1 Requirements

Common Logic has been designed and developed with several requirements in mind, all arising from its intended role as a medium for transmitting logical content on an open communication network. The use of "should" in the rest of clause 5 indicates a desired goal but is not required of either CL or its conforming dialect (in accordance with Annex H of ISO/IEC Directives – Part 2).

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5.1.1 Common Logic should include full first-order logic with equality.

Common Logic syntax and semantics shall provide for the full range of first-order syntactic forms, with their usual meanings. Any conventional first-order syntax will be directly translatable into Common Logic without loss of information or alteration of meaning.

5.1.2 Common Logic should provide a general-purpose syntax for communicating logical expressions.

a. There should be a single XML syntax for communicating Common Logic content.

b. The language should be able to express various commonly used 'syntactic sugarings' for logical forms or commonly used patterns of logical sentences.

c. The syntax should relate to existing conventions; in particular, it should be capable of rendering any content expressible in RDF, RDFS, or OWL.

d. There should be at least one compact, human-readable syntax defined which can be used to express the entire language.

5.1.3 Common Logic should be easy and natural for use on the Web

a. The XML syntax should be compatible with the published specifications for XML, URI syntax, XML Schema, Unicode, and other conventions relevant to transmission of information on the Web.

b. URIs and URI references should be usable as names in the language.

c. URIs should be usable to give names to expressions and sets of expressions, in order to facilitate Web operations such as retrieval, importation, and cross-reference.

5.1.4 Common Logic should support open networks

a. Transmission of content between Common Logic-aware agents should not require negotiation about syntactic roles of symbols, or translations between syntactic roles.

b. Any piece of Common Logic text should have the same meaning, and support the same entailments, everywhere on the network. Every name should have the same logical meaning at every node of the network.

c. No agent should be able to limit the ability of another agent to refer to any entity or to make assertions about any entity.

d. The language should support ways to refer to a local universe of discourse and be able to relate it to other such universes.

e. Users of Common Logic should be free to invent new names and use them in published Common Logic content.

5.1.5 Common Logic should not make arbitrary assumptions about semantics

a. Common Logic does not make gratuitous or arbitrary assumptions about logical relationships between different expressions.

b. If possible, Common Logic agents should express these assumptions in Common Logic directly.

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5.2 A family of notations

This (informative) section describes what is meant by a "family" of languages and gives some of the rationale behind the development of Common Logic.

If we follow the convention whereby any language has a grammar, then Common Logic is a family of languages rather than a single language. Different Common Logic languages, referred to in this International Standard as *dialects*, may differ sharply in their surface syntax, but they have a single uniform semantics and can all be transcribed into the common abstract syntax. Membership in the family is defined by being inter-translatable with the other dialects while preserving meaning, rather than by having any particular syntactic form. Several existing logical notations and languages, therefore, can be considered to be Common Logic dialects.

A Common Logic dialect called CLIF based on KIF (see Annex A) is used in giving examples throughout this International Standard. CLIF can be considered an updated and simplified form of KIF 3.0 [3], and hence a separate language in its own right, and so a complete self-contained description is given which can be understood without reference to the rest of the specification. Conceptual graphs [1] are also a well-known form of first-order logic for machine processing; the CGIF language is specified in Annex B. An XML dialect using CL semantics is specified in Annex C.

6 Common Logic abstract syntax and semantics

This section describes the normative aspects of Common Logic's syntax and semantics.

6.1 Common Logic abstract syntax.

We describe the syntax of Common Logic 'abstractly' here in order to not be committed to any particular dialect's syntactic conventions.

6.1.1 Abstract syntax categories

Each of the following entries is called an *abstract syntax category*. Additional terms in the entries may identify sub-categories, or may identify constituent parts of the category. Those terms being defined here are underlined for clarity. Other terms may be found in the definitions of clause 3.

6.1.1.1 A <u>text</u> is a set, list, or bag of phrases. A piece of text shall optionally be *identified* by a <u>name</u>. *A Common Logic text may be a sequence, a set, or a bag of phrases; dialects may specify which is intended or leave this undefined. Re-orderings and repetitions of phrases in a text are semantically irrelevant. However, applications which transmit or re-publish Common Logic text shall preserve the structure of texts, since other applications are allowed to utilize the structure for other purposes, such as indexing. If a dialect imposes conditions on texts, these conditions shall be preserved by conforming applications. A text may be empty.*

6.1.1.2 A <u>phrase</u> is either a <u>module</u>, a <u>sentence</u>, an <u>importation</u>, or a text with an attached comment.

6.1.1.3 A <u>comment</u> is a piece of data. *Comments may be attached to other comments and to commented phrases. No particular restrictions are placed on the nature of Common Logic comments; in particular, a comment may be Common Logic text. Particular dialects may impose conditions on the form of comments.*

6.1.1.4 A <u>module</u> consists of a name, an optional set of names called the <u>*exclusion set*</u>, and a text called the <u>*body text*</u>. *The module name indicates the 'local' universe of discourse in which the text is understood; the exclusion set indicates any names in the text which are explicitly excluded from this local universe. A module name may also be used to identify the module.*

6.1.1.5 An <u>importation</u> contains a name. The intention is that the name *identifies* a piece of Common Logic content represented externally to the text, and the importation re-asserts that content in the text. *The notion of identification is discussed more fully in clause 6.3.1 below.*

6.1.1.6 A <u>sentence</u> is either a quantified sentence or a Boolean sentence or an atom, or a sentence with an attached comment, or an irregular sentence.

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6.1.1.7 A quantified sentence has (i) a type, called a *quantifier*, (ii) a finite, nonrepeating sequence of names and sequence markers called the *binding sequence*, each element of which is called a *binding* of the quantified sentence, and (iii) a sentence called the *body* of the quantified sentence. Every Common Logic dialect shall distinguish the *universal* and the *existential* types of quantified sentence. A name or sequence marker which occurs in the binding sequence is said to be *bound in* the body. Any name or sequence marker which is not bound in the body is said to be *free in* the body.

6.1.1.8 A Boolean sentence has a type, called a *connective*, and a number of sentences called the *components* of the Boolean sentence. The number depends on the particular type. Every Common Logic dialect shall distinguish five types of Boolean sentences: *conjunctions* and *disjunctions,* which have any number of components, *implications* and *biconditionals*, which have exactly two components, and *negations*, which have exactly one component.

NOTE The current specification does not recognize any particular irregular sentence forms. This category is included in the abstract syntax to accommodate syntactic extensions to Common Logic whose semantics cannot be fully defined within Common Logic. Examples include modalities, non-monotonic connectives and imperative constructions.

6.1.1.9 An atom is either an *equation* containing two *arguments*, which are terms, or is an atomic sentence, which consists of a term, called the *predicate*, and a term sequence called the *argument sequence*, the elements of which are called *arguments* of the atom.

NOTE Dialects which use a name to identify equality may consider it to be a predicate, and treat an equation as an atomic sentence.

6.1.1.10 A term is either a name or a functional term, or a term with an attached comment.

6.1.1.11 A functional term consists of a term, called the *operator*, and a term sequence called the *argument sequence*, the elements of which are called *arguments* of the functional term.

6.1.1.12 A term sequence is a finite sequence of terms or sequence markers.

NOTE Term sequences may be empty, but a functional term with an empty argument sequence shall not be identified with its operator, and an atomic sentence with an empty argument sequence shall not be identified with its predicate.

6.1.1.13 A *vocabulary* is a set of names and sequence markers.

6.1.1.14 Names and sequence markers are disjoint syntax categories, and each is disjoint from all other syntax categories.

This clause completely describes the abstract syntactic structure of Common Logic. Any fully conformant Common Logic dialect **shall** provide an unambiguous syntactic representation for each of the above types of recognized expressions, except for irregular sentences.

Sentence types are commonly indicated by the inclusion of explicit text strings, such as “forall” for universal sentence and “and” for conjunction. However, no conditions are imposed on how the various syntactic categories are represented in the surface forms of a dialect. In particular, expressions in a dialect are not required to consist of character strings.

6.1.2 Metamodel of the Common Logic Abstract Syntax

In order to better describe the structure of the abstract syntax, this section provides a metamodel showing relationships among the syntactic categories, and describes some of the rationale for decisions. The abstract syntax categories and their allowable structure is depicted using UML class diagram notation [5].

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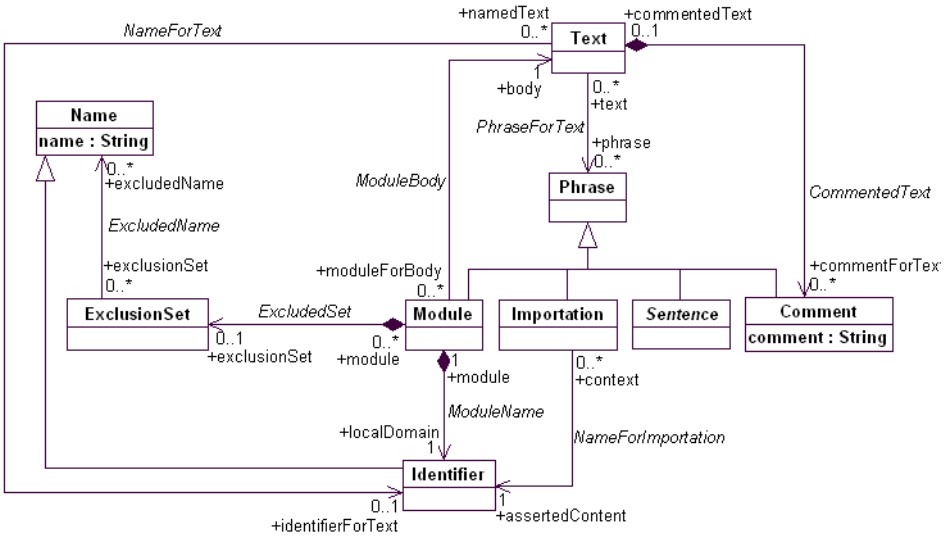

Figure 1 — Structure of a text and the taxonomy of the phrase category *text*

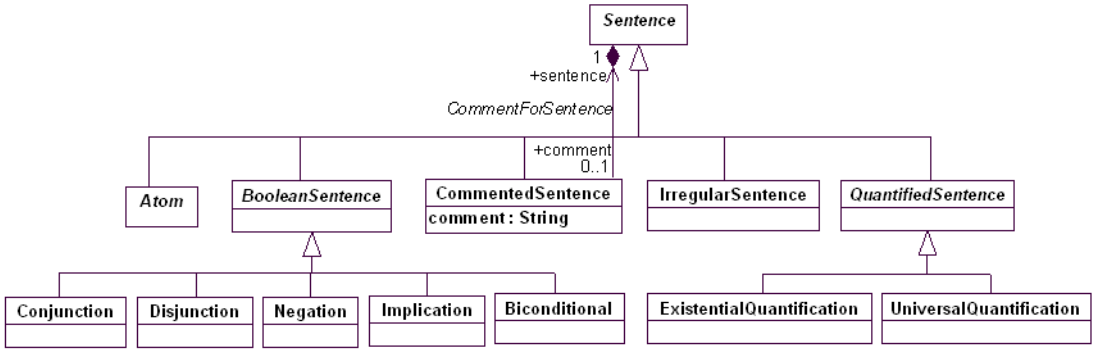

Figure 2 — Abstract syntax of sentence and its sub-categories

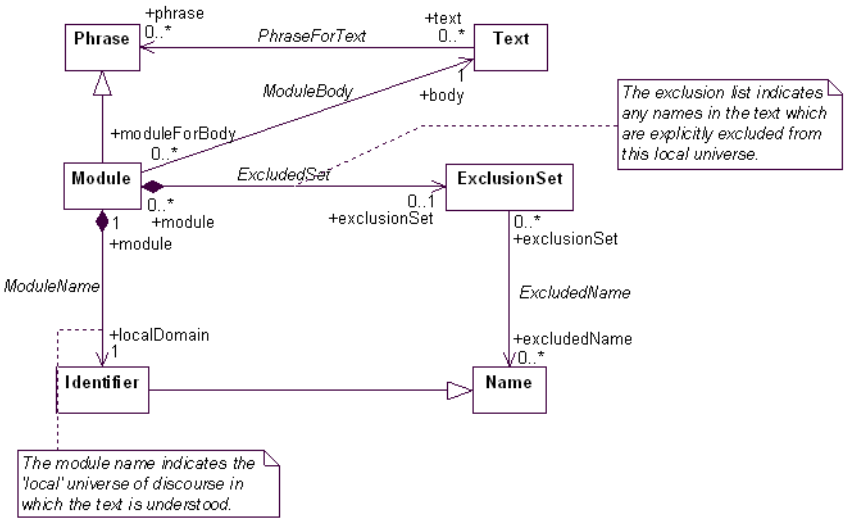

Figure 3 — Abstract syntax of a *module*

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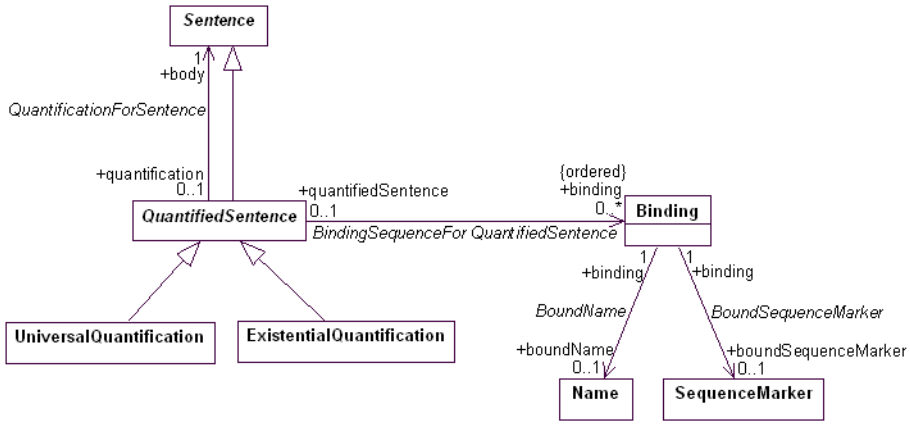

Figure 4 — Abstract syntax of a *quantified sentence*

Figure 4 depicts the abstract syntax of a quantified sentence. A *universally quantified sentence* is a quantified sentence whose quantifier is *universal*. An *existentially quantified sentence* is a quantified sentence whose quantifier is *existential*.

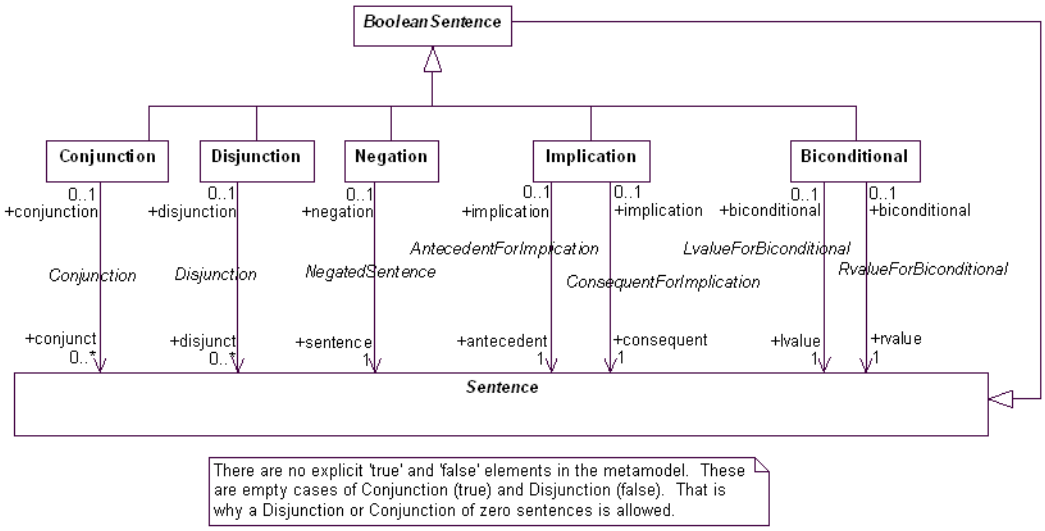

Figure 5 — Abstract syntax of a boolean sentence

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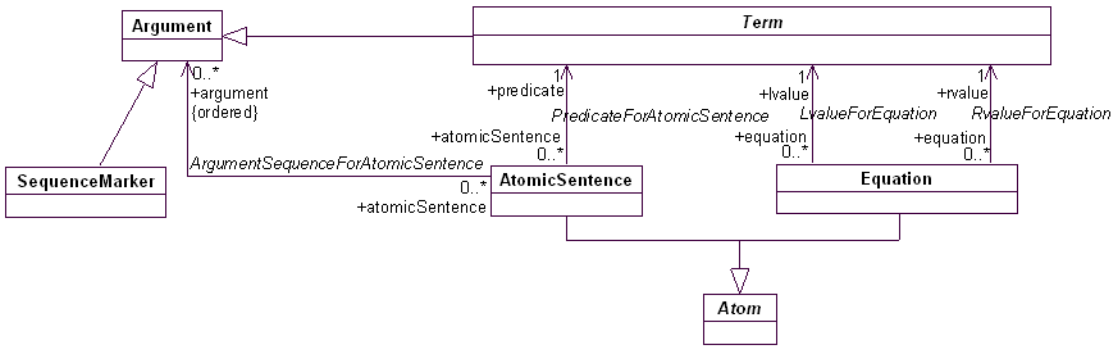

Figure 6 — Abstract syntax of an atom

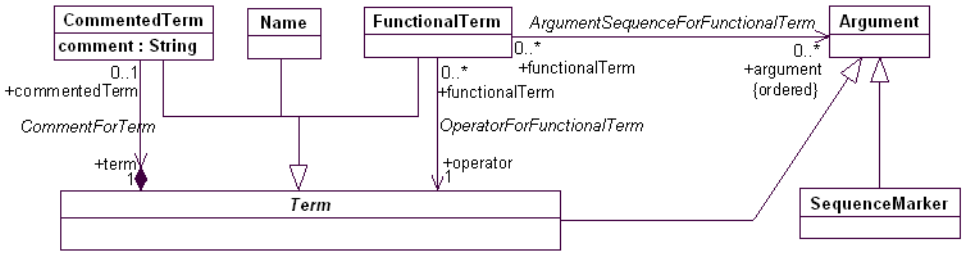

Figure 7 — Abstract syntax of a term and term sequence

6.1.3 Abstract syntactic structure of dialects

A dialect which provides only some types of the Common Logic expressions is said to be a *syntactically partial* Common Logic dialect, or *syntactically partially conformant*. In particular, a dialect that does not include sequence markers, but is otherwise fully conformant, is known as a *syntactically compact* dialect. See clause 7.1 for a description of some relationships between syntactic and semantic conformance.

Dialects **may** in addition provide for other forms of sentence construction not described by this syntax, but in order to be fully conformant, such constructions shall either be new categories defined in terms of these categories, or be extensions of these categories (e.g. new kinds of Boolean sentence, or kinds of quantifier) which are equivalent in meaning to a construction using just this syntax, interpreted according to the Common Logic semantics; that is, they can be considered to be systematic abbreviations, or macros; also known as “syntactic sugar”. The CLIF dialect, described in Annex A, contains a number of syntactic sugared forms for quantified and atomic sentences. (Other types of compliance are also recognized: see clause 7 for a full account of conformance.)

The only undefined terms in the abstract syntax clause are *name* and *sequence marker*. The only required syntactic constraint on the basic lexical categories of *name* and *sequence marker* are that they **shall be** exclusive. Dialects intended for transmission of content on a network **should not** impose arbitrary or unnecessary restrictions on the form of names, and **shall** provide for certain names to be used as identifiers of Common Logic texts; that is, character strings used as identifiers in a dialect shall be parseable as Common Logic names in that dialect. Dialects intended for use on the Web **should** allow Universal Resource Identifiers, International Resource Identifiers and URI references to be used as names [2] [4]. Common Logic dialects **should** define names in terms of Unicode (ISO/IEC 10646:2003) conventions.

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There is no notion of 'bound variable' in the CL abstract syntax. Names that can occur bound are not required to be lexically distinguished from those that can (only) occur free, nor are names required to be partitioned into distinct classes such as relation, function or individual names. There are no sortal restrictions on names. Particular Common Logic dialects **may** make these or other distinctions between subclasses of names, and impose extra restrictions on the occurrence of types of names or terms in expressions – for example, by requiring that names that can occur bound (i.e., the variables of traditional first-order languages) be written with a special prefix, as in KIF, or with a particular style, as in Prolog; or by requiring that operators be in a distinguished category of relation names, as in traditional first-order syntax.

A dialect **may** impose particular semantic conditions on some categories of names, and apply syntactic constraints to limit where such names occur in expressions. For example, the CLIF syntax treats numerals as having a fixed denotation, and prohibits their use as identifiers.

A dialect **may** require some names to be *non-discourse names*, which are understood not to denote entities in the universe of discourse. This requirement may be imposed, for example, by partitioning the vocabulary or by requiring names that occur in certain syntactic positions to be non-discourse. A dialect with non-discourse names is called *segregated*. Names which are not non-discourse names are called *discourse names*.

A segregated dialect **shall** provide sufficient syntactic constraints to guarantee that in any syntactically legal text of the dialect:

- Every name shall be classified as either discourse or as non-discourse.
- No name shall be classified as both discourse and non-discourse.
- No non-discourse name shall be an argument of an atom or functional term.
- No non-discourse name shall be bound in a quantified sentence.

As the presence of non-discourse names affects the semantics, special conditions apply to segregated dialects.

A dialect which is not segregated is called *non-segregated*. All names in a non-segregated dialect are discourse names.

6.2 Common Logic semantics

The semantics of Common Logic is defined in terms of a satisfaction relation between Common Logic text and mathematical structures called *interpretations*.

The vocabulary of a Common Logic text is the set of names and sequence markers which occur in the text. In a segregated dialect, the names in vocabularies are partitioned into discourse names and non-discourse names.

An *interpretation* I of a vocabulary V is a set UR_I , the *universe of reference*, with a distinguished nonempty subset UD_I, the *universe of discourse*, and four mappings:

- rel_I from UR_I to subsets of $UD_I^* = \{<x_1,...,x_n> \mid x_1,\ldots,x_n \in UD_I\}$ (i.e., the set of finite sequences of elements of UD_I). Note that the empty sequence is in UD_I^*, for any UD_I;
- fun_I from UR_I to total functions from UD_I^* into UD_I, that is, to functions that map each sequence in UD_I^* to a (unique) element of UD_I;
- int_I from names in V to UR_I, such that $int_I(v)$ is in UD_I if and only if v is a discourse name;

  NOTE If the dialect recognizes irregular sentences, then they are treated as names of propositions, and int_I also includes a mapping from the irregular sentences of a text to the truth values { true, false }.

- seq_I from sequence markers in V to UD_I^*.

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Intuitively, UD_I is the universe or domain of discourse containing all the individual things the interpretation is 'about' and over which the quantifiers range. UR_I is a potentially larger set of things that might also contain entities which are not in the universe of discourse. In particular, UR_I might contain relations not in UD_I to serve as the interpretations of the non-discourse names in a segregated dialect. All names are interpreted in the same way, whether or not they are understood to denote something in the universe of discourse; that is why there is only a single interpretation mapping that applies to all names, regardless of their syntactic role. In particular, rel_I(x) is in UD_I* even when x is not in UD_I. When considering only segregated dialects, the elements of the universe of reference which are outside the universe of discourse may be identified with their corresponding values of the rel_I and fun_I mappings, which are then re-interpreted to be the identity mapping. The resulting construction maps predicates directly to relations and operators to functions, yielding a more traditional interpretation structure for the segregated syntax of traditional first-order logic. On the other hand, when considering only non-segregated dialects, the distinction between universes of reference and discourse is unnecessary, since they may be considered to be identical. The distinction is made here in order to give a uniform treatment of both segregated and non-segregated dialects.

Irregular sentences are treated as though they were arbitrary propositional variables. Note this does not affect the CL interpretations of any CL sentences which occur as syntactic components of an irregular sentence. Note also that, although sequence markers are mapped into finite sequences in an interpretation, these sequences are not denoted by names, and so are not required to be in the universe of reference.

The assignment of semantic values to complex expressions – notably, the assignment of truth values to sentences – requires some auxiliary definitions.

Let S be a subset of V. An interpretation J of V is an *S-variant of* I if it is exactly like I except that int_J and seq_J might differ with int_I and seq_I on what they assign to the members of S. More formally, J is an S-variant of I if $UR_J = UR_I$, $UD_J = UD_I$, $rel_J = rel_I$, $fun_J = fun_I$, $int_J(n) = int_I(n)$ for names $n \notin S$ and $seq_J(s) = seq_I(s)$ for sequence markers $s \notin S$.

If E is a subset of UD_I, then the *restriction* of I to E is an interpretation K of the same vocabulary and over the same universe and with $int_K = int_I$ and $seq_K = seq_I$, but where UD_K = E, rel_K(v) is the restriction of rel_I(v) to E* and fun_K(v) is the restriction of fun_I(v) to E*->E, for all v in the vocabulary of I. If **N** is a set of names, the *retraction* of I *from* **N**, [I<**N**], is the restriction of I to the set (UD_I – {int_I(v): v in **N** }).

If s = <s_1, ..., s_n> and t = <t_1, ..., t_m> are finite sequences, then s;t is the concatenated sequence <s_1, ..., s_n, t_1, ..., t_m>. In particular, s;<> = s for any sequence s.

The value of any expression E in the interpretation I is given by following the rules in Table 1.

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Table 1 — Interpretations of Common Logic Expressions

	If E is an expression of the form	**Then I(E) =**
E1	name **N**	int_I(**N**)
E2	sequence marker **S**	seq_I(**S**)
E3	term sequence $\mathbf{T}_1 \ldots \mathbf{T}_n$ with $\mathbf{T}_1$ a term	<I($\mathbf{T}_1$)>;I(<$\mathbf{T}_2 \ldots \mathbf{T}_n$ >)
E4	term sequence $\mathbf{T}_1 \ldots \mathbf{T}_n$ with $\mathbf{T}_1$ a sequence marker	I($\mathbf{T}_1$);I(<$\mathbf{T}_2 \ldots \mathbf{T}_n$ >)
E5	term with operator **O** and argument sequence **S**	fun_I(I(**O**))(I(**S**))
E6	Atom which is an equation containing terms $\mathbf{T}_1$, $\mathbf{T}_2$	true if I($\mathbf{T}_1$) = I($\mathbf{T}_2$), otherwise false
E7	Atomic sentence with predicate **P** and argument sequence **S**	true if I(**S**) is in rel_I(I(**P**)), otherwise false
E8	boolean sentence of type negation and component **C**	true if I(**C**) = false, otherwise false
E9	boolean sentence of type conjunction and components $\mathbf{C}_1$ ... $\mathbf{C}_n$	true if I($\mathbf{C}_1$) = … = I($\mathbf{C}_n$) = true, otherwise false
E10	boolean sentence of type disjunction and components $\mathbf{C}_1$ ... $\mathbf{C}_n$	false if I($\mathbf{C}_1$) = … = I($\mathbf{C}_n$) = false, otherwise true
E11	boolean sentence of type implication and components $\mathbf{C}_1$, $\mathbf{C}_2$	false if I($\mathbf{C}_1$) = true and I($\mathbf{C}_2$) = false, otherwise true
E12	boolean sentence of type biconditional and components $\mathbf{C}_1$, $\mathbf{C}_2$	true if I($\mathbf{C}_1$) = I($\mathbf{C}_2$), otherwise false.
E13	quantified sentence of type universal with bindings **N** and body **B**	true if for every **N**-variant J of I, J(**B**) is true; otherwise false
E14	quantified sentence of type existential with bindings **N** and body **B**	true if for some **N**-variant J of I, J(**B**) is true; otherwise false
E15	irregular sentence **S**	int_I(**S**)
E16	phrase which is a sentence **S**	I(**S**)
E17	phrase which is an importation containing name **N**	true if I($text$(I(**N**))) = true, otherwise false
E18	module with name **N**, exclusion set **L** and body text **B**	true if [I<**L**](**B**) = true and rel_I(I(**N**)) = $UD_{[I<L]}{}^*$, otherwise false
E19	text containing phrases $\mathbf{S}_1$ … $\mathbf{S}_n$	true if I($\mathbf{S}_1$) = … = I($\mathbf{S}_n$) = true, otherwise false
E20	a text **T** with a name **N**	UR_I contains a named text value **t** with $text$(**t**) = **T** and $name$(**t**) = **N**

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The meaning of the function *text* in clauses E17 for importation and E20, and the associated notion of a *named text value*, are described in the next section.

These are the basic logical semantic conditions which all conforming dialects must satisfy. A dialect may impose further semantic conditions in addition to these. A dialect with extra semantic conditions is a *semantic extension*. In particular, semantic extensions may impose syntactic and semantic conditions on irregular sentences, but **shall not** use irregular sentence forms to represent content that is expressible in Common Logic text.

A semantic extension which fixes the meanings of certain special names (such as datatypes), or specifies relationships between Common Logic and other naming conventions, such as network identification conventions, is called *external*. External semantic constraints may refer to conventions or structures which are defined outside the model theory itself. For example, the CLIF dialect refers to numbers. The semantics of importations, described in the next section, is external and normative.

Table 1 specifies no interpretation for comments. Phrases with a comment and an empty text may be considered to be vacuously true; expressions with attached comments **shall** have identical truth-conditions as the same expressions with the comments not attached. Thus, adding or deleting comments does not change the truth-conditions of any Common Logic text. Nevertheless, comments are part of the formal syntax and applications **should** preserve them when transmitting, editing or re-publishing Common Logic text. In particular, a name used to identify a phrase in Common Logic is understood to be a globally rigid identifier of that text as written (see next section), so that the same name **shall not** be used to refer to a different text, even if the texts have the same meaning.

6.3 Importing and identification on a network

This section applies only to dialects which support importations and/or named texts. It is normative when it applies. (This treatment of naming and identifying is partly based on that in [6].)

6.3.1 Importations and named phrases

The meaning of an importation phrase is that the name it contains shall be understood to identify some Common Logic text, and the importation is true just when that text is true. Thus, an importation amounts to a virtual ‘copying’ of some Common Logic content from one ‘place’ to another. This idea of ‘place’ and ‘copying’ can be understood only in the context of deploying logical content on a communication network. A *communication network*, or simply a *network*, is a system of agents which can store, publish or process Common Logic text, and can transmit Common Logic text to one another by means of information transfer protocols associated with the network. The most widely used network is the World Wide Web [7], but the definitions in this section apply to any such system of communicating agents. In particular, a subset of Web nodes which uses special conventions for communication may be considered to be a Common Logic network. A network is presumed to support communication and publication of Common Logic content in some subset of dialects. XCL is intended to be a general-purpose dialect for distributing Common Logic content on any network which supports XML.

Names used to name texts on a network are understood to be *rigid* and to be *global* in scope, so that the name can be used to identify the thing named – in this case, the Common Logic text – across the entire communication network. (See [8] for more full discussion.) A name which is globally attached to its denotation in this way is an *identifier*, and is typically associated with a system of conventions and protocols which govern the use of such names to identify, locate and transmit pieces of information across the network on which the dialect is used. While the details of such conventions are beyond the scope of this International Standard, we can summarize their effect by saying that the act of publishing a named Common Logic text is intended to establish the name as a rigid identifier of the text, and Common Logic acknowledges this by requiring that *all* interpretations shall conform to such conventions when they apply to the network situation in which the publication takes place.

Named texts are not required to be in 1:1 correspondence to documents, files or other units of data storage. Dialects or implementations may provide for texts to be distributed across storage units, or for multiple named texts to be stored in one unit. The naming conventions for text may be related to the addressing conventions in use for data units, but this is not required. Texts may also be identified by external naming conventions, for

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example by encoding the text in documents or files which have network identifiers; the Common Logic semantics described in this section **shall** be applicable to all names used as network identifiers on a network on which Common Logic texts are published or transmitted.

The act of naming a text is distinct from that of asserting the truth of the text itself. Publishing a named text does not, in itself, necessarily make any claim about the truth of the text; but it does make a claim about the denotation of the name of the text.

In order to state semantic conditions on identifiers we need to assume appropriate values to exist in the universe of discourse. The semantic entity corresponding to a named text is called a *named text value*. The exact nature of a named text value is unimportant, but the semantics considers them to be pairs consisting of a name and a Common Logic text: **t** = <*name*(**t**), *text*(**t**)>. The rigid identifier convention is an external semantic condition which *all* interpretations of texts published on the communication network are required to satisfy. The global rigidity of the naming is captured by the universality of this requirement. Note that this is an external semantic condition since it refers to a structure defined by the network protocols. It may be considered to be a semantic condition on the network.

if **t** is a text value in UR_I and name(**t**) is in V, then int_I(name(**t**)) = **t**.

The publication of a text with a name on a communication network is considered to be an assertion of the existence of an appropriate named text value, with global scope, i.e. one that *all* interpretations of *any* text available on the network are required to acknowledge. This requirement is included in Table 1, entry E20, which can be understood to mean:

	publication on the network of:	**requires that for any interpretation *I* of a text on the network:**
E20	a text **T** with a name **N**	UR_I contains a named text value **t** with *text*(**t**) = **T** and *name*(**t**) = **N**

Since the notion of importation amounts to a virtual copying of one piece of text into another (in fact, it is a virtual copying of the *importation closure*, since one has to consider the case where the imported text itself contains an importation of another text), this makes an implicit assumption that the texts can be interpreted together, and the truth-conditions given above reflect this by applying the interpretation of the importing phrase directly to the imported text. This means, in effect, that any use of this notion of textual importing shall be based on the assumption that the texts are mutually interpretable. For example, importing implies that the quantifiers in the imported text shall be interpreted to range over the same domain as those in the importing text. All texts which are published and identified on a network **shall** be mutually interpretable with all other texts on the network which can import them, over the same universe of reference and domain of discourse, and with their vocabularies merged. This condition applies to all texts which might possibly import other texts, even if they do not in fact do so in a particular state of the network.

Real networks, being implementations, are subject to errors or breakdowns. The rigid naming conventions described in the section are understood to apply even under such failure conditions. Thus for example if a URI is used on the Web to be a rigid identifier of some text, then it remains an identifier even when an attempt to use it in an HTTP *get* protocol produces a 404 error. Applications **shall not** treat communication errors or failures as an indication that a name does not denote or is a non-discourse name.

6.3.2 Mixed networks

Text may be published in more than one dialect on a single network. This International Standard refers to such a situation as a *mixed* network. Information exchange and publication on a mixed network should be conducted in such a way that all agents can represent content written in any text in use on the network. One way to achieve this is to use the most permissive dialect for information transmission, and to require agents to express their content in this dialect.

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