LIDO - Reference Manual

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1 Introduction

This is a reference manual for LIDO, a language for specification of computations in trees. It is used to specify all computations of the analysis phase and the translation phase of a language processor, which are to be executed on the abstract tree. The main purpose of a LIDO specification is to describe which computations have to be executed in which tree context, how those computations depend on each other, and which values are propagated from one computation to another. The functions called in computations and the types of propagated values are implemented in C; those implementations are not part of a LIDO specification.

The LIGA system processes a LIDO specification and generates an evaluator C module from it. LIGA automatically determines a tree walk strategy and the evaluation order of computations on the base of the specified dependencies. Attribute grammars are the formal model for this process. In Eli a LIDO specification is usually composed of several components supplied by the user, derived from libraries, or generated by Eli tools. The components are combined into one file and then processed by LIGA.

This document is intended to be used for reference on LIDO constructs and rules of the language LIDO. Other documents related to LIDO are:

LIDO - Computation in Trees: introduces and explains typical uses of LIDO constructs.

LIGA - Control Language: describes how variants in LIGA's processing can be controlled.

Show: describes how to obtain debugging information for LIDO.

GORTO - Graphical Order Tool: describes how to trace dependencies graphically.

ModLib - Specification Module Library: describes how to use precoined solutions of common problems.

2 Overall Structure

A LIDO file specifies an evaluator for executing computations driven by a tree walk. A tree grammar specifies the structure of the trees. Computations are associated to rules and symbols of the tree grammar. Computations may depend on one another via typed attributes.

Syntax

```
LIDOSpec       ::=  Specification
Specification  ::=  Specification Specification |
                 |  RuleSpec ';' | SymComp ';'
                 |  SymSpec ';'  | TermSpec ';'
                 |  AttrSpec ';' | ChainSpec ';'
```

Examples

```
RULE p: Stmt  ::= 'while' Expr 'do' Stmt COMPUTE
  Expr.postType = boolType
END;

SYMBOL Expr COMPUTE
  Compatible (THIS.preType, THIS.postType);
END;

ATTR preType, postType: DefTableKey;
```

There is no restriction on the order of specifications. Any permutation of specifications has the same meaning.

LIDO objects like rules, symbols, or attributes are identified by their names. They are introduced by using them in LIDO constructs. Hence, there are no explicit declarations in LIDO.

Specifications associate certain properties to an object, e. g. computations to a rule or a type to an attribute name. There may be several specifications for the same object as long as the specified properties are not contradictory.

In the syntax of this document we distinguish names for objects of different kinds, e. g. `RuleName`, `SymbName`, `TypeName`. The syntax rules for names are omitted in the rest of this document. The following rules are assumed for `XYZNames`

```
XYZName  ::= Identifier
XYZNames ::= XYZName | XYZNames ',' XYZNames
```

All names are written as identifiers in C.

Restrictions

It is strongly recommended *not* to use names that begin with an underscore or which have the form `rule_i` where i is a number, in order to avoid interference with identifiers generated by LIGA.

`RuleNames`, `SymbNames`, and `TypeNames` must be mutually distinct. `AttrNames` must be different from `ChainNames`.

3 Rule Specifications

A rule specification specifies a production of the tree grammar, and may associate some computations to the rule context. They are executed in any context representing that rule in a particular tree.

Syntax

```
RuleSpec ::= 'RULE' [RuleName] ':' Production Computations 'END'
```

Example:

```
RULE p: Stmt  ::= 'while' Expr 'do' Stmt COMPUTE
  Expr.postType = boolType
END;
```

There may be several rule specifications that refer to the same rule. In that case the associated computations are accumulated.

The set of productions of all rules forms the tree grammar. It must have exactly one root symbol that does not occur on any right-hand side of a production.

Eli usually generates some rule specifications (without computations) from the concrete grammar in order to complete the tree grammar.

In general the `RuleName` is omitted. The rule is then identified by the production. LIGA generates a name of the form `rule_i`, with a unique number `i` for such a rule. A meaningful `RuleName` should be specified for rules that are part of computed subtrees, since the name of the tree construction function is derived from it (see Chapter 10 [Computed Subtrees], page 33).

Restrictions

Two unnamed rule specifications refer to the same rule if their productions are identical.

A named rule specification and an unnamed one refer to the same rule if their productions are identical. In that case there must not be another rule specification with the same production but a different name.

Two named rule specifications with the same `RuleName` must have the same production.

Note: Two rule specifications with different names but equal productions are only reasonable if they belong to computed subtrees rather to subtrees constructed by a parser.

3.1 Productions

A production being part of a rule specification describes the structure of the rule context. Computations associated to the rule may use or define attributes of nonterminal symbols that occur in the production. The set of all productions in a LIDO specification defines the tree grammar.

Syntax

```
Production     ::= SymbName '::=' Symbols
                 | SymbName 'LISTOF' Elements

Symbols        ::= Symbols Symbols |
                 | SymbName | Literal

Elements       ::=  Elements '|' Elements |
                 | SymbName

TermSpec       ::= 'TERM' SymbNames ':' TypeName
```

Examples

```
Stmt ::= 'while' Expr 'do' Stmt
DefIdent ::= Identifier
Declarations LISTOF ProcDecl | VarDecl
TERM Identifier: int;
```

Productions are composed of nonterminal symbols, named terminal symbols, and literal terminals.

The `SymbName` on the left-hand side of a production is a nonterminal. A `SymbName` that does not occur on the left-hand side of any production denotes a named terminal. A nonterminal symbol that does not occur on the right-hand side of any production is the root of the tree grammar.

We say the rule context is a *lower context* for the left-hand side nonterminal, and an *upper context* for any right-hand side nonterminal.

Literal terminals are denoted by arbitrary non empty strings enclosed in single quotes. A quote being part of such string is denoted by two single quotes (cf. Pascal strings).

Literal terminals do not contribute to the trees specified by the tree grammar. They are only used to relate tree productions to concrete productions describing the input text, and to distinguish otherwise equal productions.

Named terminal symbols do not contribute to the trees specified by the tree grammar. They are related to named terminal symbols of corresponding concrete productions describing the input text. A value derived from such an input token may be used in computations which are associated to the rule of the production or to the symbol on the left-hand side of the production. (If the tree context is constructed by a computation, rather than by parsing the input text, then that value is supplied as argument to the call of the construction function (see Section 10.1 [Tree Construction Functions], page 34).)

The type of the value provided by a named terminal symbol is specified by a `TERM` specification. If there is no such specification the type `int` is assumed.

There are two forms of productions: plain productions and `LISTOF` productions.

A plain production defines tree contexts with a node for the left-hand side nonterminal having a sequence of subtrees, one for each nonterminal on the right-hand side.

Computations may refer to any attribute of any nonterminal in the production. If one nonterminal occurs more than once in the production references to the occurrences in computations are distinguished by indices (starting from 1). A `LISTOF` production defines tree contexts with a node for the left-hand side nonterminal having an arbitrary long sequence of subtrees each rooted by a nonterminal specified as a `LISTOF` element. That sequence may be empty, even if there is no empty `LISTOF` element specified.

Computations associated to the rule of a `LISTOF` production may only refer to attributes of the left-hand side symbol. Attributes of the element subtrees are referenced only by remote attribute access (see Chapter 9 [Remote Attribute Access], page 25).

Restrictions

There must be exactly one root nonterminal which does not occur on any right-hand side of a tree grammar production.

Named terminals may not be `LISTOF` elements.

A literal terminal may not be the empty string.

4 Symbol Specifications

A symbol specification associates computations to a symbol. They are executed in any context that represents that symbol in a particular tree.

Symbols may be introduced that do not occur in the tree grammar, called `CLASS` *symbols*. They represent a computational role. Their computations may be inherited directly or indirectly to grammar symbols. Symbols that do occur in the tree grammar are called `TREE` *symbols*.

Syntax

```
SymComp    ::= SymbKind SymbName [ Inheritance ] Computations 'END'

SymbKind   ::= 'SYMBOL' | 'CLASS' 'SYMBOL' | 'TREE' 'SYMBOL'
```

Example:

```
TREE SYMBOL Expr COMPUTE
  SYNT.coercion = coerce (THIS.preType, THIS.postType);
  INH.IsValContext = true;
  Compatible (THIS.preType, THIS.postType);
END;
```

A symbol specified `TREE` occurs in a tree grammar production, a symbol specified `CLASS` does not. If neither is specified the symbol kind is determined by its occurrence in the tree grammar. (Only the computations of `CLASS` symbols may be inherited to other symbols.)

Note: There may be `TREE` symbols that do not occur in the the user supplied rules, but only in those generated from the concrete grammar. In those cases it is recommended to explicitly specify their kind to be `TREE`, in order to provide more information for the tool that completes the tree grammar.

Two sets of computations are associated to a symbol: the *lower computations*, which are executed in every lower context of the symbol, i. e. in a context whose production has the symbol on its left-hand side, and the *upper computations*, which are executed in every upper context, i. e. in a context whose production has the symbol on its right-hand side. The upper computations are executed once for each right-hand side occurrence of the symbol.

In a symbol computation only attributes of that symbol may be used or defined (except the use of remote attributes). Those attributes are denoted `SYNT.a` if `a` is a *synthesized* attribute computed in lower contexts, `INH.b` if `b` is an *inherited* attribute computed in upper contexts. An attribute of the symbol may also be denoted `THIS.c`. In this case the attribute class must be specified in another occurrence of that attribute.

A computation that defines a synthesized (an inherited) attribute of the symbol belongs to the set of lower (upper) computations. A *plain computation* defining no attribute belongs to the set of lower computations (see Chapter 5 [Computations], page 11).

There may be several symbol specifications for one symbol. In that case the associated computations are accumulated.

If both a symbol computation and a rule computation define the same attribute of that symbol, the rule computation will be executed in that context, overriding the symbol computation.

Plain computations can not be overridden.

Restrictions

The kind of a symbol, `TREE` or `CLASS` may not be specified contradictory.

`CLASS` may not be used in productions.

`TREE` may not be used in `INHERITS` clauses (see Chapter 8 [Inheritance of Computations], page 23).

5 Computations

Computations are associated to rules or to symbols. Each computation (that is not overridden) is executed exactly once for every instance of its context in a particular tree. A computation may yield a value denoted as an attribute which may be used by other computations.

Computations may also be specified to depend on one another without passing a value in order to specify dependencies on side-effects of computations (see Section 7.1 [Dependent Expressions], page 19).

Syntax

```
Computations ::=  [ 'COMPUTE' Computation ]

Computation  ::=  Computation Computation |
                | Expression Terminator
                | Attribute '=' Expression Terminator
Terminator   ::= ';'
                | 'BOTTOMUP' ';'
```

Examples

```
COMPUTE
  Expr.postType = boolType;
  Stmt[1].code = PTGWhile (Expr.code, Stmt[2].code);
  printf ("while loop in line %d\n", LINE);
  printf ("value = %d\n", Expr.val) BOTTOMUP;
```

There are two forms of computations: *attribute computations* denoted as an assignment to an attribute, and *plain computations* that are just an expression.

A computation is executed by evaluation of its expression. It depends on every attribute that occurs in the expression regardless whether the attribute is used for the evaluation. We say those attributes are the *precondition* of the computation. The attribute on the left-hand side of an attribute computation represents the *postcondition* of that computation. Plain computations do not establish a postcondition for any other computation. The evaluator is generated such that the computations are executed in an order that obeys these dependencies for any tree of the tree grammar.

If both a symbol computation and a rule computation define the same attribute of that symbol, the rule computation will be executed in that context, overriding the symbol computation.

An expression may occur in *value context*, i.e. it must yield a value, or it may occur in `VOID` *context*, i.e. it may or may not yield a value; if it does the value is discarded.

If the left-hand side attribute of an attribute computation has a type different from `VOID` the right-hand side expression is in value context; the result of the expression evaluation is assigned to the attribute.

If the attribute has the type `VOID` the right-hand side expression is in `VOID` context. In this case the attribute simply states the postcondition that the computation has been executed.

A plain computation is in `VOID` context.

Computations may be specified to be executed while the input is being read and the tree is being built by the keyword `BOTTOMUP` preceeding the terminating `;`. LIGA then tries to arrange the computations such that those are executed already when their tree node is constructed. This facility is useful for example if the generated language processor is to produce output while its input is supplied (like desktop calculators), or if a computation causes to switch the input file. Note: Due to the parser's lookahead, one token beyond the last token of the context of the `BOTTOMUP` computation is read before before the computation is executed.

Restrictions

If the attribute in an attribute computation has a non-`VOID` type the evaluation of the expression must yield a value of that type. This condition is not checked by Liga. It is checked by the compiler applied to the generated evaluator.

There may not be several symbol computations that define the same attribute.

There must be exactly one attribute computation for each synthesized attribute of the left-hand side nonterminal and for each inherited attribute of each right-hand side nonterminal in the production of a rule context.

There may not be any cyclic dependencies between computations for any tree of the tree grammar.

Computations may not be specified `BOTTOMUP` if the facility of computed subtrees is used in some production (see Chapter 10 [Computed Subtrees], page 33), or if the `TREE COMPLETE` option is set in a LIGA control specification.

LIGA may fail to allocate `BOTTOMUP` computations as required due to attribute dependencies or due to LIGA's evaluation strategy. In that case messages report cyclic dependencies where generated attributes with the name `BottomUpAttr` are involved.

6 Attributes

Attributes are associated to symbols and to rules. They are defined and used in rule computations and in symbol computations.

Each symbol has two disjoint sets of attributes: *synthesized* (`SYNT`) attributes that are defined by computations of lower contexts of the symbol, and *inherited* (`INH`) attributes that are defined by computations of upper contexts of the symbol.

Attributes are introduced by their occurrence in computations.

Syntax

```
Attribute ::= SymbolRef '.' AttrName
            | RuleAttr
RuleAttr  ::= '.' AttrName
SymbolRef ::= SymbName
            | SymbName '[' Number ']'
RhsAttrs  ::= 'RHS' '.' AttrName
```

Examples

```
RULE: Stmt ::= 'while' Expr 'do' Stmt COMPUTE ...
  ... Expr.postType ...
  ... Stmt[1].code ...
  ... .label ...
  ... RuleFct ("PTG", RHS.Ptg) ...
END;
SYMBOL Expr COMPUTE
  ... SYNT.preType ...
  ... INH.postType ...
  ... THIS.preType ...
  ... RuleFct ("PTG", RHS.Ptg) ...
END;
```

Attributes in rule computations have the form `X.a` or `X[i].a` where `X` is a nonterminal in the production of the rule. They refer to the attribute `a` of the tree node corresponding to `X`. The index distinguishes multiple occurrences of the nonterminal in the production, counting from left to right starting at 1.

Rule attributes of the form `.b` may be used in rule computations, to simplify reuse of computed values. They are defined and used within the computations of a single rule. They are not associated to any symbol.

In symbol computations only attributes of that symbol are referred to. Instead of a `SymbName` one of the predefined identifiers `SYNT`, `INH`, or `THIS` is used: `SYNT.a` for a synthesized attribute, `INH.b` for an inherited attribute, or `THIS.c` leaving the attribute class to be specified elsewhere.

An `RhsAttrs` construct, like `RHS.a`, is a shorthand for a sequence of attributes all named `a`, one for each right-hand side nonterminal of the rule context to which the computation is associated. The construct may only occur in function calls, where it contributes part of the argument sequence, or in `DependsClauses`(see Section 7.1 [Dependent Expressions], page 19). If a symbol computation contains an `RhsAttrs` its sequence of attributes is determined for each rule context of the symbol individually. In combination with the predefined function `RuleFct` an `RhsAttrs` construct may be used to specify a call pattern that is instantiated differently for each rule context (see Chapter 12 [Predefined Entities], page 39).

Restrictions

The `SymbolRef` must occur in the production of the rule.

The `SymbolRef` must be indexed if and only if the symbol occurs more than once in the production.

The index of a `SymbolRef` must identify an occurrence of the symbol in the production.

`SymbNames` and indices may not be used in attributes of symbol computations.

Rule attributes may not be used in symbol computations.

6.1 Types and Classes of Attributes

Each attribute has a certain type characterizing the values propagated by the attribute. Attributes that describe only postconditions of computations without propagating a value have the predefined type `VOID`. Non-`VOID` types must be specified explicitly.

Each attribute has either the class *synthesized* (`SYNT`), i. e. it is computed in all lower contexts of its symbols, or it has the class *inherited* (`INH`), i. e. it is computed in all upper contexts of its symbols. Attribute classes are usually derived from computations without explicit specifications.

Syntax

```
AttrSpec     ::= 'ATTR' AttrNames ':' TypeName [ AttrClass ]

SymSpec      ::= SymbKind SymbNames ':' [ AttrSpecs ]

AttrSpecs    ::= AttrSpecs ',' AttrSpecs
               | AttrNames ':' TypeName [ AttrClass ]

AttrClass    ::= 'SYNT' | 'INH'
```

Examples

```
ATTR code: PTGNode SYNT;
SYMBOL Expr, UseIdent: preType, postType: DefTableKey;
```

An attribute name specification (`ATTR`) determines the type and optionally the class of all attributes having one of the `AttrNames`.

An `AttrSpec` for a nonterminal determines the type and optionally the class of attributes given by the `AttrNames` for all nonterminals given by `SymbNames`. These specifications override the type and the attribute class stated by `ATTR` specifications.

If the type of an attribute is left unspecified it is assumed to be `VOID`.

Note: Misspelling of an attribute name in a computation leads to introduction of a `VOID` attribute, and is usually indicated by messages on missing computations for that attribute or illegal use of a `VOID` attribute.

Note: The type of non-`VOID` rule attribute has to be specified by `ATTR` specifications.

Restrictions

There may be several specifications for the same `AttrName` als long as their properties are not contradictory.

A specified attribute class must be consistent with all computations of that attribute.

`VOID` attributes may only be used in `VOID` contexts.

The type specified for an attribute must denote an assignable C type that is available in the generated evaluator.

LIGA does not check whether non-`VOID` attributes are used consistently with respect to their types. Violations will be indicated when the generated evaluator is compiled.

7 Expressions

An expressions is evaluated as part of a computation. The evaluation may yield a value, cause an effect, or both. Expressions are denoted as function calls or literals in C and may contain attribute accesses and accesses of terminal values.

7.1 Dependent Expressions

The evaluation of an expression depends on all attributes contained in it. The evaluator is generated such that the expression is evaluated after all those attributes are evaluated.

Further attributes may be added to that precondition for expression evaluation without using their values for computing the expression's result. The additional attributes may describe a computational state that has to be reached before the expression is evaluated. They are specified by a `DependsClause`.

Syntax

```
Expression    ::= SimpExpr [ DependsClause ]
DependsClause ::= 'DEPENDS_ON' DepAttrList
                | '<-' DepAttrList
DepAttrList   ::= DepAttr
                | '(' DepAttrs ')'
DepAttrs      ::= DepAttrs ',' DepAttrs
                | DepAttr
DepAttr       ::= Attribute | RemoteAttr | RhsAttrs
```

Examples

```
GetProp (UseId.Key,0) DEPENDS_ON UseId.PropIsSet
printf ("%s ", Opr.String) <- (Expr[2].printed, Expr.[3].printed)
```

A `DependsClause` is in `VOID` context, i.e. its attributes may have any type; their values are discarded.

7.2 Terminal Access

Named terminal symbols that occur in a production represent values that are usually obtained from corresponding input tokens when the tree node is constructed. Those values can be used in rule computations and in symbol computations.

Syntax

```
SimpExpr ::= SymbolRef
           | 'TERM' [ '[' Number ']' ]
```

Examples

```
RULE:   DefIdent ::= Ident COMPUTE
  DefIdent.Key = DefineIdn (DefIdent.Env, Ident);
END;
RULE:   Point ::= '(' Numb Numb ')' COMPUTE
  printf ("X = %d, Y = %d\n", Numb[1], Numb[2]);
END;
SYMBOL Point COMPUTE
  printf ("X = %d, Y = %d\n", TERM[1], TERM[2]);
END;
```

In rule computations the value of a terminal in the production is denoted by the `SymbName`, which is indexed if and only if there are multiple occurrences of the `SymbName` in the production.

Note: In a rule computation a non-indexed identifier that is not a name of a symbol in the production of this rule denotes some entity of the generated C program, even if it coincides with the name of a terminal that occurs in other productions.

In lower computations of a symbol `X` terminal values are accessed by `TERM` or `TERM[i]`, where `TERM` is equivalent to `TERM[1]`. `TERM[i]` denotes the `i`-th terminal in each production that has `X` (or a symbol `X` is inherited to) on its left-hand side, regardless what the terminal name is.

Restrictions

`TERM` must not be used in rule computations or in upper symbol computations.

A terminal accessed in a symbol computation must exist in every production the computation is associated to.

7.3 Simple Expressions

Expressions are written as nested function calls where the basic operands are attributes and C literals. The functions are either predefined in LIDO or their definitions are supplied by the user in form of C functions or macros outside the LIDO specification. There is no operator notation for expressions in LIDO.

Syntax

```
SimpExpr  ::= C_Name | C_Integer | C_Float | C_Char | C_String
            |  Attribute | RemoteAccess | RhsAttrs
            |  FunctionName '(' [ Arguments ] ')'
Arguments ::= Arguments ',' Arguments
            |  Expression
```

Examples

```
printf ("Val = %d\n", Expr.val)
IF (LT (Expr.val, 0), 0, Expr.val)
```

Evaluation of a function call notation in LIDO has the same effect and result as the equivalent notation in C.

There are some predefined `FunctionNames` that have a special meaning in LIDO (see Chapter 12 [Predefined Entities], page 39).

Function calls need not yield a value if they are in `VOID` context. All arguments of a function call are in value context.

`C_Name`, `C_Integer`, `C_Float`, `C_Char`, `C_String` are names and literals denoted as in C.

Restrictions

Every `FunctionName` and `C_Name` must be predefined in LIDO or supplied by user definitions.

All arguments of non-predefined functions must yield a (non-`VOID`) value. For predefined LIDO functions specific rules apply (see Chapter 12 [Predefined Entities], page 39).

Type consistency for non-`VOID` types is not checked by LIGA. Those checks are deferred to the compilation of the generated evaluator.

A `C_Name` or a `FunctionName` should not begin with an underscore, in order to avoid conflicts with LIGA generated identifiers.

8 Inheritance of Computations

A set of related computations can be associated to a `CLASS` symbol describing a certain computational role. It can be inherited to `TREE` symbols or to other `CLASS` symbols, hence specifying that they play this role and reusing its computations.

A symbol can play several roles at the same time (multiple inheritance).

Inherited computations are overridden by native computations of attributes having the same name. `CLASS` specifications have the same notation and meaning as `SYMBOL` specifications:

Syntax

```
Specification ::= SymbKind SymbName [ Inheritance ]
                   Computations 'END' ';'
Inheritance   ::= 'INHERITS' SymbNames
```

Example:

```
CLASS SYMBOL RootSetLine COMPUTE
  SYNT.GotLine = CONSTITUENTS KeySetLine.GotLine;
END;

CLASS SYMBOL KeySetLine COMPUTE
  SYNT.GotLine = ResetLine (THIS.Key,LINE);
END;

CLASS SYMBOL KeyPrintLine COMPUTE
  printf ("identifier in Line %d defined in line %d\n",
          LINE, GetLine (THIS.Key,o))
     <- INCLUDING RootSetLine.GotLine;
END;

SYMBOL VarDefId  INHERITS KeySetLine   END;
SYMBOL ProcDefID INHERITS KeySetLine   END;
SYMBOL UseIdent  INHERITS KeyPrintLine END;
SYMBOL Program   INHERITS RootSetLine  END;
```

`CLASS` computations obey the same rules as symbol computation.

The sets of lower and upper class computations may be accumulated from several `CLASS` specifications for the same class.

`CLASS` computations may be inherited to `TREE` symbols or to other `CLASS` symbols.

A `CLASS` or a `TREE` symbol `Target` inherits the computations from a `CLASS Source` if there is a `Target INHERITS Source` relation specified. The complete inheritance relation is accumulated by all `INHERITS` specifications.

A computation is inherited only once even if there are several paths to it in the inheritance relation.

A computation for an attribute `a` associated to a `CLASS` or a `TREE` symbol overrides any computation for `a` inherited from a `CLASS` symbol.

Note: Plain computations can not be overridden.

The computations inherited to a `CLASS` symbol belong to the computation sets of the `CLASS` symbol and may be subject to further inheritance.

Restrictions

`TREE` symbols and `CLASS` symbols may not inherit from `TREE` symbols.

The inheritance relation must not be cyclic.

If `C` inherits from `CLASS` symbols `C1` and `C2`, and if both `C1` and `C2` have computations for an attribute `a`, it is undefined which one is inherited to `C`.

9 Remote Attribute Access

Remote access constructs allow to relate computations across longer distances in the tree, rather than those of adjacent contexts. The `INCLUDING`-construct accesses attributes of symbols that are further up in the tree (i. e. closer to the root). The `CONSTITUENT(S)`-construct accesses attributes of symbols that are further down in the tree (i. e. closer to the leaves). The `CHAIN`-construct relates computations in a left-to-right depth-first order within subtrees.

These constructs may propagate values as well as they may just specify dependencies between computations.

Remote access constructs allow to abstract from the particular tree structure between the related computations. Computational patterns can be specified rather independent from the particular grammar using remote access in combination with symbol computations and `CLASS` symbols. Reusable specification modules are based on that technique.

9.1 INCLUDING

The `INCLUDING`-construct accesses an attribute of a symbol that is on the path towards the tree root. Hence, several computations in a subtree may depend on an attribute at the subtree root.

Syntax

```
RemoteAccess ::= 'INCLUDING' RemAttrList
RemAttrList  ::=  RemAttr | '(' RemAttrs ')'
RemAttrs     ::=  RemAttrs ',' RemAttrs
               |  SymbName '.' AttrName
```

Examples

```
INCLUDING Range.Env
INCLUDING (Block.Scope, Root.Env)
```

The `RemAttrList` specifies a set of attributes the `INCLUDING` refers to, called the *referred set*. On evaluation it accesses an attribute of the first symbol on the path to the root which is in that set.

An `INCLUDING` in a rule computation accesses an attribute of a symbol above the current context, even if the left-hand side symbol is in the `RemAttrList`.

An `INCLUDING` in a symbol computation accesses an attribute of a symbol above the current one, even if the current one is in the `RemAttrList`.

An attribute of a `CLASS` symbol `C.a` in the `RemAttrList` contributes attributes `X.a` to the referred set for all `TREE` symbols `X` to which `C` is inherited.

An `INCLUDING` in a `VOID` context does not cause a value to be propagated; it just states a dependency.

Restrictions

The referred set must not be empty. (That may happen in case of `CLASS` symbols only).

The tree grammar must guarantee that in every tree there is at least one of the symbols of the referred set above the context of the `INCLUDING`.

The referred set must not contain different attributes of one symbol.

The types of the attributes in the referred set must be equal, if the `INCLUDING` is not in a `VOID` context.

9.2 CONSTITUENT(S)

The `CONSTITUENTS`-construct accesses attributes of symbols that are in the subtree of the current context. Hence, it may depend on several computations in the subtree. If values are to be propagated they are combined by user defined functions.

The `CONSTITUENT`-construct accesses a single attribute instance of a symbol that is in the subtree of the current context.

Syntax

```
RemoteAccess ::= [ SymbolRef ] 'CONSTITUENT'
                  RemAttrList [ ShieldClause ]
                | [ SymbolRef ] 'CONSTITUENTS'
                  RemAttrList [ ShieldClause ] [ WithClause ]
ShieldClause ::= 'SHIELD' SymbNameList
SymbNameList ::= SymbName | '(' SymbNames ')' | '(' ')'
WithClause   ::= 'WITH' '(' TypeName ',' CombFctName ','
                             SingleFctName ',' NullFctName ')'
```

Examples

```
CONSTITUENT Declarator.type
Declarations CONSTITUENTS DefIdent.GotType
CONSTITUENTS Range.GotLocKeys SHIELD Range
CONSTITUENTS Stmt.code SHIELD Stmt
   WITH (PTGNode, PTGSey, IDENTICAL, PTGNULL)
```

The `RemAttrList` specifies a set of attributes the `CONSTITUENT(S)`-construct refers to, called the *referred set*. On evaluation it accesses all instances of attributes of that set which are in a certain range of the subtree of the current context. That range is determined by its root node, which itself does not belong to the range, and by a set of shield symbols. The tree nodes below a shield symbol are excluded from that range.

In a rule computation the root of the tree range is the node corresponding to the left-hand side of the production. The optional `SymbolRef` may restrict the root of the tree range to a node corresponding to a symbol of the right-hand side of the production.

In a (lower or upper) symbol computation the root of the tree range is the node corresponding to that symbol.

If the optional `ShieldClause` is given it specifies the set of shielded symbols. If an empty `ShieldClause` is given, no symbols are shielded from the tree range. If the `ShieldClause` is omitted then the root symbol of the tree range (as described above) is shielded from the range.

An attribute of a `CLASS` symbol `C.a` in the `RemAttrList` contributes attributes `X.a` to the referred set for all `TREE` symbols `X` to which `C` is inherited.

A `CLASS` symbol `C` in the `ShieldClause` contributes symbols `X` to the set of shielded symbols for all `TREE` symbols `X` to which `C` is inherited.

A `CONSTITUENT(S)` in a `VOID` context does not cause a value be propagated; it just states a dependency.

For a `CONSTITUENTS` that is not in `VOID` context a `WithClause` specifies how the values of the accessed attribute instances are combined into one value.

The given `TypeName` specifies the type of the result and of intermediate values.

The `CombFctName` specifies a function (or macro) that is applied to two values of the given type and yields one value of that type.

The `SingleFctName` specifies a function (or macro) that is applied to each accessed attribute instance and yields a value of the given type.

The `NullFctName` specifies a function (or macro) that has no argument and yields an intermediate value. It is called for every node in the tree range that could have referred attribute instances below it according to the tree grammar, but for the particular tree it has none. Hence, the result of this function should be neutral with respect to the combine function.

It is guaranteed that the combine function is applied to intermediate values according to a post-order projection of the accessed tree nodes. It is left open in which associative order that function combines intermediate values.

Restrictions

A `SymbolRef` must denote a right-hand side symbol of the production. It must not be specified in symbol computations.

A `CONSTITUENTS` in a value context must have a `WithClause`.

For a `CONSTITUENT` the tree grammar must guarantee that the accessed attribute instance is uniquely determined for every tree.

The `RemAttrs` must have the same type if the `CONSTITUENT(S)` is in value context.

9.3 CHAIN

Chains relate computations in left-to-right depth-first order within certain subtrees. A chain may propagate values or just specify dependencies in that order. Only effective computations, that compute a new chain value or a new post-condition need to be specified. They are automatically linked in the described order.

Chain accesses are denoted like attribute accesses with a Chain name instead of an attribute name.

Syntax

```
ChainSpec     ::= 'CHAIN' ChainNames ':' TypeName

Computation   ::= 'CHAINSTART' Attribute '=' Expression Terminator

Attribute     ::= SymbolRef '.' ChainName
```

Examples

```
CHAIN cnt : int
RULE: Block ::= '{' Decls Stmt '}' COMPUTE
  CHAINSTART Stmts.cnt = 0;
  printf ("Block has %d statements\n", Stmts.cnt);
END;
RULE: Stmt ::= Var '=' Expr ';' COMPUTE
  Stmt.cnt = ADD (Stmt.cnt, 1);
END;

CHAIN codeseq: PTGNode;
SYMBOL Block COMPUTE
  CHAINSTART HEAD.codeseq = PTGNULL;
  SYNT.transl = TAIL.codeseq;
END;
SYMBOL Stmt COMPUTE
  THIS.codeseq = PTGSeq (THIS.codeseq, THIS.transl);
END;
```

A `CHAIN` specification introduces the name and the type of a chain. Any attribute notation using a `ChainName` denotes a chain access.

A chain links computations in left-to-right depth-first order within every subtree that contains a `CHAINSTART` computation for that chain excluding such subtrees thereof which also have a `CHAINSTART` computation for the same chain.

There may be several `CHAINSTART` computations for one chain in different contexts, and a `CHAINSTART` context may occur recursively in a tree. The so specified chains are disjoint.

A `CHAINSTART` computation defines the initial value of the chain for a right-hand side symbol of the production in a rule computation. In a symbol computation the initial value is defined for the leftmost symbol of the lower context denoted by `HEAD.c` where `c` is the name of the chain.

A chain states a precondition and a postcondition for each symbol on the chain. (They can be understood as an implicitly introduced pair of attributes, an inherited one for the precondition and a synthesized one for the postcondition). Both have the same notation: `X.c` in rule computations and `THIS.c` in symbol computations. They are distinguished by their occurrence in a defining position of an attribute computation or in an applied position of an expression.

In a rule computation a defining occurrence `X.c` of a right-hand (left-hand) side symbol `X` denotes the chain's precondition (postcondition) of that symbol. An applied occurrence of a right-hand (left-hand) side symbol `X` denotes the chain's postcondition (precondition) of that symbol.

In a symbol computation a defining (applied) occurrence of `THIS.c` denotes the chain's postcondition (precondition) of that symbol.

A computation is only linked in chain order if it defines the chain and depends directly or indirectly on it. A computation that only accesses the chain without defining it is not necessarily executed in chain order.

A computation that defines a chain without directly or indirectly accessing it breaks the chain, i. e. the execution order of subsequent chain computations is independent of those prior to this computation.

The notation `HEAD.c` can be used to define the chain's precondition of the leftmost nonterminal in the lower context; the notation `TAIL.c` to use the chain's postcondition of the rightmost nonterminal in the lower context. These notations can be used in rule computations and in symbol computations.

Restrictions

Every `ChainName` must be different from any attribute name and any `AttrName`.

The tree grammar must guarantee that each access of a chain is in a subtree of a `CHAINSTART` context for that chain.

`THIS.c` must not be used in rule computations or in upper symbol computations.

`HEAD.c` must not be used in applied positions.

`TAIL.c` must not be used in defining positions.

10 Computed Subtrees

In general the tree represents the abstract structure of the input text and is built by scanning and parsing the input. That initial tree may be augmented by subtrees which result from certain computations. This feature can be used for translation into target trees which also have computations associated that are executed in the usual way.

The tree construction functions generated by LIGA are used to build such subtrees. They are inserted into the initial tree at certain positions specified in productions.

Syntax

```
Symbols ::= '$' SymbName
```

Examples

```
RULE: Block ::= '{' Decl Stmts '}' $ Target COMPUTE
  Target.GENTREE =
       MkTBlock (COORDREF, Dels.tcode, Stmt.tcode);
END;
RULE TBlock: Target ::= TSeq TSeq COMPUTE ... END;
```

Trees may be the result of computations using LIGA's tree construction functions as described below (see Section 10.1 [Tree Construction Functions], page 34).

Tree values may be propagated between computations using attributes of the predefined type `NODEPTR` (see Chapter 12 [Predefined Entities], page 39).

Tree values are inserted into the initial tree in contexts where the right-hand side of the production specifies *insertion points* of the form `$ X` where `X` is a nonterminal name.

The insertion is specified by a computation of the attribute `X.GENTREE` where `X` is the insertion point symbol and `GENTREE` is a predefined attribute name for inherited attributes of insertion symbols (see Chapter 12 [Predefined Entities], page 39). The computation must yield a value of type `NODEPTR` that is a legal tree with respect to the tree grammar for `X`: LIGA guarantees that the computation in the inserted tree are not executed before the tree is inserted.

The tree grammar productions for computed trees may be disjoint from or may overlap with the productions for the initial tree.

Computed trees may again have insertion points in their productions.

Restrictions

There must be exactly one insertion computation for each insertion point of a rule context.

There may not be an insertion computation for a symbol that is not an insertion point.

Inserted trees must be legal with respect to the tree grammar. This property is checked at runtime of the evaluator.

No computation that establishes a precondition for a tree insertion may depended on a computation within the inserted tree.

If the facility of tree insertion is used, there must not be any requirement for computations executed during bottom-up tree construction.

10.1 Tree Construction Functions

LIGA generates a set of tree construction functions, one for each rule context. They may used in computations to build trees which are then inserted at insertion points. Their names and signatures reflect the rule name and the right-hand side of the production.

For a rule

```
RULE pBlock: Block::= '{' Decls Stmts '}' END
```

there is a function

```
NODEPTR MkpBlock (POSITION *c, NODEPTR d1, NODEPTR d2)
```

The function name is the rule name prefixed by `Mk`. Hence, it is recommended not to omit the rule name when its construction function is to be used.

The first parameter of every function is a pointer to a source coordinate. That argument may be obtained from the coordinate of the context where the function is called. It is used for error reporting, see Chapter 12 [COORDREF], page 39.

The following parameters correspond to the sequence of non-literal symbols of the right-hand side of the production.

For each nonterminal in the production there is a parameter of type `NODEPTR`. Its argument must be a pointer to the root node of a suitable subtree, built by node construction functions.

For each insertion point in the production there is a parameter of type `NODEPTR`. Its argument should be `NULLNODEPTR`, since that subtree is inserted later by a computation.

For each named terminal in the production there is a parameter of the type of the terminal. Its argument is the value that is to be passed to terminal uses in computations.

Functions for chain productions, the right-handside of which consists of exactly one nonterminal, need not be called explicitly. The nodes for those contexts are inserted implicitly when the upper context is built.

`LISTOF` productions have a specific set of tree construction functions: For a rule like

```
RULE pDecls: Decls LISTOF Var|Proc|END;
```

the functions

```
NODEPTR MkpDecls (POSITION *c, NODEPTR l)
NODEPTR Mk2pDecls (POSITION *c, NODEPTR ll, NODEPTR lr)
```

are provided, where `Mk2pDecls` constructs internal list context nodes and `MkpDecls` builds the root context of the list.

The arguments for each of the parameters `l`, `ll`, and `lr` can be `NULLNODEPTR` representing an empty list, a pointer to a list element node, a node that can be made a list element subtree by implicit insertion of chain contexts, or the result of a `Mk2`-function call representing a sublist.

The `Mk2`-functions concatenate two intermediate list representations into one retaining the order of their elements.

The `LISTOF` subtree must be finally built by a call of the root context function.

11 Iterations

The general principle of computations in trees guarantees that the computations specified for each tree node context are executed exactly once. The iteration construct allows to specify cyclic dependencies that may cause certain computations to be iterated until a specified condition holds.

Syntax

```
Computation ::= Iteration Terminator
              | Attribute '=' Iteration Terminator
Iteration   ::= 'UNTIL' Expression
                'ITERATE' Attribute '=' Expression
```

Example:

```
ATTR cnt, incr: int;
RULE: R ::= X COMPUTE
  X.cnt = 1;
  R.done = UNTIL GT (X.cnt, 10) ITERATE X.cnt = X.incr;
END;
RULE: X ::= SomeThing COMPUTE
  X.incr = ORDER (printf ("%d\n", X.cnt), ADD (x.cnt, 1));
END;
```

The execution of an iteration establishes the postcondition specified by the `UNTIL` expression.

The attribute defined in the `ITERATE`-clause is the iteration attribute. The expression of that definition usually depends cyclically on the iteration attribute itself. There has to be another non cyclically dependent computation for the iteration attribute, which is executed initially before the iteration. The iteration attribute may be a `VOID` attribute. All computations that depend on the iteration attribute are executed at least once.

The `ITERATE` computation and all computations that depend on it are reexecuted if the `UNTIL` condition does not hold.

Restrictions

The `UNTIL` condition must yield an `int` value being used as a conditional value.

There must be an initializing non-cyclic definition for the iteration attribute.

The cyclic dependencies involved in the iteration may not include computations of upper contexts of the iteration context.

Some computations that do not lie on the iteration cycle may also be reexecuted on iteration if not specified otherwise. This effect can be avoided by specifying the initial iteration attribute computation to depend on them, or by specifying them to depend on the postcondition of the iteration.

There may be several iterations for the same iteration attribute. The so specified iterations may be arbitrary merged if not otherwise specified. In any case the `UNTIL` conditions hold after completion of the iterations.

Termination of iterations has to be ensured by suitable `UNTIL` conditions and computations.

The iteration attribute may not be a chain attribute.

12 Predefined Entities

The names described in this chapter have a predefined meaning in LIDO specifications.

The following types are predefined in LIDO:

`VOID` Attributes of this type describe a computational state without propagating values between computations. Those attributes do not occur as data objects in the generated evaluator.

`int` The terminal type.

`NODEPTR` Attributes of this type represent computed subtrees.

The predefined value `NULLNODEPTR` of type `NODEPTR` denotes no tree.

The following attribute is predefined in LIDO:

`GENTREE` Every insertion point symbol has an attribute `GENTREE` of type `NODEPTR`.

The following functional notations have a specific meaning in LIDO. They are translated into suitable C constructs rather than into function calls:

`IF (a, b, c)`

denotes a conditional expression. At runtime either `b` or `c` is evaluated, if `a` yields a non-zero or a zero value. For determination of the static evaluation order each of `a, b, c` contribute to the precondition of the computation that contains the `IF` construct. If it occurs in value context `b` and `c` are in value context, too. Then `b` and `c` have to yield values of the same type (not checked by LIGA). Otherwise `b` and `c` are in `VOID` context and may or may not yield a value of some type.

`IF (a, b)` is a conditional computation of `b`, which is executed only if `a` yields a non-zero value. For determination of the static evaluation order both `a` and `b` contribute to the precondition of the computation that contains the `IF` construct. This `IF` construct must occur in `VOID` context. `b` is in VOID context, too.

`ORDER (a, b, ..., x)`

The arguments are evaluated in the specified order. If it occurs in `VOID` context all arguments are in `VOID` context. If it occurs in value context it yields the result of the last argument `x`. The others are in `VOID` context and may or may not yield a value. For determination of the static evaluation order all arguments of the `ORDER` construct contribute to the precondition of the computation containing it. Any nesting of `ORDER`, `IF`, function calls, and other expressions is allowed, as long as the stated conditions for `VOID` and value contexts hold.

`RuleFct (C_String, arguments ...)`
: A call of this function is substituted by a call of a function whose name is composed of the `C_String` and the name of the rule that has (or inherits) this call. The remaining arguments are taken as arguments of the substituted call. E.g. in a rule named `rBlock` a call `RuleFct ("PTG", a, b)` is substituted by `PTGrBlock (a, b)`.

The following names are predefined to refer to source coordinates of the context they occur in.

Note: They are translated by LIGA into specific constructs of the evaluator. Hence, they can not be used with this meaning in macros that are expanded when the evaluator is translated. (That was allowed in previous versions of LIGA.)

`LINE` the current source line number

`COL` the current source column number

`COORDREF` the address of the current source coordinates, e.g. used in calls of the message routine of the error module or in calls of tree construction functions.

The following C macros are defined as described for the generated evaluator, and can be used in the LIDO text:

```
APPLY (f, a, ... )  (f*) (a, ... )    a call of the function f
                                      with the remaining arguments

CAST(tp,ex)         ( (tp) (ex) )
SELECT(str,fld)     ( (str).fld )
PTRSELECT(str,fld)  ( (str)->fld )
INDEX(arr,indx)     ( (arr)[indx] )

ADD(lop,rop)        ( lop + rop )
SUB(lop,rop)        ( lop - rop )
MUL(lop,rop)        ( lop * rop )
DIV(lop,rop)        ( lop / rop )
MOD(lop,rop)        ( lop % rop )
NEG(op)             ( -op )

NOT(op)             ( !op )
AND(lop,rop)        ( lop && rop )
OR(lop,rop)         ( lop || rop )

BITAND(lop,rop)     ( lop & rop )
```

```
BITOR(lop,rop)      ( lop | rop )
BITXOR(lop,rop)     ( lop ^ rop )

GT(lop,rop)         ( lop > rop )
LT(lop,rop)         ( lop < rop )
EQ(lop,rop)         ( lop == rop )
NE(lop,rop)         ( lop != rop )
GE(lop,rop)         ( lop >= rop )
LE(lop,rop)         ( lop <= rop )

VOIDEN(a)           ((void)a)

IDENTICAL(a)        (a)
ZERO()              0
ONE()               1
ARGTOONE(x)         1
```

The last four macros are especially useful in `WITH` clauses of `CONSTITUENTS` constructs.

13 Outdated Constructs

The following constructs are still supported to achieve compatibility with previous LIDO versions. Their use is strongly discouraged.

In previous versions of LIDO terminal symbols could have attributes, at most one synthesized and several inherited. They were associated explicitly by specifications of the form

```
TERM Identifier: Sym: int;
```

Attributes of terminals could be used in attribute notations or `CONSTITUENT(S)` constructs:

```
Identifier.Sym
CONSTITUENT Identifier.Sym
```

If the above constructs occur in a specification a new nonterminal symbol that has the specified attributes is introduced by LIGA, as well as a production that derives to the terminal.

Terminal symbols could be element of a `LISTOF` production:

```
Idents LISTOF Identifier
```

This facility is NOT allowed anymore. It is indicated by an error message, and has to be transformed explicitly.

The key word `NONTERM` should be replaced by `SYMBOL`.

```
NONTERM Stmt: code: PTGNode;
NONTERM Stmt COMPUTE ... END;
```

The pragma notations are substituted by simpler notations:

Calling a function the name of which is composed from a string and the rule name, e.g.

```
LIGAPragma (RuleFct, "PTG", ...)
```

is now achieved by

```
RuleFct ("PTG", ...)
```

See see Chapter 12 [Predefined Entities], page 39.

A pattern for the sequence of right-hand side attributes, e.g

```
LIGAPragma (RhsAttrs, Ptg)
```

is now written

```
RHS.Ptg
```

Hence a combination of both features above, like

```
SYMBOL Reproduce COMPUTE
   SYNT.Ptg = LIGAPragma (RuleFct, "PTG", LIGAPragma (RhsAttrs, Ptg));
END;
```

is now written

```
SYMBOL Reproduce COMPUTE
   SYNT.Ptg = RuleFct ("PTG", RHS.Ptg);
END:
```

See see Chapter 6 [Attributes], page 15.

Computations were specified to be executed while the input is being read and the tree is being built using a pragma

```
LIGAPragma (BottomUp, printf("early output\n"));
```

Now the keyword `BOTTOMUP` is added to the computation:

```
printf("early output\n") BOTTOMUP;
```

See see Chapter 5 [Computations], page 11.

14 Syntax

This section contains an overview over the LIDO Syntax. Outdated LIDO constructs described in the previous chapter are left out in this grammar. For further explanations refer to previous chapters.

```
LIDOSpec       ::=  Specification
Specification  ::=  Specification Specification |
                 |  RuleSpec ';' | SymComp ';'
                 |  SymSpec ';'  | TermSpec ';'
                 |  AttrSpec ';' | ChainSpec ';'

RuleSpec       ::= 'RULE' [RuleName] ':' Production Computations 'END'
SymComp        ::= SymbKind SymbName [ Inheritance ] Computations 'END'
TermSpec       ::= 'TERM' SymbNames ':' TypeName
SymSpec        ::= SymbKind SymbNames ':' [ AttrSpecs ]
AttrSpec       ::= 'ATTR' AttrNames ':' TypeName [ AttrClass ]
ChainSpec      ::= 'CHAIN' ChainNames ':' TypeName

AttrSpecs      ::= AttrSpecs ',' AttrSpecs
                 | AttrNames ':' TypeName [ AttrClass ]

SymbKind       ::= 'SYMBOL' | 'CLASS' 'SYMBOL' | 'TREE' 'SYMBOL'
AttrClass      ::= 'SYNT' | 'INH'

Production     ::= SymbName '::=' Symbols
                 | SymbName 'LISTOF' Elements

Symbols        ::= Symbols Symbols |
                 | SymbName | Literal | '$' SymbName

Elements       ::= Elements '|' Elements |
                 |   SymbName

Computations   ::= [ 'COMPUTE' Computation ]

Computation    ::= Computation Computation |
                 | Expression Terminator
                 | Attribute '=' Expression Terminator
                 | 'CHAINSTART' Attribute '=' Expression Terminator
                 | Iteration Terminator
                 | Attribute '=' Iteration Terminator
Terminator     ::= ';'
                 | BOTTOMUP ';'

Iteration      ::= 'UNTIL' Expression
                   'ITERATE' Attribute '=' Expression
```

```
Attribute      ::= SymbolRef '.' AttrName
                 | SymbolRef '.' ChainName
                 | RuleAttr
RuleAttr       ::= '.' AttrName
SymbolRef      ::= SymbName
                 | SymbName '[' Number ']'

Expression     ::= SimpExpr [ DependsClause ]

DependsClause  ::= 'DEPENDS_ON' DepAttrList
                 | '<-' DepAttrList
DepAttrList    ::= DepAttr
                 | '(' DepAttrs ')'
DepAttrs       ::= DepAttrs ',' DepAttrs
                 | DepAttr
DepAttr        ::= Attribute | RemoteAttr | RhsAttrs

SimpExpr       ::= C_Name | C_Integer | C_Float | C_Char | C_String
                 | Attribute | RemoteAccess
                 | RhsAttrs
                 | FunctionName '(' [ Arguments ] ')'
                 | SymbolRef
                 | 'TERM' [ '[' Number ']' ]

RhsAttrs       ::= 'RHS' '.' AttrName

Arguments      ::= Arguments ',' Arguments
                 |  Expression

Inheritance    ::= 'INHERITS' SymbNames

RemoteAccess   ::= 'INCLUDING' RemAttrList
                 | [ SymbolRef ] 'CONSTITUENT'
                   RemAttrList [ ShieldClause ]
                 | [ SymbolRef ] 'CONSTITUENTS'
                   RemAttrList [ ShieldClause ] [ WithClause ]

RemAttrList    ::=  RemAttr | '(' RemAttrs ')'
RemAttrs       ::=  RemAttrs ',' RemAttrs
                 |  SymbName '.' AttrName

ShieldClause   ::= 'SHIELD' SymbNameList
SymbNameList   ::= SymbName | '(' SymbNames ')' | '(' ')'

WithClause     ::= 'WITH' '(' TypeName ',' CombFctName ','
                            SingleFctName ',' NullFctName ')'
```

Literals in expressions (`C_Name`, `C_Integer`, `C_Float`, `C_Char`, `C_String`) are written as in C.

Literals in productions (`Literal`) are written as strings in Pascal.

This syntax distinguishes names for objects of different kinds, e. g. `RuleName`, `SymbName`, `TypeName`. The syntax rules for names are omitted. The following rules are assumed for `XYZNames`:

```
XYZName  ::= Identifier
XYZNames ::= XYZName | XYZNames ',' XYZNames
```

Identifiers are written as in C.

LIDO text may contain bracketed non nested comments in the style of C or Pascal

```
/* This is a comment */
(* This is a comment *)
```

or line comments like

```
% The rest of this line is a comment
```

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