The Parma Polyhedra Library Java Language Interface User's Manual* (version 0.12)

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This document describes the Parma Polyhedra Library (PPL).

For the most up-to-date information see the Parma Polyhedra Library site:

http://bugseng.com/products/ppl/

Contents

1 Main Page

The Parma Polyhedra Library comes equipped with an interface for the Java language. The Java interface provides access to the numerical abstractions (convex polyhedra, BD shapes, octagonal shapes, etc.) implemented by the PPL library. A general introduction to the numerical abstractions, their representation in the PPL and the operations provided by the PPL is given in the main *PPL user manual*. Here we just describe those aspects that are specific to the Java interface. In the sequel, `prefix` is the path prefix under which the library has been installed (typically `/usr` or `/usr/local`).

Overview

Here is a list of notes with general information and advice on the use of the Java interface.

- When the Parma Polyhedra Library is configured, it will automatically test for the existence of the Java system (unless configuration options are passed to disable the build of the Java interface; see configuration option `--enable-interfaces`). If Java is correctly installed in a standard location, things will be arranged so that the Java interface is built and installed (see configuration option `--with-java` if you need to specify a non-standard location for the Java system).

- The Java interface files are all installed in the directory `prefix/lib/ppl`. Since this includes shared and dynamically loaded libraries, you must make your dynamic linker/loader aware of this fact. If you use a GNU/Linux system, try the commands `man ld.so` and `man ldconfig` for more information.

- Any application using the PPL should:
  - Load the PPL interface library by calling `System.load` and passing the full path of the dynamic shared object;
  - Make sure that only the intended version(s) of the library has been loaded, e.g., by calling static method `version()` in class `parma_polyhedra_library.Parma_Polyhedra_Library`;
  - Starting from version 0.11, initialize the interface by calling static method `initialize_library()`; when all library work is done, finalize the interface by calling `finalize_library()`.

- The numerical abstract domains available to the Java user as Java classes consist of the *simple* domains, *powersets* of a simple domain and *products* of simple domains. Note that the default configuration will only enable a subset of these domains (if you need a different set of domains, see configuration option `--enable-instantiations`).
  - The simple domains are:
    - convex polyhedra, which consist of C_Polyhedron and NNC_Polyhedron;
    - weakly relational, which consist of BD_Shape_N and Octagonal_Shape_N where N is one of the numeric types signed_char, short, int, long, long_long, mpz_class, mpq_class;
    - boxes which consist of Int8_Box, Int16_Box, Int32_Box, Int64_Box, Uint8_Box, Uint16_Box, Uint32_Box, Uint64_Box, Float_Box, Double_Box, Long_Double_Box, Z_Box, Rational_Box; and
    - the Grid domain.
  - The powerset domains are Pointset_Powerset_S where S is a simple domain.
  - The product domains consist of Direct_Product_S_T, Smash_Product_S_T and Constraints_Product_S_T where S and T are simple domains.

- In the following, any of the above numerical abstract domains is called a PPL *domain* and any element of a PPL domain is called a *PPL object*.
- A Java program can create a new object for a PPL domain by using the constructors for the class corresponding to the domain.
- For a PPL object with space dimension `k`, the identifiers used for the PPL variables must lie between 0 and $k-1$ and correspond to the indices of the associated Cartesian axes. For example, when using methods that combine PPL polyhedra or add constraints or generators to a representation of a PPL polyhedron, the polyhedra referenced and any constraints or generators in the call should follow all the (space) dimension-compatibility rules stated in Section *Representations of Convex Polyhedra* of the main PPL user manual.
- As explained above, a polyhedron has a fixed topology C or NNC, that is determined at the time of its initialization. All subsequent operations on the polyhedron must respect all the topological compatibility rules stated in Section *Representations of Convex Polyhedra* of the main PPL user manual.

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4 Module Index

4.1 Modules

Here is a list of all modules:

5 Namespace Index

5.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

6 Class Index

6.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

7 Class Index

7.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

8 Module Documentation

8.1 Java Language Interface

Classes

- class parma_polyhedra_library::Artificial_Parameter_Sequence

  A sequence of artificial parameters.
- class parma_polyhedra_library::By_Reference< T >

An utility class implementing mutable and non-mutable call-by-reference.

- class parma_polyhedra_library::Coefficient

  A PPL coefficient.
- class parma_polyhedra_library::Congruence

  A linear congruence.
- class parma_polyhedra_library::Congruence_System

  A system of congruences.
- class parma_polyhedra_library::Constraint

  A linear equality or inequality.
- class parma_polyhedra_library::Constraint_System

  A system of constraints.
- class parma_polyhedra_library::Domain_Error_Exception

  Exceptions caused by domain errors.
- class parma_polyhedra_library::Polyhedron

  The Java base class for (C and NNC) convex polyhedra.
- class parma_polyhedra_library::C_Polyhedron

  A topologically closed convex polyhedron.
- class parma_polyhedra_library::Pointset_Powerset_C_Polyhedron

  A powerset of C_Polyhedron objects.
- class parma_polyhedra_library::Pointset_Powerset_C_Polyhedron_Iterator

  An iterator class for the disjuncts of a Pointset_Powerset_C_Polyhedron.
- class parma_polyhedra_library::Generator

  A line, ray, point or closure point.
- class parma_polyhedra_library::Generator_System

  A system of generators.
- class parma_polyhedra_library::Grid_Generator

  A grid line, parameter or grid point.
- class parma_polyhedra_library::Grid_Generator_System

  A system of grid generators.
- class parma_polyhedra_library::Invalid_Argument_Exception

  Exceptions caused by invalid arguments.
- class parma_polyhedra_library::IO

  A class collecting I/O functions.
- class parma_polyhedra_library::Length_Error_Exception

  Exceptions caused by too big length/size values.
- class parma_polyhedra_library::Linear_Expression

  A linear expression.
- class parma_polyhedra_library::Linear_Expression_Coefficient

  A linear expression built from a coefficient.
- class parma_polyhedra_library::Linear_Expression_Difference

  The difference of two linear expressions.
- class parma_polyhedra_library::Linear_Expression_Sum

  The sum of two linear expressions.
- class parma_polyhedra_library::Linear_Expression_Times

  The product of a linear expression and a coefficient.
- class parma_polyhedra_library::Linear_Expression_Unary_Minus

The negation of a linear expression.
- class parma_polyhedra_library::Linear_Expression_Variable

  A linear expression built from a variable.
- class parma_polyhedra_library::Logic_Error_Exception

  Exceptions due to errors in low-level routines.
- class parma_polyhedra_library::MIP_Problem

  A Mixed Integer (linear) Programming problem.
- class parma_polyhedra_library::Overflow_Error_Exception

  Exceptions due to overflow errors.
- class parma_polyhedra_library::Pair< K, V >

  A pair of values of type K and V.
- class parma_polyhedra_library::Parma_Polyhedra_Library

  A class collecting library-level functions.
- class parma_polyhedra_library::Partial_Function

  A partial function on space dimension indices.
- class parma_polyhedra_library::PIP_Problem

  A Parametric Integer Programming problem.
- class parma_polyhedra_library::Poly_Con_Relation

  The relation between a polyhedron and a constraint.
- class parma_polyhedra_library::Timeout_Exception

  Exceptions caused by timeout expiring.
- class parma_polyhedra_library::Variable

  A dimension of the vector space.

Namespaces

- namespace parma_polyhedra_library

  The PPL Java interface package.

Enumerations

- enum parma_polyhedra_library::Bounded_Integer_Type_Overflow { parma_polyhedra_library::OVERFLOW_-WRAPS, parma_polyhedra_library::OVERFLOW_UNDEFINED, parma_polyhedra_library::OVERFLOW_-IMPOSSIBLE }

  Overflow behavior of bounded integer types.
- enum parma_polyhedra_library::Bounded_Integer_Type_Representation { parma_polyhedra_library::UNSIGNED, parma_polyhedra_library::SIGNED_2_COMPLEMENT }

  Representation of bounded integer types.
- enum parma_polyhedra_library::Bounded_Integer_Type_Width {

  parma_polyhedra_library::BITS_8, parma_polyhedra_library::BITS_16, parma_polyhedra_library::BITS_-32, parma_polyhedra_library::BITS_64,

  parma_polyhedra_library::BITS_128 }

  Widths of bounded integer types.
- enum parma_polyhedra_library::Complexity_Class { parma_polyhedra_library::POLYNOMIAL_-COMPLEXITY, parma_polyhedra_library::SIMPLEX_COMPLEXITY, parma_polyhedra_library::ANY_-COMPLEXITY }

  Possible Complexities.

- enum parma_polyhedra_library::Control_Parameter_Name { parma_polyhedra_library::PRICING }

  Names of MIP problems' control parameters.
- enum parma_polyhedra_library::Control_Parameter_Value { parma_polyhedra_library::PRICING_STEEPEST_EDGE_FLOAT, parma_polyhedra_library::PRICING_STEEPEST_EDGE_EXACT, parma_polyhedra_library::PRICING_TEXTBOOK }

  Possible values for MIP problem's control parameters.
- enum parma_polyhedra_library::Degenerate_Element { parma_polyhedra_library::UNIVERSE, parma_polyhedra_library::EMPTY }

  Kinds of degenerate abstract elements.
- enum parma_polyhedra_library::Generator_Type { parma_polyhedra_library::LINE, parma_polyhedra_library::RAY, parma_polyhedra_library::POINT, parma_polyhedra_library::CLOSURE_POINT }

  The generator type.
- enum parma_polyhedra_library::Grid_Generator_Type { parma_polyhedra_library::LINE, parma_polyhedra_library::PARAMETER, parma_polyhedra_library::POINT }

  The grid generator type.
- enum parma_polyhedra_library::MIP_Problem_Status { parma_polyhedra_library::UNFEASIBLE_MIP_PROBLEM, parma_polyhedra_library::UNBOUNDED_MIP_PROBLEM, parma_polyhedra_library::OPTIMIZED_MIP_PROBLEM }

  Possible outcomes of the MIP_Problem solver.
- enum parma_polyhedra_library::Optimization_Mode { parma_polyhedra_library::MINIMIZATION, parma_polyhedra_library::MAXIMIZATION }

  Possible optimization modes.
- enum parma_polyhedra_library::PIP_Problem_Control_Parameter_Name { parma_polyhedra_library::CUTTING_STRATEGY, parma_polyhedra_library::PIVOT_ROW_STRATEGY }

  Names of PIP problems' control parameters.
- enum parma_polyhedra_library::PIP_Problem_Control_Parameter_Value {

  parma_polyhedra_library::CUTTING_STRATEGY_FIRST, parma_polyhedra_library::CUTTING_STRATEGY_DEEPEST, parma_polyhedra_library::CUTTING_STRATEGY_ALL, parma_polyhedra_library::PIVOT_ROW_STRATEGY_FIRST,

  parma_polyhedra_library::PIVOT_ROW_STRATEGY_MAX_COLUMN }

  Possible values for PIP problems' control parameters.
- enum parma_polyhedra_library::PIP_Problem_Status { parma_polyhedra_library::UNFEASIBLE_PIP_PROBLEM, parma_polyhedra_library::OPTIMIZED_PIP_PROBLEM }

  Possible outcomes of the PIP_Problem solver.
- enum parma_polyhedra_library::Relation_Symbol {

  parma_polyhedra_library::LESS_THAN, parma_polyhedra_library::LESS_OR_EQUAL, parma_polyhedra_library::EQUAL, parma_polyhedra_library::GREATER_OR_EQUAL,

  parma_polyhedra_library::GREATER_THAN }

  Relation symbols.

8.1.1 Detailed Description

The Parma Polyhedra Library comes equipped with an interface for the Java language.

8.1.2 Enumeration Type Documentation

8.1.2.1 enum parma_polyhedra_library::Bounded_Integer_Type_Overflow

Overflow behavior of bounded integer types.

Enumerator:

OVERFLOW_WRAPS On overflow, wrapping takes place.

OVERFLOW_UNDEFINED On overflow, the result is undefined.

OVERFLOW_IMPOSSIBLE Overflow is impossible.

8.1.2.2 enum parma_polyhedra_library::Bounded_Integer_Type_Representation

Representation of bounded integer types.

Enumerator:

UNSIGNED Unsigned binary.

SIGNED_2_COMPLEMENT Signed binary where negative values are represented by the two's complement of the absolute value.

8.1.2.3 enum parma_polyhedra_library::Bounded_Integer_Type_Width

Widths of bounded integer types.

Enumerator:

BITS_8 Minimization is requested.

BITS_16 16 bits.

BITS_32 32 bits.

BITS_64 64 bits.

BITS_128 128 bits.

8.1.2.4 enum parma_polyhedra_library::Complexity_Class

Possible Complexities.

Enumerator:

POLYNOMIAL_COMPLEXITY Worst-case polynomial complexity.

SIMPLEX_COMPLEXITY Worst-case exponential complexity but typically polynomial behavior.

ANY_COMPLEXITY Any complexity.

8.1.2.5 enum parma_polyhedra_library::Control_Parameter_Name

Names of MIP problems' control parameters.

Enumerator:

PRICING The pricing rule.

8.1.2.6 enum parma_polyhedra_library::Control_Parameter_Value

Possible values for MIP problem's control parameters.

Enumerator:

PRICING_STEEPEST_EDGE_FLOAT Steepest edge pricing method, using floating points (default).

PRICING_STEEPEST_EDGE_EXACT Steepest edge pricing method, using Coefficient.

PRICING_TEXTBOOK Textbook pricing method.

8.1.2.7 enum parma_polyhedra_library::Degenerate_Element

Kinds of degenerate abstract elements.

Enumerator:

UNIVERSE The universe element, i.e., the whole vector space.

EMPTY The empty element, i.e., the empty set.

8.1.2.8 enum parma_polyhedra_library::Generator_Type

The generator type.

Enumerator:

LINE The generator is a line.

RAY The generator is a ray.

POINT The generator is a point.

CLOSURE_POINT The generator is a closure point.

8.1.2.9 enum parma_polyhedra_library::Grid_Generator_Type

The grid generator type.

Enumerator:

LINE The generator is a line.

PARAMETER The generator is a parameter.

POINT The generator is a point.

8.1.2.10 enum parma_polyhedra_library::MIP_Problem_Status

Possible outcomes of the MIP_Problem solver.

Enumerator:

UNFEASIBLE_MIP_PROBLEM The problem is unfeasible.

UNBOUNDED_MIP_PROBLEM The problem is unbounded.

OPTIMIZED_MIP_PROBLEM The problem has an optimal solution.

8.1.2.11 enum parma_polyhedra_library::Optimization_Mode

Possible optimization modes.

Enumerator:

MINIMIZATION Minimization is requested.

MAXIMIZATION Maximization is requested.

8.1.2.12 enum parma_polyhedra_library::PIP_Problem_Control_Parameter_Name

Names of PIP problems' control parameters.

Enumerator:

CUTTING_STRATEGY The cutting strategy rule.

PIVOT_ROW_STRATEGY The pivot row strategy rule.

8.1.2.13 enum parma_polyhedra_library::PIP_Problem_Control_Parameter_Value

Possible values for PIP problems' control parameters.

Enumerator:

CUTTING_STRATEGY_FIRST Choose the first non-integer row.

CUTTING_STRATEGY_DEEPEST Choose row which generates the deepest cut.

CUTTING_STRATEGY_ALL Always generate all possible cuts.

PIVOT_ROW_STRATEGY_FIRST Choose the first row with negative parameter sign.

PIVOT_ROW_STRATEGY_MAX_COLUMN Choose the row which generates the lexico-maximal pivot column.

8.1.2.14 enum parma_polyhedra_library::PIP_Problem_Status

Possible outcomes of the PIP_Problem solver.

Enumerator:

UNFEASIBLE_PIP_PROBLEM The problem is unsatisfiable.

OPTIMIZED_PIP_PROBLEM The problem has an optimal solution.

8.1.2.15 enum parma_polyhedra_library::Relation_Symbol

Relation symbols.

Enumerator:

LESS_THAN Less than.

LESS_OR_EQUAL Less than or equal to.

EQUAL Equal to.

GREATER_OR_EQUAL Greater than or equal to.

GREATER_THAN Greater than.

9 Namespace Documentation

9.1 parma_polyhedra_library Namespace Reference

The PPL Java interface package.

Classes

- class Artificial_Parameter
- class Artificial_Parameter_Sequence

    A sequence of artificial parameters.
- class By_Reference< T >

    An utility class implementing mutable and non-mutable call-by-reference.
- class Coefficient

    A PPL coefficient.
- class Congruence

    A linear congruence.
- class Congruence_System

    A system of congruences.
- class Constraint

    A linear equality or inequality.
- class Constraint_System

    A system of constraints.
- class Domain_Error_Exception

    Exceptions caused by domain errors.
- class Polyhedron

    The Java base class for (C and NNC) convex polyhedra.
- class C_Polyhedron

    A topologically closed convex polyhedron.
- class Pointset_Powerset_C_Polyhedron

    A powerset of C_Polyhedron objects.
- class Pointset_Powerset_C_Polyhedron_Iterator

    An iterator class for the disjuncts of a Pointset_Powerset_C_Polyhedron.
- class Generator

    A line, ray, point or closure point.
- class Generator_System

    A system of generators.
- class Grid_Generator

    A grid line, parameter or grid point.
- class Grid_Generator_System

    A system of grid generators.
- class Invalid_Argument_Exception

    Exceptions caused by invalid arguments.
- class IO

    A class collecting I/O functions.
- class Length_Error_Exception

    Exceptions caused by too big length/size values.

- class Linear_Expression

  A linear expression.
- class Linear_Expression_Coefficient

  A linear expression built from a coefficient.
- class Linear_Expression_Difference

  The difference of two linear expressions.
- class Linear_Expression_Sum

  The sum of two linear expressions.
- class Linear_Expression_Times

  The product of a linear expression and a coefficient.
- class Linear_Expression_Unary_Minus

  The negation of a linear expression.
- class Linear_Expression_Variable

  A linear expression built from a variable.
- class Logic_Error_Exception

  Exceptions due to errors in low-level routines.
- class MIP_Problem

  A Mixed Integer (linear) Programming problem.
- class Overflow_Error_Exception

  Exceptions due to overflow errors.
- class Pair< K, V >

  A pair of values of type K and V.
- class Parma_Polyhedra_Library

  A class collecting library-level functions.
- class Partial_Function

  A partial function on space dimension indices.
- class PIP_Decision_Node

  An internal node of the PIP solution tree.
- class PIP_Problem

  A Parametric Integer Programming problem.
- class PIP_Solution_Node

  A leaf node of the PIP solution tree.
- class PIP_Tree_Node

  A node of the PIP solution tree.
- class Poly_Con_Relation

  The relation between a polyhedron and a constraint.
- class Poly_Gen_Relation

  The relation between a polyhedron and a generator.
- class Timeout_Exception

  Exceptions caused by timeout expiring.
- class Variable

  A dimension of the vector space.
- class Variables_Set

  A java.util.TreeSet of variables' indexes.

Enumerations

- enum Bounded_Integer_Type_Overflow { OVERFLOW_WRAPS, OVERFLOW_UNDEFINED, OVERFLOW_-IMPOSSIBLE }

  Overflow behavior of bounded integer types.
- enum Bounded_Integer_Type_Representation { UNSIGNED, SIGNED_2_COMPLEMENT }

  Representation of bounded integer types.
- enum Bounded_Integer_Type_Width {
  BITS_8, BITS_16, BITS_32, BITS_64,
  BITS_128 }

  Widths of bounded integer types.
- enum Complexity_Class { POLYNOMIAL_COMPLEXITY, SIMPLEX_COMPLEXITY, ANY_-COMPLEXITY }

  Possible Complexities.
- enum Control_Parameter_Name { PRICING }

  Names of MIP problems' control parameters.
- enum Control_Parameter_Value { PRICING_STEEPEST_EDGE_FLOAT, PRICING_STEEPEST_-EDGE_EXACT, PRICING_TEXTBOOK }

  Possible values for MIP problem's control parameters.
- enum Degenerate_Element { UNIVERSE, EMPTY }

  Kinds of degenerate abstract elements.
- enum Generator_Type { LINE, RAY, POINT, CLOSURE_POINT }

  The generator type.
- enum Grid_Generator_Type { LINE, PARAMETER, POINT }

  The grid generator type.
- enum MIP_Problem_Status { UNFEASIBLE_MIP_PROBLEM, UNBOUNDED_MIP_PROBLEM, OPTIMIZED_MIP_PROBLEM }

  Possible outcomes of the MIP_Problem solver.
- enum Optimization_Mode { MINIMIZATION, MAXIMIZATION }

  Possible optimization modes.
- enum PIP_Problem_Control_Parameter_Name { CUTTING_STRATEGY, PIVOT_ROW_STRATEGY }

  Names of PIP problems' control parameters.
- enum PIP_Problem_Control_Parameter_Value {
  CUTTING_STRATEGY_FIRST, CUTTING_STRATEGY_DEEPEST, CUTTING_STRATEGY_-ALL, PIVOT_ROW_STRATEGY_FIRST,
  PIVOT_ROW_STRATEGY_MAX_COLUMN }

  Possible values for PIP problems' control parameters.
- enum PIP_Problem_Status { UNFEASIBLE_PIP_PROBLEM, OPTIMIZED_PIP_PROBLEM }

  Possible outcomes of the PIP_Problem solver.
- enum Relation_Symbol {
  LESS_THAN, LESS_OR_EQUAL, EQUAL, GREATER_OR_EQUAL,
  GREATER_THAN }

  Relation symbols.

9.1.1 Detailed Description

The PPL Java interface package. All classes, interfaces and enums related to the Parma Polyhedra Library Java interface are included in this package.

10 Class Documentation

10.1 parma_polyhedra_library::Artificial_Parameter Class Reference

Public Member Functions

- Artificial_Parameter (Linear_Expression e, Coefficient d)

  Builds an artificial parameter from a linear expression and a denominator.
- Linear_Expression linear_expression ()

  Returns the linear expression in artificial parameter `this`*.*
- Coefficient denominator ()

  Returns the denominator in artificial parameter `this`*.*
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`*.*
- native String toString ()

  Returns a string representation of `this`*.*

10.1.1 Detailed Description

An Artificial_Parameter object represents the result of the integer division of a Linear_Expression (on the other parameters, including the previously-defined artificials) by an integer denominator (a Coefficient object). The dimensions of the artificial parameters (if any) in a tree node have consecutive indices starting from `dim+1`, where the value of `dim` is computed as follows:

- for the tree root node, `dim` is the space dimension of the PIP_Problem;
- for any other node of the tree, it is recusrively obtained by adding the value of `dim` computed for the parent node to the number of artificial parameters defined in the parent node.

> Since the numbering of dimensions for artificial parameters follows the rule above, the addition of new problem variables and/or new problem parameters to an already solved PIP_Problem object (as done when incrementally solving a problem) will result in the systematic renumbering of all the existing artificial parameters.

The documentation for this class was generated from the following file:

- Artificial_Parameter.java

10.2 parma_polyhedra_library::Artificial_Parameter_Sequence Class Reference

A sequence of artificial parameters.

Public Member Functions

- Artificial_Parameter_Sequence ()

  Default constructor: builds an empty sequence of artificial parameters.

10.2.1 Detailed Description

A sequence of artificial parameters.

An object of the class Artificial_Parameter_Sequence is a sequence of artificial parameters.

The documentation for this class was generated from the following file:

- Artificial_Parameter_Sequence.java

10.3 parma_polyhedra_library::By_Reference< T > Class Reference

An utility class implementing mutable and non-mutable call-by-reference.

Public Member Functions

- By_Reference (T object_value)

  Builds an object encapsulating `object_value`.
- void set (T y)

  Set an object to value `object_value`.
- T get ()

  Returns the value held by `this`.

Package Attributes

- T obj

  Stores the object.

10.3.1 Detailed Description

An utility class implementing mutable and non-mutable call-by-reference.

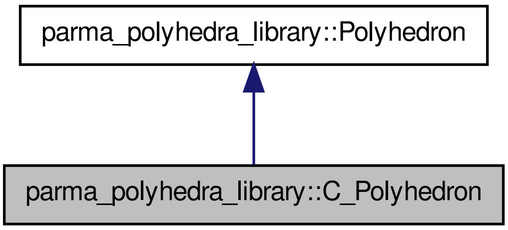
The documentation for this class was generated from the following file:

- By_Reference.java

10.4 parma_polyhedra_library::C_Polyhedron Class Reference

A topologically closed convex polyhedron.

Inheritance diagram for parma_polyhedra_library::C_Polyhedron:



Public Member Functions

Standard Constructors and Destructor

- C_Polyhedron (long d, Degenerate_Element kind)
  Builds a new C polyhedron of dimension `d`.
- C_Polyhedron (C_Polyhedron y)
  Builds a new C polyhedron that is copy of `y`.
- C_Polyhedron (C_Polyhedron y, Complexity_Class complexity)
  Builds a new C polyhedron that is a copy of `ph`.
- C_Polyhedron (Constraint_System cs)
  Builds a new C polyhedron from the system of constraints `cs`.
- C_Polyhedron (Congruence_System cgs)
  Builds a new C polyhedron from the system of congruences `cgs`.
- native void free ()
  Releases all resources managed by `this`*, also resetting it to a null reference.*

Constructors Behaving as Conversion Operators

Besides the conversions listed here below, the library also provides conversion operators that build a semantic geometric description starting from ***any*** *other semantic geometric description (e.g.,* `Grid(C_Polyhedron y)`, `C_Polyhedron(BD_Shape_mpq_class y)`*, etc.). Clearly, the conversion operators are only available if both the source and the target semantic geometric descriptions have been enabled when configuring the library. The conversions also taking as argument a complexity class sometimes provide non-trivial precision/efficiency trade-offs.*

- C_Polyhedron (NNC_Polyhedron y)
  Builds a C polyhedron that is a copy of the topological closure of the NNC polyhedron `y`.
- C_Polyhedron (NNC_Polyhedron y, Complexity_Class complexity)
  Builds a C polyhedron that is a copy of the topological closure of the NNC polyhedron `y`.
- C_Polyhedron (Generator_System gs)
  Builds a new C polyhedron from the system of generators `gs`.

Other Methods

- native boolean upper_bound_assign_if_exact (C_Polyhedron y)
  If the upper bound of `this` *and* `y` *is exact it is assigned to* `this` *and* `true` *is returned; otherwise* `false` *is returned.*

Static Public Member Functions

- static native Pair< C_Polyhedron, Pointset_Powerset_NNC_Polyhedron > linear_partition (C_Polyhedron p, C_Polyhedron q)

  Partitions q *with respect to* p*.*

Protected Member Functions

- native void finalize ()

  Releases all resources managed by this*.*

10.4.1 Detailed Description

A topologically closed convex polyhedron.

10.4.2 Constructor & Destructor Documentation

10.4.2.1 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (long *d*, Degenerate_Element *kind*)

Builds a new C polyhedron of dimension d.

If kind is EMPTY, the newly created polyhedron will be empty; otherwise, it will be a universe polyhedron.

10.4.2.2 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (C_Polyhedron *y*, Complexity_Class *complexity*)

Builds a new C polyhedron that is a copy of ph.

The complexity argument is ignored.

10.4.2.3 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (Constraint_System *cs*)

Builds a new C polyhedron from the system of constraints cs.

The new polyhedron will inherit the space dimension of cs.

10.4.2.4 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (Congruence_System *cgs*)

Builds a new C polyhedron from the system of congruences cgs.

The new polyhedron will inherit the space dimension of cgs.

10.4.2.5 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (NNC_Polyhedron *y*, Complexity_Class *complexity*)

Builds a C polyhedron that is a copy of the topological closure of the NNC polyhedron y.

The complexity argument is ignored, since the exact constructor has polynomial complexity.

10.4.2.6 parma_polyhedra_library::C_Polyhedron::C_Polyhedron (Generator_System *gs*)

Builds a new C polyhedron from the system of generators gs.

The new polyhedron will inherit the space dimension of gs.

10.4.3 Member Function Documentation

10.4.3.1 native boolean parma_polyhedra_library::C_Polyhedron::upper_bound_assign_if_exact (C_Polyhedron *y*)

If the upper bound of `this` and `y` is exact it is assigned to `this` and `true` is returned; otherwise `false` is returned.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are dimension-incompatible.

10.4.3.2 static native Pair<C_Polyhedron, Pointset_Powerset_NNC_Polyhedron> parma_polyhedra_library::C_Polyhedron::linear_partition (C_Polyhedron *p*, C_Polyhedron *q*) `[static]`

Partitions `q` with respect to `p`.

Let `p` and `q` be two polyhedra. The function returns a pair object `r` such that

- `r.first` is the intersection of `p` and `q`;
- `r.second` has the property that all its elements are pairwise disjoint and disjoint from `p`;
- the set-theoretical union of `r.first` with all the elements of `r.second` gives `q` (i.e., `r` is the representation of a partition of `q`).

The documentation for this class was generated from the following file:

- Fake_Class_for_Doxygen.java

10.5 parma_polyhedra_library::Coefficient Class Reference

A PPL coefficient.

Public Member Functions

- Coefficient (int i)

  Builds a coefficient valued `i`.
- Coefficient (long l)

  Builds a coefficient valued `l`.
- Coefficient (BigInteger bi)

  Builds a coefficient valued `bi`.
- Coefficient (String s)

  Builds a coefficient from the decimal representation in `s`.
- Coefficient (Coefficient c)

  Builds a copy of `c`.
- String toString ()

  Returns a String representation of `this`.
- BigInteger getBigInteger ()

  Returns the value held by `this`.

Static Public Member Functions

- static native int bits ()

  Returns the number of bits of PPL coefficients; 0 if unbounded.

10.5.1 Detailed Description

A PPL coefficient.

Objects of type Coefficient are used to implement the integral valued coefficients occurring in linear expressions, constraints, generators and so on.

10.5.2 Constructor & Destructor Documentation

10.5.2.1 parma_polyhedra_library::Coefficient::Coefficient (String *s*) [inline]

Builds a coefficient from the decimal representation in `s`.

Exceptions

java.lang.NumberFormatEx	Thrown if `s` does not contain a valid decimal representation.

The documentation for this class was generated from the following file:

- Coefficient.java

10.6 parma_polyhedra_library::Congruence Class Reference

A linear congruence.

Public Member Functions

- Congruence (Linear_Expression e1, Linear_Expression e2, Coefficient m)

  Returns the congruence $\mathtt{e1} = \mathtt{e2} \pmod{\mathtt{m}}$.
- Linear_Expression left_hand_side ()

  Returns the left hand side of `this`.
- Linear_Expression right_hand_side ()

  Returns the right hand side of `this`.
- Coefficient modulus ()

  Returns the relation symbol of `this`.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`.
- native String toString ()

  Returns a string representation of `this`.

Protected Attributes

- Coefficient mod

  The modulus of the congruence.

Package Attributes

- Linear_Expression lhs

  The value of the left hand side of `this`.
- Linear_Expression rhs

  The value of the right hand side of `this`.

10.6.1 Detailed Description

A linear congruence.

An object of the class Congruence is an object represeting a congruence:

- $\mathrm{cg} = \sum_{i=0}^{n-1} a_i x_i + b = 0 \pmod m$

where n is the dimension of the space, a_i is the integer coefficient of variable x_i, b is the integer inhomogeneous term and m is the integer modulus; if $m = 0$, then cg represents the equality congruence $\sum_{i=0}^{n-1} a_i x_i + b = 0$ and, if $m \neq 0$, then the congruence cg is said to be a proper congruence.

The documentation for this class was generated from the following file:

- Congruence.java

10.7 parma_polyhedra_library::Congruence_System Class Reference

A system of congruences.

Public Member Functions

- Congruence_System ()

  Default constructor: builds an empty system of congruences.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`.
- native String toString ()

  Returns a string representation of `this`.

10.7.1 Detailed Description

A system of congruences.

An object of the class Congruence_System is a system of congruences, i.e., a multiset of objects of the class Congruence.

The documentation for this class was generated from the following file:

- Congruence_System.java

10.8 parma_polyhedra_library::Constraint Class Reference

A linear equality or inequality.

Public Member Functions

- Constraint (Linear_Expression le1, Relation_Symbol rel_sym, Linear_Expression le2)

  Builds a constraint from two linear expressions with a specified relation symbol.
- Linear_Expression left_hand_side ()

  Returns the left hand side of `this`.
- Linear_Expression right_hand_side ()

  Returns the right hand side of `this`.
- Relation_Symbol kind ()

  Returns the relation symbol of `this`.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`.
- native String toString ()

  Returns a string representation of `this`.

10.8.1 Detailed Description

A linear equality or inequality.

An object of the class Constraint is either:

- a linear equality;
- a non-strict linear inequality;
- a strict linear inequality.

The documentation for this class was generated from the following file:

- Constraint.java

10.9 parma_polyhedra_library::Constraint_System Class Reference

A system of constraints.

Public Member Functions

- Constraint_System ()

  Default constructor: builds an empty system of constraints.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`.
- native String toString ()

  Returns a string representation of `this`.

10.9.1 Detailed Description

A system of constraints.

An object of the class Constraint_System is a system of constraints, i.e., a multiset of objects of the class Constraint.

The documentation for this class was generated from the following file:

- Constraint_System.java

10.10 parma_polyhedra_library::Domain_Error_Exception Class Reference

Exceptions caused by domain errors.

Public Member Functions

- Domain_Error_Exception (String s)

  Constructor.

10.10.1 Detailed Description

Exceptions caused by domain errors.

The documentation for this class was generated from the following file:

- Domain_Error_Exception.java

10.11 parma_polyhedra_library::Generator Class Reference

A line, ray, point or closure point.

Public Member Functions

- Generator_Type type ()

  Returns the generator type.
- Linear_Expression linear_expression ()

  Returns the linear expression in `this`.
- Coefficient divisor ()

  If `this` *is either a point or a closure point, returns its divisor.*
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`.
- native String toString ()

  Returns a string representation of `this`.

Static Public Member Functions

- static Generator closure_point (Linear_Expression e, Coefficient d)

  Returns the closure point at e / d*.*
- static Generator line (Linear_Expression e)

  Returns the line of direction e*.*
- static Generator point (Linear_Expression e, Coefficient d)

  Returns the point at e / d*.*
- static Generator ray (Linear_Expression e)

  Returns the ray of direction e*.*

10.11.1 Detailed Description

A line, ray, point or closure point.

An object of the class Generator is one of the following:

- a line;
- a ray;
- a point;
- a closure point.

10.11.2 Member Function Documentation

10.11.2.1 static Generator parma_polyhedra_library::Generator::closure_point (Linear_Expression *e*, Coefficient *d*) [inline, static]

Returns the closure point at e / d.

Exceptions

RuntimeErrorException	Thrown if d is zero.

10.11.2.2 static Generator parma_polyhedra_library::Generator::line (Linear_Expression *e*) [inline, static]

Returns the line of direction e.

Exceptions

RuntimeErrorException	Thrown if the homogeneous part of e represents the origin of the vector space.

10.11.2.3 static Generator parma_polyhedra_library::Generator::point (Linear_Expression *e*, Coefficient *d*) [inline, static]

Returns the point at e / d.

Exceptions

RuntimeErrorException	Thrown if d is zero.

10.11.2.4 static Generator parma_polyhedra_library::Generator::ray (Linear_Expression *e*) [inline, static]

Returns the ray of direction e.

Exceptions

RuntimeErrorException	Thrown if the homogeneous part of e represents the origin of the vector space.

10.11.2.5 Coefficient parma_polyhedra_library::Generator::divisor ( ) [inline]

If this is either a point or a closure point, returns its divisor.

Exceptions

RuntimeErrorException	Thrown if this is neither a point nor a closure point.

The documentation for this class was generated from the following file:

- Generator.java

10.12 parma_polyhedra_library::Generator_System Class Reference

A system of generators.

Public Member Functions

- Generator_System ()

  Default constructor: builds an empty system of generators.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of this*.*
- native String toString ()

  Returns a string representation of this*.*

10.12.1 Detailed Description

A system of generators.

An object of the class Generator_System is a system of generators, i.e., a multiset of objects of the class Generator (lines, rays, points and closure points).

The documentation for this class was generated from the following file:

- Generator_System.java

10.13 parma_polyhedra_library::Grid_Generator Class Reference

A grid line, parameter or grid point.

Public Member Functions

- Grid_Generator_Type type ()

    Returns the generator type.
- Linear_Expression linear_expression ()

    Returns the linear expression in `this`*.*
- Coefficient divisor ()

    If `this` *is either a grid point or a parameter, returns its divisor.*
- native String ascii_dump ()

    Returns an ascii formatted internal representation of `this`*.*
- native String toString ()

    Returns a string representation of `this`*.*

Static Public Member Functions

- static Grid_Generator grid_line (Linear_Expression e)

    Returns the line of direction `e`*.*
- static Grid_Generator parameter (Linear_Expression e, Coefficient d)

    Returns the parameter at `e` */* `d`*.*
- static Grid_Generator grid_point (Linear_Expression e, Coefficient d)

    Returns the point at `e` */* `d`*.*

10.13.1 Detailed Description

A grid line, parameter or grid point.

An object of the class Grid_Generator is one of the following:

- a grid_line;
- a parameter;
- a grid_point.

10.13.2 Member Function Documentation

10.13.2.1 static Grid_Generator parma_polyhedra_library::Grid_Generator::grid_line (Linear_Expression *e*) `[inline, static]`

Returns the line of direction `e`.

Exceptions

RuntimeErrorException	Thrown if the homogeneous part of `e` represents the origin of the vector space.

10.13.2.2 static Grid_Generator parma_polyhedra_library::Grid_Generator::parameter (Linear_Expression *e*, Coefficient *d*) `[inline, static]`

Returns the parameter at `e` / `d`.

Exceptions

RuntimeErrorException	Thrown if d is zero.

10.13.2.3 static Grid_Generator parma_polyhedra_library::Grid_Generator::grid_point (Linear_Expression *e*, Coefficient *d*) [inline, static]

Returns the point at e / d.

Exceptions

RuntimeErrorException	Thrown if d is zero.

10.13.2.4 Coefficient parma_polyhedra_library::Grid_Generator::divisor ( ) [inline]

If this is either a grid point or a parameter, returns its divisor.

Exceptions

RuntimeErrorException	Thrown if this is a line.

The documentation for this class was generated from the following file:

- Grid_Generator.java

10.14 parma_polyhedra_library::Grid_Generator_System Class Reference

A system of grid generators.

Public Member Functions

- Grid_Generator_System ()
  Default constructor: builds an empty system of grid generators.
- native String ascii_dump ()
  Returns an ascii formatted internal representation of this.
- native String toString ()
  Returns a string representation of this.

10.14.1 Detailed Description

A system of grid generators.

An object of the class Grid_Generator_System is a system of grid generators, i.e., a multiset of objects of the class Grid_Generator.

The documentation for this class was generated from the following file:

- Grid_Generator_System.java

10.15 parma_polyhedra_library::Invalid_Argument_Exception Class Reference

Exceptions caused by invalid arguments.

Public Member Functions

- Invalid_Argument_Exception (String s)

  Constructor.

10.15.1 Detailed Description

Exceptions caused by invalid arguments.

The documentation for this class was generated from the following file:

- Invalid_Argument_Exception.java

10.16 parma_polyhedra_library::IO Class Reference

A class collecting I/O functions.

Static Public Member Functions

- static native String wrap_string (String str, int indent_depth, int preferred_first_line_length, int preferred_line_length)

  Utility function for the wrapping of lines of text.

10.16.1 Detailed Description

A class collecting I/O functions.

10.16.2 Member Function Documentation

10.16.2.1 static native String parma_polyhedra_library::IO::wrap_string (String *str*, int *indent_depth*, int *preferred_first_line_length*, int *preferred_line_length*) [static]

Utility function for the wrapping of lines of text.

Parameters

str	The source string holding the lines to wrap.
indent_depth	The indentation depth.
preferred_first_line_length	The preferred length for the first line of text.
preferred_line_length	The preferred length for all the lines but the first one.

Returns

The wrapped string.

The documentation for this class was generated from the following file:

- IO.java

10.17 parma_polyhedra_library::Length_Error_Exception Class Reference

Exceptions caused by too big length/size values.

Public Member Functions

- Length_Error_Exception (String s)

    Constructor.

10.17.1 Detailed Description

Exceptions caused by too big length/size values.

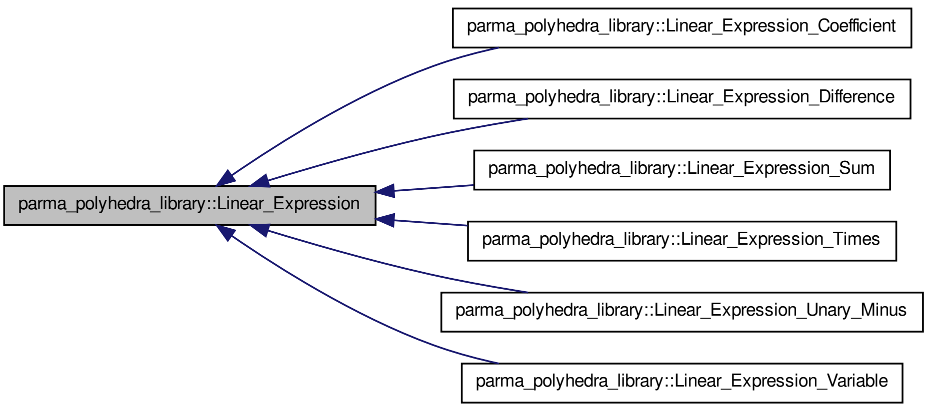
The documentation for this class was generated from the following file:

- Length_Error_Exception.java

10.18 parma_polyhedra_library::Linear_Expression Class Reference

A linear expression.

Inheritance diagram for parma_polyhedra_library::Linear_Expression:



Public Member Functions

- Linear_Expression sum (Linear_Expression y)

    Returns the sum of `this` *and* `y`*.*
- Linear_Expression subtract (Linear_Expression y)

    Returns the difference of `this` *and* `y`*.*
- Linear_Expression times (Coefficient c)

    Returns the product of `this` *times* `c`*.*
- Linear_Expression unary_minus ()

Returns the negation of `this`*.*
- abstract Linear_Expression clone ()

  Returns a copy of the linear expression.
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`*.*
- native String toString ()

  Returns a string representation of `this`*.*
- native boolean is_zero ()

  Returns `true` *if and only if* `*this` *is* 0*.*
- native boolean all_homogeneous_terms_are_zero ()

  Returns `true` *if and only if all the homogeneous terms of* `*this` *are* 0*.*

10.18.1 Detailed Description

A linear expression.

An object of the class Linear_Expression represents a linear expression that can be built from a Linear_Expression_Variable, Linear_Expression_Coefficient, Linear_Expression_Sum, Linear_Expression_Difference, Linear_Expression_Unary_Minus.

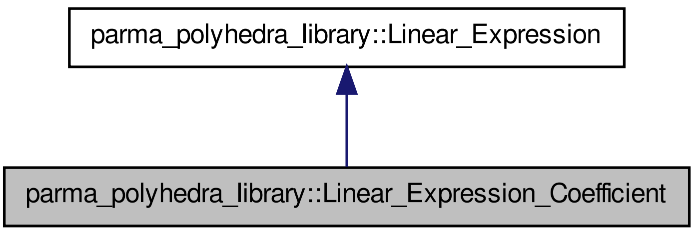
The documentation for this class was generated from the following file:

- Linear_Expression.java

10.19 parma_polyhedra_library::Linear_Expression_Coefficient Class Reference

A linear expression built from a coefficient.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Coefficient:



Public Member Functions

- Linear_Expression_Coefficient (Coefficient c)

  Builds the object corresponding to a copy of the coefficient `c`*.*
- Coefficient argument ()

Returns coefficient representing the linear expression.

- Linear_Expression_Coefficient clone ()

  Builds a copy of this.

Protected Attributes

- Coefficient coeff

  The coefficient representing the linear expression.

10.19.1 Detailed Description

A linear expression built from a coefficient.

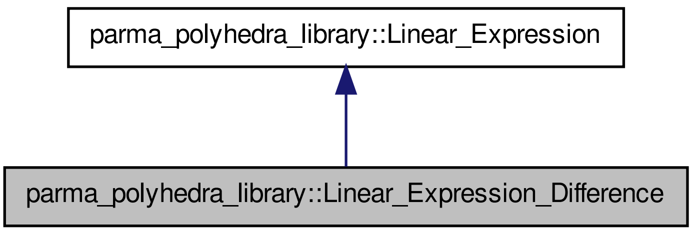
The documentation for this class was generated from the following file:

- Linear_Expression_Coefficient.java

10.20 parma_polyhedra_library::Linear_Expression_Difference Class Reference

The difference of two linear expressions.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Difference:



Public Member Functions

- Linear_Expression_Difference (Linear_Expression x, Linear_Expression y)

  Builds an object that represents the difference of the copy `x` *and* `y`*.*
- Linear_Expression left_hand_side ()

  Returns the left hand side of `this`*.*
- Linear_Expression right_hand_side ()

  Returns the left hand side of `this`*.*
- Linear_Expression_Difference clone ()

  Builds a copy of this.

Protected Attributes

- Linear_Expression lhs

  The value of the left hand side of `this`*.*
- Linear_Expression rhs

  The value of the right hand side of `this`*.*

10.20.1 Detailed Description

The difference of two linear expressions.

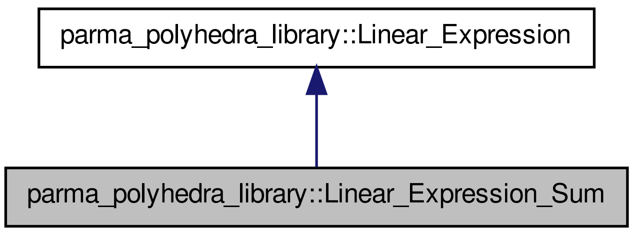
The documentation for this class was generated from the following file:

- Linear_Expression_Difference.java

10.21 parma_polyhedra_library::Linear_Expression_Sum Class Reference

The sum of two linear expressions.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Sum:



Public Member Functions

- Linear_Expression_Sum (Linear_Expression x, Linear_Expression y)

  Builds an object that represents the sum of the copy of `x` *and* `y`*.*
- Linear_Expression left_hand_side ()

  Returns the left hand side of `this`*.*
- Linear_Expression right_hand_side ()

  Returns the right hand side of `this`*.*
- Linear_Expression_Sum clone ()

  Builds a copy of this.

Protected Attributes

- Linear_Expression lhs

  The value of the left hand side of `this`.
- Linear_Expression rhs

  The value of the right hand side of `this`.

10.21.1 Detailed Description

The sum of two linear expressions.

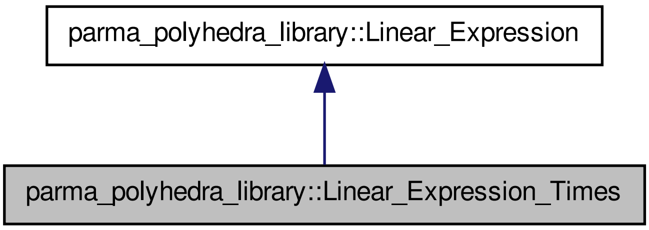
The documentation for this class was generated from the following file:

- Linear_Expression_Sum.java

10.22 parma_polyhedra_library::Linear_Expression_Times Class Reference

The product of a linear expression and a coefficient.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Times:



Public Member Functions

- Linear_Expression_Times (Coefficient c, Variable v)

  Builds an object cloning the input arguments.
- Linear_Expression_Times (Coefficient c, Linear_Expression l)

  Builds an object cloning the input arguments.
- Linear_Expression_Times (Linear_Expression l, Coefficient c)

  Builds an object cloning the input arguments.
- Coefficient coefficient ()

  Returns the coefficient of `this`.
- Linear_Expression linear_expression ()

  Returns the linear expression subobject of `this`.
- Linear_Expression_Times clone ()

  Builds a copy of this.

Protected Attributes

- Coefficient coeff

    The value of the coefficient.
- Linear_Expression lin_expr

    The value of the inner linear expression.

10.22.1 Detailed Description

The product of a linear expression and a coefficient.

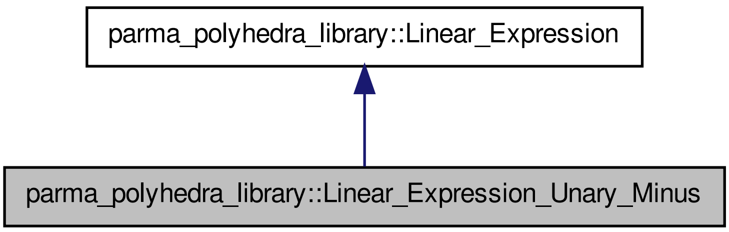
The documentation for this class was generated from the following file:

- Linear_Expression_Times.java

10.23 parma_polyhedra_library::Linear_Expression_Unary_Minus Class Reference

The negation of a linear expression.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Unary_Minus:



Public Member Functions

- Linear_Expression_Unary_Minus (Linear_Expression x)

    Builds an object that represents the negation of the copy `x`*.*
- Linear_Expression argument ()

    Returns the value that `this` *negates.*
- Linear_Expression_Unary_Minus clone ()

    Builds a copy of this.

Protected Attributes

- Linear_Expression arg

    The value that `this` *negates.*

10.23.1 Detailed Description

The negation of a linear expression.

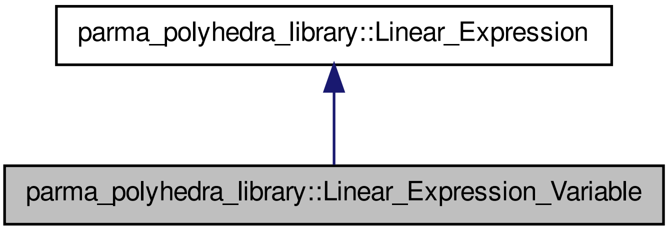
The documentation for this class was generated from the following file:

- Linear_Expression_Unary_Minus.java

10.24 parma_polyhedra_library::Linear_Expression_Variable Class Reference

A linear expression built from a variable.

Inheritance diagram for parma_polyhedra_library::Linear_Expression_Variable:



Public Member Functions

- Linear_Expression_Variable (Variable v)

  Builds the object associated to the copy of v*.*
- Variable argument ()

  Returns the variable representing the linear expression.
- Linear_Expression_Variable clone ()

  Builds a copy of this.

10.24.1 Detailed Description

A linear expression built from a variable.

The documentation for this class was generated from the following file:

- Linear_Expression_Variable.java

10.25 parma_polyhedra_library::Logic_Error_Exception Class Reference

Exceptions due to errors in low-level routines.

Public Member Functions

- Logic_Error_Exception (String s)
  Constructor.

10.25.1 Detailed Description

Exceptions due to errors in low-level routines.

These exceptions may be generated, for instance, by the inability of querying/controlling the FPU behavior with respect to rounding modes.

The documentation for this class was generated from the following file:

- Logic_Error_Exception.java

10.26 parma_polyhedra_library::MIP_Problem Class Reference

A Mixed Integer (linear) Programming problem.

Inherits parma_polyhedra_library::PPL_Object.

Public Member Functions

Functions that Do Not Modify the MIP_Problem

- native long max_space_dimension ()
  Returns the maximum space dimension an MIP_Problem can handle.
- native long space_dimension ()
  Returns the space dimension of the MIP problem.
- native Variables_Set integer_space_dimensions ()
  Returns a set containing all the variables' indexes constrained to be integral.
- native Constraint_System constraints ()
  Returns the constraints .
- native Linear_Expression objective_function ()
  Returns the objective function.
- native Optimization_Mode optimization_mode ()
  Returns the optimization mode.
- native String ascii_dump ()
  Returns an ascii formatted internal representation of `this`.
- native String toString ()
  Returns a string representation of `this`.
- native long total_memory_in_bytes ()
  Returns the total size in bytes of the memory occupied by the underlying C++ object.
- native boolean OK ()
  Checks if all the invariants are satisfied.

Functions that May Modify the MIP_Problem

- native void clear ()
  Resets `this` *to be equal to the trivial MIP problem.*
- native void add_space_dimensions_and_embed (long m)

Adds `m` *new space dimensions and embeds the old MIP problem in the new vector space.*
- native void add_to_integer_space_dimensions (Variables_Set i_vars)

  Sets the variables whose indexes are in set `i_vars` *to be integer space dimensions.*
- native void add_constraint (Constraint c)

  Adds a copy of constraint `c` *to the MIP problem.*
- native void add_constraints (Constraint_System cs)

  Adds a copy of the constraints in `cs` *to the MIP problem.*
- native void set_objective_function (Linear_Expression obj)

  Sets the objective function to `obj`*.*
- native void set_optimization_mode (Optimization_Mode mode)

  Sets the optimization mode to `mode`*.*

Computing the Solution of the MIP_Problem

- native boolean is_satisfiable ()

  Checks satisfiability of `*this`*.*
- native MIP_Problem_Status solve ()

  Optimizes the MIP problem.
- native void evaluate_objective_function (Generator evaluating_point, Coefficient num, Coefficient den)

  Sets `num` *and* `den` *so that* $\frac{num}{den}$ *is the result of evaluating the objective function on* `evaluating_point`*.*
- native Generator feasible_point ()

  Returns a feasible point for `*this`*, if it exists.*
- native Generator optimizing_point ()

  Returns an optimal point for `this`*, if it exists.*
- native void optimal_value (Coefficient num, Coefficient den)

  Sets `num` *and* `den` *so that* $\frac{num}{den}$ *is the solution of the optimization problem.*

Querying/Setting Control Parameters

- native Control_Parameter_Value get_control_parameter (Control_Parameter_Name name)

  Returns the value of control parameter `name`*.*
- native void set_control_parameter (Control_Parameter_Value value)

  Sets control parameter `value`*.*

Constructors and Destructor

- MIP_Problem (long dim)

  Builds a trivial MIP problem.
- MIP_Problem (long dim, Constraint_System cs, Linear_Expression obj, Optimization_Mode mode)

  Builds an MIP problem having space dimension `dim` *from the constraint system* `cs`*, the objective function* `obj` *and optimization mode* `mode`*.*
- MIP_Problem (MIP_Problem y)

  Builds a copy of `y`*.*
- native void free ()

  Releases all resources managed by `this`*, also resetting it to a null reference.*
- native void finalize ()

  Releases all resources managed by `this`*.*

10.26.1 Detailed Description

A Mixed Integer (linear) Programming problem.

An object of this class encodes a mixed integer (linear) programming problem. The MIP problem is specified by providing:

- the dimension of the vector space;
- the feasible region, by means of a finite set of linear equality and non-strict inequality constraints;
- the subset of the unknown variables that range over the integers (the other variables implicitly ranging over the reals);
- the objective function, described by a Linear_Expression;
- the optimization mode (either maximization or minimization).

The class provides support for the (incremental) solution of the MIP problem based on variations of the revised simplex method and on branch-and-bound techniques. The result of the resolution process is expressed in terms of an enumeration, encoding the feasibility and the unboundedness of the optimization problem. The class supports simple feasibility tests (i.e., no optimization), as well as the extraction of an optimal (resp., feasible) point, provided the MIP_Problem is optimizable (resp., feasible).

By exploiting the incremental nature of the solver, it is possible to reuse part of the computational work already done when solving variants of a given MIP_Problem: currently, incremental resolution supports the addition of space dimensions, the addition of constraints, the change of objective function and the change of optimization mode.

10.26.2 Constructor & Destructor Documentation

10.26.2.1 parma_polyhedra_library::MIP_Problem::MIP_Problem (long *dim*) `[inline]`

Builds a trivial MIP problem.

A trivial MIP problem requires to maximize the objective function 0 on a vector space under no constraints at all: the origin of the vector space is an optimal solution.

Parameters

dim	The dimension of the vector space enclosing `this`.

Exceptions

std::length_error	Thrown if `dim` exceeds `max_space_dimension()`.

10.26.2.2 parma_polyhedra_library::MIP_Problem::MIP_Problem (long *dim*, Constraint_System *cs*, Linear_Expression *obj*, Optimization_Mode *mode*) `[inline]`

Builds an MIP problem having space dimension `dim` from the constraint system `cs`, the objective function `obj` and optimization mode `mode`.

Parameters

dim	The dimension of the vector space enclosing `this`.
cs	The constraint system defining the feasible region.
obj	The objective function.

mode	The optimization mode.

Exceptions

std::length_error	Thrown if `dim` exceeds `max_space_dimension()`.
std::invalid_argument	Thrown if the constraint system contains any strict inequality or if the space dimension of the constraint system (resp., the objective function) is strictly greater than `dim`.

10.26.3 Member Function Documentation

10.26.3.1 native void parma_polyhedra_library::MIP_Problem::clear ( )

Resets `this` to be equal to the trivial MIP problem.

The space dimension is reset to 0.

10.26.3.2 native void parma_polyhedra_library::MIP_Problem::add_space_dimensions_and_embed (long *m*)

Adds `m` new space dimensions and embeds the old MIP problem in the new vector space.

Parameters

m	The number of dimensions to add.

Exceptions

std::length_error	Thrown if adding `m` new space dimensions would cause the vector space to exceed dimension `max_space_dimension()`.

The new space dimensions will be those having the highest indexes in the new MIP problem; they are initially unconstrained.

10.26.3.3 native void parma_polyhedra_library::MIP_Problem::add_to_integer_space_dimensions (Variables_Set *i_vars*)

Sets the variables whose indexes are in set `i_vars` to be integer space dimensions.

Exceptions

std::invalid_argument	Thrown if some index in `i_vars` does not correspond to a space dimension in `this`.

10.26.3.4 native void parma_polyhedra_library::MIP_Problem::add_constraint (Constraint *c*)

Adds a copy of constraint `c` to the MIP problem.

Exceptions

std::invalid_argument	Thrown if the constraint `c` is a strict inequality or if its space dimension is strictly greater than the space dimension of `this`.

10.26.3.5 native void parma_polyhedra_library::MIP_Problem::add_constraints (Constraint_System *cs*)

Adds a copy of the constraints in `cs` to the MIP problem.

Exceptions

std::invalid_argument	Thrown if the constraint system `cs` contains any strict inequality or if its space dimension is strictly greater than the space dimension of `*this`.

10.26.3.6 native void parma_polyhedra_library::MIP_Problem::set_objective_function (Linear_Expression *obj*)

Sets the objective function to `obj`.

Exceptions

std::invalid_argument	Thrown if the space dimension of `obj` is strictly greater than the space dimension of `this`.

10.26.3.7 native boolean parma_polyhedra_library::MIP_Problem::is_satisfiable ( )

Checks satisfiability of `*this`.

Returns

`true` if and only if the MIP problem is satisfiable.

10.26.3.8 native MIP_Problem_Status parma_polyhedra_library::MIP_Problem::solve ( )

Optimizes the MIP problem.

Returns

An MIP_Problem_Status flag indicating the outcome of the optimization attempt (unfeasible, unbounded or optimized problem).

10.26.3.9 native void parma_polyhedra_library::MIP_Problem::evaluate_objective_function (Generator *evaluating_point*, Coefficient *num*, Coefficient *den*)

Sets `num` and `den` so that $\frac{num}{den}$ is the result of evaluating the objective function on `evaluating_point`.

Parameters

evaluating_-point	The point on which the objective function will be evaluated.
num	On exit will contain the numerator of the evaluated value.
den	On exit will contain the denominator of the evaluated value.

Exceptions

std::invalid_argument	Thrown if `this` and `evaluating_point` are dimension-incompatible or if the generator `evaluating_point` is not a point.

10.26.3.10 native Generator parma_polyhedra_library::MIP_Problem::feasible_point ( )

Returns a feasible point for *this, if it exists.

Exceptions

std::domain_error	Thrown if the MIP problem is not satisfiable.

10.26.3.11 native Generator parma_polyhedra_library::MIP_Problem::optimizing_point ( )

Returns an optimal point for this, if it exists.

Exceptions

std::domain_error	Thrown if this doesn't not have an optimizing point, i.e., if the MIP problem is unbounded or not satisfiable.

10.26.3.12 native void parma_polyhedra_library::MIP_Problem::optimal_value (Coefficient *num*, Coefficient *den*)

Sets num and den so that $\frac{num}{den}$ is the solution of the optimization problem.

Exceptions

std::domain_error	Thrown if *this doesn't not have an optimizing point, i.e., if the MIP problem is unbounded or not satisfiable.

The documentation for this class was generated from the following file:

- MIP_Problem.java

10.27 parma_polyhedra_library::Overflow_Error_Exception Class Reference

Exceptions due to overflow errors.

Public Member Functions

- Overflow_Error_Exception (String s)

  Constructor.

10.27.1 Detailed Description

Exceptions due to overflow errors.

These exceptions can be obtained when the library has been configured to use integer coefficients having bounded size.

The documentation for this class was generated from the following file:

- Overflow_Error_Exception.java

10.28 parma_polyhedra_library::Pair< K, V > Class Reference

A pair of values of type K and V.

Public Member Functions

- K getFirst ()

  Returns the object of type K.
- V getSecond ()

  Returns the object of type V.

10.28.1 Detailed Description

A pair of values of type K and V.

An object of this class holds an ordered pair of values of type K and V.

The documentation for this class was generated from the following file:

- Pair.java

10.29 parma_polyhedra_library::Parma_Polyhedra_Library Class Reference

A class collecting library-level functions.

Static Public Member Functions

Library initialization and finalization

- static native void initialize_library ()

  Initializes the Parma Polyhedra Library.
- static native void finalize_library ()

  Finalizes the Parma Polyhedra Library.

Version Checking

- static native int version_major ()

  Returns the major number of the PPL version.
- static native int version_minor ()

  Returns the minor number of the PPL version.
- static native int version_revision ()

  Returns the revision number of the PPL version.
- static native int version_beta ()

  Returns the beta number of the PPL version.
- static native String version ()

  Returns a string containing the PPL version.
- static native String banner ()

  Returns a string containing the PPL banner.

Floating-point rounding and precision settings.

- static native void set_rounding_for_PPL ()
  Sets the FPU rounding mode so that the PPL abstractions based on floating point numbers work correctly.
- static native void restore_pre_PPL_rounding ()
  Sets the FPU rounding mode as it was before initialization of the PPL.
- static native int irrational_precision ()
  Returns the precision parameter for irrational calculations.
- static native void set_irrational_precision (int p)
  Sets the precision parameter used for irrational calculations.

Timeout handling

- static native void set_timeout (int csecs)
  Sets the timeout for computations whose completion could require an exponential amount of time.
- static native void reset_timeout ()
  Resets the timeout time so that the computation is not interrupted.
- static native void set_deterministic_timeout (int weight)
  Sets a threshold for computations whose completion could require an exponential amount of time.
- static native void reset_deterministic_timeout ()
  Resets the deterministic timeout so that the computation is not interrupted.

10.29.1 Detailed Description

A class collecting library-level functions.

10.29.2 Member Function Documentation

10.29.2.1 static native void parma_polyhedra_library::Parma_Polyhedra_Library::initialize_library ( ) [static]

Initializes the Parma Polyhedra Library.

This method must be called after loading the library and before calling any other method from any other PPL package class.

10.29.2.2 static native void parma_polyhedra_library::Parma_Polyhedra_Library::finalize_library ( ) [static]

Finalizes the Parma Polyhedra Library.

This method must be called when work with the library is done. After finalization, no other library method can be called (except those in class Parma_Polyhedra_Library), unless the library is re-initialized by calling `initialize_library()`.

10.29.2.3 static native String parma_polyhedra_library::Parma_Polyhedra_Library::banner ( ) [static]

Returns a string containing the PPL banner.

The banner provides information about the PPL version, the licensing, the lack of any warranty whatsoever, the C++ compiler used to build the library, where to report bugs and where to look for further information.

10.29.2.4 static native void parma_polyhedra_library::Parma_Polyhedra_Library::set_rounding_for_PPL ( ) [static]

Sets the FPU rounding mode so that the PPL abstractions based on floating point numbers work correctly.

This is performed automatically at initialization-time. Calling this function is needed only if restore_pre_-PPL_rounding() has been previously called.

10.29.2.5 static native void parma_polyhedra_library::Parma_Polyhedra_Library::restore_pre_PPL_rounding ( ) [static]

Sets the FPU rounding mode as it was before initialization of the PPL.

After calling this function it is absolutely necessary to call set_rounding_for_PPL() before using any PPL abstractions based on floating point numbers. This is performed automatically at finalization-time.

10.29.2.6 static native void parma_polyhedra_library::Parma_Polyhedra_Library::set_irrational_precision (int *p*) [static]

Sets the precision parameter used for irrational calculations.

If `p` is less than or equal to `INT_MAX`, sets the precision parameter used for irrational calculations to `p`. Then, in the irrational calculations returning an unbounded rational, (e.g., when computing a square root), the lesser between numerator and denominator will be limited to `2**p`.

10.29.2.7 static native void parma_polyhedra_library::Parma_Polyhedra_Library::set_timeout (int *csecs*) [static]

Sets the timeout for computations whose completion could require an exponential amount of time.

Parameters

csecs	The number of centiseconds sometimes after which a timeout will occur; it must be strictly greater than zero.

Computations taking exponential time will be interrupted some time after `csecs` centiseconds have elapsed since the call to the timeout setting function, by throwing a `Timeout_Exception` object. Otherwise, if the computation completes without being interrupted, then the timeout should be reset by calling `reset_-timeout()`.

10.29.2.8 static native void parma_polyhedra_library::Parma_Polyhedra_Library::set_deterministic_timeout (int *weight*) [static]

Sets a threshold for computations whose completion could require an exponential amount of time.

Parameters

weight	The maximum computational weight allowed; it must be strictly greater than zero.

Computations taking exponential time will be interrupted some time after reaching the `weight` complexity threshold, by throwing a `Timeout_Exception` object. Otherwise, if the computation completes without being interrupted, then the deterministic timeout should be reset by calling `reset_deterministic_-timeout()`.

Note

This "timeout" checking functionality is said to be *deterministic* because it is not based on actual elapsed time. Its behavior will only depend on (some of the) computations performed in the PPL library and it will be otherwise independent from the computation environment (CPU, operating system, compiler, etc.).

Warning

The weight mechanism is under alpha testing. In particular, there is still no clear relation between the weight threshold and the actual computational complexity. As a consequence, client applications should be ready to reconsider the tuning of these weight thresholds when upgrading to newer version of the PPL.

The documentation for this class was generated from the following file:

- Parma_Polyhedra_Library.java

10.30 parma_polyhedra_library::Partial_Function Class Reference

A partial function on space dimension indices.

Inherits parma_polyhedra_library::PPL_Object.

Public Member Functions

- Partial_Function ()

  Builds the empty map.
- native void insert (long i, long j)

  Inserts mapping from `i` to `j`.
- native boolean has_empty_codomain ()

  Returns `true` if and only if the partial function has an empty codomain (i.e., it is always undefined).
- native long max_in_codomain ()

  Returns the maximum value that belongs to the codomain of the partial function.
- native long maps (long i)

  If the partial function is defined on index `i`, returns its value.
- native void free ()

  Releases all resources managed by `this`, also resetting it to a null reference.

Protected Member Functions

- native void finalize ()

  Releases all resources managed by `this`.

10.30.1 Detailed Description

A partial function on space dimension indices.

This class is used in order to specify how space dimensions should be mapped by methods named `map_-space_dimensions`.

10.30.2 Member Function Documentation

10.30.2.1 native boolean parma_polyhedra_library::Partial_Function::has_empty_codomain ( )

Returns `true` if and only if the partial function has an empty codomain (i.e., it is always undefined).

This method will always be called before the other methods of the interface. Moreover, if `true` is returned, then none of the other interface methods will be called.

10.30.2.2 native long parma_polyhedra_library::Partial_Function::maps (long *i*)

If the partial function is defined on index `i`, returns its value.

The function returns a negative value if the partial function is not defined on domain value `i`.

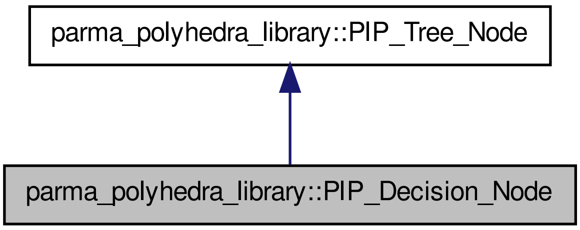
The documentation for this class was generated from the following file:

- Partial_Function.java

10.31 parma_polyhedra_library::PIP_Decision_Node Class Reference

An internal node of the PIP solution tree.

Inheritance diagram for parma_polyhedra_library::PIP_Decision_Node:



Public Member Functions

- native PIP_Tree_Node child_node (boolean branch)

  Returns the true branch (if `branch` is true) or the false branch (if `branch` is false) of `this`.

10.31.1 Detailed Description

An internal node of the PIP solution tree.

The documentation for this class was generated from the following file:

- PIP_Decision_Node.java

10.32 parma_polyhedra_library::PIP_Problem Class Reference

A Parametric Integer Programming problem.

Inherits parma_polyhedra_library::PPL_Object.

Public Member Functions

- PIP_Problem (long dim)

  Builds a trivial PIP problem.
- PIP_Problem (long dim, Constraint_System cs, Variables_Set params)

  Builds a PIP problem from a sequence of constraints.
- PIP_Problem (PIP_Problem y)

  Builds a copy of `y`*.*
- native void free ()

  Releases all resources managed by `this`*, also resetting it to a null reference.*

Functions that Do Not Modify the PIP_Problem

- native long max_space_dimension ()

  Returns the maximum space dimension an PIP_Problem can handle.
- native long space_dimension ()

  Returns the space dimension of the PIP problem.
- native long number_of_parameter_space_dimensions ()

  Returns the number of parameter space dimensions of the PIP problem.
- native Variables_Set parameter_space_dimensions ()

  Returns all the parameter space dimensions of problem `pip`*.*
- native long get_big_parameter_dimension ()

  Returns the big parameter dimension of PIP problem `pip`*.*
- native long number_of_constraints ()

  Returns the number of constraints defining the feasible region of `pip`*.*
- native Constraint constraint_at_index (long dim)

  Returns the `i-th` *constraint defining the feasible region of the PIP problem* `pip`*.*
- native Constraint_System constraints ()

  Returns the constraints .
- native String ascii_dump ()

  Returns an ascii formatted internal representation of `this`*.*
- native String toString ()

  Returns a string representation of `this`*.*
- native long total_memory_in_bytes ()

  Returns the size in bytes of the memory occupied by the underlying C++ object.
- native long external_memory_in_bytes ()

  Returns the size in bytes of the memory managed by the underlying C++ object.
- native boolean OK ()

  Returns true if the pip problem is well formed, i.e., if it satisfies all its implementation invariants; returns 0 and perhaps makes some noise if broken. Useful for debugging purposes.

Functions that May Modify the PIP_Problem

- native void clear ()

  Resets `this` *to be equal to the trivial PIP problem.*
- native void add_space_dimensions_and_embed (long pip_vars, long pip_params)

  Adds `pip_vars + pip_params` *new space dimensions and embeds the PIP problem in the new vector space.*
- native void add_to_parameter_space_dimensions (Variables_Set vars)

  Sets the space dimensions in `vars` *to be parameter dimensions of the PIP problem.*
- native void set_big_parameter_dimension (long d)

  Sets the big parameter dimension of PIP problem to `d`*.*
- native void add_constraint (Constraint c)

  Adds a copy of constraint `c` *to the PIP problem.*
- native void add_constraints (Constraint_System cs)

  Adds a copy of the constraints in `cs` *to the PIP problem.*

Computing the Solution of the PIP_Problem

- native boolean is_satisfiable ()

  Checks satisfiability of `*this`*.*
- native PIP_Problem_Status solve ()

  Optimizes the PIP problem.
- native PIP_Tree_Node solution ()

  Returns a solution for the PIP problem, if it exists.
- native PIP_Tree_Node optimizing_solution ()

  Returns an optimizing solution for the PIP problem, if it exists.

Querying/Setting Control Parameters

- native PIP_Problem_Control_Parameter_Value get_pip_problem_control_parameter (PIP_Problem_-Control_Parameter_Name name)

  Returns the value of control parameter `name`*.*
- native void set_pip_problem_control_parameter (PIP_Problem_Control_Parameter_Value value)

  Sets control parameter `value`*.*

Protected Member Functions

- native void finalize ()

  Releases all resources managed by `this`*.*

10.32.1 Detailed Description

A Parametric Integer Programming problem.

An object of this class encodes a parametric integer (linear) programming problem. The PIP problem is specified by providing:

- the dimension of the vector space;
- the subset of those dimensions of the vector space that are interpreted as integer parameters (the other space dimensions are interpreted as non-parameter integer variables);

- a finite set of linear equality and (strict or non-strict) inequality constraints involving variables and/or parameters; these constraints are used to define:
  - the *feasible region*, if they involve one or more problem variable (and maybe some parameters);
  - the *initial context*, if they only involve the parameters;
- optionally, the so-called *big parameter*, i.e., a problem parameter to be considered arbitrarily big.

Note that all problem variables and problem parameters are assumed to take non-negative integer values, so that there is no need to specify non-negativity constraints.

The class provides support for the (incremental) solution of the PIP problem based on variations of the revised simplex method and on Gomory cut generation techniques.

The solution for a PIP problem is the lexicographic minimum of the integer points of the feasible region, expressed in terms of the parameters. As the problem to be solved only involves non-negative variables and parameters, the problem will always be either unfeasible or optimizable.

As the feasibility and the solution value of a PIP problem depend on the values of the parameters, the solution is a binary decision tree, dividing the context parameter set into subsets. The tree nodes are of two kinds:

- *Decision* nodes. These are internal tree nodes encoding one or more linear tests on the parameters; if all the tests are satisfied, then the solution is the node's *true* child; otherwise, the solution is the node's *false* child;
- *Solution* nodes. These are leaf nodes in the tree, encoding the solution of the problem in the current context subset, where each variable is defined in terms of a linear expression of the parameters. Solution nodes also optionally embed a set of parameter constraints: if all these constraints are satisfied, the solution is described by the node, otherwise the problem has no solution.

It may happen that a decision node has no *false* child. This means that there is no solution if at least one of the corresponding constraints is not satisfied. Decision nodes having two or more linear tests on the parameters cannot have a *false* child. Decision nodes always have a *true* child.

Both kinds of tree nodes may also contain the definition of extra parameters which are artificially introduced by the solver to enforce an integral solution. Such artificial parameters are defined by the integer division of a linear expression on the parameters by an integer coefficient.

By exploiting the incremental nature of the solver, it is possible to reuse part of the computational work already done when solving variants of a given PIP_Problem: currently, incremental resolution supports the addition of space dimensions, the addition of parameters and the addition of constraints.

10.32.2 Constructor & Destructor Documentation

10.32.2.1 parma_polyhedra_library::PIP_Problem::PIP_Problem (long *dim*) [inline]

Builds a trivial PIP problem.

A trivial PIP problem requires to compute the lexicographic minimum on a vector space under no constraints and with no parameters: due to the implicit non-negativity constraints, the origin of the vector space is an optimal solution.

Parameters

dim	The dimension of the vector space enclosing `*this` (optional argument with default value 0).

Exceptions

std::length_error	Thrown if dim exceeds max_space_dimension().

10.32.2.2 parma_polyhedra_library::PIP_Problem::PIP_Problem (long *dim*, Constraint_System *cs*, Variables_Set *params*) [inline]

Builds a PIP problem from a sequence of constraints.

Builds a PIP problem having space dimension dim from the constraint system cs; the dimensions vars are interpreted as parameters.

10.32.3 Member Function Documentation

10.32.3.1 native void parma_polyhedra_library::PIP_Problem::clear ( )

Resets this to be equal to the trivial PIP problem.

The space dimension is reset to 0.

10.32.3.2 native void parma_polyhedra_library::PIP_Problem::add_space_dimensions_and_embed (long *pip_vars*, long *pip_params*)

Adds pip_vars + pip_params new space dimensions and embeds the PIP problem in the new vector space.

Parameters

pip_vars	The number of space dimensions to add that are interpreted as PIP problem variables (i.e., non parameters). These are added before adding the pip_params parameters.
pip_params	The number of space dimensions to add that are interpreted as PIP problem parameters. These are added after having added the pip_vars problem variables.

The new space dimensions will be those having the highest indexes in the new PIP problem; they are initially unconstrained.

10.32.3.3 native void parma_polyhedra_library::PIP_Problem::add_constraint (Constraint *c*)

Adds a copy of constraint c to the PIP problem.

Exceptions

std::invalid_argument	Thrown if the constraint c is a strict inequality or if its space dimension is strictly greater than the space dimension of this.

10.32.3.4 native void parma_polyhedra_library::PIP_Problem::add_constraints (Constraint_System *cs*)

Adds a copy of the constraints in cs to the PIP problem.

Exceptions

std::invalid_argument	Thrown if the constraint system cs contains any strict inequality or if its space dimension is strictly greater than the space dimension of *this.

10.32.3.5 native boolean parma_polyhedra_library::PIP_Problem::is_satisfiable ( )

Checks satisfiability of *this.

Returns

true if and only if the PIP problem is satisfiable.

10.32.3.6 native PIP_Problem_Status parma_polyhedra_library::PIP_Problem::solve ( )

Optimizes the PIP problem.

Solves the PIP problem, returning an exit status.

Returns

UNFEASIBLE_PIP_PROBLEM if the PIP problem is not satisfiable; OPTIMIZED_PIP_PROBLEM if the PIP problem admits an optimal solution.

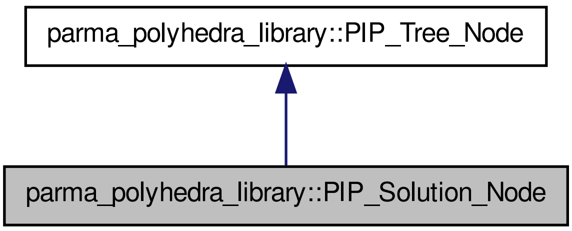
The documentation for this class was generated from the following file:

- PIP_Problem.java

10.33 parma_polyhedra_library::PIP_Solution_Node Class Reference

A leaf node of the PIP solution tree.

Inheritance diagram for parma_polyhedra_library::PIP_Solution_Node:



Public Member Functions

- native Linear_Expression parametric_values (Variable var)

  Returns the parametric expression of the values of variable var *in solution node* this.

10.33.1 Detailed Description

A leaf node of the PIP solution tree.

10.33.2 Member Function Documentation

10.33.2.1 native Linear_Expression parma_polyhedra_library::PIP_Solution_Node::parametric_values (Variable *var*)

Returns the parametric expression of the values of variable `var` in solution node `this`.

The returned parametric expression will only refer to (problem or artificial) parameters.

Parameters

var	The variable being queried.

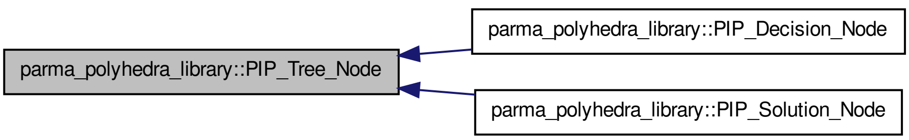
The documentation for this class was generated from the following file:

- PIP_Solution_Node.java

10.34 parma_polyhedra_library::PIP_Tree_Node Class Reference

A node of the PIP solution tree.

Inheritance diagram for parma_polyhedra_library::PIP_Tree_Node:



Public Member Functions

- native PIP_Solution_Node as_solution ()

  Returns the solution node if `this` *is a solution node, and 0 otherwise.*
- native PIP_Decision_Node as_decision ()

  Returns the decision node if `this` *is a decision node, and 0 otherwise.*
- native boolean OK ()

  Returns true if the pip tree is well formed, i.e., if it satisfies all its implementation invariants; returns 0 and perhaps makes some noise if broken. Useful for debugging purposes.
- native long number_of_artificials ()

  Returns the number of artificial parameters in the PIP_Tree_Node.
- native Artificial_Parameter_Sequence artificials ()

  Returns the sequence of (Java) artificial parameters in the PIP_Tree_Node.
- native Constraint_System constraints ()

  Returns the system of parameter constraints controlling the PIP_Tree_Node.
- native String toString ()

  Returns a string representation of `this`*.*

10.34.1 Detailed Description

A node of the PIP solution tree.

This is the base class for the nodes of the binary trees representing the solutions of PIP problems. From this one, two classes are derived:

- PIP_Decision_Node, for the internal nodes of the tree;
- PIP_Solution_Node, for the leaves of the tree.

10.34.2 Member Function Documentation

10.34.2.1 native Constraint_System parma_polyhedra_library::PIP_Tree_Node::constraints ( )

Returns the system of parameter constraints controlling the PIP_Tree_Node.

The indices in the constraints are the same as the original variables and parameters. Coefficients in indices corresponding to variables always are zero.

The documentation for this class was generated from the following file:

- PIP_Tree_Node.java

10.35 parma_polyhedra_library::Pointset_Powerset_C_Polyhedron Class Reference

A powerset of C_Polyhedron objects.

Inherits parma_polyhedra_library::PPL_Object.

Public Member Functions

Ad Hoc Functions for Pointset_Powerset domains

- native void omega_reduce ()

  Drops from the sequence of disjuncts in `this` all the non-maximal elements, so that a non-redundant powerset if obtained.
- native long size ()

  Returns the number of disjuncts.
- native boolean geometrically_covers (Pointset_Powerset_C_Polyhedron y)

  Returns `true` if and only if `this` geometrically covers `y`.
- native boolean geometrically_equals (Pointset_Powerset_C_Polyhedron y)

  Returns `true` if and only if `this` is geometrically equal to `y`.
- native Pointset_Powerset_C_Polyhedron_Iterator begin_iterator ()

  Returns an iterator referring to the beginning of the sequence of disjuncts of `this`.
- native Pointset_Powerset_C_Polyhedron_Iterator end_iterator ()

  Returns an iterator referring to past the end of the sequence of disjuncts of `this`.
- native void add_disjunct (C_Polyhedron d)

  Adds to `this` a copy of disjunct `d`.
- native void drop_disjunct (Pointset_Powerset_C_Polyhedron_Iterator iter)

  Drops from `this` the disjunct referred by `iter`; returns an iterator referring to the disjunct following the dropped one.
- native void drop_disjuncts (Pointset_Powerset_C_Polyhedron_Iterator first, Pointset_Powerset_C_Polyhedron_Iterator last)

Drops from `this` all the disjuncts from `first` to `last` (excluded).

- native void pairwise_reduce ()

  Modifies `this` by (recursively) merging together the pairs of disjuncts whose upper-bound is the same as their set-theoretical union.

10.35.1 Detailed Description

A powerset of C_Polyhedron objects.

The powerset domains can be instantiated by taking as a base domain any fixed semantic geometric description (C and NNC polyhedra, BD and octagonal shapes, boxes and grids). An element of the powerset domain represents a disjunctive collection of base objects (its disjuncts), all having the same space dimension.

Besides the methods that are available in all semantic geometric descriptions (whose documentation is not repeated here), the powerset domain also provides several ad hoc methods. In particular, the iterator types allow for the examination and manipulation of the collection of disjuncts.

10.35.2 Member Function Documentation

10.35.2.1 native long parma_polyhedra_library::Pointset_Powerset_C_Polyhedron::size ( )

Returns the number of disjuncts.

If present, Omega-redundant elements will be counted too.

The documentation for this class was generated from the following file:

- Fake_Class_for_Doxygen.java

10.36 parma_polyhedra_library::Pointset_Powerset_C_Polyhedron_Iterator Class Reference

An iterator class for the disjuncts of a Pointset_Powerset_C_Polyhedron.

Inherits parma_polyhedra_library::PPL_Object.

Public Member Functions

- Pointset_Powerset_C_Polyhedron_Iterator (Pointset_Powerset_C_Polyhedron_Iterator y)

  Builds a copy of iterator `y`.

- native boolean equals (Pointset_Powerset_C_Polyhedron_Iterator itr)

  Returns `true` if and only if `this` and `itr` are equal.

- native void next ()

  Modifies `this` so that it refers to the next disjunct.

- native void prev ()

  Modifies `this` so that it refers to the previous disjunct.

- native C_Polyhedron get_disjunct ()

  Returns the disjunct referenced by `this`.

- native void free ()

  Releases resources and resets `this` to a null reference.

Protected Member Functions

- native void finalize ()

  Releases the resources managed by `this`*.*

10.36.1 Detailed Description

An iterator class for the disjuncts of a Pointset_Powerset_C_Polyhedron.

10.36.2 Member Function Documentation

10.36.2.1 native C_Polyhedron parma_polyhedra_library::Pointset_Powerset_C_Polyhedron_Iterator::get_-disjunct ( )

Returns the disjunct referenced by `this`.

Warning

On exit, the C_Polyhedron disjunct is still owned by the powerset object: any function call on the owning powerset object may invalidate it. Moreover, the disjunct is meant to be immutable and should not be modified in any way (its resources will be released when deleting the owning powerset). If really needed, the disjunct may be copied into a new object, which will be under control of the user.

The documentation for this class was generated from the following file:

- Fake_Class_for_Doxygen.java

10.37 parma_polyhedra_library::Poly_Con_Relation Class Reference

The relation between a polyhedron and a constraint.

Public Member Functions

- Poly_Con_Relation (int val)

  Constructs from a integer value.
- boolean implies (Poly_Con_Relation y)

  True if and only if `*this` *implies* `y`*.*

Static Public Member Functions

- static Poly_Con_Relation nothing ()

  The assertion that says nothing.
- static Poly_Con_Relation is_disjoint ()

  The polyhedron and the set of points satisfying the constraint are disjoint.
- static Poly_Con_Relation strictly_intersects ()

  The polyhedron intersects the set of points satisfying the constraint, but it is not included in it.
- static Poly_Con_Relation is_included ()

  The polyhedron is included in the set of points satisfying the constraint.
- static Poly_Con_Relation saturates ()

  The polyhedron is included in the set of points saturating the constraint.

10.37.1 Detailed Description

The relation between a polyhedron and a constraint.

This class implements conjunctions of assertions on the relation between a polyhedron and a constraint.

The documentation for this class was generated from the following file:

- Poly_Con_Relation.java

10.38 parma_polyhedra_library::Poly_Gen_Relation Class Reference

The relation between a polyhedron and a generator.

Public Member Functions

- Poly_Gen_Relation (int val)

    Constructs from a integer value.

- boolean implies (Poly_Gen_Relation y)

    True if and only if `*this` *implies* `y`.

Static Public Member Functions

- static Poly_Gen_Relation nothing ()

    The assertion that says nothing.

- static Poly_Gen_Relation subsumes ()

    Adding the generator would not change the polyhedron.

10.38.1 Detailed Description

The relation between a polyhedron and a generator.

This class implements conjunctions of assertions on the relation between a polyhedron and a generator.

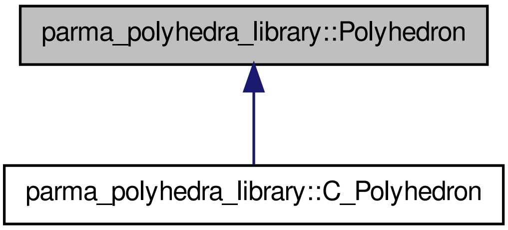
The documentation for this class was generated from the following file:

- Poly_Gen_Relation.java

10.39 parma_polyhedra_library::Polyhedron Class Reference

The Java base class for (C and NNC) convex polyhedra.

Inheritance diagram for parma_polyhedra_library::Polyhedron:



Public Member Functions

Member Functions that Do Not Modify the Polyhedron

- native long space_dimension ()
  Returns the dimension of the vector space enclosing `this`.
- native long affine_dimension ()
  Returns 0*, if `this` is empty; otherwise, returns the affine dimension of `this`.*
- native Constraint_System constraints ()
  Returns the system of constraints.
- native Congruence_System congruences ()
  Returns a system of (equality) congruences satisfied by `this`.
- native Constraint_System minimized_constraints ()
  Returns the system of constraints, with no redundant constraint.
- native Congruence_System minimized_congruences ()
  Returns a system of (equality) congruences satisfied by `this`, with no redundant congruences and having the same affine dimension as `this`.
- native boolean is_empty ()
  Returns `true` if and only if `this` is an empty polyhedron.
- native boolean is_universe ()
  Returns `true` if and only if `this` is a universe polyhedron.
- native boolean is_bounded ()
  Returns `true` if and only if `this` is a bounded polyhedron.
- native boolean is_discrete ()
  Returns `true` if and only if `this` is discrete.
- native boolean is_topologically_closed ()
  Returns `true` if and only if `this` is a topologically closed subset of the vector space.
- native boolean contains_integer_point ()
  Returns `true` if and only if `this` contains at least one integer point.
- native boolean constrains (Variable var)
  Returns `true` if and only if `var` is constrained in `this`.
- native boolean bounds_from_above (Linear_Expression expr)
  Returns `true` if and only if `expr` is bounded from above in `this`.
- native boolean bounds_from_below (Linear_Expression expr)

Returns `true` *if and only if* `expr` *is bounded from below in* `this`*.*

- native boolean maximize (Linear_Expression expr, Coefficient sup_n, Coefficient sup_d, By_-Reference< Boolean > maximum)

  Returns `true` *if and only if* `this` *is not empty and* `expr` *is bounded from above in* `this`*, in which case the supremum value is computed.*
- native boolean minimize (Linear_Expression expr, Coefficient inf_n, Coefficient inf_d, By_-Reference< Boolean > minimum)

  Returns `true` *if and only if* `this` *is not empty and* `expr` *is bounded from below in* `this`*, in which case the infimum value is computed.*
- native boolean maximize (Linear_Expression expr, Coefficient sup_n, Coefficient sup_d, By_-Reference< Boolean > maximum, Generator g)

  Returns `true` *if and only if* `this` *is not empty and* `expr` *is bounded from above in* `this`*, in which case the supremum value and a point where* `expr` *reaches it are computed.*
- native boolean minimize (Linear_Expression expr, Coefficient inf_n, Coefficient inf_d, By_-Reference< Boolean > minimum, Generator g)

  Returns `true` *if and only if* `this` *is not empty and* `expr` *is bounded from below in* `this`*, in which case the infimum value and a point where* `expr` *reaches it are computed.*
- native Poly_Con_Relation relation_with (Constraint c)

  Returns the relations holding between the polyhedron `this` *and the constraint* `c`*.*
- native Poly_Gen_Relation relation_with (Generator c)

  Returns the relations holding between the polyhedron `this` *and the generator* `g`*.*
- native Poly_Con_Relation relation_with (Congruence c)

  Returns the relations holding between the polyhedron `this` *and the congruence* `c`*.*
- native boolean contains (Polyhedron y)

  Returns `true` *if and only if* `this` *contains* `y`*.*
- native boolean strictly_contains (Polyhedron y)

  Returns `true` *if and only if* `this` *strictly contains* `y`*.*
- native boolean is_disjoint_from (Polyhedron y)

  Returns `true` *if and only if* `this` *and* `y` *are disjoint.*
- native boolean equals (Polyhedron y)

  Returns `true` *if and only if* `this` *and* `y` *are equal.*
- boolean equals (Object y)

  Returns `true` *if and only if* `this` *and* `y` *are equal.*
- native int hashCode ()

  Returns a hash code for `this`*.*
- native long external_memory_in_bytes ()

  Returns the size in bytes of the memory managed by `this`*.*
- native long total_memory_in_bytes ()

  Returns the total size in bytes of the memory occupied by `this`*.*
- native String toString ()

  Returns a string representing `this`*.*
- native String ascii_dump ()

  Returns a string containing a low-level representation of `this`*.*
- native boolean OK ()

  Checks if all the invariants are satisfied.

Space Dimension Preserving Member Functions that May Modify the Polyhedron

- native void add_constraint (Constraint c)

  Adds a copy of constraint `c` *to the system of constraints of* `this` *(without minimizing the result).*
- native void add_congruence (Congruence cg)

  Adds a copy of congruence `cg` *to* `this`*, if* `cg` *can be exactly represented by a polyhedron.*
- native void add_constraints (Constraint_System cs)

  Adds a copy of the constraints in `cs` *to the system of constraints of* `this` *(without minimizing the result).*

- native void add_congruences (Congruence_System cgs)

  Adds a copy of the congruences in `cgs` to `this`, if all the congruences can be exactly represented by a polyhedron.
- native void refine_with_constraint (Constraint c)

  Uses a copy of constraint `c` to refine `this`.
- native void refine_with_congruence (Congruence cg)

  Uses a copy of congruence `cg` to refine `this`.
- native void refine_with_constraints (Constraint_System cs)

  Uses a copy of the constraints in `cs` to refine `this`.
- native void refine_with_congruences (Congruence_System cgs)

  Uses a copy of the congruences in `cgs` to refine `this`.
- native void intersection_assign (Polyhedron y)

  Assigns to `this` the intersection of `this` and `y`. The result is not guaranteed to be minimized.
- native void upper_bound_assign (Polyhedron y)

  Assigns to `this` the upper bound of `this` and `y`.
- native void difference_assign (Polyhedron y)

  Assigns to `this` the poly-difference of `this` and `y`. The result is not guaranteed to be minimized.
- native void time_elapse_assign (Polyhedron y)

  Assigns to `this` the result of computing the time-elapse between `this` and `y`.
- native void topological_closure_assign ()

  Assigns to `this` its topological closure.
- native boolean simplify_using_context_assign (Polyhedron y)

  Assigns to `this` a meet-preserving simplification of `this` with respect to `y`. If `false` is returned, then the intersection is empty.
- native void affine_image (Variable var, Linear_Expression expr, Coefficient denominator)

  Assigns to `this` the affine image of `this` under the function mapping variable `var` to the affine expression specified by `expr` and `denominator`.
- native void affine_preimage (Variable var, Linear_Expression expr, Coefficient denominator)

  Assigns to `this` the affine preimage of `this` under the function mapping variable `var` to the affine expression specified by `expr` and `denominator`.
- native void bounded_affine_image (Variable var, Linear_Expression lb_expr, Linear_Expression ub_expr, Coefficient denominator)

  Assigns to `this` the image of `this` with respect to the bounded affine relation $\frac{\mathrm{lb\_expr}}{\mathrm{denominator}} \leq \mathrm{var}' \leq \frac{\mathrm{ub\_expr}}{\mathrm{denominator}}$.
- native void bounded_affine_preimage (Variable var, Linear_Expression lb_expr, Linear_Expression ub_expr, Coefficient denominator)

  Assigns to `this` the preimage of `this` with respect to the bounded affine relation $\frac{\mathrm{lb\_expr}}{\mathrm{denominator}} \leq \mathrm{var}' \leq \frac{\mathrm{ub\_expr}}{\mathrm{denominator}}$.
- native void generalized_affine_image (Variable var, Relation_Symbol relsym, Linear_Expression expr, Coefficient denominator)

  Assigns to `this` the image of `this` with respect to the generalized affine relation $\mathrm{var}' \bowtie \frac{\mathrm{expr}}{\mathrm{denominator}}$*, where* $\bowtie$ *is the relation symbol encoded by `relsym`.*
- native void generalized_affine_preimage (Variable var, Relation_Symbol relsym, Linear_Expression expr, Coefficient denominator)

  Assigns to `this` the preimage of `this` with respect to the generalized affine relation $\mathrm{var}' \bowtie \frac{\mathrm{expr}}{\mathrm{denominator}}$*, where* $\bowtie$ *is the relation symbol encoded by `relsym`.*
- native void generalized_affine_image (Linear_Expression lhs, Relation_Symbol relsym, Linear_Expression rhs)

  Assigns to `this` the image of `this` with respect to the generalized affine relation $\mathrm{lhs}' \bowtie \mathrm{rhs}$*, where* $\bowtie$ *is the relation symbol encoded by `relsym`.*
- native void generalized_affine_preimage (Linear_Expression lhs, Relation_Symbol relsym, Linear_Expression rhs)

  Assigns to `this` the preimage of `this` with respect to the generalized affine relation $\mathrm{lhs}' \bowtie \mathrm{rhs}$*, where* $\bowtie$ *is the relation symbol encoded by `relsym`.*
- native void unconstrain_space_dimension (Variable var)

Computes the cylindrification of `this` with respect to space dimension `var`, assigning the result to `this`.

- native void unconstrain_space_dimensions (Variables_Set vars)
  Computes the cylindrification of `this` with respect to the set of space dimensions `vars`, assigning the result to `this`.
- native void widening_assign (Polyhedron y, By_Reference< Integer > tp)
  Assigns to `this` the result of computing the H79-widening between `this` and `y`.

Member Functions that May Modify the Dimension of the Vector Space

- native void swap (Polyhedron y)
  Swaps `this` with polyhedron `y`. (`this` and `y` can be dimension-incompatible.)
- native void add_space_dimensions_and_embed (long m)
  Adds `m` new space dimensions and embeds the old polyhedron in the new vector space.
- native void add_space_dimensions_and_project (long m)
  Adds `m` new space dimensions to the polyhedron and does not embed it in the new vector space.
- native void concatenate_assign (Polyhedron y)
  Assigns to `this` the concatenation of `this` and `y`, taken in this order.
- native void remove_space_dimensions (Variables_Set vars)
  Removes all the specified dimensions from the vector space.
- native void remove_higher_space_dimensions (long new_dimension)
  Removes the higher dimensions of the vector space so that the resulting space will have dimension `new_dimension`.
- native void expand_space_dimension (Variable var, long m)
  Creates `m` copies of the space dimension corresponding to `var`.
- native void fold_space_dimensions (Variables_Set vars, Variable dest)
  Folds the space dimensions in `vars` into `dest`.
- native void map_space_dimensions (Partial_Function pfunc)
  Remaps the dimensions of the vector space according to a partial function.

Ad Hoc Functions for (C or NNC) Polyhedra

The functions listed here below, being specific of the polyhedron domains, do not have a correspondence in other semantic geometric descriptions.

- native Generator_System generators ()
  Returns the system of generators.
- native Generator_System minimized_generators ()
  Returns the system of generators, with no redundant generator.
- native void add_generator (Generator g)
  Adds a copy of generator `g` to the system of generators of `this` (without minimizing the result).
- native void add_generators (Generator_System gs)
  Adds a copy of the generators in `gs` to the system of generators of `this` (without minimizing the result).
- native void poly_hull_assign (Polyhedron y)
  Same as upper_bound_assign.
- native void poly_difference_assign (Polyhedron y)
  Same as difference_assign.
- native void BHRZ03_widening_assign (Polyhedron y, By_Reference< Integer > tp)
  Assigns to `this` the result of computing the BHRZ03-widening between `this` and `y`.
- native void H79_widening_assign (Polyhedron y, By_Reference< Integer > tp)
  Assigns to `this` the result of computing the H79-widening between `this` and `y`.
- native void limited_BHRZ03_extrapolation_assign (Polyhedron y, Constraint_System cs, By_Reference< Integer > tp)
  Improves the result of the BHRZ03-widening computation by also enforcing those constraints in `cs` that are satisfied by all the points of `this`.

- native void limited_H79_extrapolation_assign (Polyhedron y, Constraint_System cs, By_Reference< Integer > tp)

  Improves the result of the H79-widening computation by also enforcing those constraints in `cs` *that are satisfied by all the points of* `this`*.*
- native void bounded_BHRZ03_extrapolation_assign (Polyhedron y, Constraint_System cs, By_-Reference< Integer > tp)

  Improves the result of the BHRZ03-widening computation by also enforcing those constraints in `cs` *that are satisfied by all the points of* `this`*, plus all the constraints of the form* $\pm x \leq r$ *and* $\pm x < r$*, with* $r \in \mathbb{Q}$*, that are satisfied by all the points of* `this`*.*
- native void bounded_H79_extrapolation_assign (Polyhedron y, Constraint_System cs, By_Reference< Integer > tp)

  Improves the result of the H79-widening computation by also enforcing those constraints in `cs` *that are satisfied by all the points of* `this`*, plus all the constraints of the form* $\pm x \leq r$ *and* $\pm x < r$*, with* $r \in \mathbb{Q}$*, that are satisfied by all the points of* `this`*.*

10.39.1 Detailed Description

The Java base class for (C and NNC) convex polyhedra.

The base class Polyhedron provides declarations for most of the methods common to classes C_Polyhedron and NNC_Polyhedron. Note that the user should always use the derived classes. Moreover, C and NNC polyhedra can not be freely interchanged: as specified in the main manual, most library functions require their arguments to be topologically compatible.

10.39.2 Member Function Documentation

10.39.2.1 native boolean parma_polyhedra_library::Polyhedron::constrains (Variable *var*)

Returns `true` if and only if `var` is constrained in `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `var` is not a space dimension of `this`.

10.39.2.2 native boolean parma_polyhedra_library::Polyhedron::bounds_from_above (Linear_Expression *expr*)

Returns `true` if and only if `expr` is bounded from above in `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `expr` and `this` are dimension-incompatible.

10.39.2.3 native boolean parma_polyhedra_library::Polyhedron::bounds_from_below (Linear_Expression *expr*)

Returns `true` if and only if `expr` is bounded from below in `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `expr` and `this` are dimension-incompatible.

10.39.2.4 native boolean parma_polyhedra_library::Polyhedron::maximize (Linear_Expression *expr*, Coefficient *sup_n*, Coefficient *sup_d*, By_Reference< Boolean > *maximum*)

Returns true if and only if this is not empty and expr is bounded from above in this, in which case the supremum value is computed.

Parameters

expr	The linear expression to be maximized subject to this;
sup_n	The numerator of the supremum value;
sup_d	The denominator of the supremum value;
maximum	true if and only if the supremum is also the maximum value.

Exceptions

Invalid_Argument_-Exception	Thrown if expr and this are dimension-incompatible.

If this is empty or expr is not bounded from above, false is returned and sup_n, sup_d and maximum are left untouched.

10.39.2.5 native boolean parma_polyhedra_library::Polyhedron::minimize (Linear_Expression *expr*, Coefficient *inf_n*, Coefficient *inf_d*, By_Reference< Boolean > *minimum*)

Returns true if and only if this is not empty and expr is bounded from below in this, in which case the infimum value is computed.

Parameters

expr	The linear expression to be minimized subject to this;
inf_n	The numerator of the infimum value;
inf_d	The denominator of the infimum value;
minimum	true if and only if the infimum is also the minimum value.

Exceptions

Invalid_Argument_-Exception	Thrown if expr and this are dimension-incompatible.

If this is empty or expr is not bounded from below, false is returned and inf_n, inf_d and minimum are left untouched.

10.39.2.6 native boolean parma_polyhedra_library::Polyhedron::maximize (Linear_Expression *expr*, Coefficient *sup_n*, Coefficient *sup_d*, By_Reference< Boolean > *maximum*, Generator *g*)

Returns true if and only if this is not empty and expr is bounded from above in this, in which case the supremum value and a point where expr reaches it are computed.

Parameters

expr	The linear expression to be maximized subject to this;
sup_n	The numerator of the supremum value;
sup_d	The denominator of the supremum value;
maximum	true if and only if the supremum is also the maximum value;
g	When maximization succeeds, will be assigned the point or closure point where expr reaches its supremum value.

Exceptions

Invalid_Argument_-Exception	Thrown if `expr` and `this` are dimension-incompatible.

If `this` is empty or `expr` is not bounded from above, `false` is returned and `sup_n`, `sup_d`, `maximum` and `g` are left untouched.

10.39.2.7 native boolean parma_polyhedra_library::Polyhedron::minimize (Linear_Expression *expr*, Coefficient *inf_n*, Coefficient *inf_d*, By_Reference< Boolean > *minimum*, Generator *g*)

Returns `true` if and only if `this` is not empty and `expr` is bounded from below in `this`, in which case the infimum value and a point where `expr` reaches it are computed.

Parameters

expr	The linear expression to be minimized subject to `this`;
inf_n	The numerator of the infimum value;
inf_d	The denominator of the infimum value;
minimum	`true` if and only if the infimum is also the minimum value;
g	When minimization succeeds, will be assigned a point or closure point where `expr` reaches its infimum value.

Exceptions

Invalid_Argument_-Exception	Thrown if `expr` and `this` are dimension-incompatible.

If `this` is empty or `expr` is not bounded from below, `false` is returned and `inf_n`, `inf_d`, `minimum` and `g` are left untouched.

10.39.2.8 native Poly_Con_Relation parma_polyhedra_library::Polyhedron::relation_with (Constraint *c*)

Returns the relations holding between the polyhedron `this` and the constraint `c`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and constraint `c` are dimension-incompatible.

10.39.2.9 native Poly_Gen_Relation parma_polyhedra_library::Polyhedron::relation_with (Generator *c*)

Returns the relations holding between the polyhedron `this` and the generator `g`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and generator `g` are dimension-incompatible.

10.39.2.10 native Poly_Con_Relation parma_polyhedra_library::Polyhedron::relation_with (Congruence *c*)

Returns the relations holding between the polyhedron `this` and the congruence `c`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and congruence `c` are dimension-incompatible.

10.39.2.11 native boolean parma_polyhedra_library::Polyhedron::contains (Polyhedron *y*)

Returns `true` if and only if `this` contains `y`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.12 native boolean parma_polyhedra_library::Polyhedron::strictly_contains (Polyhedron *y*)

Returns `true` if and only if `this` strictly contains `y`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.13 native boolean parma_polyhedra_library::Polyhedron::is_disjoint_from (Polyhedron *y*)

Returns `true` if and only if `this` and `y` are disjoint.

Exceptions

Invalid_Argument_-Exception	Thrown if `x` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.14 native int parma_polyhedra_library::Polyhedron::hashCode ( )

Returns a hash code for `this`.

If `x` and `y` are such that `x == y`, then `x.hash_code() == y.hash_code()`.

10.39.2.15 native String parma_polyhedra_library::Polyhedron::ascii_dump ( )

Returns a string containing a low-level representation of `this`.

Useful for debugging purposes.

10.39.2.16 native void parma_polyhedra_library::Polyhedron::add_constraint (Constraint *c*)

Adds a copy of constraint `c` to the system of constraints of `this` (without minimizing the result).

Parameters

c	The constraint that will be added to the system of constraints of `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and constraint `c` are topology-incompatible or dimension-incompatible.

10.39.2.17 native void parma_polyhedra_library::Polyhedron::add_congruence (Congruence *cg*)

Adds a copy of congruence cg to this, if cg can be exactly represented by a polyhedron.

Exceptions

Invalid_Argument_-Exception	Thrown if this and congruence cg are dimension-incompatible, of if cg is a proper congruence which is neither a tautology, nor a contradiction.

10.39.2.18 native void parma_polyhedra_library::Polyhedron::add_constraints (Constraint_System *cs*)

Adds a copy of the constraints in cs to the system of constraints of this (without minimizing the result).

Parameters

cs	Contains the constraints that will be added to the system of constraints of this.

Exceptions

Invalid_Argument_-Exception	Thrown if this and cs are topology-incompatible or dimension-incompatible.

10.39.2.19 native void parma_polyhedra_library::Polyhedron::add_congruences (Congruence_System *cgs*)

Adds a copy of the congruences in cgs to this, if all the congruences can be exactly represented by a polyhedron.

Parameters

cgs	The congruences to be added.

Exceptions

Invalid_Argument_-Exception	Thrown if this and cgs are dimension-incompatible, of if there exists in cgs a proper congruence which is neither a tautology, nor a contradiction.

10.39.2.20 native void parma_polyhedra_library::Polyhedron::refine_with_constraint (Constraint *c*)

Uses a copy of constraint c to refine this.

Exceptions

Invalid_Argument_-Exception	Thrown if this and constraint c are dimension-incompatible.

10.39.2.21 native void parma_polyhedra_library::Polyhedron::refine_with_congruence (Congruence *cg*)

Uses a copy of congruence cg to refine this.

Exceptions

Invalid_Argument_-Exception	Thrown if this and congruence cg are dimension-incompatible.

10.39.2.22 native void parma_polyhedra_library::Polyhedron::refine_with_constraints (Constraint_System *cs*)

Uses a copy of the constraints in `cs` to refine `this`.

Parameters

cs	Contains the constraints used to refine the system of constraints of `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `cs` are dimension-incompatible.

10.39.2.23 native void parma_polyhedra_library::Polyhedron::refine_with_congruences (Congruence_System *cgs*)

Uses a copy of the congruences in `cgs` to refine `this`.

Parameters

cgs	Contains the congruences used to refine the system of constraints of `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `cgs` are dimension-incompatible.

10.39.2.24 native void parma_polyhedra_library::Polyhedron::intersection_assign (Polyhedron *y*)

Assigns to `this` the intersection of `this` and `y`. The result is not guaranteed to be minimized.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.25 native void parma_polyhedra_library::Polyhedron::upper_bound_assign (Polyhedron *y*)

Assigns to `this` the upper bound of `this` and `y`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.26 native void parma_polyhedra_library::Polyhedron::difference_assign (Polyhedron *y*)

Assigns to `this` the *poly-difference* of `this` and `y`. The result is not guaranteed to be minimized.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.27 native void parma_polyhedra_library::Polyhedron::time_elapse_assign (Polyhedron y)

Assigns to this the result of computing the *time-elapse* between this and y.

Exceptions

Invalid_Argument_-Exception	Thrown if this and y are topology-incompatible or dimension-incompatible.

10.39.2.28 native boolean parma_polyhedra_library::Polyhedron::simplify_using_context_assign (Polyhedron y)

Assigns to this a *meet-preserving simplification* of this with respect to y. If false is returned, then the intersection is empty.

Exceptions

Invalid_Argument_-Exception	Thrown if this and y are topology-incompatible or dimension-incompatible.

10.39.2.29 native void parma_polyhedra_library::Polyhedron::affine_image (Variable var, Linear_Expression expr, Coefficient denominator)

Assigns to this the *affine image* of this under the function mapping variable var to the affine expression specified by expr and denominator.

Parameters

var	The variable to which the affine expression is assigned;
expr	The numerator of the affine expression;
denominator	The denominator of the affine expression (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if denominator is zero or if expr and this are dimension-incompatible or if var is not a space dimension of this.

10.39.2.30 native void parma_polyhedra_library::Polyhedron::affine_preimage (Variable var, Linear_Expression expr, Coefficient denominator)

Assigns to this the *affine preimage* of this under the function mapping variable var to the affine expression specified by expr and denominator.

Parameters

var	The variable to which the affine expression is substituted;
expr	The numerator of the affine expression;
denominator	The denominator of the affine expression (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if denominator is zero or if expr and this are dimension-incompatible or if var is not a space dimension of this.

10.39.2.31 native void parma_polyhedra_library::Polyhedron::bounded_affine_image (Variable *var*, Linear_Expression *lb_expr*, Linear_Expression *ub_expr*, Coefficient *denominator*)

Assigns to `this` the image of `this` with respect to the *bounded affine relation* $\frac{\mathrm{lb\_expr}}{\mathrm{denominator}} \leq \mathrm{var}' \leq \frac{\mathrm{ub\_expr}}{\mathrm{denominator}}$.

Parameters

var	The variable updated by the affine relation;
lb_expr	The numerator of the lower bounding affine expression;
ub_expr	The numerator of the upper bounding affine expression;
denominator	The (common) denominator for the lower and upper bounding affine expressions (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if `denominator` is zero or if `lb_expr` (resp., `ub_expr`) and `this` are dimension-incompatible or if `var` is not a space dimension of `this`.

10.39.2.32 native void parma_polyhedra_library::Polyhedron::bounded_affine_preimage (Variable *var*, Linear_Expression *lb_expr*, Linear_Expression *ub_expr*, Coefficient *denominator*)

Assigns to `this` the preimage of `this` with respect to the *bounded affine relation* $\frac{\mathrm{lb\_expr}}{\mathrm{denominator}} \leq \mathrm{var}' \leq \frac{\mathrm{ub\_expr}}{\mathrm{denominator}}$.

Parameters

var	The variable updated by the affine relation;
lb_expr	The numerator of the lower bounding affine expression;
ub_expr	The numerator of the upper bounding affine expression;
denominator	The (common) denominator for the lower and upper bounding affine expressions (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if `denominator` is zero or if `lb_expr` (resp., `ub_expr`) and `this` are dimension-incompatible or if `var` is not a space dimension of `this`.

10.39.2.33 native void parma_polyhedra_library::Polyhedron::generalized_affine_image (Variable *var*, Relation_Symbol *relsym*, Linear_Expression *expr*, Coefficient *denominator*)

Assigns to `this` the image of `this` with respect to the *generalized affine relation* $\mathrm{var}' \bowtie \frac{\mathrm{expr}}{\mathrm{denominator}}$, where $\bowtie$ is the relation symbol encoded by `relsym`.

Parameters

var	The left hand side variable of the generalized affine relation;
relsym	The relation symbol;
expr	The numerator of the right hand side affine expression;
denominator	The denominator of the right hand side affine expression (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if `denominator` is zero or if `expr` and `this` are dimension-incompatible or if `var` is not a space dimension of `this` or if `this` is a C_-Polyhedron and `relsym` is a strict relation symbol.

10.39.2.34 native void parma_polyhedra_library::Polyhedron::generalized_affine_preimage (Variable *var*, Relation_Symbol *relsym*, Linear_Expression *expr*, Coefficient *denominator*)

Assigns to `this` the preimage of `this` with respect to the *generalized affine relation* $\mathrm{var}' \bowtie \frac{\mathrm{expr}}{\mathrm{denominator}}$, where $\bowtie$ is the relation symbol encoded by `relsym`.

Parameters

var	The left hand side variable of the generalized affine relation;
relsym	The relation symbol;
expr	The numerator of the right hand side affine expression;
denominator	The denominator of the right hand side affine expression (optional argument with default value 1).

Exceptions

Invalid_Argument_-Exception	Thrown if `denominator` is zero or if `expr` and `this` are dimension-incompatible or if `var` is not a space dimension of `this` or if `this` is a C_-Polyhedron and `relsym` is a strict relation symbol.

10.39.2.35 native void parma_polyhedra_library::Polyhedron::generalized_affine_image (Linear_Expression *lhs*, Relation_Symbol *relsym*, Linear_Expression *rhs*)

Assigns to `this` the image of `this` with respect to the *generalized affine relation* $\mathrm{lhs}' \bowtie \mathrm{rhs}$, where $\bowtie$ is the relation symbol encoded by `relsym`.

Parameters

lhs	The left hand side affine expression;
relsym	The relation symbol;
rhs	The right hand side affine expression.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` is dimension-incompatible with `lhs` or `rhs` or if `this` is a C_Polyhedron and `relsym` is a strict relation symbol.

10.39.2.36 native void parma_polyhedra_library::Polyhedron::generalized_affine_preimage (Linear_Expression *lhs*, Relation_Symbol *relsym*, Linear_Expression *rhs*)

Assigns to `this` the preimage of `this` with respect to the *generalized affine relation* $\mathrm{lhs}' \bowtie \mathrm{rhs}$, where $\bowtie$ is the relation symbol encoded by `relsym`.

Parameters

lhs	The left hand side affine expression;
relsym	The relation symbol;
rhs	The right hand side affine expression.

Exceptions

Invalid_Argument_-Exception	Thrown if this is dimension-incompatible with lhs or rhs or if this is a C_Polyhedron and relsym is a strict relation symbol.

10.39.2.37 native void parma_polyhedra_library::Polyhedron::unconstrain_space_dimension (Variable *var*)

Computes the *cylindrification* of this with respect to space dimension var, assigning the result to this.

Parameters

var	The space dimension that will be unconstrained.

Exceptions

Invalid_Argument_-Exception	Thrown if var is not a space dimension of this.

10.39.2.38 native void parma_polyhedra_library::Polyhedron::unconstrain_space_dimensions (Variables_Set *vars*)

Computes the *cylindrification* of this with respect to the set of space dimensions vars, assigning the result to this.

Parameters

vars	The set of space dimension that will be unconstrained.

Exceptions

Invalid_Argument_-Exception	Thrown if this is dimension-incompatible with one of the Variable objects contained in vars.

10.39.2.39 native void parma_polyhedra_library::Polyhedron::widening_assign (Polyhedron *y*, By_Reference< Integer > *tp*)

Assigns to this the result of computing the *H79-widening* between this and y.

Parameters

y	A polyhedron that *must* be contained in this;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if this and y are topology-incompatible or dimension-incompatible.

10.39.2.40 native void parma_polyhedra_library::Polyhedron::swap (Polyhedron *y*)

Swaps this with polyhedron y. (this and y can be dimension-incompatible.)

Exceptions

Invalid_Argument_-Exception	Thrown if x and y are topology-incompatible.

10.39.2.41 native void parma_polyhedra_library::Polyhedron::add_space_dimensions_and_embed (long *m*)

Adds m new space dimensions and embeds the old polyhedron in the new vector space.

Parameters

m	The number of dimensions to add.

Exceptions

Length_Error_Exception	Thrown if adding m new space dimensions would cause the vector space to exceed dimension max_space_dimension().

10.39.2.42 native void parma_polyhedra_library::Polyhedron::add_space_dimensions_and_project (long *m*)

Adds m new space dimensions to the polyhedron and does not embed it in the new vector space.

Parameters

m	The number of space dimensions to add.

Exceptions

Length_Error_Exception	Thrown if adding m new space dimensions would cause the vector space to exceed dimension max_space_dimension().

10.39.2.43 native void parma_polyhedra_library::Polyhedron::concatenate_assign (Polyhedron *y*)

Assigns to this the *concatenation* of this and y, taken in this order.

Exceptions

Invalid_Argument_-Exception	Thrown if this and y are topology-incompatible.
Length_Error_Exception	Thrown if the concatenation would cause the vector space to exceed dimension max_space_dimension().

10.39.2.44 native void parma_polyhedra_library::Polyhedron::remove_space_dimensions (Variables_Set *vars*)

Removes all the specified dimensions from the vector space.

Parameters

vars	The set of Variable objects corresponding to the space dimensions to be removed.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` is dimension-incompatible with one of the Variable objects contained in `vars`.

10.39.2.45 native void parma_polyhedra_library::Polyhedron::remove_higher_space_dimensions (long *new_dimension*)

Removes the higher dimensions of the vector space so that the resulting space will have dimension `new_dimension`.

Exceptions

Invalid_Argument_-Exception	Thrown if `new_dimensions` is greater than the space dimension of `this`.

10.39.2.46 native void parma_polyhedra_library::Polyhedron::expand_space_dimension (Variable *var*, long *m*)

Creates `m` copies of the space dimension corresponding to `var`.

Parameters

var	The variable corresponding to the space dimension to be replicated;
m	The number of replicas to be created.

Exceptions

Invalid_Argument_-Exception	Thrown if `var` does not correspond to a dimension of the vector space.
Length_Error_Exception	Thrown if adding `m` new space dimensions would cause the vector space to exceed dimension `max_space_dimension()`.

10.39.2.47 native void parma_polyhedra_library::Polyhedron::fold_space_dimensions (Variables_Set *vars*, Variable *dest*)

Folds the space dimensions in `vars` into `dest`.

Parameters

vars	The set of Variable objects corresponding to the space dimensions to be folded;
dest	The variable corresponding to the space dimension that is the destination of the folding operation.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` is dimension-incompatible with `dest` or with one of the Variable objects contained in `vars`. Also thrown if `dest` is contained in `vars`.

10.39.2.48 native void parma_polyhedra_library::Polyhedron::map_space_dimensions (Partial_Function *pfunc*)

Remaps the dimensions of the vector space according to a *partial function*.

Parameters

pfunc	The partial function specifying the destiny of each space dimension.

10.39.2.49 native void parma_polyhedra_library::Polyhedron::add_generator (Generator *g*)

Adds a copy of generator `g` to the system of generators of `this` (without minimizing the result).

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and generator `g` are topology-incompatible or dimension-incompatible, or if `this` is an empty polyhedron and `g` is not a point.

10.39.2.50 native void parma_polyhedra_library::Polyhedron::add_generators (Generator_System *gs*)

Adds a copy of the generators in `gs` to the system of generators of `this` (without minimizing the result).

Parameters

gs	Contains the generators that will be added to the system of generators of `this`.

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `gs` are topology-incompatible or dimension-incompatible, or if `this` is empty and the system of generators `gs` is not empty, but has no points.

10.39.2.51 native void parma_polyhedra_library::Polyhedron::BHRZ03_widening_assign (Polyhedron *y*, By_Reference< Integer > *tp*)

Assigns to `this` the result of computing the *BHRZ03-widening* between `this` and `y`.

Parameters

y	A polyhedron that *must* be contained in `this`;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.52 native void parma_polyhedra_library::Polyhedron::H79_widening_assign (Polyhedron *y*, By_Reference< Integer > *tp*)

Assigns to `this` the result of computing the *H79-widening* between `this` and `y`.

Parameters

y	A polyhedron that *must* be contained in `this`;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this` and `y` are topology-incompatible or dimension-incompatible.

10.39.2.53 native void parma_polyhedra_library::Polyhedron::limited_BHRZ03_extrapolation_assign (Polyhedron *y*, Constraint_System *cs*, By_Reference< Integer > *tp*)

Improves the result of the *BHRZ03-widening* computation by also enforcing those constraints in `cs` that are satisfied by all the points of `this`.

Parameters

y	A polyhedron that *must* be contained in `this`;
cs	The system of constraints used to improve the widened polyhedron;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this`, `y` and `cs` are topology-incompatible or dimension-incompatible.

10.39.2.54 native void parma_polyhedra_library::Polyhedron::limited_H79_extrapolation_assign (Polyhedron *y*, Constraint_System *cs*, By_Reference< Integer > *tp*)

Improves the result of the *H79-widening* computation by also enforcing those constraints in `cs` that are satisfied by all the points of `this`.

Parameters

y	A polyhedron that *must* be contained in `this`;
cs	The system of constraints used to improve the widened polyhedron;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this`, `y` and `cs` are topology-incompatible or dimension-incompatible.

10.39.2.55 native void parma_polyhedra_library::Polyhedron::bounded_BHRZ03_extrapolation_assign (Polyhedron *y*, Constraint_System *cs*, By_Reference< Integer > *tp*)

Improves the result of the *BHRZ03-widening* computation by also enforcing those constraints in `cs` that are satisfied by all the points of `this`, plus all the constraints of the form $\pm x \leq r$ and $\pm x < r$, with $r \in \mathbb{Q}$, that are satisfied by all the points of `this`.

Parameters

y	A polyhedron that *must* be contained in `this`;
cs	The system of constraints used to improve the widened polyhedron;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this`, `y` and `cs` are topology-incompatible or dimension-incompatible.

10.39.2.56 native void parma_polyhedra_library::Polyhedron::bounded_H79_extrapolation_assign (Polyhedron *y*, Constraint_System *cs*, By_Reference< Integer > *tp*)

Improves the result of the *H79-widening* computation by also enforcing those constraints in `cs` that are satisfied by all the points of `this`, plus all the constraints of the form $\pm x \leq r$ and $\pm x < r$, with $r \in \mathbb{Q}$, that are satisfied by all the points of `this`.

Parameters

y	A polyhedron that *must* be contained in `this`;
cs	The system of constraints used to improve the widened polyhedron;
tp	A reference to an unsigned variable storing the number of available tokens (to be used when applying the *widening with tokens* delay technique).

Exceptions

Invalid_Argument_-Exception	Thrown if `this`, `y` and `cs` are topology-incompatible or dimension-incompatible.

The documentation for this class was generated from the following file:

- Fake_Class_for_Doxygen.java

10.40 parma_polyhedra_library::Timeout_Exception Class Reference

Exceptions caused by timeout expiring.

Public Member Functions

- Timeout_Exception (String s)

  Constructor.

10.40.1 Detailed Description

Exceptions caused by timeout expiring.

The documentation for this class was generated from the following file:

- Timeout_Exception.java

10.41 parma_polyhedra_library::Variable Class Reference

A dimension of the vector space.

Public Member Functions

- Variable (int i)

  Builds the variable corresponding to the Cartesian axis of index `i`.
- int id ()

  Returns the index of the Cartesian axis associated to `this`.
- int compareTo (Variable v)

  Returns a negative number if `this` *comes first than* `v`*, a zero if* `this` *equals* `v`*, a positive number if if* `this` *comes first than* `v`.

10.41.1 Detailed Description

A dimension of the vector space.

An object of the class Variable represents a dimension of the space, that is one of the Cartesian axes. Variables are used as basic blocks in order to build more complex linear expressions. Each variable is identified by a non-negative integer, representing the index of the corresponding Cartesian axis (the first axis has index 0).

10.41.2 Constructor & Destructor Documentation

10.41.2.1 parma_polyhedra_library::Variable::Variable (int *i*) [inline]

Builds the variable corresponding to the Cartesian axis of index `i`.

Exceptions

RuntimeErrorException	Thrown if `i` is has negative value.

The documentation for this class was generated from the following file:

- Variable.java

10.42 parma_polyhedra_library::Variables_Set Class Reference

A java.util.TreeSet of variables' indexes.

Public Member Functions

- Variables_Set ()

  Builds the empty set of variable indexes.

10.42.1 Detailed Description

A java.util.TreeSet of variables' indexes.

The documentation for this class was generated from the following file:

- Variables_Set.java

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