

# The bliss C++ API

0.77 (Debian 0.77-ok1)

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|                                                    |           |
|----------------------------------------------------|-----------|
| <b>1 Outline</b>                                   | <b>1</b>  |
| 1.1 The C language API . . . . .                   | 1         |
| <b>2 The bliss executable</b>                      | <b>3</b>  |
| <b>3 Namespace Index</b>                           | <b>7</b>  |
| 3.1 Namespace List . . . . .                       | 7         |
| <b>4 Hierarchical Index</b>                        | <b>9</b>  |
| 4.1 Class Hierarchy . . . . .                      | 9         |
| <b>5 Class Index</b>                               | <b>11</b> |
| 5.1 Class List . . . . .                           | 11        |
| <b>6 File Index</b>                                | <b>13</b> |
| 6.1 File List . . . . .                            | 13        |
| <b>7 Namespace Documentation</b>                   | <b>15</b> |
| 7.1 bliss Namespace Reference . . . . .            | 15        |
| 7.1.1 Detailed Description . . . . .               | 16        |
| 7.1.2 Function Documentation . . . . .             | 16        |
| 7.1.2.1 is_permutation() [1/2] . . . . .           | 16        |
| 7.1.2.2 is_permutation() [2/2] . . . . .           | 16        |
| 7.1.2.3 print_permutation() [1/2] . . . . .        | 16        |
| 7.1.2.4 print_permutation() [2/2] . . . . .        | 16        |
| <b>8 Class Documentation</b>                       | <b>17</b> |
| 8.1 bliss::AbstractGraph Class Reference . . . . . | 17        |
| 8.1.1 Detailed Description . . . . .               | 18        |
| 8.1.2 Member Function Documentation . . . . .      | 18        |
| 8.1.2.1 add_edge() . . . . .                       | 18        |
| 8.1.2.2 add_vertex() . . . . .                     | 18        |
| 8.1.2.3 canonical_form() . . . . .                 | 19        |
| 8.1.2.4 change_color() . . . . .                   | 19        |
| 8.1.2.5 find_automorphisms() . . . . .             | 19        |
| 8.1.2.6 get_color() . . . . .                      | 20        |
| 8.1.2.7 get_hash() . . . . .                       | 20        |
| 8.1.2.8 get_nof_vertices() . . . . .               | 20        |
| 8.1.2.9 is_automorphism() [1/2] . . . . .          | 20        |
| 8.1.2.10 is_automorphism() [2/2] . . . . .         | 20        |
| 8.1.2.11 permute() [1/2] . . . . .                 | 21        |
| 8.1.2.12 permute() [2/2] . . . . .                 | 21        |
| 8.1.2.13 set_component_recursion() . . . . .       | 21        |
| 8.1.2.14 set_failure_recording() . . . . .         | 21        |
| 8.1.2.15 set_long_prune_activity() . . . . .       | 22        |

|                                              |    |
|----------------------------------------------|----|
| 8.1.2.16 set_verbose_file()                  | 22 |
| 8.1.2.17 set_verbose_level()                 | 22 |
| 8.1.2.18 write_dimacs()                      | 22 |
| 8.1.2.19 write_dot() [1/2]                   | 23 |
| 8.1.2.20 write_dot() [2/2]                   | 23 |
| 8.2 bliss::BigNum Class Reference            | 23 |
| 8.2.1 Detailed Description                   | 24 |
| 8.2.2 Constructor & Destructor Documentation | 24 |
| 8.2.2.1 BigNum()                             | 24 |
| 8.2.2.2 ~BigNum()                            | 24 |
| 8.2.3 Member Function Documentation          | 24 |
| 8.2.3.1 assign()                             | 24 |
| 8.2.3.2 get_factors()                        | 24 |
| 8.2.3.3 multiply()                           | 25 |
| 8.2.3.4 print()                              | 25 |
| 8.2.3.5 to_string()                          | 25 |
| 8.3 bliss_graph_struct Struct Reference      | 25 |
| 8.3.1 Detailed Description                   | 25 |
| 8.4 bliss_stats_struct Struct Reference      | 25 |
| 8.4.1 Detailed Description                   | 26 |
| 8.5 bliss::Partition::Cell Class Reference   | 26 |
| 8.5.1 Detailed Description                   | 26 |
| 8.5.2 Member Function Documentation          | 26 |
| 8.5.2.1 is_in_splitting_queue()              | 26 |
| 8.5.2.2 is_unit()                            | 27 |
| 8.6 bliss::Digraph Class Reference           | 27 |
| 8.6.1 Detailed Description                   | 28 |
| 8.6.2 Member Enumeration Documentation       | 28 |
| 8.6.2.1 SplittingHeuristic                   | 28 |
| 8.6.3 Constructor & Destructor Documentation | 29 |
| 8.6.3.1 Digraph()                            | 29 |
| 8.6.3.2 ~Digraph()                           | 29 |
| 8.6.4 Member Function Documentation          | 29 |
| 8.6.4.1 add_edge()                           | 29 |
| 8.6.4.2 add_vertex()                         | 30 |
| 8.6.4.3 canonical_form()                     | 30 |
| 8.6.4.4 change_color()                       | 30 |
| 8.6.4.5 cmp()                                | 30 |
| 8.6.4.6 copy()                               | 31 |
| 8.6.4.7 find_automorphisms()                 | 31 |
| 8.6.4.8 get_color()                          | 31 |
| 8.6.4.9 get_hash()                           | 31 |

|                                                    |    |
|----------------------------------------------------|----|
| 8.6.4.10 <a href="#">get_nof_vertices()</a>        | 32 |
| 8.6.4.11 <a href="#">is_automorphism()</a> [1/2]   | 32 |
| 8.6.4.12 <a href="#">is_automorphism()</a> [2/2]   | 32 |
| 8.6.4.13 <a href="#">permute()</a> [1/2]           | 32 |
| 8.6.4.14 <a href="#">permute()</a> [2/2]           | 32 |
| 8.6.4.15 <a href="#">read_dimacs()</a>             | 33 |
| 8.6.4.16 <a href="#">set_component_recursion()</a> | 33 |
| 8.6.4.17 <a href="#">set_failure_recording()</a>   | 33 |
| 8.6.4.18 <a href="#">set_long_prune_activity()</a> | 34 |
| 8.6.4.19 <a href="#">set_splitting_heuristic()</a> | 34 |
| 8.6.4.20 <a href="#">set_verbose_file()</a>        | 34 |
| 8.6.4.21 <a href="#">set_verbose_level()</a>       | 34 |
| 8.6.4.22 <a href="#">write_dimacs()</a>            | 35 |
| 8.6.4.23 <a href="#">write_dot()</a> [1/2]         | 35 |
| 8.6.4.24 <a href="#">write_dot()</a> [2/2]         | 35 |
| 8.7 bliss::Graph Class Reference                   | 36 |
| 8.7.1 Detailed Description                         | 37 |
| 8.7.2 Member Enumeration Documentation             | 37 |
| 8.7.2.1 SplittingHeuristic                         | 37 |
| 8.7.3 Constructor & Destructor Documentation       | 38 |
| 8.7.3.1 Graph()                                    | 38 |
| 8.7.3.2 ~Graph()                                   | 38 |
| 8.7.4 Member Function Documentation                | 38 |
| 8.7.4.1 <a href="#">add_edge()</a>                 | 38 |
| 8.7.4.2 <a href="#">add_vertex()</a>               | 38 |
| 8.7.4.3 <a href="#">canonical_form()</a>           | 38 |
| 8.7.4.4 <a href="#">change_color()</a>             | 39 |
| 8.7.4.5 <a href="#">cmp()</a>                      | 39 |
| 8.7.4.6 <a href="#">copy()</a>                     | 39 |
| 8.7.4.7 <a href="#">find_automorphisms()</a>       | 39 |
| 8.7.4.8 <a href="#">get_color()</a>                | 40 |
| 8.7.4.9 <a href="#">get_hash()</a>                 | 40 |
| 8.7.4.10 <a href="#">get_nof_vertices()</a>        | 40 |
| 8.7.4.11 <a href="#">is_automorphism()</a> [1/2]   | 40 |
| 8.7.4.12 <a href="#">is_automorphism()</a> [2/2]   | 40 |
| 8.7.4.13 <a href="#">permute()</a> [1/2]           | 41 |
| 8.7.4.14 <a href="#">permute()</a> [2/2]           | 41 |
| 8.7.4.15 <a href="#">read_dimacs()</a>             | 41 |
| 8.7.4.16 <a href="#">set_component_recursion()</a> | 42 |
| 8.7.4.17 <a href="#">set_failure_recording()</a>   | 42 |
| 8.7.4.18 <a href="#">set_long_prune_activity()</a> | 42 |
| 8.7.4.19 <a href="#">set_splitting_heuristic()</a> | 42 |

|                                                                                 |    |
|---------------------------------------------------------------------------------|----|
| 8.7.4.20 <code>set_verbose_file()</code> . . . . .                              | 43 |
| 8.7.4.21 <code>set_verbose_level()</code> . . . . .                             | 43 |
| 8.7.4.22 <code>write_dimacs()</code> . . . . .                                  | 43 |
| 8.7.4.23 <code>write_dot()</code> [1/2] . . . . .                               | 43 |
| 8.7.4.24 <code>write_dot()</code> [2/2] . . . . .                               | 44 |
| 8.8 <code>bliss::Heap</code> Class Reference . . . . .                          | 44 |
| 8.8.1 Detailed Description . . . . .                                            | 44 |
| 8.8.2 Member Function Documentation . . . . .                                   | 44 |
| 8.8.2.1 <code>clear()</code> . . . . .                                          | 44 |
| 8.8.2.2 <code>insert()</code> . . . . .                                         | 45 |
| 8.8.2.3 <code>is_empty()</code> . . . . .                                       | 45 |
| 8.8.2.4 <code>remove()</code> . . . . .                                         | 45 |
| 8.8.2.5 <code>size()</code> . . . . .                                           | 45 |
| 8.8.2.6 <code>smallest()</code> . . . . .                                       | 45 |
| 8.9 <code>bliss::KQueue&lt; Type &gt;</code> Class Template Reference . . . . . | 45 |
| 8.9.1 Detailed Description . . . . .                                            | 46 |
| 8.9.2 Constructor & Destructor Documentation . . . . .                          | 46 |
| 8.9.2.1 <code>KQueue()</code> . . . . .                                         | 46 |
| 8.9.3 Member Function Documentation . . . . .                                   | 46 |
| 8.9.3.1 <code>clear()</code> . . . . .                                          | 46 |
| 8.9.3.2 <code>front()</code> . . . . .                                          | 46 |
| 8.9.3.3 <code>init()</code> . . . . .                                           | 47 |
| 8.9.3.4 <code>is_empty()</code> . . . . .                                       | 47 |
| 8.9.3.5 <code>pop_back()</code> . . . . .                                       | 47 |
| 8.9.3.6 <code>pop_front()</code> . . . . .                                      | 47 |
| 8.9.3.7 <code>push_back()</code> . . . . .                                      | 47 |
| 8.9.3.8 <code>push_front()</code> . . . . .                                     | 47 |
| 8.9.3.9 <code>size()</code> . . . . .                                           | 48 |
| 8.10 <code>bliss::Orbit</code> Class Reference . . . . .                        | 48 |
| 8.10.1 Detailed Description . . . . .                                           | 48 |
| 8.10.2 Constructor & Destructor Documentation . . . . .                         | 48 |
| 8.10.2.1 <code>Orbit()</code> . . . . .                                         | 48 |
| 8.10.3 Member Function Documentation . . . . .                                  | 49 |
| 8.10.3.1 <code>get_minimal_representative()</code> . . . . .                    | 49 |
| 8.10.3.2 <code>init()</code> . . . . .                                          | 49 |
| 8.10.3.3 <code>is_minimal_representative()</code> . . . . .                     | 49 |
| 8.10.3.4 <code>merge_orbits()</code> . . . . .                                  | 49 |
| 8.10.3.5 <code>nof_orbits()</code> . . . . .                                    | 49 |
| 8.10.3.6 <code>orbit_size()</code> . . . . .                                    | 49 |
| 8.10.3.7 <code>reset()</code> . . . . .                                         | 50 |
| 8.11 <code>bliss::Partition</code> Class Reference . . . . .                    | 50 |
| 8.11.1 Detailed Description . . . . .                                           | 50 |

|                                         |           |
|-----------------------------------------|-----------|
| 8.11.2 Member Typedef Documentation     | 51        |
| 8.11.2.1 BacktrackPoint                 | 51        |
| 8.11.3 Member Function Documentation    | 51        |
| 8.11.3.1 clear_ivs()                    | 51        |
| 8.11.3.2 get_cell()                     | 51        |
| 8.11.3.3 goto_backtrack_point()         | 51        |
| 8.11.3.4 individualize()                | 51        |
| 8.11.3.5 init()                         | 52        |
| 8.11.3.6 is_discrete()                  | 52        |
| 8.11.3.7 print()                        | 52        |
| 8.11.3.8 print_signature()              | 52        |
| 8.11.3.9 set_backtrack_point()          | 52        |
| 8.12 bliss::Stats Class Reference       | 52        |
| 8.12.1 Detailed Description             | 53        |
| 8.12.2 Member Function Documentation    | 53        |
| 8.12.2.1 get_group_size()               | 53        |
| 8.12.2.2 get_group_size_approx()        | 53        |
| 8.12.2.3 get_max_level()                | 53        |
| 8.12.2.4 get_nof_bad_nodes()            | 53        |
| 8.12.2.5 get_nof_canupdates()           | 53        |
| 8.12.2.6 get_nof_generators()           | 54        |
| 8.12.2.7 get_nof_leaf_nodes()           | 54        |
| 8.12.2.8 get_nof_nodes()                | 54        |
| 8.12.2.9 print()                        | 54        |
| 8.13 bliss::Timer Class Reference       | 54        |
| 8.13.1 Detailed Description             | 55        |
| 8.14 bliss::UIntSeqHash Class Reference | 55        |
| 8.14.1 Detailed Description             | 55        |
| 8.14.2 Member Function Documentation    | 55        |
| 8.14.2.1 cmp()                          | 55        |
| 8.14.2.2 get_value()                    | 55        |
| 8.14.2.3 is_equal()                     | 56        |
| 8.14.2.4 is_le()                        | 56        |
| 8.14.2.5 is_lt()                        | 56        |
| 8.14.2.6 reset()                        | 56        |
| 8.14.2.7 update()                       | 56        |
| <b>9 File Documentation</b>             | <b>57</b> |
| 9.1 abstractgraph.hh                    | 57        |
| 9.2 bignum.hh                           | 60        |
| 9.3 src/bliss_C.h File Reference        | 62        |
| 9.3.1 Detailed Description              | 63        |

|                                         |           |
|-----------------------------------------|-----------|
| 9.3.2 Function Documentation            | 64        |
| 9.3.2.1 bliss_add_edge()                | 64        |
| 9.3.2.2 bliss_add_vertex()              | 64        |
| 9.3.2.3 bliss_cmp()                     | 64        |
| 9.3.2.4 bliss_find_automorphisms()      | 64        |
| 9.3.2.5 bliss_find_canonical_labeling() | 65        |
| 9.3.2.6 bliss_get_nof_vertices()        | 65        |
| 9.3.2.7 bliss_hash()                    | 65        |
| 9.3.2.8 bliss_new()                     | 65        |
| 9.3.2.9 bliss_permute()                 | 65        |
| 9.3.2.10 bliss_read_dimacs()            | 66        |
| 9.3.2.11 bliss_release()                | 66        |
| 9.3.2.12 bliss_write_dimacs()           | 66        |
| 9.3.2.13 bliss_write_dot()              | 66        |
| 9.4 bliss_C.h                           | 66        |
| 9.5 src/defs.hh File Reference          | 67        |
| 9.5.1 Detailed Description              | 68        |
| 9.6 defs.hh                             | 68        |
| 9.7 digraph.hh                          | 69        |
| 9.8 graph.hh                            | 71        |
| 9.9 heap.hh                             | 73        |
| 9.10 kqueue.hh                          | 73        |
| 9.11 orbit.hh                           | 75        |
| 9.12 partition.hh                       | 76        |
| 9.13 stats.hh                           | 79        |
| 9.14 timer.hh                           | 80        |
| 9.15 uintseqhash.hh                     | 80        |
| 9.16 src/utils.hh File Reference        | 81        |
| 9.16.1 Detailed Description             | 82        |
| 9.17 utils.hh                           | 82        |
| <b>Index</b>                            | <b>83</b> |



# Chapter 1

## Outline

This is the C++ API documentation of bliss, produced by running [doxygen](#) in the source directory.

The algorithms and data structures used in bliss, the graph file format, as well as the compilation process can be found at the [bliss web site](#).

The C++ language API is the main API to bliss. It basically consists of the public methods in the classes

- [bliss::Graph](#) and
- [bliss::Digraph](#).

For an example of its use, see the [source of the bliss executable](#).

### 1.1 The C language API

The C language API is given in the file [bliss\\_C.h](#). It is currently only a subset of the C++ API, so consider using the C++ API whenever possible.



## Chapter 2

# The bliss executable

```
/*
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This file is part of bliss.

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it under the terms of the GNU Lesser General Public License as published by
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along with bliss. If not, see <http://www.gnu.org/licenses/>.
*/

#include <functional>
#include <cstdlib>
#include <cstdio>
#include <cstring>
#include <cassert>
#include <bliss/defs.hh>
#include <bliss/timer.hh>
#include <bliss/utils.hh>
#include <bliss/graph.hh>
#include <bliss/digraph.hh>

/* Input file name */
static const char* infilename = 0;

static bool opt_directed = false;
static bool opt_canonize = false;
static const char* opt_output_can_file = 0;
static const char* opt_splitting_heuristics = "fsm";
static bool opt_use_failure_recording = true;
static bool opt_use_component_recursion = true;

/* Verbosity level and target stream */
static unsigned int verbose_level = 1;
static FILE* verbstr = stdout;

#if !defined(BLISS_COMPILED_DATE)
#define BLISS_COMPILED_DATE "compiled " __DATE__
#endif

static void
version(FILE* const fp)
{
    fprintf(fp,
"bliss version %s (" BLISS_COMPILED_DATE ") \n"
"Copyright (C) 2003-2015 Tommi Junttila. \n"
"\n"
"License LGPLv3+: GNU LGPL version 3 or later, <http://gnu.org/licenses/lgpl.html>. \n"
"This program comes with ABSOLUTELY NO WARRANTY. This is free software, \n"
"and you are welcome to redistribute it under certain conditions; \n"

```

```

"see COPYING and COPYING.LESSER for details.\n"
    , bliss::version
    );
}

static void
usage(FILE* const fp, const char* argv0)
{
    const char* program_name = strrchr(argv0, '/');

    if(program_name) program_name++;
    else program_name = argv0;
    if(!program_name or *program_name == 0) program_name = "bliss";

    fprintf(fp,
"Usage: %s [options] [<graphfile>]\n"
"  Run bliss on <graphfile>.\n"
"Options:\n"
"  -directed    the input graph is directed\n"
"  -can         compute canonical form\n"
"  -ocan=f      compute canonical form and output it in file f\n"
"  -v=N         set verbose level to N [N >= 0, default: 1]\n"
"  -sh=X       select splitting heuristics, where X is\n"
"               f    first non-singleton cell\n"
"               fl   first largest non-singleton cell\n"
"               fs   first smallest non-singleton cell\n"
"               fm   first maximally non-trivially connected\n"
"                   non-singleton cell\n"
"               flm  first largest maximally non-trivially connected\n"
"                   non-singleton cell\n"
"               fsm  first smallest maximally non-trivially connected\n"
"                   non-singleton cell [default]\n"
"  -fr=X       use failure recording? [X=y/n, default: y]\n"
"  -cr=X       use component recursion? [X=y/n, default: y]\n"
"  -version    print the version number and exit\n"
"  -help      print this help and exit\n"
"\n"
    ,program_name
    );
}

static void
parse_options(const int argc, const char** argv)
{
    unsigned int tmp;
    for(int i = 1; i < argc; i++)
    {
        if(strcmp(argv[i], "-can") == 0)
            opt_canonize = true;
        else if((strncmp(argv[i], "-ocan=", 6) == 0) and (strlen(argv[i]) > 6))
        {
            opt_canonize = true;
            opt_output_can_file = argv[i]+6;
        }
        else if(sscanf(argv[i], "-v=%u", &tmp) == 1)
            verbose_level = tmp;
        else if(strcmp(argv[i], "-directed") == 0)
            opt_directed = true;
        else if(strcmp(argv[i], "-fr=n") == 0)
            opt_use_failure_recording = false;
        else if(strcmp(argv[i], "-fr=y") == 0)
            opt_use_failure_recording = true;
        else if(strcmp(argv[i], "-cr=n") == 0)
            opt_use_component_recursion = false;
        else if(strcmp(argv[i], "-cr=y") == 0)
            opt_use_component_recursion = true;
        else if((strncmp(argv[i], "-sh=", 4) == 0) and (strlen(argv[i]) > 4))
        {
            opt_splitting_heuristics = argv[i]+4;
        }
        else if(strcmp(argv[i], "-version") == 0)
        {
            version(stdout);
            exit(0);
        }
        else if(strcmp(argv[i], "-help") == 0)
        {
            usage(stdout, argv[0]);
            exit(0);
        }
        else if(argv[i][0] == '-')
        {
            fprintf(stderr, "Unknown command line argument '%s'\n", argv[i]);
            usage(stderr, argv[0]);
            exit(1);
        }
    }
}

```

```

    }
    else
    {
        if(infilename)
        {
            fprintf(stderr, "Too many file arguments\n");
            usage(stderr, argv[0]);
            exit(1);
        }
        else
        {
            infilename = argv[i];
        }
    }
}
}

/* Output an error message and exit the whole program with the exit value 1. */
static void
_fatal(const char* fmt, ...)
{
    va_list ap;
    va_start(ap, fmt);
    vfprintf(stderr, fmt, ap); fprintf(stderr, "\n");
    va_end(ap);
    exit(1);
}

int
main(const int argc, const char** argv)
{
    bliss::Timer timer;
    bliss::AbstractGraph* g = 0;

    parse_options(argc, argv);

    /* Parse splitting heuristics */
    bliss::Digraph::SplittingHeuristic shs_directed = bliss::Digraph::shs_fsm;
    bliss::Graph::SplittingHeuristic shs_undirected = bliss::Graph::shs_fsm;
    if(opt_directed)
    {
        if(strcmp(opt_splitting_heuristics, "f") == 0)
            shs_directed = bliss::Digraph::shs_f;
        else if(strcmp(opt_splitting_heuristics, "fs") == 0)
            shs_directed = bliss::Digraph::shs_fs;
        else if(strcmp(opt_splitting_heuristics, "fl") == 0)
            shs_directed = bliss::Digraph::shs_fl;
        else if(strcmp(opt_splitting_heuristics, "fm") == 0)
            shs_directed = bliss::Digraph::shs_fm;
        else if(strcmp(opt_splitting_heuristics, "fsm") == 0)
            shs_directed = bliss::Digraph::shs_fsm;
        else if(strcmp(opt_splitting_heuristics, "flm") == 0)
            shs_directed = bliss::Digraph::shs_flm;
        else
            _fatal("Illegal option -sh=%s, aborting", opt_splitting_heuristics);
    }
    else
    {
        if(strcmp(opt_splitting_heuristics, "f") == 0)
            shs_undirected = bliss::Graph::shs_f;
        else if(strcmp(opt_splitting_heuristics, "fs") == 0)
            shs_undirected = bliss::Graph::shs_fs;
        else if(strcmp(opt_splitting_heuristics, "fl") == 0)
            shs_undirected = bliss::Graph::shs_fl;
        else if(strcmp(opt_splitting_heuristics, "fm") == 0)
            shs_undirected = bliss::Graph::shs_fm;
        else if(strcmp(opt_splitting_heuristics, "fsm") == 0)
            shs_undirected = bliss::Graph::shs_fsm;
        else if(strcmp(opt_splitting_heuristics, "flm") == 0)
            shs_undirected = bliss::Graph::shs_flm;
        else
            _fatal("Illegal option -sh=%s, aborting", opt_splitting_heuristics);
    }

    /* Open the input file */
    FILE* infile = stdin;
    if(infilename)
    {
        infile = fopen(infilename, "r");
        if(!infile)
            _fatal("Cannot not open '%s' for input, aborting", infilename);
    }
}

```

```

    }

    /* Read the graph from the file */
    if(opt_directed)
    {
        /* Read directed graph in the DIMACS format */
        g = bliss::Digraph::read_dimacs(infile);
    }
    else
    {
        /* Read undirected graph in the DIMACS format */
        g = bliss::Graph::read_dimacs(infile);
    }

    if(infile != stdin)
        fclose(infile);

    if(!g)
        _fatal("Failed to read the graph, aborting");

    if(verbose_level >= 2)
    {
        fprintf(verbstr, "Graph read in %.2f seconds\n", timer.get_duration());
        fflush(verbstr);
    }

    bliss::Stats stats;

    /* Set splitting heuristics and verbose level */
    if(opt_directed)
        ((bliss::Digraph*)g)->set_splitting_heuristic(shs_directed);
    else
        ((bliss::Graph*)g)->set_splitting_heuristic(shs_undirected);
    g->set_verbose_level(verbose_level);
    g->set_verbose_file(verbstr);
    g->set_failure_recording(opt_use_failure_recording);
    g->set_component_recursion(opt_use_component_recursion);

    auto report_aut = [&](const unsigned int n, const unsigned int* aut) -> void {
        fprintf(stdout, "Generator: ");
        bliss::print_permutation(stdout, n, aut, 1);
        fprintf(stdout, "\n");
    };

    if(opt_canonize == false)
    {
        /* No canonical labeling, only automorphism group */
        g->find_automorphisms(stats, report_aut);
    }
    else
    {
        /* Canonical labeling and automorphism group */
        const unsigned int* cl = g->canonical_form(stats, report_aut);

        fprintf(stdout, "Canonical labeling: ");
        bliss::print_permutation(stdout, g->get_nof_vertices(), cl, 1);
        fprintf(stdout, "\n");

        if(opt_output_can_file)
        {
            bliss::AbstractGraph* cf = g->permute(cl);
            FILE* const fp = fopen(opt_output_can_file, "w");
            if(!fp)
                _fatal("Cannot open '%s' for outputting the canonical form, aborting", opt_output_can_file);
            cf->write_dimacs(fp);
            fclose(fp);
            delete cf;
        }
    }

    /* Output search statistics */
    if(verbose_level > 0 and verbstr)
        stats.print(verbstr);

    if(verbose_level > 0)
    {
        fprintf(verbstr, "Total time:\t%.2f seconds\n", timer.get_duration());
        fflush(verbstr);
    }

    delete g; g = 0;

    return 0;
}

```

## Chapter 3

# Namespace Index

### 3.1 Namespace List

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

|                                 |    |
|---------------------------------|----|
| <a href="#">bliss</a> . . . . . | 15 |
|---------------------------------|----|





## Chapter 4

# Hierarchical Index

### 4.1 Class Hierarchy

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

|                                  |    |
|----------------------------------|----|
| bliss::AbstractGraph . . . . .   | 17 |
| bliss::Digraph . . . . .         | 27 |
| bliss::Graph . . . . .           | 36 |
| bliss::BigNum . . . . .          | 23 |
| bliss_graph_struct . . . . .     | 25 |
| bliss_stats_struct . . . . .     | 25 |
| bliss::Partition::Cell . . . . . | 26 |
| bliss::Heap . . . . .            | 44 |
| bliss::KQueue< Type > . . . . .  | 45 |
| bliss::Orbit . . . . .           | 48 |
| bliss::Partition . . . . .       | 50 |
| bliss::Stats . . . . .           | 52 |
| bliss::Timer . . . . .           | 54 |
| bliss::UIntSeqHash . . . . .     | 55 |



## Chapter 5

# Class Index

### 5.1 Class List

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

|                                             |                                                                                              |    |
|---------------------------------------------|----------------------------------------------------------------------------------------------|----|
| <a href="#">bliss::AbstractGraph</a>        | An abstract base class for different types of graphs . . . . .                               | 17 |
| <a href="#">bliss::BigNum</a>               | A simple wrapper class for non-negative big integers (or approximation of them) . . . . .    | 23 |
| <a href="#">bliss_graph_struct</a>          | The true bliss graph is hiding in this struct . . . . .                                      | 25 |
| <a href="#">bliss_stats_struct</a>          | The C API version of the statistics returned by the bliss search algorithm . . . . .         | 25 |
| <a href="#">bliss::Partition::Cell</a>      | Data structure for holding information about a cell in a <a href="#">Partition</a> . . . . . | 26 |
| <a href="#">bliss::Digraph</a>              | The class for directed, vertex colored graphs . . . . .                                      | 27 |
| <a href="#">bliss::Graph</a>                | The class for undirected, vertex colored graphs . . . . .                                    | 36 |
| <a href="#">bliss::Heap</a>                 | A min-heap of unsigned integers . . . . .                                                    | 44 |
| <a href="#">bliss::KQueue&lt; Type &gt;</a> | A simple implementation of queues with fixed maximum capacity . . . . .                      | 45 |
| <a href="#">bliss::Orbit</a>                | A class for representing orbit information . . . . .                                         | 48 |
| <a href="#">bliss::Partition</a>            | A class for refinable, backtrackable ordered partitions . . . . .                            | 50 |
| <a href="#">bliss::Stats</a>                | Statistics returned by the bliss search algorithm . . . . .                                  | 52 |
| <a href="#">bliss::Timer</a>                | A simple helper class for measuring elapsed time . . . . .                                   | 54 |
| <a href="#">bliss::UIntSeqHash</a>          | A updatable hash for sequences of unsigned ints . . . . .                                    | 55 |



## Chapter 6

# File Index

### 6.1 File List

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

|                                                 |    |
|-------------------------------------------------|----|
| src/ <a href="#">abstractgraph.hh</a> . . . . . | 57 |
| src/ <a href="#">bignum.hh</a> . . . . .        | 60 |
| src/ <a href="#">bliss_C.h</a>                  |    |
| The bliss C API . . . . .                       | 62 |
| src/ <a href="#">defs.hh</a>                    |    |
| Some common definitions . . . . .               | 67 |
| src/ <a href="#">digraph.hh</a> . . . . .       | 69 |
| src/ <a href="#">graph.hh</a> . . . . .         | 71 |
| src/ <a href="#">heap.hh</a> . . . . .          | 73 |
| src/ <a href="#">kqueue.hh</a> . . . . .        | 73 |
| src/ <a href="#">orbit.hh</a> . . . . .         | 75 |
| src/ <a href="#">partition.hh</a> . . . . .     | 76 |
| src/ <a href="#">stats.hh</a> . . . . .         | 79 |
| src/ <a href="#">timer.hh</a> . . . . .         | 80 |
| src/ <a href="#">uintseqhash.hh</a> . . . . .   | 80 |
| src/ <a href="#">utils.hh</a>                   |    |
| Some small utilities . . . . .                  | 81 |



# Chapter 7

## Namespace Documentation

### 7.1 bliss Namespace Reference

#### Classes

- class **TreeNode**
- class [AbstractGraph](#)  
*An abstract base class for different types of graphs.*
- class [BigNum](#)  
*A simple wrapper class for non-negative big integers (or approximation of them).*
- class [Digraph](#)  
*The class for directed, vertex colored graphs.*
- class [Graph](#)  
*The class for undirected, vertex colored graphs.*
- class [Heap](#)  
*A min-heap of unsigned integers.*
- class [KQueue](#)  
*A simple implementation of queues with fixed maximum capacity.*
- class [Orbit](#)  
*A class for representing orbit information.*
- class [Partition](#)  
*A class for refinable, backtrackable ordered partitions.*
- class [Stats](#)  
*Statistics returned by the bliss search algorithm.*
- class [Timer](#)  
*A simple helper class for measuring elapsed time.*
- class [UIntSeqHash](#)  
*A updatable hash for sequences of unsigned ints.*

#### Functions

- `size_t print\_permutation (FILE *const fp, const unsigned int N, const unsigned int *perm, const unsigned int offset)`
- `size_t print\_permutation (FILE *const fp, const std::vector< unsigned int > &perm, const unsigned int offset)`
- `bool is\_permutation (const unsigned int N, const unsigned int *perm)`
- `bool is\_permutation (const std::vector< unsigned int > &perm)`

## Variables

- static const char \*const **version** = "0.77"  
*The version number of bliss.*

### 7.1.1 Detailed Description

The namespace `bliss` contains all the classes and functions of the bliss tool except for the C programming language API.

### 7.1.2 Function Documentation

#### 7.1.2.1 `is_permutation()` [1/2]

```
bool bliss::is_permutation (
    const std::vector< unsigned int > & perm)
```

Check whether *perm* is a valid permutation on {0,...,N-1}. Slow, mainly for debugging and validation purposes.

#### 7.1.2.2 `is_permutation()` [2/2]

```
bool bliss::is_permutation (
    const unsigned int N,
    const unsigned int * perm)
```

Check whether *perm* is a valid permutation on {0,...,N-1}. Slow, mainly for debugging and validation purposes.

#### 7.1.2.3 `print_permutation()` [1/2]

```
size_t bliss::print_permutation (
    FILE * fp,
    const std::vector< unsigned int > & perm,
    const unsigned int offset = 0)
```

Print the permutation *perm* of {0,...,N-1} in the cycle format in the file stream *fp*. The amount *offset* is added to each element before printing, e.g. the permutation (2 4) is printed as (3 5) when *offset* is 1.

#### 7.1.2.4 `print_permutation()` [2/2]

```
size_t bliss::print_permutation (
    FILE * fp,
    const unsigned int N,
    const unsigned int * perm,
    const unsigned int offset = 0)
```

Print the permutation *perm* of {0,...,N-1} in the cycle format in the file stream *fp*. The amount *offset* is added to each element before printing, e.g. the permutation (2 4) is printed as (3 5) when *offset* is 1.



## Chapter 8

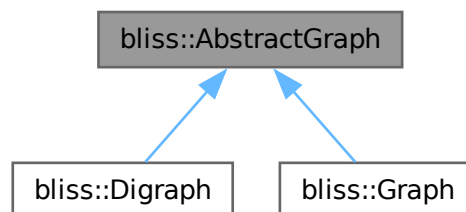
# Class Documentation

### 8.1 bliss::AbstractGraph Class Reference

An abstract base class for different types of graphs.

```
#include <abstractgraph.hh>
```

Inheritance diagram for bliss::AbstractGraph:



#### Classes

- struct **PathInfo**
- class **CR\_CEP**

#### Public Member Functions

- void [set\\_verbose\\_level](#) (const unsigned int level)
- void [set\\_verbose\\_file](#) (FILE \*const fp)
- virtual unsigned int [add\\_vertex](#) (const unsigned int color=0)=0
- virtual void [add\\_edge](#) (const unsigned int source, const unsigned int target)=0
- virtual unsigned int [get\\_color](#) (const unsigned int vertex) const =0
- virtual void [change\\_color](#) (const unsigned int vertex, const unsigned int color)=0

- void [set\\_failure\\_recording](#) (const bool active)
- void [set\\_component\\_recursion](#) (const bool active)
- virtual unsigned int [get\\_nof\\_vertices](#) () const =0
- virtual AbstractGraph \* [permute](#) (const unsigned int \*const perm) const =0
- virtual AbstractGraph \* [permute](#) (const std::vector< unsigned int > &perm) const =0
- virtual bool [is\\_automorphism](#) (unsigned int \*const perm) const =0
- virtual bool [is\\_automorphism](#) (const std::vector< unsigned int > &perm) const =0
- void [find\\_automorphisms](#) (Stats &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- const unsigned int \* [canonical\\_form](#) (Stats &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- virtual void [write\\_dimacs](#) (FILE \*const fp)=0
- virtual void [write\\_dot](#) (FILE \*const fp)=0
- virtual void [write\\_dot](#) (const char \*const file\_name)=0
- virtual unsigned int [get\\_hash](#) ()=0
- void [set\\_long\\_prune\\_activity](#) (const bool active)

### 8.1.1 Detailed Description

An abstract base class for different types of graphs.

### 8.1.2 Member Function Documentation

#### 8.1.2.1 add\_edge()

```
virtual void bliss::AbstractGraph::add_edge (
    const unsigned int source,
    const unsigned int target) [pure virtual]
```

Add an edge between vertices *source* and *target*. Duplicate edges between vertices are ignored but try to avoid introducing them in the first place as they are not ignored immediately but will consume memory and computation resources for a while.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

#### 8.1.2.2 add\_vertex()

```
virtual unsigned int bliss::AbstractGraph::add_vertex (
    const unsigned int color = 0) [pure virtual]
```

Add a new vertex with color *color* in the graph and return its index.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

### 8.1.2.3 canonical\_form()

```
const unsigned int * bliss::AbstractGraph::canonical_form (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
nullptr,
    const std::function< bool()> & terminate = nullptr)
```

Otherwise the same as [find\\_automorphisms\(\)](#) except that a canonical labeling of the graph (a bijection on  $\{0, \dots, \text{get\_nof\_vertices}() - 1\}$ ) is returned. The memory allocated for the returned canonical labeling will remain valid only until the next call to a member function with the exception that constant member functions (for example, [bliss::Graph::permute\(\)](#)) can be called without invalidating the labeling. To compute the canonical version of an undirected graph, call this function and then [bliss::Graph::permute\(\)](#) with the returned canonical labeling. Note that the computed canonical version may depend on the applied version of bliss as well as on some other options (for instance, the splitting heuristic selected with [bliss::Graph::set\\_splitting\\_heuristic\(\)](#)).

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus (i) not all the automorphisms may have been generated and (ii) the returned labeling may not be canonical. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

### 8.1.2.4 change\_color()

```
virtual void bliss::AbstractGraph::change_color (
    const unsigned int vertex,
    const unsigned int color) [pure virtual]
```

Change the color of the vertex *vertex* to *color*.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

### 8.1.2.5 find\_automorphisms()

```
void bliss::AbstractGraph::find_automorphisms (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
nullptr,
    const std::function< bool()> & terminate = nullptr)
```

Find a set of generators for the automorphism group of the graph. The function *report* (if non-null) is called each time a new generator for the automorphism group is found. The first argument *n* for the function is the length of the automorphism (equal to [get\\_nof\\_vertices\(\)](#)), and the second argument *aut* is the automorphism (a bijection on  $\{0, \dots, \text{get\_nof\_vertices}() - 1\}$ ). The memory for the automorphism *aut* will be invalidated immediately after the return from the *report* function; if you want to use the automorphism later, you have to take a copy of it. Do not call any member functions from the *report* function.

The search statistics are copied in *stats*.

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus not all the automorphisms may have been generated. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

#### 8.1.2.6 `get_color()`

```
virtual unsigned int bliss::AbstractGraph::get_color (
    const unsigned int vertex) const [pure virtual]
```

Get the color of a vertex.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

#### 8.1.2.7 `get_hash()`

```
virtual unsigned int bliss::AbstractGraph::get_hash () [pure virtual]
```

Get a hash value for the graph.

##### Returns

the hash value

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

#### 8.1.2.8 `get_nof_vertices()`

```
virtual unsigned int bliss::AbstractGraph::get_nof_vertices () const [pure virtual]
```

Return the number of vertices in the graph.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

#### 8.1.2.9 `is_automorphism()` [1/2]

```
virtual bool bliss::AbstractGraph::is_automorphism (
    const std::vector< unsigned int > & perm) const [pure virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

#### 8.1.2.10 `is_automorphism()` [2/2]

```
virtual bool bliss::AbstractGraph::is_automorphism (
    unsigned int *const perm) const [pure virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

**8.1.2.11 permute()** [1/2]

```
virtual AbstractGraph * bliss::AbstractGraph::permute (
    const std::vector< unsigned int > & perm) const [pure virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain  $N=\text{this.get\_nof\_vertices}()$  elements and be a bijection on  $\{0,1,\dots,N-1\}$ , otherwise the result is undefined or a segfault.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

**8.1.2.12 permute()** [2/2]

```
virtual AbstractGraph * bliss::AbstractGraph::permute (
    const unsigned int *const perm) const [pure virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain  $N=\text{this.get\_nof\_vertices}()$  elements and be a bijection on  $\{0,1,\dots,N-1\}$ , otherwise the result is undefined or a segfault.

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

**8.1.2.13 set\_component\_recursion()**

```
void bliss::AbstractGraph::set_component_recursion (
    const bool active) [inline]
```

Activate/deactivate component recursion. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

**Parameters**

|               |                                                             |
|---------------|-------------------------------------------------------------|
| <i>active</i> | if true, activate component recursion, deactivate otherwise |
|---------------|-------------------------------------------------------------|

**8.1.2.14 set\_failure\_recording()**

```
void bliss::AbstractGraph::set_failure_recording (
    const bool active) [inline]
```

Activate/deactivate failure recording. May not be called during the search, i.e. from an automorphism reporting hook function.

**Parameters**

|               |                                                           |
|---------------|-----------------------------------------------------------|
| <i>active</i> | if true, activate failure recording, deactivate otherwise |
|---------------|-----------------------------------------------------------|

### 8.1.2.15 set\_long\_prune\_activity()

```
void bliss::AbstractGraph::set_long_prune_activity (
    const bool active) [inline]
```

Disable/enable the "long prune" method. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

#### Parameters

|               |                                                      |
|---------------|------------------------------------------------------|
| <i>active</i> | if true, activate "long prune", deactivate otherwise |
|---------------|------------------------------------------------------|

### 8.1.2.16 set\_verbose\_file()

```
void bliss::AbstractGraph::set_verbose_file (
    FILE *const fp)
```

Set the file stream for the verbose output.

#### Parameters

|           |                                                        |
|-----------|--------------------------------------------------------|
| <i>fp</i> | the file stream; if null, no verbose output is written |
|-----------|--------------------------------------------------------|

### 8.1.2.17 set\_verbose\_level()

```
void bliss::AbstractGraph::set_verbose_level (
    const unsigned int level)
```

Set the verbose output level for the algorithms.

#### Parameters

|              |                                                        |
|--------------|--------------------------------------------------------|
| <i>level</i> | the level of verbose output, 0 means no verbose output |
|--------------|--------------------------------------------------------|

### 8.1.2.18 write\_dimacs()

```
virtual void bliss::AbstractGraph::write_dimacs (
    FILE *const fp) [pure virtual]
```

Write the graph to a file in a variant of the DIMACS format. See the [bliss website](#) for the definition of the file format. Note that in the DIMACS file the vertices are numbered from 1 to N while in this C++ API they are from 0 to N-1. Thus the vertex n in the file corresponds to the vertex n-1 in the API.

**Parameters**

|           |                                            |
|-----------|--------------------------------------------|
| <i>fp</i> | the file stream where the graph is written |
|-----------|--------------------------------------------|

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

**8.1.2.19 write\_dot() [1/2]**

```
virtual void bliss::AbstractGraph::write_dot (
    const char *const file_name) [pure virtual]
```

Write the graph in a file in the graphviz dotty format. Do nothing if the file cannot be written.

**Parameters**

|                  |                                                    |
|------------------|----------------------------------------------------|
| <i>file_name</i> | the name of the file to which the graph is written |
|------------------|----------------------------------------------------|

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

**8.1.2.20 write\_dot() [2/2]**

```
virtual void bliss::AbstractGraph::write_dot (
    FILE *const fp) [pure virtual]
```

Write the graph to a file in the graphviz dotty format.

**Parameters**

|           |                                            |
|-----------|--------------------------------------------|
| <i>fp</i> | the file stream where the graph is written |
|-----------|--------------------------------------------|

Implemented in [bliss::Digraph](#), and [bliss::Graph](#).

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

- src/abstractgraph.hh
- src/abstractgraph.cc

**8.2 bliss::BigNum Class Reference**

A simple wrapper class for non-negative big integers (or approximation of them).

```
#include <bignum.hh>
```

## Public Member Functions

- [BigNum](#) ()
- [~BigNum](#) ()
- void [assign](#) (unsigned int n)
- void [multiply](#) (unsigned int n)
- size\_t [print](#) (FILE \*const fp) const
- const std::vector< unsigned int > & [get\\_factors](#) () const
- std::string [to\\_string](#) () const

### 8.2.1 Detailed Description

A simple wrapper class for non-negative big integers (or approximation of them).

If the compile time flag `BLISS_USE_GMP` is set, then the GNU Multiple Precision Arithmetic library (GMP) is used to obtain arbitrary precision. Otherwise, if the compile time flag `BLISS_BIGNUM_APPROX` is set, a "long double" is used to approximate a big integer. Otherwise, by default, a big integer is represented by a product of integer-sized factors.

### 8.2.2 Constructor & Destructor Documentation

#### 8.2.2.1 [BigNum\(\)](#)

```
bliss::BigNum::BigNum () [inline]
```

Create a new big number and set it to zero.

#### 8.2.2.2 [~BigNum\(\)](#)

```
bliss::BigNum::~~BigNum () [inline]
```

Destroy the number.

### 8.2.3 Member Function Documentation

#### 8.2.3.1 [assign\(\)](#)

```
void bliss::BigNum::assign (
    unsigned int n) [inline]
```

Set the number to *n*.

#### 8.2.3.2 [get\\_factors\(\)](#)

```
const std::vector< unsigned int > & bliss::BigNum::get_factors () const [inline]
```

Get a reference to the factors vector.



### 8.2.3.3 multiply()

```
void bliss::BigNum::multiply (
    unsigned int n) [inline]
```

Multiply the number with *n*.

### 8.2.3.4 print()

```
size_t bliss::BigNum::print (
    FILE *const fp) const [inline]
```

Print the number in the file stream *fp*. In the current version, the returned number of characters printed, is incorrect (either -1 or 0).

### 8.2.3.5 to\_string()

```
std::string bliss::BigNum::to_string () const [inline]
```

Get the string representation of the number. Unoptimized, uses an elementary school algorithm to multiply the factors.

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

- src/bignum.hh

## 8.3 bliss\_graph\_struct Struct Reference

The true bliss graph is hiding in this struct.

### 8.3.1 Detailed Description

The true bliss graph is hiding in this struct.

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

- src/bliss\_C.cc

## 8.4 bliss\_stats\_struct Struct Reference

The C API version of the statistics returned by the bliss search algorithm.

```
#include <bliss_C.h>
```

## Public Attributes

- long double **group\_size\_approx**  
*An approximation (due to possible rounding errors) of the size of the automorphism group.*
- long unsigned int **nof\_nodes**  
*The number of nodes in the search tree.*
- long unsigned int **nof\_leaf\_nodes**  
*The number of leaf nodes in the search tree.*
- long unsigned int **nof\_bad\_nodes**  
*The number of bad nodes in the search tree.*
- long unsigned int **nof\_canupdates**  
*The number of canonical representative updates.*
- long unsigned int **nof\_generators**  
*The number of generator permutations.*
- unsigned long int **max\_level**  
*The maximal depth of the search tree.*

### 8.4.1 Detailed Description

The C API version of the statistics returned by the bliss search algorithm.

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

- src/[bliss\\_C.h](#)

## 8.5 bliss::Partition::Cell Class Reference

Data structure for holding information about a cell in a [Partition](#).

```
#include <partition.hh>
```

### Public Member Functions

- bool [is\\_unit](#) () const
- bool [is\\_in\\_splitting\\_queue](#) () const

#### 8.5.1 Detailed Description

Data structure for holding information about a cell in a [Partition](#).

#### 8.5.2 Member Function Documentation

##### 8.5.2.1 is\_in\_splitting\_queue()

```
bool bliss::Partition::Cell::is_in_splitting_queue () const [inline]
```

Is this cell in splitting queue?

### 8.5.2.2 is\_unit()

```
bool bliss::Partition::Cell::is_unit () const [inline]
```

Is this a unit cell?

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

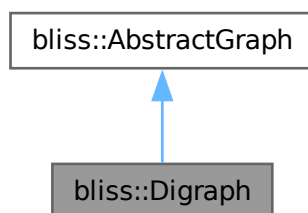
- src/partition.hh

## 8.6 bliss::Digraph Class Reference

The class for directed, vertex colored graphs.

```
#include <digraph.hh>
```

Inheritance diagram for bliss::Digraph:



### Classes

- class **Vertex**

### Public Types

- enum [SplittingHeuristic](#) {  
    [shs\\_f](#) = 0 , [shs\\_fs](#) , [shs\\_fl](#) , [shs\\_fm](#) ,  
    [shs\\_fsm](#) , [shs\\_flm](#) }

## Public Member Functions

- [Digraph](#) (const unsigned int N=0)
- [~Digraph](#) ()
- void [write\\_dimacs](#) (FILE \*const fp)
- void [write\\_dot](#) (FILE \*const fp)
- void [write\\_dot](#) (const char \*const file\_name)
- virtual unsigned int [get\\_hash](#) ()
- unsigned int [get\\_nof\\_vertices](#) () const
- unsigned int [add\\_vertex](#) (const unsigned int color=0)
- void [add\\_edge](#) (const unsigned int source, const unsigned int target)
- unsigned int [get\\_color](#) (const unsigned int vertex) const
- void [change\\_color](#) (const unsigned int vertex, const unsigned int color)
- [Digraph](#) \* [copy](#) () const
- int [cmp](#) ([Digraph](#) &other)
- void [set\\_splitting\\_heuristic](#) ([SplittingHeuristic](#) shs)
- [Digraph](#) \* [permute](#) (const unsigned int \*const perm) const
- [Digraph](#) \* [permute](#) (const std::vector< unsigned int > &perm) const
- bool [is\\_automorphism](#) (unsigned int \*const perm) const
- bool [is\\_automorphism](#) (const std::vector< unsigned int > &perm) const
- void [set\\_verbose\\_level](#) (const unsigned int level)
- void [set\\_verbose\\_file](#) (FILE \*const fp)
- void [set\\_failure\\_recording](#) (const bool active)
- void [set\\_component\\_recursion](#) (const bool active)
- void [find\\_automorphisms](#) ([Stats](#) &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- const unsigned int \* [canonical\\_form](#) ([Stats](#) &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- void [set\\_long\\_prune\\_activity](#) (const bool active)

## Static Public Member Functions

- static [Digraph](#) \* [read\\_dimacs](#) (FILE \*const fp, FILE \*const errstr=stderr)

### 8.6.1 Detailed Description

The class for directed, vertex colored graphs.

Multiple edges between vertices are not allowed (copies will be ignored).

### 8.6.2 Member Enumeration Documentation

#### 8.6.2.1 SplittingHeuristic

```
enum bliss::Digraph::SplittingHeuristic
```

The possible splitting heuristics. The selected splitting heuristics affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same splitting heuristics for both graphs.

**Enumerator**

|         |                                                                                                                                                           |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| shs_f   | First non-unit cell. Very fast but may result in large search spaces on difficult graphs. Use for large but easy graphs.                                  |
| shs_fs  | First smallest non-unit cell. Fast, should usually produce smaller search spaces than shs_f.                                                              |
| shs_fl  | First largest non-unit cell. Fast, should usually produce smaller search spaces than shs_f.                                                               |
| shs_fm  | First maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl.          |
| shs_fsm | First smallest maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl. |
| shs_flm | First largest maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl.  |

**8.6.3 Constructor & Destructor Documentation****8.6.3.1 Digraph()**

```
bliss::Digraph::Digraph (
    const unsigned int N = 0)
```

Create a new directed graph with  $N$  vertices and no edges.

**8.6.3.2 ~Digraph()**

```
bliss::Digraph::~~Digraph ()
```

Destroy the graph.

**8.6.4 Member Function Documentation****8.6.4.1 add\_edge()**

```
void bliss::Digraph::add_edge (
    const unsigned int source,
    const unsigned int target) [virtual]
```

Add an edge from the vertex *source* to the vertex *target*. Duplicate edges are ignored but try to avoid introducing them in the first place as they are not ignored immediately but will consume memory and computation resources for a while.

Implements [bliss::AbstractGraph](#).

#### 8.6.4.2 add\_vertex()

```
unsigned int bliss::Digraph::add_vertex (
    const unsigned int color = 0) [virtual]
```

Add a new vertex with color 'color' in the graph and return its index.

Implements [bliss::AbstractGraph](#).

#### 8.6.4.3 canonical\_form()

```
const unsigned int * bliss::AbstractGraph::canonical_form (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
nullptr,
    const std::function< bool()> & terminate = nullptr) [inherited]
```

Otherwise the same as [find\\_automorphisms\(\)](#) except that a canonical labeling of the graph (a bijection on  $\{0, \dots, \text{get\_nof\_vertices}() - 1\}$ ) is returned. The memory allocated for the returned canonical labeling will remain valid only until the next call to a member function with the exception that constant member functions (for example, [bliss::Graph::permute\(\)](#)) can be called without invalidating the labeling. To compute the canonical version of an undirected graph, call this function and then [bliss::Graph::permute\(\)](#) with the returned canonical labeling. Note that the computed canonical version may depend on the applied version of bliss as well as on some other options (for instance, the splitting heuristic selected with [bliss::Graph::set\\_splitting\\_heuristic\(\)](#)).

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus (i) not all the automorphisms may have been generated and (ii) the returned labeling may not be canonical. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

#### 8.6.4.4 change\_color()

```
void bliss::Digraph::change_color (
    const unsigned int vertex,
    const unsigned int color) [virtual]
```

Change the color of the vertex 'vertex' to 'color'.

Implements [bliss::AbstractGraph](#).

#### 8.6.4.5 cmp()

```
int bliss::Digraph::cmp (
    Digraph & other)
```

Compare this graph to the *other* graph in a total order on graphs.

##### Returns

0 if the graphs are equal, -1 if this graph is "smaller than" the other, and 1 if this graph is "greater than" the other.

#### 8.6.4.6 copy()

```
Digraph * bliss::Digraph::copy () const
```

Get a copy of the graph.

#### 8.6.4.7 find\_automorphisms()

```
void bliss::AbstractGraph::find_automorphisms (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
nullptr,
    const std::function< bool()> & terminate = nullptr) [inherited]
```

Find a set of generators for the automorphism group of the graph. The function *report* (if non-null) is called each time a new generator for the automorphism group is found. The first argument *n* for the function is the length of the automorphism (equal to [get\\_nof\\_vertices\(\)](#)), and the second argument *aut* is the automorphism (a bijection on {0,...,[get\\_nof\\_vertices\(\)](#)-1}). The memory for the automorphism *aut* will be invalidated immediately after the return from the *report* function; if you want to use the automorphism later, you have to take a copy of it. Do not call any member functions from the *report* function.

The search statistics are copied in *stats*.

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus not all the automorphisms may have been generated. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

#### 8.6.4.8 get\_color()

```
unsigned int bliss::Digraph::get_color (
    const unsigned int vertex) const [virtual]
```

Get the color of a vertex.

Implements [bliss::AbstractGraph](#).

#### 8.6.4.9 get\_hash()

```
unsigned int bliss::Digraph::get_hash () [virtual]
```

Get a hash value for the graph.

##### Returns

the hash value

Implements [bliss::AbstractGraph](#).

**8.6.4.10 get\_nof\_vertices()**

```
unsigned int bliss::Digraph::get_nof_vertices () const [inline], [virtual]
```

Return the number of vertices in the graph.

Implements [bliss::AbstractGraph](#).

**8.6.4.11 is\_automorphism() [1/2]**

```
bool bliss::Digraph::is_automorphism (
    const std::vector< unsigned int > & perm) const [virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implements [bliss::AbstractGraph](#).

**8.6.4.12 is\_automorphism() [2/2]**

```
bool bliss::Digraph::is_automorphism (
    unsigned int *const perm) const [virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implements [bliss::AbstractGraph](#).

**8.6.4.13 permute() [1/2]**

```
Digraph * bliss::Digraph::permute (
    const std::vector< unsigned int > & perm) const [virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain  $N=\text{this.get\_nof\_vertices}()$  elements and be a bijection on  $\{0,1,\dots,N-1\}$ , otherwise the result is undefined or a segfault.

Implements [bliss::AbstractGraph](#).

**8.6.4.14 permute() [2/2]**

```
Digraph * bliss::Digraph::permute (
    const unsigned int *const perm) const [virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain  $N=\text{this.get\_nof\_vertices}()$  elements and be a bijection on  $\{0,1,\dots,N-1\}$ , otherwise the result is undefined or a segfault.

Implements [bliss::AbstractGraph](#).



## 8.6.4.15 read\_dimacs()

```
Digraph * bliss::Digraph::read_dimacs (
    FILE *const fp,
    FILE *const errstr = stderr) [static]
```

Read the graph from the file *fp* in a variant of the DIMACS format. See the [bliss website](#) for the definition of the file format. Note that in the DIMACS file the vertices are numbered from 1 to N while in this C++ API they are from 0 to N-1. Thus the vertex *n* in the file corresponds to the vertex *n*-1 in the API.

## Parameters

|               |                                                                          |
|---------------|--------------------------------------------------------------------------|
| <i>fp</i>     | the file stream for the graph file                                       |
| <i>errstr</i> | if non-null, the possible error messages are printed in this file stream |

## Returns

a new [Digraph](#) object or 0 if reading failed for some reason

## 8.6.4.16 set\_component\_recursion()

```
void bliss::AbstractGraph::set_component_recursion (
    const bool active) [inline], [inherited]
```

Activate/deactivate component recursion. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

## Parameters

|               |                                                             |
|---------------|-------------------------------------------------------------|
| <i>active</i> | if true, activate component recursion, deactivate otherwise |
|---------------|-------------------------------------------------------------|

## 8.6.4.17 set\_failure\_recording()

```
void bliss::AbstractGraph::set_failure_recording (
    const bool active) [inline], [inherited]
```

Activate/deactivate failure recording. May not be called during the search, i.e. from an automorphism reporting hook function.

## Parameters

|               |                                                           |
|---------------|-----------------------------------------------------------|
| <i>active</i> | if true, activate failure recording, deactivate otherwise |
|---------------|-----------------------------------------------------------|

#### 8.6.4.18 set\_long\_prune\_activity()

```
void bliss::AbstractGraph::set_long_prune_activity (
    const bool active) [inline], [inherited]
```

Disable/enable the "long prune" method. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

##### Parameters

|               |                                                      |
|---------------|------------------------------------------------------|
| <i>active</i> | if true, activate "long prune", deactivate otherwise |
|---------------|------------------------------------------------------|

#### 8.6.4.19 set\_splitting\_heuristic()

```
void bliss::Digraph::set_splitting_heuristic (
    SplittingHeuristic shs) [inline]
```

Set the splitting heuristic used by the automorphism and canonical labeling algorithm. The selected splitting heuristics affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same splitting heuristics for both graphs.

#### 8.6.4.20 set\_verbose\_file()

```
void bliss::AbstractGraph::set_verbose_file (
    FILE *const fp) [inherited]
```

Set the file stream for the verbose output.

##### Parameters

|           |                                                        |
|-----------|--------------------------------------------------------|
| <i>fp</i> | the file stream; if null, no verbose output is written |
|-----------|--------------------------------------------------------|

#### 8.6.4.21 set\_verbose\_level()

```
void bliss::AbstractGraph::set_verbose_level (
    const unsigned int level) [inherited]
```

Set the verbose output level for the algorithms.

##### Parameters

|              |                                                        |
|--------------|--------------------------------------------------------|
| <i>level</i> | the level of verbose output, 0 means no verbose output |
|--------------|--------------------------------------------------------|

#### 8.6.4.22 write\_dimacs()

```
void bliss::Digraph::write_dimacs (
    FILE *const fp) [virtual]
```

Write the graph to a file in a variant of the DIMACS format. See the [bliss website](#) for the definition of the file format. Note that in the DIMACS file the vertices are numbered from 1 to N while in this C++ API they are from 0 to N-1. Thus the vertex n in the file corresponds to the vertex n-1 in the API.

##### Parameters

|           |                                            |
|-----------|--------------------------------------------|
| <i>fp</i> | the file stream where the graph is written |
|-----------|--------------------------------------------|

Implements [bliss::AbstractGraph](#).

#### 8.6.4.23 write\_dot() [1/2]

```
void bliss::Digraph::write_dot (
    const char *const file_name) [virtual]
```

Write the graph in a file in the graphviz dotty format. Do nothing if the file cannot be written.

##### Parameters

|                  |                                                    |
|------------------|----------------------------------------------------|
| <i>file_name</i> | the name of the file to which the graph is written |
|------------------|----------------------------------------------------|

Implements [bliss::AbstractGraph](#).

#### 8.6.4.24 write\_dot() [2/2]

```
void bliss::Digraph::write_dot (
    FILE *const fp) [virtual]
```

Write the graph to a file in the graphviz dotty format.

##### Parameters

|           |                                            |
|-----------|--------------------------------------------|
| <i>fp</i> | the file stream where the graph is written |
|-----------|--------------------------------------------|

Implements [bliss::AbstractGraph](#).

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

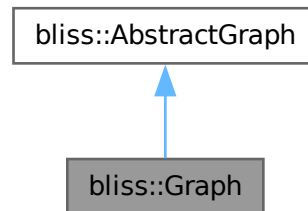
- src/digraph.hh
- src/digraph.cc

## 8.7 bliss::Graph Class Reference

The class for undirected, vertex colored graphs.

```
#include <graph.hh>
```

Inheritance diagram for bliss::Graph:



### Classes

- class **Vertex**

### Public Types

- enum `SplittingHeuristic` {  
`shs_f = 0`, `shs_fs`, `shs_fl`, `shs_fm`,  
`shs_fsm`, `shs_flm` }

### Public Member Functions

- `Graph` (const unsigned int N=0)
- `~Graph` ()
- void `write_dimacs` (FILE \*const fp)
- void `write_dot` (FILE \*const fp)
- void `write_dot` (const char \*const file\_name)
- virtual unsigned int `get_hash` ()
- unsigned int `get_nof_vertices` () const
- `Graph` \* `permute` (const unsigned int \*const perm) const
- `Graph` \* `permute` (const std::vector< unsigned int > &perm) const
- bool `is_automorphism` (unsigned int \*const perm) const
- bool `is_automorphism` (const std::vector< unsigned int > &perm) const
- unsigned int `add_vertex` (const unsigned int color=0)
- void `add_edge` (const unsigned int v1, const unsigned int v2)
- unsigned int `get_color` (const unsigned int vertex) const
- void `change_color` (const unsigned int vertex, const unsigned int color)
- `Graph` \* `copy` () const
- int `cmp` (`Graph` &other)
- void `set_splitting_heuristic` (const `SplittingHeuristic` shs)

- void [set\\_verbose\\_level](#) (const unsigned int level)
- void [set\\_verbose\\_file](#) (FILE \*const fp)
- void [set\\_failure\\_recording](#) (const bool active)
- void [set\\_component\\_recursion](#) (const bool active)
- void [find\\_automorphisms](#) (Stats &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- const unsigned int \* [canonical\\_form](#) (Stats &stats, const std::function< void(unsigned int n, const unsigned int \*aut)> &report=nullptr, const std::function< bool()> &terminate=nullptr)
- void [set\\_long\\_prune\\_activity](#) (const bool active)

### Static Public Member Functions

- static [Graph](#) \* [read\\_dimacs](#) (FILE \*const fp, FILE \*const errstr=stderr)

## 8.7.1 Detailed Description

The class for undirected, vertex colored graphs.

Multiple edges between vertices are not allowed (i.e., are ignored).

## 8.7.2 Member Enumeration Documentation

### 8.7.2.1 SplittingHeuristic

```
enum bliss::Graph::SplittingHeuristic
```

The possible splitting heuristics. The selected splitting heuristics affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same splitting heuristics for both graphs.

### Enumerator

|         |                                                                                                                                                           |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| shs_f   | First non-unit cell. Very fast but may result in large search spaces on difficult graphs. Use for large but easy graphs.                                  |
| shs_fs  | First smallest non-unit cell. Fast, should usually produce smaller search spaces than shs_f.                                                              |
| shs_fl  | First largest non-unit cell. Fast, should usually produce smaller search spaces than shs_f.                                                               |
| shs_fm  | First maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl.          |
| shs_fsm | First smallest maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl. |
| shs_flm | First largest maximally non-trivially connected non-unit cell. Not so fast, should usually produce smaller search spaces than shs_f, shs_fs, and shs_fl.  |

## 8.7.3 Constructor & Destructor Documentation

### 8.7.3.1 Graph()

```
bliss::Graph::Graph (
    const unsigned int N = 0)
```

Create a new graph with  $N$  vertices and no edges.

### 8.7.3.2 ~Graph()

```
bliss::Graph::~Graph ()
```

Destroy the graph.

## 8.7.4 Member Function Documentation

### 8.7.4.1 add\_edge()

```
void bliss::Graph::add_edge (
    const unsigned int v1,
    const unsigned int v2) [virtual]
```

Add an edge between vertices  $v1$  and  $v2$ . Duplicate edges between vertices are ignored but try to avoid introducing them in the first place as they are not ignored immediately but will consume memory and computation resources for a while.

Implements [bliss::AbstractGraph](#).

### 8.7.4.2 add\_vertex()

```
unsigned int bliss::Graph::add_vertex (
    const unsigned int color = 0) [virtual]
```

Add a new vertex with color  $color$  in the graph and return its index.

Implements [bliss::AbstractGraph](#).

### 8.7.4.3 canonical\_form()

```
const unsigned int * bliss::AbstractGraph::canonical_form (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
    nullptr,
    const std::function< bool()> & terminate = nullptr) [inherited]
```

Otherwise the same as [find\\_automorphisms\(\)](#) except that a canonical labeling of the graph (a bijection on  $\{0, \dots, \text{get\_nof\_vertices}() - 1\}$ ) is returned. The memory allocated for the returned canonical labeling will remain valid only until the next call to a member function with the exception that constant member functions (for example, [bliss::Graph::permute\(\)](#)) can be called without invalidating the labeling. To compute the canonical version of an undirected graph, call this function and then [bliss::Graph::permute\(\)](#) with the returned canonical labeling. Note that the computed canonical version may depend on the applied version of bliss as well as on some other options (for instance, the splitting heuristic selected with [bliss::Graph::set\\_splitting\\_heuristic\(\)](#)).

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus (i) not all the automorphisms may have been generated and (ii) the returned labeling may not be canonical. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

#### 8.7.4.4 change\_color()

```
void bliss::Graph::change_color (
    const unsigned int vertex,
    const unsigned int color) [virtual]
```

Change the color of the vertex *vertex* to *color*.

Implements [bliss::AbstractGraph](#).

#### 8.7.4.5 cmp()

```
int bliss::Graph::cmp (
    Graph & other)
```

Compare this graph to the *other* graph in a total order on graphs.

##### Returns

0 if the graphs are equal, -1 if this graph is "smaller than" the other, and 1 if this graph is "greater than" the other.

#### 8.7.4.6 copy()

```
Graph * bliss::Graph::copy () const
```

Get a copy of the graph.

#### 8.7.4.7 find\_automorphisms()

```
void bliss::AbstractGraph::find_automorphisms (
    Stats & stats,
    const std::function< void(unsigned int n, const unsigned int *aut)> & report =
nullptr,
    const std::function< bool()> & terminate = nullptr) [inherited]
```

Find a set of generators for the automorphism group of the graph. The function *report* (if non-null) is called each time a new generator for the automorphism group is found. The first argument *n* for the function is the length of the automorphism (equal to [get\\_nof\\_vertices\(\)](#)), and the second argument *aut* is the automorphism (a bijection on {0,...,[get\\_nof\\_vertices\(\)](#)-1}). The memory for the automorphism *aut* will be invalidated immediately after the return from the *report* function; if you want to use the automorphism later, you have to take a copy of it. Do not call any member functions from the *report* function.

The search statistics are copied in *stats*.

If the *terminate* function argument is given, it is called in each search tree node: if the function returns true, then the search is terminated and thus not all the automorphisms may have been generated. The *terminate* function may be used to limit the time spent in bliss in case the graph is too difficult under the available time constraints. If used, keep the function simple to evaluate so that it does not consume too much time.

#### 8.7.4.8 `get_color()`

```
unsigned int bliss::Graph::get_color (
    const unsigned int vertex) const [virtual]
```

Get the color of a vertex.

Implements [bliss::AbstractGraph](#).

#### 8.7.4.9 `get_hash()`

```
unsigned int bliss::Graph::get_hash () [virtual]
```

Get a hash value for the graph.

##### Returns

the hash value

Implements [bliss::AbstractGraph](#).

#### 8.7.4.10 `get_nof_vertices()`

```
unsigned int bliss::Graph::get_nof_vertices () const [inline], [virtual]
```

Return the number of vertices in the graph.

Implements [bliss::AbstractGraph](#).

#### 8.7.4.11 `is_automorphism()` [1/2]

```
bool bliss::Graph::is_automorphism (
    const std::vector< unsigned int > & perm) const [virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implements [bliss::AbstractGraph](#).

#### 8.7.4.12 `is_automorphism()` [2/2]

```
bool bliss::Graph::is_automorphism (
    unsigned int *const perm) const [virtual]
```

Check whether *perm* is an automorphism of this graph. Unoptimized, mainly for debugging purposes.

Implements [bliss::AbstractGraph](#).



**8.7.4.13 permute()** [1/2]

```
Graph * bliss::Graph::permute (
    const std::vector< unsigned int > & perm) const [virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain N=this.get\_nof\_vertices() elements and be a bijection on {0,1,...,N-1}, otherwise the result is undefined or a segfault.

Implements [bliss::AbstractGraph](#).

**8.7.4.14 permute()** [2/2]

```
Graph * bliss::Graph::permute (
    const unsigned int *const perm) const [virtual]
```

Return a new graph that is the result of applying the permutation *perm* to this graph. This graph is not modified. *perm* must contain N=this.get\_nof\_vertices() elements and be a bijection on {0,1,...,N-1}, otherwise the result is undefined or a segfault.

Implements [bliss::AbstractGraph](#).

**8.7.4.15 read\_dimacs()**

```
Graph * bliss::Graph::read_dimacs (
    FILE *const fp,
    FILE *const errstr = stderr) [static]
```

Read the graph from the file *fp* in a variant of the DIMACS format. See the [bliss website](#) for the definition of the file format. Note that in the DIMACS file the vertices are numbered from 1 to N while in this C++ API they are from 0 to N-1. Thus the vertex *n* in the file corresponds to the vertex *n-1* in the API.

**Parameters**

|               |                                                                          |
|---------------|--------------------------------------------------------------------------|
| <i>fp</i>     | the file stream for the graph file                                       |
| <i>errstr</i> | if non-null, the possible error messages are printed in this file stream |

**Returns**

a new [Graph](#) object or 0 if reading failed for some reason

#### 8.7.4.16 set\_component\_recursion()

```
void bliss::AbstractGraph::set_component_recursion (
    const bool active) [inline], [inherited]
```

Activate/deactivate component recursion. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

##### Parameters

|               |                                                             |
|---------------|-------------------------------------------------------------|
| <i>active</i> | if true, activate component recursion, deactivate otherwise |
|---------------|-------------------------------------------------------------|

#### 8.7.4.17 set\_failure\_recording()

```
void bliss::AbstractGraph::set_failure_recording (
    const bool active) [inline], [inherited]
```

Activate/deactivate failure recording. May not be called during the search, i.e. from an automorphism reporting hook function.

##### Parameters

|               |                                                           |
|---------------|-----------------------------------------------------------|
| <i>active</i> | if true, activate failure recording, deactivate otherwise |
|---------------|-----------------------------------------------------------|

#### 8.7.4.18 set\_long\_prune\_activity()

```
void bliss::AbstractGraph::set_long_prune_activity (
    const bool active) [inline], [inherited]
```

Disable/enable the "long prune" method. The choice affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same choice for both graphs. May not be called during the search, i.e. from an automorphism reporting hook function.

##### Parameters

|               |                                                      |
|---------------|------------------------------------------------------|
| <i>active</i> | if true, activate "long prune", deactivate otherwise |
|---------------|------------------------------------------------------|

#### 8.7.4.19 set\_splitting\_heuristic()

```
void bliss::Graph::set_splitting_heuristic (
    const SplittingHeuristic shs) [inline]
```

Set the splitting heuristic used by the automorphism and canonical labeling algorithm. The selected splitting heuristics affects the computed canonical labelings; therefore, if you want to compare whether two graphs are isomorphic by computing and comparing (for equality) their canonical versions, be sure to use the same splitting heuristics for both graphs.

**8.7.4.20 set\_verbose\_file()**

```
void bliss::AbstractGraph::set_verbose_file (
    FILE *const fp) [inherited]
```

Set the file stream for the verbose output.

**Parameters**

|           |                                                        |
|-----------|--------------------------------------------------------|
| <i>fp</i> | the file stream; if null, no verbose output is written |
|-----------|--------------------------------------------------------|

**8.7.4.21 set\_verbose\_level()**

```
void bliss::AbstractGraph::set_verbose_level (
    const unsigned int level) [inherited]
```

Set the verbose output level for the algorithms.

**Parameters**

|              |                                                        |
|--------------|--------------------------------------------------------|
| <i>level</i> | the level of verbose output, 0 means no verbose output |
|--------------|--------------------------------------------------------|

**8.7.4.22 write\_dimacs()**

```
void bliss::Graph::write_dimacs (
    FILE *const fp) [virtual]
```

Write the graph to a file in a variant of the DIMACS format. See the [bliss website](#) for the definition of the file format.

Implements [bliss::AbstractGraph](#).

**8.7.4.23 write\_dot() [1/2]**

```
void bliss::Graph::write_dot (
    const char *const file_name) [virtual]
```

Write the graph in a file in the graphviz dotty format. Do nothing if the file cannot be written.

**Parameters**

|                  |                                                    |
|------------------|----------------------------------------------------|
| <i>file_name</i> | the name of the file to which the graph is written |
|------------------|----------------------------------------------------|

Implements [bliss::AbstractGraph](#).

#### 8.7.4.24 write\_dot() [2/2]

```
void bliss::Graph::write_dot (
    FILE *const fp) [virtual]
```

Write the graph to a file in the graphviz dotty format.

##### Parameters

|           |                                            |
|-----------|--------------------------------------------|
| <i>fp</i> | the file stream where the graph is written |
|-----------|--------------------------------------------|

Implements [bliss::AbstractGraph](#).

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

- src/graph.hh
- src/graph.cc

## 8.8 bliss::Heap Class Reference

A min-heap of unsigned integers.

```
#include <heap.hh>
```

### Public Member Functions

- bool [is\\_empty](#) () const
- void [clear](#) ()
- void [insert](#) (const unsigned int e)
- unsigned int [smallest](#) () const
- unsigned int [remove](#) ()
- size\_t [size](#) () const

#### 8.8.1 Detailed Description

A min-heap of unsigned integers.

#### 8.8.2 Member Function Documentation

##### 8.8.2.1 clear()

```
void bliss::Heap::clear () [inline]
```

Remove all the elements in the heap. Time complexity is O(1).

### 8.8.2.2 insert()

```
void bliss::Heap::insert (
    const unsigned int e) [inline]
```

Insert the element  $e$  in the heap. Time complexity is  $O(\log(N))$ , where  $N$  is the number of elements currently in the heap.

### 8.8.2.3 is\_empty()

```
bool bliss::Heap::is_empty () const [inline]
```

Is the heap empty? Time complexity is  $O(1)$ .

### 8.8.2.4 remove()

```
unsigned int bliss::Heap::remove () [inline]
```

Remove and return the smallest element in the heap. Time complexity is  $O(\log(N))$ , where  $N$  is the number of elements currently in the heap.

### 8.8.2.5 size()

```
size_t bliss::Heap::size () const [inline]
```

Get the number of elements in the heap.

### 8.8.2.6 smallest()

```
unsigned int bliss::Heap::smallest () const [inline]
```

Return the smallest element in the heap. Time complexity is  $O(1)$ .

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

- src/heap.hh

## 8.9 bliss::KQueue< Type > Class Template Reference

A simple implementation of queues with fixed maximum capacity.

```
#include <kqueue.hh>
```

## Public Member Functions

- [KQueue](#) ()
- void [init](#) (const unsigned int N)
- bool [is\\_empty](#) () const
- unsigned int [size](#) () const
- void [clear](#) ()
- Type [front](#) () const
- Type [pop\\_front](#) ()
- void [push\\_front](#) (Type e)
- Type [pop\\_back](#) ()
- void [push\\_back](#) (Type e)

### 8.9.1 Detailed Description

```
template<class Type>  
class bliss::KQueue< Type >
```

A simple implementation of queues with fixed maximum capacity.

### 8.9.2 Constructor & Destructor Documentation

#### 8.9.2.1 KQueue()

```
template<class Type>  
bliss::KQueue< Type >::KQueue ()
```

Create a new queue with capacity zero. The function [init\(\)](#) should be called next.

### 8.9.3 Member Function Documentation

#### 8.9.3.1 clear()

```
template<class Type>  
void bliss::KQueue< Type >::clear ()
```

Remove all the elements in the queue.

#### 8.9.3.2 front()

```
template<class Type>  
Type bliss::KQueue< Type >::front () const
```

Return (but don't remove) the first element in the queue.

### 8.9.3.3 init()

```
template<class Type>
void bliss::KQueue< Type >::init (
    const unsigned int N)
```

Initialize the queue to have the capacity to hold at most  $N$  elements.

### 8.9.3.4 is\_empty()

```
template<class Type>
bool bliss::KQueue< Type >::is_empty () const
```

Is the queue empty?

### 8.9.3.5 pop\_back()

```
template<class Type>
Type bliss::KQueue< Type >::pop_back ()
```

Remove and return the last element of the queue.

### 8.9.3.6 pop\_front()

```
template<class Type>
Type bliss::KQueue< Type >::pop_front ()
```

Remove and return the first element of the queue.

### 8.9.3.7 push\_back()

```
template<class Type>
void bliss::KQueue< Type >::push_back (
    Type e)
```

Push the element  $e$  in the back of the queue.

### 8.9.3.8 push\_front()

```
template<class Type>
void bliss::KQueue< Type >::push_front (
    Type e)
```

Push the element  $e$  in the front of the queue.

### 8.9.3.9 size()

```
template<class Type>
unsigned int bliss::KQueue< Type >::size () const
```

Return the number of elements in the queue.

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

- src/kqueue.hh

## 8.10 bliss::Orbit Class Reference

A class for representing orbit information.

```
#include <orbit.hh>
```

### Public Member Functions

- [Orbit](#) ()
- void [init](#) (const unsigned int N)
- void [reset](#) ()
- void [merge\\_orbits](#) (unsigned int e1, unsigned int e2)
- bool [is\\_minimal\\_representative](#) (unsigned int e) const
- unsigned int [get\\_minimal\\_representative](#) (unsigned int e) const
- unsigned int [orbit\\_size](#) (unsigned int e) const
- unsigned int [nof\\_orbits](#) () const

### 8.10.1 Detailed Description

A class for representing orbit information.

Given a set {0,...,N-1} of N elements, represent equivalence classes (that is, unordered partitions) of the elements. Supports only equivalence class merging, not splitting. Merging two classes requires time  $O(k)$ , where  $k$  is the number of the elements in the smaller of the merged classes. Getting the smallest representative in a class (and thus testing whether two elements belong to the same class) is a constant time operation.

### 8.10.2 Constructor & Destructor Documentation

#### 8.10.2.1 Orbit()

```
bliss::Orbit::Orbit ()
```

Create a new orbit information object. The [init\(\)](#) function must be called next to actually initialize the object.



## 8.10.3 Member Function Documentation

### 8.10.3.1 get\_minimal\_representative()

```
unsigned int bliss::Orbit::get_minimal_representative (  
    unsigned int e) const
```

Get the smallest element in the orbit of the element *e*. Time complexity is  $O(1)$ .

### 8.10.3.2 init()

```
void bliss::Orbit::init (  
    const unsigned int N)
```

Initialize the orbit information to consider sets of *N* elements. It is required that  $N > 0$ . The orbit information is reset so that each element forms an orbit of its own. Time complexity is  $O(N)$ .

See also

[reset\(\)](#)

### 8.10.3.3 is\_minimal\_representative()

```
bool bliss::Orbit::is_minimal_representative (  
    unsigned int e) const
```

Is the element *e* the smallest element in its orbit? Time complexity is  $O(1)$ .

### 8.10.3.4 merge\_orbits()

```
void bliss::Orbit::merge_orbits (  
    unsigned int e1,  
    unsigned int e2)
```

Merge the orbits of the elements *e1* and *e2*. Time complexity is  $O(k)$ , where *k* is the number of elements in the smaller of the merged orbits.

### 8.10.3.5 nof\_orbits()

```
unsigned int bliss::Orbit::nof_orbits () const [inline]
```

Get the number of orbits. Time complexity is  $O(1)$ .

### 8.10.3.6 orbit\_size()

```
unsigned int bliss::Orbit::orbit_size (  
    unsigned int e) const
```

Get the number of elements in the orbit of the element *e*. Time complexity is  $O(1)$ .

### 8.10.3.7 reset()

```
void bliss::Orbit::reset ()
```

Reset the orbits so that each element forms an orbit of its own. Time complexity is  $O(N)$ .

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

- src/orbit.hh
- src/orbit.cc

## 8.11 bliss::Partition Class Reference

A class for refinable, backtrackable ordered partitions.

```
#include <partition.hh>
```

### Classes

- class [Cell](#)  
*Data structure for holding information about a cell in a [Partition](#).*

### Public Types

- typedef unsigned int [BacktrackPoint](#)

### Public Member Functions

- [BacktrackPoint](#) [set\\_backtrack\\_point](#) ()
- void [goto\\_backtrack\\_point](#) ([BacktrackPoint](#) p)
- [Cell](#) \* [individualize](#) ([Cell](#) \*const cell, const unsigned int element)
- [Cell](#) \* [get\\_cell](#) (const unsigned int e) const
- void [init](#) (const unsigned int N)
- bool [is\\_discrete](#) () const
- size\_t [print](#) (FILE \*const fp, const bool add\_newline=true) const
- size\_t [print\\_signature](#) (FILE \*const fp, const bool add\_newline=true) const
- void [clear\\_ivs](#) ([Cell](#) \*const cell)

### 8.11.1 Detailed Description

A class for refinable, backtrackable ordered partitions.

This is rather a data structure with some helper functions than a proper self-contained class. That is, for efficiency reasons the fields of this class are directly manipulated from [bliss::AbstractGraph](#) and its subclasses. Conversely, some methods of this class modify the fields of [bliss::AbstractGraph](#), too.

## 8.11.2 Member Typedef Documentation

### 8.11.2.1 BacktrackPoint

```
typedef unsigned int bliss::Partition::BacktrackPoint
```

Type for backtracking points.

## 8.11.3 Member Function Documentation

### 8.11.3.1 clear\_ivs()

```
void bliss::Partition::clear_ivs (
    Cell *const cell)
```

Clear the invariant\_values of the elements in the Cell *cell*.

### 8.11.3.2 get\_cell()

```
Cell * bliss::Partition::get_cell (
    const unsigned int e) const [inline]
```

Get the cell of the element *e*

### 8.11.3.3 goto\_backtrack\_point()

```
void bliss::Partition::goto_backtrack_point (
    BacktrackPoint p)
```

Backtrack to the point *p* and remove it.

### 8.11.3.4 individualize()

```
Partition::Cell * bliss::Partition::individualize (
    Partition::Cell *const cell,
    const unsigned int element)
```

Split the non-unit Cell *cell* = {*element*,*e1*,*e2*,...,*en*} containing the element *element* in two: *cell* = {*e1*,...,*en*} and *newcell* = {*element*}.

#### Parameters

|                |                           |
|----------------|---------------------------|
| <i>cell</i>    | a non-unit Cell           |
| <i>element</i> | an element in <i>cell</i> |

#### Returns

the new unit Cell *newcell*

### 8.11.3.5 init()

```
void bliss::Partition::init (
    const unsigned int N)
```

Initialize the partition to the unit partition (all elements in one cell) over the  $N > 0$  elements  $\{0, \dots, N-1\}$ .

### 8.11.3.6 is\_discrete()

```
bool bliss::Partition::is_discrete () const [inline]
```

Returns true iff the partition is discrete, meaning that all the elements are in their own cells.

### 8.11.3.7 print()

```
size_t bliss::Partition::print (
    FILE *const fp,
    const bool add_newline = true) const
```

Print the partition into the file stream *fp*.

### 8.11.3.8 print\_signature()

```
size_t bliss::Partition::print_signature (
    FILE *const fp,
    const bool add_newline = true) const
```

Print the partition cell sizes into the file stream *fp*.

### 8.11.3.9 set\_backtrack\_point()

```
Partition::BacktrackPoint bliss::Partition::set_backtrack_point ()
```

Get a new backtrack point for the current partition

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

- src/partition.hh
- src/partition.cc

## 8.12 bliss::Stats Class Reference

Statistics returned by the bliss search algorithm.

```
#include <stats.hh>
```

## Public Member Functions

- `size_t print (FILE *const fp) const`
- `const BigNum & get_group_size () const`
- `long double get_group_size_approx () const`
- `long unsigned int get_nof_nodes () const`
- `long unsigned int get_nof_leaf_nodes () const`
- `long unsigned int get_nof_bad_nodes () const`
- `long unsigned int get_nof_canupdates () const`
- `long unsigned int get_nof_generators () const`
- `unsigned long int get_max_level () const`

### 8.12.1 Detailed Description

Statistics returned by the bliss search algorithm.

### 8.12.2 Member Function Documentation

#### 8.12.2.1 get\_group\_size()

```
const BigNum & bliss::Stats::get_group_size () const [inline]
```

The size of the automorphism group.

#### 8.12.2.2 get\_group\_size\_approx()

```
long double bliss::Stats::get_group_size_approx () const [inline]
```

An approximation (due to possible overflows/rounding errors) of the size of the automorphism group.

#### 8.12.2.3 get\_max\_level()

```
unsigned long int bliss::Stats::get_max_level () const [inline]
```

The maximal depth of the search tree.

#### 8.12.2.4 get\_nof\_bad\_nodes()

```
long unsigned int bliss::Stats::get_nof_bad_nodes () const [inline]
```

The number of bad nodes in the search tree.

#### 8.12.2.5 get\_nof\_canupdates()

```
long unsigned int bliss::Stats::get_nof_canupdates () const [inline]
```

The number of canonical representative updates.

#### 8.12.2.6 `get_nof_generators()`

```
long unsigned int bliss::Stats::get_nof_generators () const [inline]
```

The number of generator permutations.

#### 8.12.2.7 `get_nof_leaf_nodes()`

```
long unsigned int bliss::Stats::get_nof_leaf_nodes () const [inline]
```

The number of leaf nodes in the search tree.

#### 8.12.2.8 `get_nof_nodes()`

```
long unsigned int bliss::Stats::get_nof_nodes () const [inline]
```

The number of nodes in the search tree.

#### 8.12.2.9 `print()`

```
size_t bliss::Stats::print (
    FILE *const fp) const [inline]
```

Print the statistics.

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

- `src/stats.hh`

## 8.13 `bliss::Timer` Class Reference

A simple helper class for measuring elapsed time.

```
#include <timer.hh>
```

### Public Member Functions

- **`Timer ()`**  
*Create and start a new timer.*
- **`void reset ()`**  
*Reset the timer.*
- **`double get_duration () const`**  
*Get the time (in seconds) elapsed since the creation or the last [reset\(\)](#) call of the timer.*

### 8.13.1 Detailed Description

A simple helper class for measuring elapsed time.

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

- src/timer.hh

## 8.14 bliss::UIntSeqHash Class Reference

A updatable hash for sequences of unsigned ints.

```
#include <uintseqhash.hh>
```

### Public Member Functions

- void [reset](#) ()
- void [update](#) (unsigned int n)
- unsigned int [get\\_value](#) () const
- int [cmp](#) (const UIntSeqHash &other) const
- bool [is\\_lt](#) (const UIntSeqHash &other) const
- bool [is\\_le](#) (const UIntSeqHash &other) const
- bool [is\\_equal](#) (const UIntSeqHash &other) const

### 8.14.1 Detailed Description

A updatable hash for sequences of unsigned ints.

### 8.14.2 Member Function Documentation

#### 8.14.2.1 cmp()

```
int bliss::UIntSeqHash::cmp (  
    const UIntSeqHash & other) const [inline]
```

Compare the hash values of this and *other*. Return -1/0/1 if the value of this is smaller/equal/greater than that of *other*.

#### 8.14.2.2 get\_value()

```
unsigned int bliss::UIntSeqHash::get_value () const [inline]
```

Get the hash value of the sequence seen so far.

#### 8.14.2.3 is\_equal()

```
bool bliss::UIntSeqHash::is_equal (
    const UIntSeqHash & other) const [inline]
```

An abbreviation for `cmp(other) == 0`

#### 8.14.2.4 is\_le()

```
bool bliss::UIntSeqHash::is_le (
    const UIntSeqHash & other) const [inline]
```

An abbreviation for `cmp(other) <= 0`

#### 8.14.2.5 is\_lt()

```
bool bliss::UIntSeqHash::is_lt (
    const UIntSeqHash & other) const [inline]
```

An abbreviation for `cmp(other) < 0`

#### 8.14.2.6 reset()

```
void bliss::UIntSeqHash::reset () [inline]
```

Reset the hash value.

#### 8.14.2.7 update()

```
void bliss::UIntSeqHash::update (
    unsigned int n)
```

Add the unsigned int *n* to the sequence.

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

- `src/uintseqhash.hh`
- `src/uintseqhash.cc`



# Chapter 9

## File Documentation

### 9.1 abstractgraph.hh

```
00001 #pragma once
00002
00003 /*
00004  Copyright (c) 2003-2021 Tommi Junttila
00005  Released under the GNU Lesser General Public License version 3.
00006
00007  This file is part of bliss.
00008
00009  bliss is free software: you can redistribute it and/or modify
00010  it under the terms of the GNU Lesser General Public License as published by
00011  the Free Software Foundation, version 3 of the License.
00012
00013  bliss is distributed in the hope that it will be useful,
00014  but WITHOUT ANY WARRANTY; without even the implied warranty of
00015  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016  GNU Lesser General Public License for more details.
00017
00018  You should have received a copy of the GNU Lesser General Public License
00019  along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 namespace bliss {
00023     class AbstractGraph;
00024 }
00025
00026 #include <cstdio>
00027 #include <functional>
00028 #include <vector>
00029 #include <bliss/stats.hh>
00030 #include <bliss/kqueue.hh>
00031 #include <bliss/heap.hh>
00032 #include <bliss/orbit.hh>
00033 #include <bliss/partition.hh>
00034 #include <bliss/uintseqhash.hh>
00035
00036 namespace bliss {
00037
00038     class AbstractGraph
00039     {
00040     friend class Partition;
00041
00042     public:
00043         AbstractGraph();
00044         virtual ~AbstractGraph();
00045
00046         void set_verbose_level(const unsigned int level);
00047
00048         void set_verbose_file(FILE * const fp);
00049
00050         virtual unsigned int add_vertex(const unsigned int color = 0) = 0;
00051
00052         virtual void add_edge(const unsigned int source, const unsigned int target) = 0;
00053
00054         virtual unsigned int get_color(const unsigned int vertex) const = 0;
00055
00056         virtual void change_color(const unsigned int vertex, const unsigned int color) = 0;
00057     };
00058 }
```

```

00089
00090
00096 void set_failure_recording(const bool active) {
00097     assert(not in_search);
00098     opt_use_failure_recording = active;
00099 }
00100
00110 void set_component_recursion(const bool active) {
00111     assert(not in_search);
00112     opt_use_comprec = active;
00113 }
00114
00115
00116
00120 virtual unsigned int get_nof_vertices() const = 0;
00121
00128 virtual AbstractGraph* permute(const unsigned int* const perm) const = 0;
00129
00136 virtual AbstractGraph* permute(const std::vector<unsigned int>& perm) const = 0;
00137
00142 virtual bool is_automorphism(unsigned int* const perm) const = 0;
00143
00148 virtual bool is_automorphism(const std::vector<unsigned int>& perm) const = 0;
00149
00174 void find_automorphisms(Stats& stats,
00175     const std::function<void(unsigned int n, const unsigned int* aut)>& report = nullptr,
00176     const std::function<bool()>& terminate = nullptr);
00177
00203 const unsigned int* canonical_form(Stats& stats,
00204     const std::function<void(unsigned int n, const unsigned int* aut)>& report =
nullptr,
00205     const std::function<bool()>& terminate = nullptr);
00206
00216 virtual void write_dimacs(FILE * const fp) = 0;
00217
00222 virtual void write_dot(FILE * const fp) = 0;
00223
00229 virtual void write_dot(const char * const file_name) = 0;
00230
00235 virtual unsigned int get_hash() = 0;
00236
00247 void set_long_prune_activity(const bool active) {
00248     assert(not in_search);
00249     opt_use_long_prune = active;
00250 }
00251
00252
00253
00254 protected:
00257 unsigned int verbose_level;
00258
00261 FILE *verbstr;
00262
00265 Partition p;
00266
00271 bool in_search;
00272
00276 bool opt_use_failure_recording;
00277
00278 /* The "tree-specific" invariant value for the point when current path
00279  * got different from the first path */
00280 unsigned int failure_recording_fp_deviation;
00281
00285 bool opt_use_comprec;
00286
00287
00288 unsigned int refine_current_path_certificate_index;
00289 bool refine_compare_certificate;
00290 bool refine_equal_to_first;
00291 unsigned int refine_first_path_subcertificate_end;
00292 int refine_cmp_to_best;
00293 unsigned int refine_best_path_subcertificate_end;
00294
00295 static const unsigned int CERT_SPLIT = 0; //UINT_MAX;
00296 static const unsigned int CERT_EDGE = 1; //UINT_MAX-1;
00301 void cert_add(const unsigned int v1,
00302     const unsigned int v2,
00303     const unsigned int v3);
00304
00310 void cert_add_redundant(const unsigned int x,
00311     const unsigned int y,
00312     const unsigned int z);
00313
00317 bool opt_use_long_prune;
00322 static const unsigned int long_prune_options_max_mem = 50;
00327 static const unsigned int long_prune_options_max_stored_auts = 100;
00328

```

```

00329 unsigned int long_prune_max_stored_autss;
00330 std::vector<std::vector<bool>*> long_prune_fixed;
00331 std::vector<std::vector<bool>*> long_prune_mcrs;
00332 std::vector<bool> long_prune_temp;
00333 unsigned int long_prune_begin;
00334 unsigned int long_prune_end;
00338 void long_prune_init();
00342 void long_prune_deallocate();
00343 void long_prune_add_automorphism(const unsigned int *aut);
00344 std::vector<bool>& long_prune_get_fixed(const unsigned int index);
00345 std::vector<bool>& long_prune_allocget_fixed(const unsigned int index);
00346 std::vector<bool>& long_prune_get_mcrs(const unsigned int index);
00347 std::vector<bool>& long_prune_allocget_mcrs(const unsigned int index);
00352 void long_prune_swap(const unsigned int i, const unsigned int j);
00353
00354 /*
00355  * Data structures and routines for refining the partition p into equitable
00356  */
00357 Heap neighbour_heap;
00358 virtual bool split_neighbourhood_of_unit_cell(Partition::Cell * const) = 0;
00359 virtual bool split_neighbourhood_of_cell(Partition::Cell * const) = 0;
00360 void refine_to_equitable();
00361 void refine_to_equitable(Partition::Cell * const unit_cell);
00362 void refine_to_equitable(Partition::Cell * const unit_cell1,
00363                          Partition::Cell * const unit_cell2);
00364
00365
00371 bool do_refine_to_equitable();
00372
00373 unsigned int eqref_max_certificate_index;
00377 bool compute_eqref_hash;
00378 UIntSeqHash eqref_hash;
00379
00380
00385 virtual bool is_equitable() const = 0;
00386
00387 unsigned int *first_path_labeling;
00388 unsigned int *first_path_labeling_inv;
00389 Orbit first_path_orbits;
00390 unsigned int *first_path_automorphism;
00391
00392 unsigned int *best_path_labeling;
00393 unsigned int *best_path_labeling_inv;
00394 Orbit best_path_orbits;
00395 unsigned int *best_path_automorphism;
00396
00397 void update_labeling(unsigned int * const lab);
00398 void update_labeling_and_its_inverse(unsigned int * const lab,
00399                                     unsigned int * const lab_inv);
00400 void update_orbit_information(Orbit &o, const unsigned int *perm);
00401
00402 void reset_permutation(unsigned int *perm);
00403
00404 std::vector<unsigned int> certificate_current_path;
00405 std::vector<unsigned int> certificate_first_path;
00406 std::vector<unsigned int> certificate_best_path;
00407
00408 unsigned int certificate_index;
00409 virtual void initialize_certificate() = 0;
00410
00411 /* Remove duplicates from seq.
00412  * If m is the largest element in seq, then m < tmp.size() must hold.
00413  * All entries in tmp must be false when called.
00414  * Under that condition, all entries in tmp are false on exit as well.
00415  */
00416 static void remove_duplicates(std::vector<unsigned int>& seq, std::vector<bool>& tmp);
00417
00418 virtual void remove_duplicate_edges() = 0;
00419 virtual void make_initial_equitable_partition() = 0;
00420 virtual Partition::Cell* find_next_cell_to_beSplitted(Partition::Cell *cell) = 0;
00421
00422
00427 typedef struct {
00428     unsigned int splitting_element;
00429     unsigned int certificate_index;
00430     unsigned int subcertificate_length;
00431     UIntSeqHash eqref_hash;
00432 } PathInfo;
00433
00434 void search(const bool canonical, Stats &stats,
00435            const std::function<void(unsigned int n, const unsigned int* aut)>& report_function =
00436            nullptr,
00437            const std::function<bool()>& terminate = nullptr);
00438
00439 /*
00440  */

```

```

00441     * Nonuniform component recursion (NUCR)
00442     *
00443     */
00444
00445     /* The currently traversed component */
00446     unsigned int cr_level;
00447
00451     class CR_CEP {
00452     public:
00454         unsigned int creation_level;
00457         unsigned int discrete_cell_limit;
00459         unsigned int next_cr_level;
00461         unsigned int next_cep_index;
00462         bool first_checked;
00463         bool best_checked;
00464     };
00468     std::vector<CR_CEP> cr_cep_stack;
00469
00481     virtual bool nucr_find_first_component(const unsigned int level) = 0;
00482     virtual bool nucr_find_first_component(const unsigned int level,
00483         std::vector<unsigned int>& component,
00484         unsigned int& component_elements,
00485         Partition::Cell*& sh_return) = 0;
00490     std::vector<unsigned int> cr_component;
00494     unsigned int cr_component_elements;
00495
00496
00497
00498
00499
00500
00501 };
00502
00503 } // namespace bliss

```

## 9.2 bignum.hh

```

00001 #pragma once
00002
00003 /*
00004     Copyright (c) 2003-2021 Tommi Junttila
00005     Released under the GNU Lesser General Public License version 3.
00006
00007     This file is part of bliss.
00008
00009     bliss is free software: you can redistribute it and/or modify
00010     it under the terms of the GNU Lesser General Public License as published by
00011     the Free Software Foundation, version 3 of the License.
00012
00013     bliss is distributed in the hope that it will be useful,
00014     but WITHOUT ANY WARRANTY; without even the implied warranty of
00015     MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016     GNU Lesser General Public License for more details.
00017
00018     You should have received a copy of the GNU Lesser General Public License
00019     along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #if defined(BLISS_USE_GMP)
00023 #include <gmp.h>
00024 #else
00025 #include <vector>
00026 #include <string>
00027 #endif
00028
00029 #include <cstdlib>
00030 #include <cstdio>
00031 #include <bliss/defs.hh>
00032
00033
00034 namespace bliss {
00035
00047
00048 #if defined(BLISS_USE_GMP)
00049
00050 class BigNum
00051 {
00052     mpz_t v;
00053 public:
00057     BigNum() {mpz_init(v); }
00058
00062     ~BigNum() {mpz_clear(v); }
00063

```

```

00067 void assign(unsigned int n) {mpz_set_ui(v, n); }
00068
00072 void multiply(unsigned int n) {mpz_mul_ui(v, v, n); }
00073
00077 size_t print(FILE* const fp) const {return mpz_out_str(fp, 10, v); }
00078
00084 void get(mpz_t& result) const {mpz_set(result, v); }
00085 };
00086
00087 #elif defined(BLISS_BIGNUM_APPROX)
00088
00089 class BigNum
00090 {
00091     long double v;
00092 public:
00096     BigNum(): v(0.0) {}
00097
00101 void assign(unsigned int n) {v = (long double)n; }
00102
00106 void multiply(unsigned int n) {v *= (long double)n; }
00107
00111 size_t print(FILE* const fp) const {return fprintf(fp, "%Lg", v); }
00112 };
00113
00114 #else
00115
00116
00117 class BigNum
00118 {
00119     /* This is a version that does not actually compute the number
00120      * but rather only stores the factor integers.
00121      */
00122     std::vector<unsigned int> factors;
00123 public:
00127     BigNum() {
00128         factors.push_back(0);
00129     }
00130
00134     ~BigNum() {}
00135
00139 void assign(unsigned int n) {
00140     factors.clear();
00141     factors.push_back(n);
00142 }
00143
00147 void multiply(unsigned int n) {
00148     factors.push_back(n);
00149 }
00150
00156 size_t print(FILE* const fp) const {
00157     assert(not factors.empty());
00158     size_t r = 0;
00159     /*
00160     const char* sep = "";
00161     for(int v: factors) {
00162         r += fprintf(fp, "%s%d", sep, v);
00163         sep = "*";
00164     }
00165     */
00166     for(char d: to_string())
00167         r += fprintf(fp, "%c", d);
00168     return r;
00169 }
00170
00174 const std::vector<unsigned int>& get_factors() const {
00175     return factors;
00176 }
00177
00182 std::string to_string() const {
00183     // Base 100 result, in reverse order
00184     std::vector<unsigned int> result;
00185     result.push_back(1);
00186     for(unsigned int factor: factors) {
00187         std::vector<unsigned int> summand;
00188         unsigned int offset = 0;
00189         while(factor != 0) {
00190             const unsigned int multiplier = factor % 100;
00191             // Multiplication by a "digit"
00192             std::vector<unsigned int> product;
00193             for(unsigned int i = 0; i < offset; i++)
00194                 product.push_back(0);
00195             unsigned int carry = 0;
00196             for(unsigned int digit: result) {
00197                 unsigned int v = digit * multiplier + carry;
00198                 product.push_back(v % 100);
00199                 carry = v / 100;
00200             }

```

```

00201     if(carry > 0)
00202         product.push_back(carry);
00203     // Addition
00204     add(summand, product);
00205     // Next "digit" in factor
00206     factor = factor / 100;
00207     offset++;
00208     }
00209     result = summand;
00210     }
00211     return _string(result);
00212 }
00213
00214 protected:
00215 static void add(std::vector<unsigned int>& num, const std::vector<unsigned int>& summand) {
00216     unsigned int carry = 0;
00217     unsigned int i = 0;
00218     while(i < num.size() and i < summand.size()) {
00219         const unsigned int v = carry + num[i] + summand[i];
00220         num[i] = v % 100;
00221         carry = v / 100;
00222         i++;
00223     }
00224     while(i < summand.size()) {
00225         const unsigned int v = carry + summand[i];
00226         num.push_back(v % 100);
00227         carry = v / 100;
00228         i++;
00229     }
00230     while(i < num.size()) {
00231         const unsigned int v = carry + num[i];
00232         num[i] = v % 100;
00233         carry = v / 100;
00234         i++;
00235     }
00236     if(carry != 0)
00237         num.push_back(carry);
00238 }
00239
00240
00241 static std::string _string(const std::vector<unsigned int> n) {
00242     const char digits[] = {'0','1','2','3','4','5','6','7','8','9'};
00243     std::string r;
00244     bool first = true;
00245     for(auto it = n.cbegin(); it != n.crend(); it++) {
00246         unsigned int digit = *it;
00247         unsigned int high = digit / 10;
00248         if(not first or high > 0)
00249             r.push_back(digits[high]);
00250         first = false;
00251         r.push_back(digits[digit % 10]);
00252     }
00253     return r;
00254 }
00255
00256 };
00257
00258 #endif
00259
00260 } //namespace bliss

```

## 9.3 src/bliss\_C.h File Reference

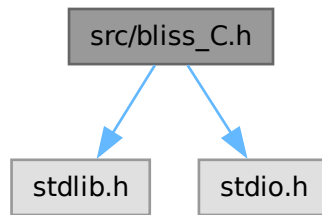
The bliss C API.

```

#include <stdlib.h>
#include <stdio.h>

```

Include dependency graph for bliss\_C.h:



## Classes

- struct [bliss\\_stats\\_struct](#)

*The C API version of the statistics returned by the bliss search algorithm.*

## Typedefs

- typedef struct [bliss\\_graph\\_struct](#) **BlissGraph**

*The true bliss graph is hiding behind this typedef.*

- typedef struct [bliss\\_stats\\_struct](#) **BlissStats**

*The C API version of the statistics returned by the bliss search algorithm.*

## Functions

- [BlissGraph](#) \* [bliss\\_new](#) (const unsigned int N)
- [BlissGraph](#) \* [bliss\\_read\\_dimacs](#) (FILE \*fp)
- void [bliss\\_write\\_dimacs](#) ([BlissGraph](#) \*graph, FILE \*fp)
- void [bliss\\_release](#) ([BlissGraph](#) \*graph)
- void [bliss\\_write\\_dot](#) ([BlissGraph](#) \*graph, FILE \*fp)
- unsigned int [bliss\\_get\\_nof\\_vertices](#) ([BlissGraph](#) \*graph)
- unsigned int [bliss\\_add\\_vertex](#) ([BlissGraph](#) \*graph, unsigned int c)
- void [bliss\\_add\\_edge](#) ([BlissGraph](#) \*graph, unsigned int v1, unsigned int v2)
- int [bliss\\_cmp](#) ([BlissGraph](#) \*graph1, [BlissGraph](#) \*graph2)
- unsigned int [bliss\\_hash](#) ([BlissGraph](#) \*graph)
- [BlissGraph](#) \* [bliss\\_permute](#) ([BlissGraph](#) \*graph, const unsigned int \*perm)
- void [bliss\\_find\\_automorphisms](#) ([BlissGraph](#) \*graph, void(\*hook)(void \*user\_param, unsigned int N, const unsigned int \*aut), void \*hook\_user\_param, [BlissStats](#) \*stats)
- const unsigned int \* [bliss\\_find\\_canonical\\_labeling](#) ([BlissGraph](#) \*graph, void(\*hook)(void \*user\_param, unsigned int N, const unsigned int \*aut), void \*hook\_user\_param, [BlissStats](#) \*stats)

### 9.3.1 Detailed Description

The bliss C API.

This is the C language API to [bliss](#). Note that this C API is only a subset of the C++ API; please consider using the C++ API whenever possible.

## 9.3.2 Function Documentation

### 9.3.2.1 bliss\_add\_edge()

```
void bliss_add_edge (
    BlissGraph * graph,
    unsigned int v1,
    unsigned int v2)
```

Add a new undirected edge in the graph. *v1* and *v2* are vertex indices returned by [bliss\\_add\\_vertex\(\)](#). If duplicate edges are added, they will be ignored (however, they are not necessarily physically ignored immediately but may consume memory for a while so please try to avoid adding duplicate edges whenever possible).

### 9.3.2.2 bliss\_add\_vertex()

```
unsigned int bliss_add_vertex (
    BlissGraph * graph,
    unsigned int c)
```

Add a new vertex with color *c* in the graph *graph* and return its index. The vertex indices are always in the range `[0,bliss::bliss_get_nof_vertices(bliss)-1]`.

### 9.3.2.3 bliss\_cmp()

```
int bliss_cmp (
    BlissGraph * graph1,
    BlissGraph * graph2)
```

Compare two graphs according to a total order. Return -1, 0, or 1 if the first graph was smaller than, equal to, or greater than, resp., the other graph. If 0 is returned, then the graphs have the same number vertices, the vertices in them are colored in the same way, and they contain the same edges; that is, the graphs are equal.

### 9.3.2.4 bliss\_find\_automorphisms()

```
void bliss_find_automorphisms (
    BlissGraph * graph,
    void(* hook )(void *user_param, unsigned int N, const unsigned int *aut),
    void * hook_user_param,
    BlissStats * stats)
```

Find a set of generators for the automorphism group of the graph. The hook function *hook* (if non-null) is called each time a new generator for the automorphism group is found. The first argument *user\_param* for the hook function is the *hook\_user\_param* argument, the second argument *N* is the length of the automorphism (equal to `bliss::bliss_get_nof_vertices(graph)`) and the third argument *aut* is the automorphism (a bijection on  $\{0, \dots, N-1\}$ ). The memory for the automorphism *aut* will be invalidated immediately after the return from the hook; if you want to use the automorphism later, you have to take a copy of it. Do not call `bliss_*` functions in the hook. If *stats* is non-null, then some search statistics are copied there.



### 9.3.2.5 bliss\_find\_canonical\_labeling()

```
const unsigned int * bliss_find_canonical_labeling (  
    BlissGraph * graph,  
    void(* hook )(void *user_param, unsigned int N, const unsigned int *aut),  
    void * hook_user_param,  
    BlissStats * stats)
```

Otherwise the same as [bliss\\_find\\_automorphisms\(\)](#) except that a canonical labeling for the graph (a bijection on  $\{0, \dots, N-1\}$ ) is returned. The returned canonical labeling will remain valid only until the next call to a `bliss_*` function with the exception that [bliss\\_permute\(\)](#) can be called without invalidating the labeling. To compute the canonical version of a graph, call this function and then [bliss\\_permute\(\)](#) with the returned canonical labeling. Note that the computed canonical version may depend on the applied version of bliss.

### 9.3.2.6 bliss\_get\_nof\_vertices()

```
unsigned int bliss_get_nof_vertices (  
    BlissGraph * graph)
```

Return the number of vertices in the graph.

### 9.3.2.7 bliss\_hash()

```
unsigned int bliss_hash (  
    BlissGraph * graph)
```

Get a hash value for the graph.

### 9.3.2.8 bliss\_new()

```
BlissGraph * bliss_new (  
    const unsigned int N)
```

Create a new graph instance with  $N$  vertices and no edges.  $N$  can be zero and [bliss\\_add\\_vertex\(\)](#) called afterwards to add new vertices on-the-fly.

### 9.3.2.9 bliss\_permute()

```
BlissGraph * bliss_permute (  
    BlissGraph * graph,  
    const unsigned int * perm)
```

Permute the graph with the given permutation *perm*. Returns the permuted graph, the original graph is not modified. The argument *perm* should be an array of  $N = \text{bliss::bliss\_get\_nof\_vertices}(graph)$  elements describing a bijection on  $\{0, \dots, N-1\}$ .

### 9.3.2.10 bliss\_read\_dimacs()

```
BlissGraph * bliss_read_dimacs (
    FILE * fp)
```

Read an undirected graph from a file in the DIMACS format into a new bliss instance. Returns 0 if an error occurred. Note that in the DIMACS file the vertices are numbered from 1 to N while in the bliss C API they are from 0 to N-1. Thus the vertex n in the file corresponds to the vertex n-1 in the API.

### 9.3.2.11 bliss\_release()

```
void bliss_release (
    BlissGraph * graph)
```

Release the graph. Note that the memory pointed by the arguments of hook functions for [bliss\\_find\\_automorphisms\(\)](#) and [bliss\\_find\\_canonical\\_labeling\(\)](#) is deallocated and thus should not be accessed after calling this function.

### 9.3.2.12 bliss\_write\_dimacs()

```
void bliss_write_dimacs (
    BlissGraph * graph,
    FILE * fp)
```

Output the graph in the file stream *fp* in the DIMACS format. See the User's Guide for the file format details. Note that in the DIMACS file the vertices are numbered from 1 to N while in bliss they are from 0 to N-1.

### 9.3.2.13 bliss\_write\_dot()

```
void bliss_write_dot (
    BlissGraph * graph,
    FILE * fp)
```

Print the graph in graphviz dot format.

## 9.4 bliss\_C.h

[Go to the documentation of this file.](#)

```
00001 #ifndef BLISS_C_H
00002 #define BLISS_C_H
00003
00004 /*
00005  Copyright (c) 2003-2021 Tommi Junttila
00006  Released under the GNU Lesser General Public License version 3.
00007
00008  This file is part of bliss.
00009
00010  bliss is free software: you can redistribute it and/or modify
00011  it under the terms of the GNU Lesser General Public License as published by
00012  the Free Software Foundation, version 3 of the License.
00013
00014  bliss is distributed in the hope that it will be useful,
00015  but WITHOUT ANY WARRANTY; without even the implied warranty of
00016  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00017  GNU Lesser General Public License for more details.
00018
00019  You should have received a copy of the GNU Lesser General Public License
```

```

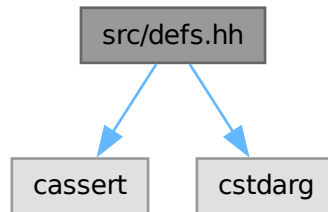
00020     along with bliss.  If not, see <http://www.gnu.org/licenses/>.
00021 */
00022
00031
00032 #include <stdlib.h>
00033 #include <stdio.h>
00034
00035
00039 typedef struct bliss_graph_struct BlissGraph;
00040
00041
00046 typedef struct bliss_stats_struct
00047 {
00052     long double group_size_approx;
00054     long unsigned int nof_nodes;
00056     long unsigned int nof_leaf_nodes;
00058     long unsigned int nof_bad_nodes;
00060     long unsigned int nof_canupdates;
00062     long unsigned int nof_generators;
00064     unsigned long int max_level;
00065 } BlissStats;
00066
00067
00073 BlissGraph *bliss_new(const unsigned int N);
00074
00075
00084 BlissGraph *bliss_read_dimacs(FILE *fp);
00085
00086
00093 void bliss_write_dimacs(BlissGraph *graph, FILE *fp);
00094
00095
00102 void bliss_release(BlissGraph *graph);
00103
00104
00108 void bliss_write_dot(BlissGraph *graph, FILE *fp);
00109
00110
00114 unsigned int bliss_get_nof_vertices(BlissGraph *graph);
00115
00116
00122 unsigned int bliss_add_vertex(BlissGraph *graph, unsigned int c);
00123
00124
00132 void bliss_add_edge(BlissGraph *graph, unsigned int v1, unsigned int v2);
00133
00134
00143 int bliss_cmp(BlissGraph *graph1, BlissGraph *graph2);
00144
00145
00149 unsigned int bliss_hash(BlissGraph *graph);
00150
00151
00159 BlissGraph *bliss_permute(BlissGraph *graph, const unsigned int *perm);
00160
00161
00177 void
00178 bliss_find_automorphisms(BlissGraph *graph,
00179     void (*hook)(void *user_param,
00180         unsigned int N,
00181         const unsigned int *aut),
00182     void *hook_user_param,
00183     BlissStats *stats);
00184
00185
00197 const unsigned int *
00198 bliss_find_canonical_labeling(BlissGraph *graph,
00199     void (*hook)(void *user_param,
00200         unsigned int N,
00201         const unsigned int *aut),
00202     void *hook_user_param,
00203     BlissStats *stats);
00204
00205 #endif

```

## 9.5 src/defs.hh File Reference

Some common definitions.

```
#include <cassert>
#include <cstdarg>
Include dependency graph for defs.hh:
```



## Namespaces

- namespace [bliss](#)

## Variables

- static const char \*const **bliss::version** = "0.77"  
*The version number of bliss.*

## 9.5.1 Detailed Description

Some common definitions.

## 9.6 defs.hh

[Go to the documentation of this file.](#)

```
00001 #pragma once
00002
00003 /*
00004  Copyright (c) 2003-2021 Tommi Junttila
00005  Released under the GNU Lesser General Public License version 3.
00006
00007  This file is part of bliss.
00008
00009  bliss is free software: you can redistribute it and/or modify
00010  it under the terms of the GNU Lesser General Public License as published by
00011  the Free Software Foundation, version 3 of the License.
00012
00013  bliss is distributed in the hope that it will be useful,
00014  but WITHOUT ANY WARRANTY; without even the implied warranty of
00015  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016  GNU Lesser General Public License for more details.
00017
00018  You should have received a copy of the GNU Lesser General Public License
00019  along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #include <cassert>
00023 #include <cstdarg>
00024
```

```

00028
00029 #define BLISS_VERSION "0.77"
00030 #define BLISS_VERSION_MAJOR 0
00031 #define BLISS_VERSION_MINOR 77
00032
00033 namespace bliss {
00034
00035     static const char * const version = "0.77";
00036
00037
00038
00039
00040     #if defined(BLISS_DEBUG)
00041     #define BLISS_CONSISTENCY_CHECKS
00042     #define BLISS_EXPENSIVE_CONSISTENCY_CHECKS
00043     #endif
00044
00045
00046     #if defined(BLISS_CONSISTENCY_CHECKS)
00047     /* Force a check that the found automorphisms are valid */
00048     #define BLISS_VERIFY_AUTOMORPHISMS
00049     #endif
00050
00051
00052     #if defined(BLISS_CONSISTENCY_CHECKS)
00053     /* Force a check that the generated partitions are equitable */
00054     #define BLISS_VERIFY_EQUITABLEDNESS
00055     #endif
00056
00057 } // namespace bliss
00058
00059

```

## 9.7 digraph.hh

```

00001 #pragma once
00002
00003 /*
00004     Copyright (c) 2003-2021 Tommi Junttila
00005     Released under the GNU Lesser General Public License version 3.
00006
00007     This file is part of bliss.
00008
00009     bliss is free software: you can redistribute it and/or modify
00010     it under the terms of the GNU Lesser General Public License as published by
00011     the Free Software Foundation, version 3 of the License.
00012
00013     bliss is distributed in the hope that it will be useful,
00014     but WITHOUT ANY WARRANTY; without even the implied warranty of
00015     MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016     GNU Lesser General Public License for more details.
00017
00018     You should have received a copy of the GNU Lesser General Public License
00019     along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #include <bliss/abstractgraph.hh>
00023
00024 namespace bliss {
00025
00026     class Digraph : public AbstractGraph
00027     {
00028     public:
00029         typedef enum {
00030             shs_f = 0,
00031             shs_fs,
00032             shs_fl,
00033             shs_fm,
00034             shs_fsm,
00035             shs_flm
00036         } SplittingHeuristic;
00037
00038     protected:
00039         class Vertex {
00040         public:
00041             Vertex();
00042             ~Vertex();
00043             void add_edge_to(const unsigned int dest_vertex);
00044             void add_edge_from(const unsigned int source_vertex);
00045             void remove_duplicate_edges(std::vector<bool>& tmp);
00046             void sort_edges();
00047             unsigned int color;
00048             std::vector<unsigned int> edges_out;
00049             std::vector<unsigned int> edges_in;
00050

```

```

00079     unsigned int nof_edges_in() const {return edges_in.size(); }
00080     unsigned int nof_edges_out() const {return edges_out.size(); }
00081 };
00082 std::vector<Vertex> vertices;
00083 void remove_duplicate_edges();
00084
00090     static unsigned int vertex_color_invariant(const Digraph* const g,
00091                                                 const unsigned int v);
00098     static unsigned int indegree_invariant(const Digraph* const g,
00099                                             const unsigned int v);
00106     static unsigned int outdegree_invariant(const Digraph* const g,
00107                                              const unsigned int v);
00113     static unsigned int selfloop_invariant(const Digraph* const g,
00114                                             const unsigned int v);
00115
00120     bool refine_according_to_invariant(unsigned int (*inv)(const Digraph* const g,
00121                                                           const unsigned int v));
00122
00123     /*
00124      * Routines needed when refining the partition p into equitable
00125      */
00126     bool split_neighbourhood_of_unit_cell(Partition::Cell* const);
00127     bool split_neighbourhood_of_cell(Partition::Cell* const);
00128
00129
00133     bool is_equitable() const;
00134
00135     /* Splitting heuristics, documented in more detail in the cc-file. */
00136     SplittingHeuristic sh;
00137     Partition::Cell* find_next_cell_to_be_split(Partition::Cell *cell);
00138     Partition::Cell* sh_first();
00139     Partition::Cell* sh_first_smallest();
00140     Partition::Cell* sh_first_largest();
00141     Partition::Cell* sh_first_max_neighbours();
00142     Partition::Cell* sh_first_smallest_max_neighbours();
00143     Partition::Cell* sh_first_largest_max_neighbours();
00144
00145     /* A data structure used in many functions.
00146      * Allocated only once to reduce allocation overhead,
00147      * may be used only in one function at a time.
00148      */
00149     std::vector<Partition::Cell> _neighbour_cells;
00150
00151     void make_initial_equitable_partition();
00152
00153     void initialize_certificate();
00154
00155     void sort_edges();
00156
00157     bool nucr_find_first_component(const unsigned int level);
00158     bool nucr_find_first_component(const unsigned int level,
00159                                   std::vector<unsigned int>& component,
00160                                   unsigned int& component_elements,
00161                                   Partition::Cell*& sh_return);
00162
00163 public:
00167     Digraph(const unsigned int N = 0);
00168
00172     ~Digraph();
00173
00187     static Digraph* read_dimacs(FILE* const fp, FILE* const errstr = stderr);
00188
00192     void write_dimacs(FILE* const fp);
00193
00194
00198     void write_dot(FILE * const fp);
00199
00203     void write_dot(const char * const file_name);
00204
00205
00206
00210     virtual unsigned int get_hash();
00211
00215     unsigned int get_nof_vertices() const {return vertices.size(); }
00216
00220     unsigned int add_vertex(const unsigned int color = 0);
00221
00228     void add_edge(const unsigned int source, const unsigned int target);
00229
00233     unsigned int get_color(const unsigned int vertex) const;
00234
00238     void change_color(const unsigned int vertex, const unsigned int color);
00239
00243     Digraph* copy() const;
00244
00251     int cmp(Digraph& other);
00252

```

```

00262 void set_splitting_heuristic(SplittingHeuristic shs) {sh = shs; }
00263
00267 Digraph* permute(const unsigned int* const perm) const;
00268
00272 Digraph* permute(const std::vector<unsigned int>& perm) const;
00273
00277 bool is_automorphism(unsigned int* const perm) const;
00278
00282 bool is_automorphism(const std::vector<unsigned int>& perm) const;
00283 };
00284
00285 } // namespace bliss

```

## 9.8 graph.hh

```

00001 #pragma once
00002
00003 /*
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00015 MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016 GNU Lesser General Public License for more details.
00017
00018 You should have received a copy of the GNU Lesser General Public License
00019 along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #include <bliss/abstractgraph.hh>
00023
00024 namespace bliss {
00025
00031 class Graph : public AbstractGraph
00032 {
00033 public:
00042 typedef enum {
00046 shs_f = 0,
00049 shs_fs,
00052 shs_fl,
00056 shs_fm,
00060 shs_fsm,
00064 shs_flm
00065 } SplittingHeuristic;
00066
00067 protected:
00068 class Vertex {
00069 public:
00070 Vertex();
00071 ~Vertex();
00072 void add_edge(const unsigned int other_vertex);
00073 void remove_duplicate_edges(std::vector<bool>& tmp);
00074 void sort_edges();
00075
00076 unsigned int color;
00077 std::vector<unsigned int> edges;
00078 unsigned int nof_edges() const {return edges.size(); }
00079 };
00080 std::vector<Vertex> vertices;
00081 void sort_edges();
00082 void remove_duplicate_edges();
00083
00089 static unsigned int vertex_color_invariant(const Graph* const g,
00090 const unsigned int v);
00091
00098 static unsigned int degree_invariant(const Graph* const g,
00099 const unsigned int v);
00100
00106 static unsigned int selfloop_invariant(const Graph* const g,
00107 const unsigned int v);
00108
00109
00110 bool refine_according_to_invariant(unsigned int (*inv)(const Graph* const g,
00111 const unsigned int v));
00112
00113 /*

```

```

00114     * Routines needed when refining the partition p into equitable
00115     */
00116     bool split_neighbourhood_of_unit_cell(Partition::Cell * const);
00117     bool split_neighbourhood_of_cell(Partition::Cell * const);
00118
00122     bool is_equitable() const;
00123
00124     /* Splitting heuristics, documented in more detail in graph.cc */
00125     SplittingHeuristic sh;
00126     Partition::Cell* find_next_cell_to_beSplitted(Partition::Cell *cell);
00127     Partition::Cell* sh_first();
00128     Partition::Cell* sh_first_smallest();
00129     Partition::Cell* sh_first_largest();
00130     Partition::Cell* sh_first_max_neighbours();
00131     Partition::Cell* sh_first_smallest_max_neighbours();
00132     Partition::Cell* sh_first_largest_max_neighbours();
00133
00134
00135     /* A data structure used in many functions.
00136     * Allocated only once to reduce allocation overhead,
00137     * may be used only in one function at a time.
00138     */
00139     std::vector<Partition::Cell> _neighbour_cells;
00140
00141     void make_initial_equitable_partition();
00142
00143     void initialize_certificate();
00144
00145
00146
00147     bool nucr_find_first_component(const unsigned int level);
00148     bool nucr_find_first_component(const unsigned int level,
00149                                   std::vector<unsigned int>& component,
00150                                   unsigned int& component_elements,
00151                                   Partition::Cell*& sh_return);
00152
00153
00154
00155
00156 public:
00160     Graph(const unsigned int N = 0);
00161
00165     ~Graph();
00166
00181     static Graph* read_dimacs(FILE* const fp, FILE* const errstr = stderr);
00182
00188     void write_dimacs(FILE* const fp);
00189
00193     void write_dot(FILE* const fp);
00194
00198     void write_dot(const char* const file_name);
00199
00200
00201
00205     virtual unsigned int get_hash();
00206
00210     unsigned int get_nof_vertices() const {return vertices.size(); }
00211
00215     Graph* permute(const unsigned int* const perm) const;
00219     Graph* permute(const std::vector<unsigned int>& perm) const;
00220
00224     bool is_automorphism(unsigned int* const perm) const;
00225
00229     bool is_automorphism(const std::vector<unsigned int>& perm) const;
00230
00234     unsigned int add_vertex(const unsigned int color = 0);
00235
00242     void add_edge(const unsigned int v1, const unsigned int v2);
00243
00247     unsigned int get_color(const unsigned int vertex) const;
00248
00252     void change_color(const unsigned int vertex, const unsigned int color);
00253
00257     Graph* copy() const;
00258
00265     int cmp(Graph& other);
00266
00276     void set_splitting_heuristic(const SplittingHeuristic shs) {sh = shs; }
00277
00278
00279 };
00280
00281 } // namespace bliss

```



## 9.9 heap.hh

```

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00002
00003 /*
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00014  but WITHOUT ANY WARRANTY; without even the implied warranty of
00015  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016  GNU Lesser General Public License for more details.
00017
00018  You should have received a copy of the GNU Lesser General Public License
00019  along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #include <vector>
00023 #include <algorithm>
00024
00025 namespace bliss {
00026
00030
00031 class Heap
00032 {
00033     std::vector<unsigned int> contents;
00037     struct {
00039         bool operator() (const unsigned int e1, const unsigned int e2) {return e1 > e2; }
00040     } gt;
00041 public:
00042
00047     bool is_empty() const {return contents.empty(); }
00048
00053     void clear() {contents.clear(); }
00054
00060     void insert(const unsigned int e) {
00061         contents.push_back(e);
00062         std::push_heap(contents.begin(), contents.end(), gt);
00063     }
00064
00069     unsigned int smallest() const {return contents.front(); }
00070
00076     unsigned int remove() {
00077         const unsigned int result = smallest();
00078         std::pop_heap(contents.begin(), contents.end(), gt);
00079         contents.pop_back();
00080         return result;
00081     }
00082
00086     size_t size() const {return contents.size(); }
00087 };
00088
00089 } // namespace bliss

```

## 9.10 kqueue.hh

```

00001 #pragma once
00002
00003 /*
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00015  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00016  GNU Lesser General Public License for more details.
00017
00018  You should have received a copy of the GNU Lesser General Public License
00019  along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */

```

```

00021
00022 #include <new>
00023 #include <cassert>
00024
00025 namespace bliss {
00026
00030 template <class Type>
00031 class KQueue
00032 {
00033 public:
00038     KQueue();
00039
00040     ~KQueue();
00041
00045     void init(const unsigned int N);
00046
00048     bool is_empty() const;
00049
00051     unsigned int size() const;
00052
00054     void clear();
00055
00057     Type front() const;
00058
00060     Type pop_front();
00061
00063     void push_front(Type e);
00064
00066     Type pop_back();
00067
00069     void push_back(Type e);
00070 private:
00071     Type *entries, *end;
00072     Type *head, *tail;
00073 };
00074
00075 template <class Type>
00076 KQueue<Type>::KQueue()
00077 {
00078     entries = nullptr;
00079     end = nullptr;
00080     head = nullptr;
00081     tail = nullptr;
00082 }
00083
00084 template <class Type>
00085 KQueue<Type>::~~KQueue()
00086 {
00087     delete[] entries;
00088     entries = nullptr;
00089     end = nullptr;
00090     head = nullptr;
00091     tail = nullptr;
00092 }
00093
00094 template <class Type>
00095 void KQueue<Type>::init(const unsigned int k)
00096 {
00097     assert(k > 0);
00098     delete[] entries;
00099     entries = new Type[k+1];
00100     end = entries + k + 1;
00101     head = entries;
00102     tail = head;
00103 }
00104
00105 template <class Type>
00106 void KQueue<Type>::clear()
00107 {
00108     head = entries;
00109     tail = head;
00110 }
00111
00112 template <class Type>
00113 bool KQueue<Type>::is_empty() const
00114 {
00115     return head == tail;
00116 }
00117
00118 template <class Type>
00119 unsigned int KQueue<Type>::size() const
00120 {
00121     if(tail >= head)
00122         return(tail - head);
00123     return (end - head) + (tail - entries);
00124 }
00125

```

```

00126 template <class Type>
00127 Type KQueue<Type>::front() const
00128 {
00129     assert(head != tail);
00130     return *head;
00131 }
00132
00133 template <class Type>
00134 Type KQueue<Type>::pop_front()
00135 {
00136     assert(head != tail);
00137     Type *old_head = head;
00138     head++;
00139     if(head == end)
00140         head = entries;
00141     return *old_head;
00142 }
00143
00144 template <class Type>
00145 void KQueue<Type>::push_front(Type e)
00146 {
00147     if(head == entries)
00148         head = end - 1;
00149     else
00150         head--;
00151     assert(head != tail);
00152     *head = e;
00153 }
00154
00155 template <class Type>
00156 void KQueue<Type>::push_back(Type e)
00157 {
00158     *tail = e;
00159     tail++;
00160     if(tail == end)
00161         tail = entries;
00162     assert(head != tail);
00163 }
00164
00165 } // namespace bliss

```

## 9.11 orbit.hh

```

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00016     GNU Lesser General Public License for more details.
00017
00018     You should have received a copy of the GNU Lesser General Public License
00019     along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 namespace bliss {
00023
00036 class Orbit
00037 {
00038     class OrbitEntry
00039     {
00040     public:
00041         unsigned int element;
00042         OrbitEntry *next;
00043         unsigned int size;
00044     };
00045
00046     OrbitEntry *orbits;
00047     OrbitEntry **in_orbit;
00048     unsigned int nof_elements;
00049     unsigned int _nof_orbits;
00050     void merge_orbits(OrbitEntry *o1, OrbitEntry *o2);
00051
00052 public:

```

```

00058     Orbit();
00059     ~Orbit();
00060
00069     void init(const unsigned int N);
00070
00075     void reset();
00076
00082     void merge_orbits(unsigned int e1, unsigned int e2);
00083
00088     bool is_minimal_representative(unsigned int e) const;
00089
00094     unsigned int get_minimal_representative(unsigned int e) const;
00095
00100     unsigned int orbit_size(unsigned int e) const;
00101
00106     unsigned int nof_orbits() const {return _nof_orbits; }
00107 };
00108
00109 } // namespace bliss

```

## 9.12 partition.hh

```

00001 #pragma once
00002
00003 /*
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00016     GNU Lesser General Public License for more details.
00017
00018     You should have received a copy of the GNU Lesser General Public License
00019     along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 namespace bliss {
00023     class Partition;
00024 }
00025
00026 #include <vector>
00027 #include <climits>
00028 #include <bliss/kqueue.hh>
00029 #include <bliss/abstractgraph.hh>
00030
00031 namespace bliss {
00032     class Partition
00033     {
00044     public:
00050         class Cell
00051         {
00052             friend class Partition;
00053         public:
00054             unsigned int length;
00055             /* Index of the first element of the cell in
00056              the Partition::elements array */
00057             unsigned int first;
00058             unsigned int max_ival;
00059             unsigned int max_ival_count;
00060         private:
00061             bool in_splitting_queue;
00062         public:
00063             bool in_neighbour_heap;
00064             /* Pointer to the next cell, null if this is the last one. */
00065             Cell* next;
00066             Cell* prev;
00067             Cell* next_nonsingleton;
00068             Cell* prev_nonsingleton;
00069             unsigned int split_level;
00071             bool is_unit() const {return (length == 1); }
00073             bool is_in_splitting_queue() const {return (in_splitting_queue); }
00074         };
00075
00076

```

```

00077 private:
00078
00083     class RefInfo {
00084     public:
00085         unsigned int split_cell_first;
00086         int prev_nonsingleton_first;
00087         int next_nonsingleton_first;
00088     };
00092     std::vector<RefInfo> refinement_stack;
00093
00094     class BacktrackInfo {
00095     public:
00096         unsigned int refinement_stack_size;
00097         unsigned int cr_backtrack_point;
00098     };
00099
00103     std::vector<BacktrackInfo> bt_stack;
00104
00105 public:
00106     AbstractGraph* graph;
00107
00108     /* Used during equitable partition refinement */
00109     KQueue<Cell*> splitting_queue;
00110     void splitting_queue_add(Cell* const cell);
00111     Cell* splitting_queue_pop();
00112     bool splitting_queue_is_empty() const;
00113     void splitting_queue_clear();
00114
00115     typedef unsigned int BacktrackPoint;
00117     BacktrackPoint set_backtrack_point();
00123
00127     void goto_backtrack_point(BacktrackPoint p);
00128
00137     Cell* individualize(Cell* const cell,
00138                         const unsigned int element);
00139
00140     Cell* aux_split_in_two(Cell* const cell,
00141                           const unsigned int first_half_size);
00142
00143 private:
00145     unsigned int N;
00146     Cell* cells;
00147     Cell* free_cells;
00148     unsigned int discrete_cell_count;
00149 public:
00150     Cell* first_cell;
00151     Cell* first_nonsingleton_cell;
00152     unsigned int *elements;
00153     /* invariant_values[e] gives the invariant value of the element e */
00154     unsigned int *invariant_values;
00155     /* element_to_cell_map[e] gives the cell of the element e */
00156     Cell **element_to_cell_map;
00158     Cell* get_cell(const unsigned int e) const {
00159         assert(e < N);
00160         return element_to_cell_map[e];
00161     }
00162     /* in_pos[e] points to the elements array s.t. *in_pos[e] = e */
00163     unsigned int **in_pos;
00164
00165     Partition();
00166     ~Partition();
00167
00172     void init(const unsigned int N);
00173
00178     bool is_discrete() const {return(free_cells == 0); }
00179
00180     unsigned int nof_discrete_cells() const {return(discrete_cell_count); }
00181
00185     size_t print(FILE* const fp, const bool add_newline = true) const;
00186
00190     size_t print_signature(FILE* const fp, const bool add_newline = true) const;
00191
00192     /*
00193     * Splits the Cell \a cell into [cell_1,...,cell_n]
00194     * according to the invariant_values of the elements in \a cell.
00195     * After splitting, cell_1 == \a cell.
00196     * Returns the pointer to the Cell cell_n;
00197     * cell_n != cell iff the Cell \a cell was actually splitted.
00198     * The flag \a max_ival_info_ok indicates whether the max_ival and
00199     * max_ival_count fields of the Cell \a cell have consistent values
00200     * when the method is called.
00201     * Clears the invariant values of the elements in the Cell \a cell as well as
00202     * the max_ival and max_ival_count fields of the Cell \a cell.
00203     */

```

```

00204 Cell *zsplit_cell(Cell * const cell, const bool max_ival_info_ok);
00205
00206 /*
00207  * Routines for component recursion
00208  */
00209 void cr_init();
00210 void cr_free();
00211 unsigned int cr_get_level(const unsigned int cell_index) const;
00212 unsigned int cr_split_level(const unsigned int level,
00213                             const std::vector<unsigned int>& cells);
00214
00216 void clear_ivs(Cell* const cell);
00217
00218 private:
00219 /*
00220  * Component recursion data structures
00221  */
00222
00223 /* Is component recursion support in use? */
00224 bool cr_enabled;
00225
00226 class CRCell {
00227 public:
00228     unsigned int level;
00229     CRCell* next;
00230     CRCell** prev_next_ptr;
00231     void detach() {
00232         if(next)
00233             next->prev_next_ptr = prev_next_ptr;
00234         *(prev_next_ptr) = next;
00235         level = UINT_MAX;
00236         next = nullptr;
00237         prev_next_ptr = nullptr;
00238     }
00239 };
00240 CRCell* cr_cells;
00241 CRCell** cr_levels;
00242 class CR_BTInfo {
00243 public:
00244     unsigned int created_trail_index;
00245     unsigned int splitted_level_trail_index;
00246 };
00247 std::vector<unsigned int> cr_created_trail;
00248 std::vector<unsigned int> cr_splitted_level_trail;
00249 std::vector<CR_BTInfo> cr_bt_info;
00250 unsigned int cr_max_level;
00251 void cr_create_at_level(const unsigned int cell_index, unsigned int level);
00252 void cr_create_at_level_trailed(const unsigned int cell_index, unsigned int level);
00253 unsigned int cr_get_backtrack_point();
00254 void cr_goto_backtrack_point(const unsigned int btpoint);
00255
00256
00257 /*
00258  *
00259  * Auxiliary routines for sorting and splitting cells
00260  *
00261  */
00262 Cell* sort_and_split_cell1(Cell* cell);
00263 Cell* sort_and_split_cell255(Cell* const cell, const unsigned int max_ival);
00264 bool shellsort_cell(Cell* cell);
00265 Cell* split_cell(Cell* const cell);
00266
00267 /*
00268  * Some auxiliary stuff needed for distribution count sorting.
00269  * To make the code thread-safe (modulo the requirement that each graph is
00270  * only accessed in one thread at a time), the arrays are owned by
00271  * the partition instance, not statically defined.
00272  */
00273 unsigned int dcs_count[256];
00274 unsigned int dcs_start[256];
00275 void dcs_cumulate_count(const unsigned int max);
00276 };
00277
00278
00279 inline Partition::Cell*
00280 Partition::splitting_queue_pop()
00281 {
00282     assert(!splitting_queue.is_empty());
00283     Cell* const cell = splitting_queue.pop_front();
00284     assert(cell->in_splitting_queue);
00285     cell->in_splitting_queue = false;
00286     return cell;
00287 }
00288
00289 inline bool
00290 Partition::splitting_queue_is_empty() const
00291 {

```

```

00292     return splitting_queue.is_empty();
00293 }
00294
00295
00296 inline unsigned int
00297 Partition::cr_get_level(const unsigned int cell_index) const
00298 {
00299     assert(cr_enabled);
00300     assert(cell_index < N);
00301     assert(cr_cells[cell_index].level != UINT_MAX);
00302     return cr_cells[cell_index].level;
00303 }
00304
00305 } // namespace bliss

```

## 9.13 stats.hh

```

00001 #pragma once
00002
00003 /*
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00020 */
00021
00022 #include <cstdio>
00023 #include <bliss/abstractgraph.hh>
00024 #include <bliss/bignum.hh>
00025
00026 namespace bliss {
00027
00031 class Stats
00032 {
00033     friend class AbstractGraph;
00035     Bignum group_size;
00038     long double group_size_approx;
00040     long unsigned int nof_nodes;
00042     long unsigned int nof_leaf_nodes;
00044     long unsigned int nof_bad_nodes;
00046     long unsigned int nof_canupdates;
00048     long unsigned int nof_generators;
00050     unsigned long int max_level;
00052     void reset()
00053     {
00054         group_size.assign(1);
00055         group_size_approx = 1.0;
00056         nof_nodes = 0;
00057         nof_leaf_nodes = 0;
00058         nof_bad_nodes = 0;
00059         nof_canupdates = 0;
00060         nof_generators = 0;
00061         max_level = 0;
00062     }
00063 public:
00064     Stats() { reset(); }
00066     size_t print(FILE* const fp) const
00067     {
00068         size_t r = 0;
00069         r += fprintf(fp, "Nodes:           %lu\n", nof_nodes);
00070         r += fprintf(fp, "Leaf nodes:        %lu\n", nof_leaf_nodes);
00071         r += fprintf(fp, "Bad nodes:         %lu\n", nof_bad_nodes);
00072         r += fprintf(fp, "Canrep updates:    %lu\n", nof_canupdates);
00073         r += fprintf(fp, "Generators:        %lu\n", nof_generators);
00074         r += fprintf(fp, "Max level:         %lu\n", max_level);
00075         r += fprintf(fp, "|Aut|:             ") + group_size.print(fp) + fprintf(fp, "\n");
00076         fflush(fp);
00077         return r;
00078     }
00080     const Bignum& get_group_size() const {return group_size;}
00083     long double get_group_size_approx() const {return group_size_approx;}

```

```

00085     long unsigned int get_nof_nodes() const {return nof_nodes;}
00087     long unsigned int get_nof_leaf_nodes() const {return nof_leaf_nodes;}
00089     long unsigned int get_nof_bad_nodes() const {return nof_bad_nodes;}
00091     long unsigned int get_nof_canupdates() const {return nof_canupdates;}
00093     long unsigned int get_nof_generators() const {return nof_generators;}
00095     unsigned long int get_max_level() const {return max_level;}
00096 };
00097
00098 } // namespace bliss

```

## 9.14 timer.hh

```

00001 #pragma once
00002
00003 /*
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00018     You should have received a copy of the GNU Lesser General Public License
00019     along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022 #include <chrono>
00023
00024 namespace bliss {
00025
00026     class Timer
00027     {
00028     public:
00029         Timer() {
00030             reset();
00031         }
00032
00033         void reset() {
00034             start_time_ = std::chrono::high_resolution_clock::now();
00035         }
00036
00037         double get_duration() const {
00038             return std::chrono::duration_cast<std::chrono::duration<double>>
00039                 >(std::chrono::high_resolution_clock::now() - start_time_).count();
00040         }
00041     };
00042
00043 } // namespace bliss

```

## 9.15 uintseqhash.hh

```

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00003 /*
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```



```

00019  along with bliss.  If not, see <http://www.gnu.org/licenses/>.
00020  */
00021
00022 namespace bliss {
00023
00027 class UIntSeqHash
00028 {
00029 protected:
00030     unsigned int h;
00031 public:
00032     UIntSeqHash() {h = 0; }
00033     UIntSeqHash(const UIntSeqHash &other) {h = other.h; }
00034     UIntSeqHash& operator=(const UIntSeqHash &other) {h = other.h; return *this; }
00035
00037     void reset() {h = 0; }
00038
00040     void update(unsigned int n);
00041
00043     unsigned int get_value() const {return h; }
00044
00048     int cmp(const UIntSeqHash &other) const {
00049         return (h < other.h)?-1:((h == other.h)?0:1);
00050     }
00052     bool is_lt(const UIntSeqHash &other) const {return cmp(other) < 0; }
00054     bool is_le(const UIntSeqHash &other) const {return cmp(other) <= 0; }
00056     bool is_equal(const UIntSeqHash &other) const {return cmp(other) == 0; }
00057 };
00058
00059
00060 } // namespace bliss

```

## 9.16 src/utils.hh File Reference

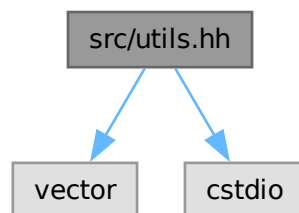
Some small utilities.

```

#include <vector>
#include <cstdio>

```

Include dependency graph for utils.hh:



### Namespaces

- namespace [bliss](#)

### Functions

- size\_t [bliss::print\\_permutation](#) (FILE \*const fp, const unsigned int N, const unsigned int \*perm, const unsigned int offset)
- size\_t [bliss::print\\_permutation](#) (FILE \*const fp, const std::vector< unsigned int > &perm, const unsigned int offset)
- bool [bliss::is\\_permutation](#) (const unsigned int N, const unsigned int \*perm)
- bool [bliss::is\\_permutation](#) (const std::vector< unsigned int > &perm)

### 9.16.1 Detailed Description

Some small utilities.

## 9.17 utils.hh

[Go to the documentation of this file.](#)

```
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00017
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00019  along with bliss. If not, see <http://www.gnu.org/licenses/>.
00020 */
00021
00022
00023 #include <vector>
00024 #include <cstdio>
00025
00026 namespace bliss {
00027
00028 size_t print_permutation(FILE* fp,
00029                          const unsigned int N,
00030                          const unsigned int* perm,
00031                          const unsigned int offset = 0);
00032
00033 size_t print_permutation(FILE* fp,
00034                          const std::vector<unsigned int>& perm,
00035                          const unsigned int offset = 0);
00036
00037 bool is_permutation(const unsigned int N, const unsigned int* perm);
00038
00039 bool is_permutation(const std::vector<unsigned int>& perm);
00040
00041 } // namespace bliss
```

# Index

- ~BigNum
  - bliss::BigNum, [24](#)
- ~Digraph
  - bliss::Digraph, [29](#)
- ~Graph
  - bliss::Graph, [38](#)
- add\_edge
  - bliss::AbstractGraph, [18](#)
  - bliss::Digraph, [29](#)
  - bliss::Graph, [38](#)
- add\_vertex
  - bliss::AbstractGraph, [18](#)
  - bliss::Digraph, [29](#)
  - bliss::Graph, [38](#)
- assign
  - bliss::BigNum, [24](#)
- BacktrackPoint
  - bliss::Partition, [51](#)
- BigNum
  - bliss::BigNum, [24](#)
- bliss, [15](#)
  - is\_permutation, [16](#)
  - print\_permutation, [16](#)
- bliss::AbstractGraph, [17](#)
  - add\_edge, [18](#)
  - add\_vertex, [18](#)
  - canonical\_form, [18](#)
  - change\_color, [19](#)
  - find\_automorphisms, [19](#)
  - get\_color, [19](#)
  - get\_hash, [20](#)
  - get\_nof\_vertices, [20](#)
  - is\_automorphism, [20](#)
  - permute, [20](#), [21](#)
  - set\_component\_recursion, [21](#)
  - set\_failure\_recording, [21](#)
  - set\_long\_prune\_activity, [21](#)
  - set\_verbose\_file, [22](#)
  - set\_verbose\_level, [22](#)
  - write\_dimacs, [22](#)
  - write\_dot, [23](#)
- bliss::BigNum, [23](#)
  - ~BigNum, [24](#)
  - assign, [24](#)
  - BigNum, [24](#)
  - get\_factors, [24](#)
  - multiply, [24](#)
  - print, [25](#)
  - to\_string, [25](#)
- bliss::Digraph, [27](#)
  - ~Digraph, [29](#)
  - add\_edge, [29](#)
  - add\_vertex, [29](#)
  - canonical\_form, [30](#)
  - change\_color, [30](#)
  - cmp, [30](#)
  - copy, [30](#)
  - Digraph, [29](#)
  - find\_automorphisms, [31](#)
  - get\_color, [31](#)
  - get\_hash, [31](#)
  - get\_nof\_vertices, [31](#)
  - is\_automorphism, [32](#)
  - permute, [32](#)
  - read\_dimacs, [32](#)
  - set\_component\_recursion, [33](#)
  - set\_failure\_recording, [33](#)
  - set\_long\_prune\_activity, [33](#)
  - set\_splitting\_heuristic, [34](#)
  - set\_verbose\_file, [34](#)
  - set\_verbose\_level, [34](#)
  - shs\_f, [29](#)
  - shs\_fl, [29](#)
  - shs\_flm, [29](#)
  - shs\_fm, [29](#)
  - shs\_fs, [29](#)
  - shs\_fsm, [29](#)
  - SplittingHeuristic, [28](#)
  - write\_dimacs, [34](#)
  - write\_dot, [35](#)
- bliss::Graph, [36](#)
  - ~Graph, [38](#)
  - add\_edge, [38](#)
  - add\_vertex, [38](#)
  - canonical\_form, [38](#)
  - change\_color, [38](#)
  - cmp, [39](#)
  - copy, [39](#)
  - find\_automorphisms, [39](#)
  - get\_color, [39](#)
  - get\_hash, [40](#)
  - get\_nof\_vertices, [40](#)
  - Graph, [38](#)
  - is\_automorphism, [40](#)
  - permute, [40](#), [41](#)
  - read\_dimacs, [41](#)
  - set\_component\_recursion, [41](#)

- set\_failure\_recording, 42
- set\_long\_prune\_activity, 42
- set\_splitting\_heuristic, 42
- set\_verbose\_file, 42
- set\_verbose\_level, 43
- shs\_f, 37
- shs\_fl, 37
- shs\_flm, 37
- shs\_fm, 37
- shs\_fs, 37
- shs\_fsm, 37
- SplittingHeuristic, 37
- write\_dimacs, 43
- write\_dot, 43
- bliss::Heap, 44
  - clear, 44
  - insert, 44
  - is\_empty, 45
  - remove, 45
  - size, 45
  - smallest, 45
- bliss::KQueue< Type >, 45
  - clear, 46
  - front, 46
  - init, 46
  - is\_empty, 47
  - KQueue, 46
  - pop\_back, 47
  - pop\_front, 47
  - push\_back, 47
  - push\_front, 47
  - size, 47
- bliss::Orbit, 48
  - get\_minimal\_representative, 49
  - init, 49
  - is\_minimal\_representative, 49
  - merge\_orbits, 49
  - nof\_orbits, 49
  - Orbit, 48
  - orbit\_size, 49
  - reset, 49
- bliss::Partition, 50
  - BacktrackPoint, 51
  - clear\_ivs, 51
  - get\_cell, 51
  - goto\_backtrack\_point, 51
  - individualize, 51
  - init, 51
  - is\_discrete, 52
  - print, 52
  - print\_signature, 52
  - set\_backtrack\_point, 52
- bliss::Partition::Cell, 26
  - is\_in\_splitting\_queue, 26
  - is\_unit, 26
- bliss::Stats, 52
  - get\_group\_size, 53
  - get\_group\_size\_approx, 53
  - get\_max\_level, 53
  - get\_nof\_bad\_nodes, 53
  - get\_nof\_canupdates, 53
  - get\_nof\_generators, 53
  - get\_nof\_leaf\_nodes, 54
  - get\_nof\_nodes, 54
  - print, 54
- bliss::Timer, 54
- bliss::UIntSeqHash, 55
  - cmp, 55
  - get\_value, 55
  - is\_equal, 55
  - is\_le, 56
  - is\_lt, 56
  - reset, 56
  - update, 56
- bliss\_add\_edge
  - bliss\_C.h, 64
- bliss\_add\_vertex
  - bliss\_C.h, 64
- bliss\_C.h
  - bliss\_add\_edge, 64
  - bliss\_add\_vertex, 64
  - bliss\_cmp, 64
  - bliss\_find\_automorphisms, 64
  - bliss\_find\_canonical\_labeling, 64
  - bliss\_get\_nof\_vertices, 65
  - bliss\_hash, 65
  - bliss\_new, 65
  - bliss\_permute, 65
  - bliss\_read\_dimacs, 65
  - bliss\_release, 66
  - bliss\_write\_dimacs, 66
  - bliss\_write\_dot, 66
- bliss\_cmp
  - bliss\_C.h, 64
- bliss\_find\_automorphisms
  - bliss\_C.h, 64
- bliss\_find\_canonical\_labeling
  - bliss\_C.h, 64
- bliss\_get\_nof\_vertices
  - bliss\_C.h, 65
- bliss\_graph\_struct, 25
- bliss\_hash
  - bliss\_C.h, 65
- bliss\_new
  - bliss\_C.h, 65
- bliss\_permute
  - bliss\_C.h, 65
- bliss\_read\_dimacs
  - bliss\_C.h, 65
- bliss\_release
  - bliss\_C.h, 66
- bliss\_stats\_struct, 25
- bliss\_write\_dimacs
  - bliss\_C.h, 66
- bliss\_write\_dot
  - bliss\_C.h, 66

- canonical\_form
  - bliss::AbstractGraph, 18
  - bliss::Digraph, 30
  - bliss::Graph, 38
- change\_color
  - bliss::AbstractGraph, 19
  - bliss::Digraph, 30
  - bliss::Graph, 38
- clear
  - bliss::Heap, 44
  - bliss::KQueue< Type >, 46
- clear\_ivs
  - bliss::Partition, 51
- cmp
  - bliss::Digraph, 30
  - bliss::Graph, 39
  - bliss::UIntSeqHash, 55
- copy
  - bliss::Digraph, 30
  - bliss::Graph, 39
- Digraph
  - bliss::Digraph, 29
- find\_automorphisms
  - bliss::AbstractGraph, 19
  - bliss::Digraph, 31
  - bliss::Graph, 39
- front
  - bliss::KQueue< Type >, 46
- get\_cell
  - bliss::Partition, 51
- get\_color
  - bliss::AbstractGraph, 19
  - bliss::Digraph, 31
  - bliss::Graph, 39
- get\_factors
  - bliss::BigNum, 24
- get\_group\_size
  - bliss::Stats, 53
- get\_group\_size\_approx
  - bliss::Stats, 53
- get\_hash
  - bliss::AbstractGraph, 20
  - bliss::Digraph, 31
  - bliss::Graph, 40
- get\_max\_level
  - bliss::Stats, 53
- get\_minimal\_representative
  - bliss::Orbit, 49
- get\_nof\_bad\_nodes
  - bliss::Stats, 53
- get\_nof\_canupdates
  - bliss::Stats, 53
- get\_nof\_generators
  - bliss::Stats, 53
- get\_nof\_leaf\_nodes
  - bliss::Stats, 54
- get\_nof\_nodes
  - bliss::Stats, 54
- get\_nof\_vertices
  - bliss::AbstractGraph, 20
  - bliss::Digraph, 31
  - bliss::Graph, 40
- get\_value
  - bliss::UIntSeqHash, 55
- goto\_backtrack\_point
  - bliss::Partition, 51
- Graph
  - bliss::Graph, 38
- individualize
  - bliss::Partition, 51
- init
  - bliss::KQueue< Type >, 46
  - bliss::Orbit, 49
  - bliss::Partition, 51
- insert
  - bliss::Heap, 44
- is\_automorphism
  - bliss::AbstractGraph, 20
  - bliss::Digraph, 32
  - bliss::Graph, 40
- is\_discrete
  - bliss::Partition, 52
- is\_empty
  - bliss::Heap, 45
  - bliss::KQueue< Type >, 47
- is\_equal
  - bliss::UIntSeqHash, 55
- is\_in\_splitting\_queue
  - bliss::Partition::Cell, 26
- is\_le
  - bliss::UIntSeqHash, 56
- is\_lt
  - bliss::UIntSeqHash, 56
- is\_minimal\_representative
  - bliss::Orbit, 49
- is\_permutation
  - bliss, 16
- is\_unit
  - bliss::Partition::Cell, 26
- KQueue
  - bliss::KQueue< Type >, 46
- merge\_orbits
  - bliss::Orbit, 49
- multiply
  - bliss::BigNum, 24
- nof\_orbits
  - bliss::Orbit, 49
- Orbit
  - bliss::Orbit, 48
- orbit\_size

- bliss::Orbit, 49
- Outline, 1
- permute
  - bliss::AbstractGraph, 20, 21
  - bliss::Digraph, 32
  - bliss::Graph, 40, 41
- pop\_back
  - bliss::KQueue< Type >, 47
- pop\_front
  - bliss::KQueue< Type >, 47
- print
  - bliss::BigNum, 25
  - bliss::Partition, 52
  - bliss::Stats, 54
- print\_permutation
  - bliss, 16
- print\_signature
  - bliss::Partition, 52
- push\_back
  - bliss::KQueue< Type >, 47
- push\_front
  - bliss::KQueue< Type >, 47
- read\_dimacs
  - bliss::Digraph, 32
  - bliss::Graph, 41
- remove
  - bliss::Heap, 45
- reset
  - bliss::Orbit, 49
  - bliss::UIntSeqHash, 56
- set\_backtrack\_point
  - bliss::Partition, 52
- set\_component\_recursion
  - bliss::AbstractGraph, 21
  - bliss::Digraph, 33
  - bliss::Graph, 41
- set\_failure\_recording
  - bliss::AbstractGraph, 21
  - bliss::Digraph, 33
  - bliss::Graph, 42
- set\_long\_prune\_activity
  - bliss::AbstractGraph, 21
  - bliss::Digraph, 33
  - bliss::Graph, 42
- set\_splitting\_heuristic
  - bliss::Digraph, 34
  - bliss::Graph, 42
- set\_verbose\_file
  - bliss::AbstractGraph, 22
  - bliss::Digraph, 34
  - bliss::Graph, 42
- set\_verbose\_level
  - bliss::AbstractGraph, 22
  - bliss::Digraph, 34
  - bliss::Graph, 43
- shs\_f
  - bliss::Digraph, 29
  - bliss::Graph, 37
- shs\_fl
  - bliss::Digraph, 29
  - bliss::Graph, 37
- shs\_flm
  - bliss::Digraph, 29
  - bliss::Graph, 37
- shs\_fm
  - bliss::Digraph, 29
  - bliss::Graph, 37
- shs\_fs
  - bliss::Digraph, 29
  - bliss::Graph, 37
- shs\_fsm
  - bliss::Digraph, 29
  - bliss::Graph, 37
- size
  - bliss::Heap, 45
  - bliss::KQueue< Type >, 47
- smallest
  - bliss::Heap, 45
- SplittingHeuristic
  - bliss::Digraph, 28
  - bliss::Graph, 37
- src/abstractgraph.hh, 57
- src/bignum.hh, 60
- src/bliss\_C.h, 62, 66
- src/defs.hh, 67, 68
- src/digraph.hh, 69
- src/graph.hh, 71
- src/heap.hh, 73
- src/kqueue.hh, 73
- src/orbit.hh, 75
- src/partition.hh, 76
- src/stats.hh, 79
- src/timer.hh, 80
- src/uintseqhash.hh, 80
- src/utils.hh, 81, 82
- The bliss executable, 3
- to\_string
  - bliss::BigNum, 25
- update
  - bliss::UIntSeqHash, 56
- write\_dimacs
  - bliss::AbstractGraph, 22
  - bliss::Digraph, 34
  - bliss::Graph, 43
- write\_dot
  - bliss::AbstractGraph, 23
  - bliss::Digraph, 35
  - bliss::Graph, 43