primesieve

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Contents

Chapter 1

Main Page

1.1 About

primesieve is a C/C++ library for fast prime number generation. http://primesieve.org/build.html explains how to build and install primesieve.

primesieve is written in C++03 and includes C bindings for all of its functions so that it can easily be used in languages other than C++. Multi-threading is implemented using OpenMP 2.0 (2002) or later. primesieve is very portable, it builds on most Unix-like operating system (GNU Autotools) and Windows (MSVC) is also supported.

primesieve generates primes using a highly optimized implementation of the segmented sieve of Eratosthenes. It generates the primes below 10^9 in just 0.2 seconds on a single core of an Intel Core i7-4770 3.4GHz CPU from 2013. primesieve can generate primes and prime k-tuplets up to 2^64 - 2^32 * 10. primesieve's memory requirement is about pi(sqrt(n)) * 8 bytes per thread, its run-time complexity is O(n log log n) operations.

1.2 C++ API

- primesieve.hpp - primesieve C++ header.
- store_primes_in_vector.cpp - Example that shows how to store primes in a std::vector object.
- primesieve_iterator.cpp - Example that shows how to iterate over primes using a primesieve::iterator object.

1.3 C API

- primesieve.h - primesieve C header.
- store_primes_in_array.c - Example that shows how to store primes in an array.
- primesieve_iterator.c - Example that shows how to iterate over primes using the primesieve_iterator C data structure.

Chapter 2

Namespace Index

2.1 Namespace List

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

Chapter 3

Hierarchical Index

3.1 Class Hierarchy

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

Chapter 4

Class Index

4.1 Class List

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

Chapter 5

File Index

5.1 File List

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

Chapter 6

Namespace Documentation

6.1 primesieve Namespace Reference

All of primesieve's C++ functions and classes are declared inside this namespace.

Classes

- class Callback

  callback interface class.
- class Callback< uint64_t, int >

  Parallel callback interface class.
- class iterator

  primesieve::iterator allows to easily iterate over primes both forwards and backwards.
- class None

  Internal class.
- class primesieve_error

  primesieve throws a primesieve_error exception if an error occurs that cannot be handled e.g.

Enumerations

- enum { MAX_THREADS = -1 }

Functions

- template<typename T >
  void generate_primes (uint64_t stop, std::vector< T > *primes)

  Store the primes <= stop in the primes vector.
- template<typename T >
  void generate_primes (uint64_t start, uint64_t stop, std::vector< T > *primes)

  Store the primes within the interval [start, stop] in the primes vector.
- template<typename T >
  void generate_n_primes (uint64_t n, std::vector< T > *primes)

  Store the first n primes in the primes vector.
- template<typename T >
  void generate_n_primes (uint64_t n, uint64_t start, std::vector< T > *primes)

  Store the first n primes >= start in the primes vector.
- uint64_t nth_prime (int64_t n, uint64_t start=0)

Find the nth prime.

- uint64_t parallel_nth_prime (int64_t n, uint64_t start=0)

  Find the nth prime in parallel.
- uint64_t count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop].
- uint64_t count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop].
- uint64_t count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop].
- uint64_t count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop].
- uint64_t count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop].
- uint64_t count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop].
- uint64_t parallel_count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop] in parallel.
- uint64_t parallel_count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop] in parallel.
- uint64_t parallel_count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop] in parallel.
- uint64_t parallel_count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop] in parallel.
- uint64_t parallel_count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop] in parallel.
- uint64_t parallel_count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop] in parallel.
- void print_primes (uint64_t start, uint64_t stop)

  Print the primes within the interval [start, stop] to the standard output.
- void print_twins (uint64_t start, uint64_t stop)

  Print the twin primes within the interval [start, stop] to the standard output.
- void print_triplets (uint64_t start, uint64_t stop)

  Print the prime triplets within the interval [start, stop] to the standard output.
- void print_quadruplets (uint64_t start, uint64_t stop)

  Print the prime quadruplets within the interval [start, stop] to the standard output.
- void print_quintuplets (uint64_t start, uint64_t stop)

  Print the prime quintuplets within the interval [start, stop] to the standard output.
- void print_sextuplets (uint64_t start, uint64_t stop)

  Print the prime sextuplets within the interval [start, stop] to the standard output.
- void callback_primes (uint64_t start, uint64_t stop, void(*callback)(uint64_t prime))

  Call back the primes within the interval [start, stop].
- void callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t > *callback)

  Call back the primes within the interval [start, stop].
- void parallel_callback_primes (uint64_t start, uint64_t stop, void(*callback)(uint64_t prime))

  Call back the primes within the interval [start, stop].
- void parallel_callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t > *callback)

  Call back the primes within the interval [start, stop].
- void parallel_callback_primes (uint64_t start, uint64_t stop, void(*callback)(uint64_t prime, int thread_id))

  Call back the primes within the interval [start, stop].
- void parallel_callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t, int > *callback)

  Call back the primes within the interval [start, stop].

- int get_sieve_size ()

  Get the current set sieve size in kilobytes.
- int get_num_threads ()

  Get the current set number of threads.
- uint64_t get_max_stop ()

  Returns the largest valid stop number for primesieve.
- void set_sieve_size (int sieve_size)

  Set the sieve size in kilobytes.
- void set_num_threads (int num_threads)

  Set the number of threads for use in subsequent primesieve::parallel_∗ function calls.
- bool primesieve_test ()

  Run extensive correctness tests.
- std::string primesieve_version ()

  Get the primesieve version number, in the form "i.j.k".

6.1.1 Detailed Description

All of primesieve's C++ functions and classes are declared inside this namespace.

6.1.2 Enumeration Type Documentation

6.1.2.1 anonymous enum

Enumerator

MAX_THREADS Use all CPU cores for prime sieving.

6.1.3 Function Documentation

6.1.3.1 void primesieve::callback_primes (uint64_t *start*, uint64_t *stop*, void(∗)(uint64_t prime) *callback*)

Call back the primes within the interval [start, stop].

Parameters

callback	A callback function.

Precondition

stop <= 2^64 - 2^32 ∗ 10.

Examples:

callback_primes.cpp.

6.1.3.2 void primesieve::callback_primes (uint64_t *start*, uint64_t *stop*, primesieve::Callback< uint64_t > ∗ *callback*)

Call back the primes within the interval [start, stop].

Parameters

callback	An object derived from primesieve::Callback<uint64_t>.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.3 uint64_t primesieve::count_primes (uint64_t *start*, uint64_t *stop*)

Count the primes within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

count_primes.cpp.

6.1.3.4 uint64_t primesieve::count_quadruplets (uint64_t *start*, uint64_t *stop*)

Count the prime quadruplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.5 uint64_t primesieve::count_quintuplets (uint64_t *start*, uint64_t *stop*)

Count the prime quintuplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.6 uint64_t primesieve::count_sextuplets (uint64_t *start*, uint64_t *stop*)

Count the prime sextuplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.7 uint64_t primesieve::count_triplets (uint64_t *start*, uint64_t *stop*)

Count the prime triplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.8 uint64_t primesieve::count_twins (uint64_t *start,* uint64_t *stop*)

Count the twin primes within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.9 template<typename T > void primesieve::generate_n_primes (uint64_t *n,* uint64_t *start,* std::vector< T > * *primes*) [inline]

Store the first n primes >= start in the primes vector.

Precondition

start <= 2^64 - 2^32 * 10.

6.1.3.10 template<typename T > void primesieve::generate_primes (uint64_t *stop,* std::vector< T > * *primes*) [inline]

Store the primes <= stop in the primes vector.

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

store_primes_in_vector.cpp.

6.1.3.11 template<typename T > void primesieve::generate_primes (uint64_t *start,* uint64_t *stop,* std::vector< T > * *primes*) [inline]

Store the primes within the interval [start, stop] in the primes vector.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.12 uint64_t primesieve::get_max_stop ( )

Returns the largest valid stop number for primesieve.

Returns

(2^64-1) - (2^32-1) * 10.

6.1.3.13 int primesieve::get_num_threads ( )

Get the current set number of threads.

Note

By default MAX_THREADS (-1) is returned.

6.1.3.14 uint64_t primesieve::nth_prime (int64_t *n*, uint64_t *start* = 0)

Find the nth prime.

Parameters

n	if n = 0 finds the 1st prime >= start, if n > 0 finds the nth prime > start, if n < 0 finds the nth prime < start (backwards).

Precondition

start <= 2^64 - 2^32 * 11.

Examples:

nth_prime.cpp.

6.1.3.15 void primesieve::parallel_callback_primes (uint64_t *start*, uint64_t *stop*, void(*)(uint64_t prime) *callback*)

Call back the primes within the interval [start, stop].

This function is synchronized, only one thread at a time calls back primes. By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Warning

Primes are not called back in arithmetic order.

Parameters

callback	A callback function.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.16 void primesieve::parallel_callback_primes (uint64_t *start*, uint64_t *stop*, primesieve::Callback< uint64_t > * *callback*)

Call back the primes within the interval [start, stop].

This function is synchronized, only one thread at a time calls back primes. By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Warning

Primes are not called back in arithmetic order.

Parameters

callback	An object derived from primesieve::Callback<uint64_t>.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.17 void primesieve::parallel_callback_primes (uint64_t *start*, uint64_t *stop*, void(*)(uint64_t prime, int thread_id) *callback*)

Call back the primes within the interval [start, stop].

This function is not synchronized, multiple threads call back primes in parallel. By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Warning

Primes are not called back in arithmetic order.

Parameters

callback	A callback function.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.18 void primesieve::parallel_callback_primes (uint64_t *start*, uint64_t *stop*, primesieve::Callback< uint64_t, int > * *callback*)

Call back the primes within the interval [start, stop].

This function is not synchronized, multiple threads call back primes in parallel. By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Warning

Primes are not called back in arithmetic order.

Parameters

callback	An object derived from primesieve::Callback<uint64_t, int>.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.19 uint64_t primesieve::parallel_count_primes (uint64_t *start*, uint64_t *stop*)

Count the primes within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

count_primes.cpp.

6.1.3.20 uint64_t primesieve::parallel_count_quadruplets (uint64_t *start*, uint64_t *stop*)

Count the prime quadruplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.21 uint64_t primesieve::parallel_count_quintuplets (uint64_t *start*, uint64_t *stop*)

Count the prime quintuplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.22 uint64_t primesieve::parallel_count_sextuplets (uint64_t *start*, uint64_t *stop*)

Count the prime sextuplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.23 uint64_t primesieve::parallel_count_triplets (uint64_t *start*, uint64_t *stop*)

Count the prime triplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.24 uint64_t primesieve::parallel_count_twins (uint64_t *start*, uint64_t *stop*)

Count the twin primes within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.25 uint64_t primesieve::parallel_nth_prime (int64_t *n*, uint64_t *start* = 0)

Find the nth prime in parallel.

By default all CPU cores are used, use primesieve::set_num_threads(int) to change the number of threads.

Parameters

n	if n = 0 finds the 1st prime >= start, if n > 0 finds the nth prime > start, if n < 0 finds the nth prime < start (backwards).

Precondition

start <= 2^64 - 2^32 * 11.

6.1.3.26 bool primesieve::primesieve_test ( )

Run extensive correctness tests.

The tests last about one minute on a quad core CPU from 2013 and use up to 1 gigabyte of memory.

Returns

true if success else false.

6.1.3.27 void primesieve::print_primes (uint64_t *start,* uint64_t *stop*)

Print the primes within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.28 void primesieve::print_quadruplets (uint64_t *start,* uint64_t *stop*)

Print the prime quadruplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.29 void primesieve::print_quintuplets (uint64_t *start,* uint64_t *stop*)

Print the prime quintuplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.30 void primesieve::print_sextuplets (uint64_t *start,* uint64_t *stop*)

Print the prime sextuplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.31 void primesieve::print_triplets (uint64_t *start,* uint64_t *stop*)

Print the prime triplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.32 void primesieve::print_twins (uint64_t *start,* uint64_t *stop*)

Print the twin primes within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

6.1.3.33 void primesieve::set_num_threads (int *num_threads*)

Set the number of threads for use in subsequent primesieve::parallel_* function calls.

Note that this only changes the number of threads for the current process.

Parameters

num_threads	Number of threads for sieving or MAX_THREADS to use all CPU cores.

6.1.3.34 void primesieve::set_sieve_size (int *sieve_size*)

Set the sieve size in kilobytes.

The best sieving performance is achieved with a sieve size of your CPU's L1 data cache size (per core). For sieving >= 10^17 a sieve size of your CPU's L2 cache size sometimes performs better.

Parameters

sieve_size	Sieve size in kilobytes.

Precondition

sieve_size >= 1 && sieve_size <= 2048.

Chapter 7

Class Documentation

7.1 primesieve::Callback< T, T2 > Class Template Reference

callback interface class.

`#include <Callback.hpp>`

Public Member Functions

- virtual void **callback** (T prime)=0

7.1.1 Detailed Description

template<typename T, typename T2 = None>class primesieve::Callback< T, T2 >

callback interface class.

Objects derived from this class can be passed to the primesieve::generate_primes() functions.

Parameters

T	must be uint64_t.

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

- Callback.hpp

7.2 primesieve::Callback< uint64_t, int > Class Template Reference

Parallel callback interface class.

`#include <Callback.hpp>`

Public Member Functions

- virtual void **callback** (uint64_t prime, int thread_num)=0

7.2.1 Detailed Description

template<>class primesieve::Callback< uint64_t, int >

Parallel callback interface class.

Objects derived from this class can be passed to the primesieve::parallel_generate_primes() functions.

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

- Callback.hpp

7.3 primesieve::iterator Class Reference

primesieve::iterator allows to easily iterate over primes both forwards and backwards.

`#include <iterator.hpp>`

Public Member Functions

- iterator (uint64_t start=0, uint64_t stop_hint=get_max_stop())

  Create a new iterator object.
- void skipto (uint64_t start, uint64_t stop_hint=get_max_stop())

  Reinitialize this iterator object to start.
- uint64_t next_prime ()

  Advance the iterator by one position.
- uint64_t previous_prime ()

  Get the previous prime, or 0 if input <= 2 e.g.

7.3.1 Detailed Description

primesieve::iterator allows to easily iterate over primes both forwards and backwards.

Generating the first prime has a complexity of O(r log log r) operations with r = n^0.5, after that any additional prime is generated in amortized O(log n log log n) operations. The memory usage is about pi(n^0.5) * 16 bytes. primesieve::iterator objects are very convenient to use at the cost of being slightly slower than the callback_primes() functions.

Examples:

previous_prime.cpp, and primesieve_iterator.cpp.

7.3.2 Constructor & Destructor Documentation

7.3.2.1 primesieve::iterator::iterator (uint64_t *start* = 0, uint64_t *stop_hint* = get_max_stop ())

Create a new iterator object.

Parameters

start	Generate primes > start (or < start).
stop_hint	Stop number optimization hint, gives significant speed up if few primes are generated. E.g. if you want to generate the primes below 1000 use stop_hint = 1000.

Precondition

start <= 2^64 - 2^32 * 10

7.3.3 Member Function Documentation

7.3.3.1 uint64_t primesieve::iterator::next_prime ( ) [inline]

Advance the iterator by one position.

Returns

The next prime.

Examples:

primesieve_iterator.cpp.

7.3.3.2 uint64_t primesieve::iterator::previous_prime ( ) [inline]

Get the previous prime, or 0 if input <= 2 e.g.

previous_prime(2) = 0.

Examples:

previous_prime.cpp.

7.3.3.3 void primesieve::iterator::skipto (uint64_t *start*, uint64_t *stop_hint* = get_max_stop())

Reinitialize this iterator object to start.

Parameters

start	Generate primes > start (or < start).
stop_hint	Stop number optimization hint, gives significant speed up if few primes are generated. E.g. if you want to generate the primes below 1000 use stop_hint = 1000.

Precondition

start <= 2^64 - 2^32 * 10

Examples:

previous_prime.cpp.

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

- iterator.hpp

7.4 primesieve::None Class Reference

Internal class.

`#include <Callback.hpp>`

7.4.1 Detailed Description

Internal class.

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

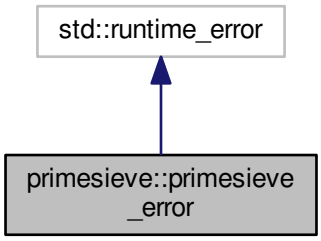
- Callback.hpp

7.5 primesieve::primesieve_error Class Reference

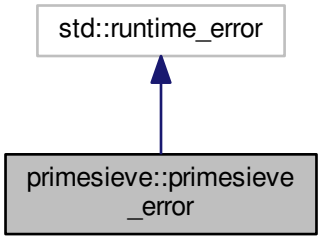
primesieve throws a primesieve_error exception if an error occurs that cannot be handled e.g.

`#include <primesieve_error.hpp>`

Inheritance diagram for primesieve::primesieve_error:



Collaboration diagram for primesieve::primesieve_error:



Public Member Functions

- **primesieve_error** (const std::string &msg)

7.5.1 Detailed Description

primesieve throws a primesieve_error exception if an error occurs that cannot be handled e.g.

stop > primesieve::max_stop().

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

- primesieve_error.hpp

7.6 primesieve_iterator Struct Reference

C prime iterator, please refer to primesieve_iterator.h for more information.

```
#include <primesieve_iterator.h>
```

Public Attributes

- size_t **i_**
- size_t **last_idx_**
- uint64_t * **primes_**
- uint64_t * **primes_pimpl_**
- uint64_t **start_**
- uint64_t **stop_**
- uint64_t **stop_hint_**
- uint64_t **tiny_cache_size_**
- int **is_error_**

7.6.1 Detailed Description

C prime iterator, please refer to primesieve_iterator.h for more information.

Examples:

previous_prime.c, and primesieve_iterator.c.

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

- primesieve_iterator.h

Chapter 8

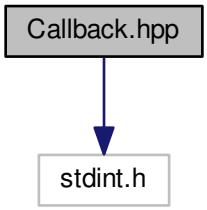
File Documentation

8.1 Callback.hpp File Reference

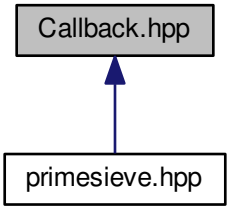
Callback interface classes.

```
#include <stdint.h>
```

Include dependency graph for Callback.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- class primesieve::None

  Internal class.

- class primesieve::Callback< T, T2 >

  callback interface class.

- class primesieve::Callback< uint64_t, int >

  Parallel callback interface class.

Namespaces

- primesieve

  All of primesieve's C++ functions and classes are declared inside this namespace.

8.1.1 Detailed Description

Callback interface classes.

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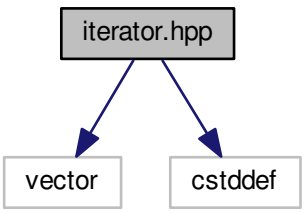
8.2 iterator.hpp File Reference

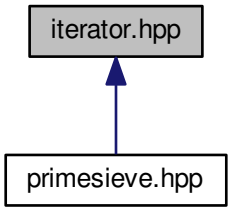
The iterator class allows to easily iterate (forward and backward) over prime numbers.

```
#include <vector>
#include <cstddef>
```

Include dependency graph for iterator.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- class primesieve::iterator

  primesieve::iterator allows to easily iterate over primes both forwards and backwards.

Namespaces

- primesieve

  All of primesieve's C++ functions and classes are declared inside this namespace.

Functions

- uint64_t primesieve::get_max_stop ()

  Returns the largest valid stop number for primesieve.

8.2.1 Detailed Description

The iterator class allows to easily iterate (forward and backward) over prime numbers.

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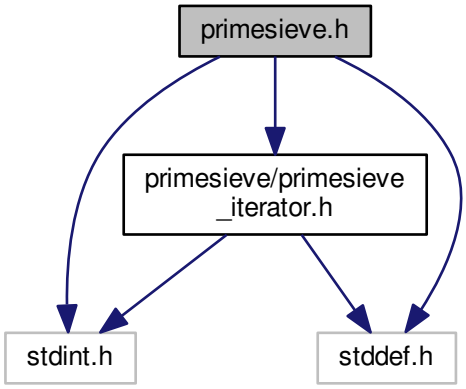
8.3 primesieve.h File Reference

primesieve C API.

```
#include <primesieve/primesieve_iterator.h>
#include <stdint.h>
#include <stddef.h>
```

Include dependency graph for primesieve.h:



Macros

- #define **PRIMESIEVE_VERSION** "5.5.0-rc1"
- #define **PRIMESIEVE_VERSION_MAJOR** 5
- #define **PRIMESIEVE_VERSION_MINOR** 5
- #define **PRIMESIEVE_VERSION_PATCH** 0
- #define PRIMESIEVE_ERROR ((uint64_t)∼((uint64_t)0))

  primesieve functions return PRIMESIEVE_ERROR (UINT64_MAX) if any error occurs.

Enumerations

- enum {
  MAX_THREADS = - 1, SHORT_PRIMES, USHORT_PRIMES, INT_PRIMES,
  UINT_PRIMES, LONG_PRIMES, ULONG_PRIMES, LONGLONG_PRIMES,
  ULONGLONG_PRIMES, INT16_PRIMES, UINT16_PRIMES, INT32_PRIMES,
  UINT32_PRIMES, INT64_PRIMES, UINT64_PRIMES }

Functions

- void ∗ primesieve_generate_primes (uint64_t start, uint64_t stop, size_t ∗size, int type)

  Get an array with the primes inside the interval [start, stop].
- void ∗ primesieve_generate_n_primes (uint64_t n, uint64_t start, int type)

  Get an array with the first n primes >= start.
- uint64_t primesieve_nth_prime (int64_t n, uint64_t start)

  Find the nth prime.
- uint64_t primesieve_parallel_nth_prime (int64_t n, uint64_t start)

  Find the nth prime in parallel.
- uint64_t primesieve_count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop].
- uint64_t primesieve_count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop].

- uint64_t primesieve_count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop].
- uint64_t primesieve_count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop].
- uint64_t primesieve_count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop].
- uint64_t primesieve_count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop].
- uint64_t primesieve_parallel_count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop] in parallel.
- uint64_t primesieve_parallel_count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop] in parallel.
- uint64_t primesieve_parallel_count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop] in parallel.
- uint64_t primesieve_parallel_count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop] in parallel.
- uint64_t primesieve_parallel_count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop] in parallel.
- uint64_t primesieve_parallel_count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop] in parallel.
- void primesieve_print_primes (uint64_t start, uint64_t stop)

  Print the primes within the interval [start, stop] to the standard output.
- void primesieve_print_twins (uint64_t start, uint64_t stop)

  Print the twin primes within the interval [start, stop] to the standard output.
- void primesieve_print_triplets (uint64_t start, uint64_t stop)

  Print the prime triplets within the interval [start, stop] to the standard output.
- void primesieve_print_quadruplets (uint64_t start, uint64_t stop)

  Print the prime quadruplets within the interval [start, stop] to the standard output.
- void primesieve_print_quintuplets (uint64_t start, uint64_t stop)

  Print the prime quintuplets within the interval [start, stop] to the standard output.
- void primesieve_print_sextuplets (uint64_t start, uint64_t stop)

  Print the prime sextuplets within the interval [start, stop] to the standard output.
- void primesieve_callback_primes (uint64_t start, uint64_t stop, void(*callback)(uint64_t prime))

  Call back the primes within the interval [start, stop].
- void primesieve_parallel_callback_primes (uint64_t start, uint64_t stop, void(*callback)(uint64_t prime, int thread_id))

  Call back the primes within the interval [start, stop] in parallel.
- int primesieve_get_sieve_size ()

  Get the current set sieve size in kilobytes.
- int primesieve_get_num_threads ()

  Get the current set number of threads.
- uint64_t primesieve_get_max_stop ()

  Returns the largest valid stop number for primesieve.
- void primesieve_set_sieve_size (int sieve_size)

  Set the sieve size in kilobytes.
- void primesieve_set_num_threads (int num_threads)

  Set the number of threads for use in subsequent primesieve_parallel_* function calls.
- void primesieve_free (void *primes)

  Deallocate a primes array created using the primesieve_generate_primes() or primesieve_generate_n_primes() functions.
- int primesieve_test ()

  Run extensive correctness tests.
- const char * primesieve_version ()

  Get the primesieve version number, in the form "i.j.k".

8.3.1 Detailed Description

primesieve C API.

primesieve is a library for fast prime number generation. In case of an error all functions set errno to EDOM and functions that have a uint64_t return type return UINT64_MAX (= PRIMESIEVE_ERROR).

8.3.2 Enumeration Type Documentation

8.3.2.1 anonymous enum

Enumerator

MAX_THREADS Use all CPU cores for prime sieving.

SHORT_PRIMES Generate primes of short type.

USHORT_PRIMES Generate primes of unsigned short type.

INT_PRIMES Generate primes of int type.

UINT_PRIMES Generate primes of unsigned int type.

LONG_PRIMES Generate primes of long type.

ULONG_PRIMES Generate primes of unsigned long type.

LONGLONG_PRIMES Generate primes of long long type.

ULONGLONG_PRIMES Generate primes of unsigned long long type.

INT16_PRIMES Generate primes of int16_t type.

UINT16_PRIMES Generate primes of uint16_t type.

INT32_PRIMES Generate primes of int32_t type.

UINT32_PRIMES Generate primes of uint32_t type.

INT64_PRIMES Generate primes of int64_t type.

UINT64_PRIMES Generate primes of uint64_t type.

8.3.3 Function Documentation

8.3.3.1 void primesieve_callback_primes (uint64_t *start,* uint64_t *stop,* void(∗)(uint64_t prime) *callback*)

Call back the primes within the interval [start, stop].

Parameters

callback	A callback function.

Precondition

stop <= 2^64 - 2^32 ∗ 10.

8.3.3.2 uint64_t primesieve_count_primes (uint64_t *start,* uint64_t *stop*)

Count the primes within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

count_primes.c.

8.3.3.3 uint64_t primesieve_count_quadruplets (uint64_t *start,* uint64_t *stop*)

Count the prime quadruplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.4 uint64_t primesieve_count_quintuplets (uint64_t *start,* uint64_t *stop*)

Count the prime quintuplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.5 uint64_t primesieve_count_sextuplets (uint64_t *start,* uint64_t *stop*)

Count the prime sextuplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.6 uint64_t primesieve_count_triplets (uint64_t *start,* uint64_t *stop*)

Count the prime triplets within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.7 uint64_t primesieve_count_twins (uint64_t *start,* uint64_t *stop*)

Count the twin primes within the interval [start, stop].

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.8 void* primesieve_generate_n_primes (uint64_t *n,* uint64_t *start,* int *type*)

Get an array with the first n primes >= start.

Parameters

type	The type of the primes to generate, e.g. INT_PRIMES.

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

store_primes_in_array.c.

8.3.3.9 void* primesieve_generate_primes (uint64_t *start*, uint64_t *stop*, size_t * *size*, int *type*)

Get an array with the primes inside the interval [start, stop].

Parameters

size	The size of the returned primes array.
type	The type of the primes to generate, e.g. INT_PRIMES.

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

store_primes_in_array.c.

8.3.3.10 uint64_t primesieve_get_max_stop ( )

Returns the largest valid stop number for primesieve.

Returns

(2^64-1) - (2^32-1) * 10.

8.3.3.11 int primesieve_get_num_threads ( )

Get the current set number of threads.

Note

By default MAX_THREADS (-1) is returned.

8.3.3.12 int primesieve_get_sieve_size ( )

Get the current set sieve size in kilobytes.

8.3.3.13 uint64_t primesieve_nth_prime (int64_t *n*, uint64_t *start*)

Find the nth prime.

Parameters

n	if n = 0 finds the 1st prime >= start, if n > 0 finds the nth prime > start, if n < 0 finds the nth prime < start (backwards).

Precondition

start <= 2^64 - 2^32 * 11.

Examples:

nth_prime.c.

8.3.3.14 void primesieve_parallel_callback_primes (uint64_t *start,* uint64_t *stop,* void(*)(uint64_t prime, int thread_id) *callback*)

Call back the primes within the interval [start, stop] in parallel.

This function is not synchronized, multiple threads call back primes in parallel. By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Warning

Primes are not called back in arithmetic order.

Parameters

callback	A callback function.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.15 uint64_t primesieve_parallel_count_primes (uint64_t *start,* uint64_t *stop*)

Count the primes within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

Examples:

count_primes.c.

8.3.3.16 uint64_t primesieve_parallel_count_quadruplets (uint64_t *start,* uint64_t *stop*)

Count the prime quadruplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.17 uint64_t primesieve_parallel_count_quintuplets (uint64_t *start,* uint64_t *stop*)

Count the prime quintuplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.18 uint64_t primesieve_parallel_count_sextuplets (uint64_t *start,* uint64_t *stop*)

Count the prime sextuplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.19 uint64_t primesieve_parallel_count_triplets (uint64_t *start,* uint64_t *stop*)

Count the prime triplets within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.20 uint64_t primesieve_parallel_count_twins (uint64_t *start,* uint64_t *stop*)

Count the twin primes within the interval [start, stop] in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.21 uint64_t primesieve_parallel_nth_prime (int64_t *n,* uint64_t *start*)

Find the nth prime in parallel.

By default all CPU cores are used, use primesieve_set_num_threads(int) to change the number of threads.

Parameters

n	if n = 0 finds the 1st prime >= start, if n > 0 finds the nth prime > start, if n < 0 finds the nth prime < start (backwards).

Precondition

start <= 2^64 - 2^32 * 11.

8.3.3.22 void primesieve_print_primes (uint64_t *start,* uint64_t *stop*)

Print the primes within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.23 void primesieve_print_quadruplets (uint64_t *start,* uint64_t *stop*)

Print the prime quadruplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.24 void primesieve_print_quintuplets (uint64_t *start,* uint64_t *stop*)

Print the prime quintuplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.25 void primesieve_print_sextuplets (uint64_t *start,* uint64_t *stop*)

Print the prime sextuplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.26 void primesieve_print_triplets (uint64_t *start,* uint64_t *stop*)

Print the prime triplets within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.27 void primesieve_print_twins (uint64_t *start,* uint64_t *stop*)

Print the twin primes within the interval [start, stop] to the standard output.

Precondition

stop <= 2^64 - 2^32 * 10.

8.3.3.28 void primesieve_set_num_threads (int *num_threads*)

Set the number of threads for use in subsequent primesieve_parallel_* function calls.

Note that this only changes the number of threads for the current process.

Parameters

num_threads	Number of threads for sieving or MAX_THREADS to use all CPU cores.

8.3.3.29 void primesieve_set_sieve_size (int *sieve_size*)

Set the sieve size in kilobytes.

The best sieving performance is achieved with a sieve size of your CPU's L1 data cache size (per core). For sieving >= 10^17 a sieve size of your CPU's L2 cache size sometimes performs better.

Parameters

sieve_size	Sieve size in kilobytes.

Precondition

sieve_size >= 1 && <= 2048.

8.3.3.30 int primesieve_test ( )

Run extensive correctness tests.

The tests last about one minute on a quad core CPU from 2013 and use up to 1 gigabyte of memory.

Returns

1 if success, 0 if error.

8.3.3.31 const char* primesieve_version ( )

Get the primesieve version number, in the form "i.j.k".

8.4 primesieve.hpp File Reference

primesieve C++ API.

```
#include "primesieve/PrimeSieve.hpp"
#include "primesieve/ParallelPrimeSieve.hpp"
#include "primesieve/cancel_callback.hpp"
#include "primesieve/iterator.hpp"
#include "primesieve/PushBackPrimes.hpp"
#include "primesieve/primesieve_error.hpp"
```

Include dependency graph for primesieve.hpp:

Namespaces

- primesieve

  All of primesieve's C++ functions and classes are declared inside this namespace.

Macros

- #define **PRIMESIEVE_VERSION** "5.5.0-rc1"
- #define **PRIMESIEVE_VERSION_MAJOR** 5
- #define **PRIMESIEVE_VERSION_MINOR** 5
- #define **PRIMESIEVE_VERSION_PATCH** 0

Enumerations

- enum { primesieve::MAX_THREADS = -1 }

Functions

- template<typename T >
  void primesieve::generate_primes (uint64_t stop, std::vector< T > *primes)

  Store the primes <= stop in the primes vector.
- template<typename T >
  void primesieve::generate_primes (uint64_t start, uint64_t stop, std::vector< T > *primes)

  Store the primes within the interval [start, stop] in the primes vector.
- template<typename T >
  void primesieve::generate_n_primes (uint64_t n, std::vector< T > *primes)

  Store the first n primes in the primes vector.
- template<typename T >
  void primesieve::generate_n_primes (uint64_t n, uint64_t start, std::vector< T > *primes)

  Store the first n primes >= start in the primes vector.
- uint64_t primesieve::nth_prime (int64_t n, uint64_t start=0)

  Find the nth prime.
- uint64_t primesieve::parallel_nth_prime (int64_t n, uint64_t start=0)

  Find the nth prime in parallel.
- uint64_t primesieve::count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop].
- uint64_t primesieve::count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop].
- uint64_t primesieve::count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop].
- uint64_t primesieve::count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop].
- uint64_t primesieve::count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop].
- uint64_t primesieve::count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop].
- uint64_t primesieve::parallel_count_primes (uint64_t start, uint64_t stop)

  Count the primes within the interval [start, stop] in parallel.
- uint64_t primesieve::parallel_count_twins (uint64_t start, uint64_t stop)

  Count the twin primes within the interval [start, stop] in parallel.
- uint64_t primesieve::parallel_count_triplets (uint64_t start, uint64_t stop)

  Count the prime triplets within the interval [start, stop] in parallel.
- uint64_t primesieve::parallel_count_quadruplets (uint64_t start, uint64_t stop)

  Count the prime quadruplets within the interval [start, stop] in parallel.
- uint64_t primesieve::parallel_count_quintuplets (uint64_t start, uint64_t stop)

  Count the prime quintuplets within the interval [start, stop] in parallel.

- uint64_t primesieve::parallel_count_sextuplets (uint64_t start, uint64_t stop)

  Count the prime sextuplets within the interval [start, stop] in parallel.
- void primesieve::print_primes (uint64_t start, uint64_t stop)

  Print the primes within the interval [start, stop] to the standard output.
- void primesieve::print_twins (uint64_t start, uint64_t stop)

  Print the twin primes within the interval [start, stop] to the standard output.
- void primesieve::print_triplets (uint64_t start, uint64_t stop)

  Print the prime triplets within the interval [start, stop] to the standard output.
- void primesieve::print_quadruplets (uint64_t start, uint64_t stop)

  Print the prime quadruplets within the interval [start, stop] to the standard output.
- void primesieve::print_quintuplets (uint64_t start, uint64_t stop)

  Print the prime quintuplets within the interval [start, stop] to the standard output.
- void primesieve::print_sextuplets (uint64_t start, uint64_t stop)

  Print the prime sextuplets within the interval [start, stop] to the standard output.
- void primesieve::callback_primes (uint64_t start, uint64_t stop, void(∗callback)(uint64_t prime))

  Call back the primes within the interval [start, stop].
- void primesieve::callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t > ∗callback)

  Call back the primes within the interval [start, stop].
- void primesieve::parallel_callback_primes (uint64_t start, uint64_t stop, void(∗callback)(uint64_t prime))

  Call back the primes within the interval [start, stop].
- void primesieve::parallel_callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t > ∗callback)

  Call back the primes within the interval [start, stop].
- void primesieve::parallel_callback_primes (uint64_t start, uint64_t stop, void(∗callback)(uint64_t prime, int thread_id))

  Call back the primes within the interval [start, stop].
- void primesieve::parallel_callback_primes (uint64_t start, uint64_t stop, primesieve::Callback< uint64_t, int > ∗callback)

  Call back the primes within the interval [start, stop].
- int primesieve::get_sieve_size ()

  Get the current set sieve size in kilobytes.
- int primesieve::get_num_threads ()

  Get the current set number of threads.
- uint64_t primesieve::get_max_stop ()

  Returns the largest valid stop number for primesieve.
- void primesieve::set_sieve_size (int sieve_size)

  Set the sieve size in kilobytes.
- void primesieve::set_num_threads (int num_threads)

  Set the number of threads for use in subsequent primesieve::parallel_∗ function calls.
- bool primesieve::primesieve_test ()

  Run extensive correctness tests.
- std::string primesieve::primesieve_version ()

  Get the primesieve version number, in the form "i.j.k".

8.4.1 Detailed Description

primesieve C++ API.

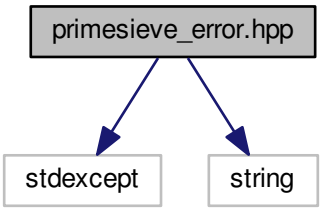
primesieve is a library for fast prime number generation. In case an error occurs the functions declared in this header will throw a primesieve::primesieve_error exception (derived form std::runtime_error).

8.5 primesieve_error.hpp File Reference

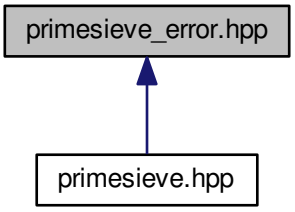
The primesieve_error class is used for all exceptions within primesieve.

```
#include <stdexcept>
#include <string>
```

Include dependency graph for primesieve_error.hpp:



This graph shows which files directly or indirectly include this file:



Classes

- class primesieve::primesieve_error

  primesieve throws a primesieve_error exception if an error occurs that cannot be handled e.g.

Namespaces

- primesieve

  All of primesieve's C++ functions and classes are declared inside this namespace.

8.5.1 Detailed Description

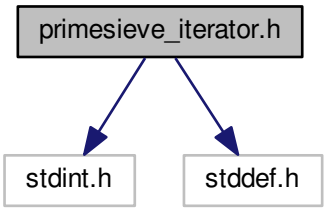
The primesieve_error class is used for all exceptions within primesieve.

8.6 primesieve_iterator.h File Reference

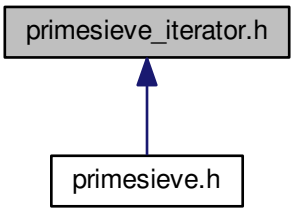
primesieve_iterator allows to easily iterate over primes both forwards and backwards.

```
#include <stdint.h>
#include <stddef.h>
```

Include dependency graph for primesieve_iterator.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct primesieve_iterator

  C prime iterator, please refer to primesieve_iterator.h for more information.

Functions

- void primesieve_init (primesieve_iterator *pi)

  Initialize the primesieve iterator before first using it.
- void primesieve_free_iterator (primesieve_iterator *pi)

  Free all memory.
- void primesieve_skipto (primesieve_iterator *pi, uint64_t start, uint64_t stop_hint)

  Set the primesieve iterator to start.
- static uint64_t primesieve_next_prime (primesieve_iterator *pi)

  Get the next prime.

- static uint64_t primesieve_previous_prime (primesieve_iterator *pi)

  Get the previous prime, or 0 if input <= 2 e.g.

8.6.1 Detailed Description

primesieve_iterator allows to easily iterate over primes both forwards and backwards.

Generating the first prime has a complexity of O(r log log r) operations with r = n^0.5, after that any additional prime is generated in amortized O(log n log log n) operations. The memory usage is about pi(n^0.5) * 16 bytes. primesieve_iterator objects are very convenient to use at the cost of being slightly slower than the primesieve_callback_primes() functions.

The primesieve_iterator.c example shows how to use primesieve_iterator. If any error occurs errno is set to EDOM and primesieve_next_prime() and primesieve_previous_prime() return PRIMESIEVE_ERROR (UINT64_MAX).

8.6.2 Function Documentation

8.6.2.1 void primesieve_free_iterator (primesieve_iterator * *pi*)

Free all memory.

Examples:

previous_prime.c, and primesieve_iterator.c.

8.6.2.2 void primesieve_init (primesieve_iterator * *pi*)

Initialize the primesieve iterator before first using it.

Examples:

previous_prime.c, and primesieve_iterator.c.

8.6.2.3 static uint64_t primesieve_next_prime (primesieve_iterator * *pi*) [inline], [static]

Get the next prime.

Examples:

primesieve_iterator.c.

8.6.2.4 static uint64_t primesieve_previous_prime (primesieve_iterator * *pi*) [inline], [static]

Get the previous prime, or 0 if input <= 2 e.g.

previous_prime(2) = 0.

Examples:

previous_prime.c.

8.6.2.5 void primesieve_skipto (primesieve_iterator * *pi,* uint64_t *start,* uint64_t *stop_hint*)

Set the primesieve iterator to start.

Parameters

start	Generate primes > start (or < start).
stop_hint	Stop number optimization hint. E.g. if you want to generate the primes below 1000 use stop_hint = 1000, if you don't know use primesieve_get_max_stop().

Precondition

start <= 2^64 - 2^32 * 10

Examples:

previous_prime.c.

Chapter 9

Example Documentation

9.1 callback_primes.cpp

This example shows how to use callback functions.

```
#include <primesieve.hpp>
#include <stdint.h>
#include <iostream>

void callback(uint64_t prime)
{
  std::cout << prime << std::endl;
}

int main()
{
  primesieve::callback_primes(2, 1000, callback);
  return 0;
}
```

9.2 count_primes.c

C program that shows how to count primes.

```
#include <primesieve.h>
#include <inttypes.h>
#include <stdio.h>

int main()
{
  uint64_t count = primesieve_count_primes(0, 1000);
  printf("Primes below 1000 = %" PRIu64 "\n", count);

  /* use multi-threading for large intervals */
  count = primesieve_parallel_count_primes(0, 1000000000);
  printf("Primes below 10^9 = %" PRIu64 "\n", count);

  return 0;
}
```

9.3 count_primes.cpp

This example shows how to count primes.

```
#include <primesieve.hpp>
#include <stdint.h>
#include <iostream>
```

```
int main()
{
  uint64_t count = primesieve::count_primes(0, 1000);
  std::cout << "Primes below 1000 = " << count << std::endl;

  // use multi-threading for large intervals
  uint64_t stop = 1000000000;
  count = primesieve::parallel_count_primes(0, stop);
  std::cout << "Primes below 10^9 = " << count << std::endl;

  return 0;
}
```

9.4 nth_prime.c

C program that finds the nth prime.

```
#include <primesieve.h>
#include <stdlib.h>
#include <inttypes.h>
#include <stdio.h>

int main(int argc, char** argv)
{
  uint64_t n = 1000;
  if (argv[1])
    n = atol(argv[1]);

  uint64_t prime = primesieve_nth_prime(n, 0);
  printf("%" PRIu64 "th prime = %" PRIu64 "\n", n, prime);

  return 0;
}
```

9.5 nth_prime.cpp

Find the nth prime.

```
#include <primesieve.hpp>
#include <stdint.h>
#include <iostream>
#include <cstdlib>

int main(int, char** argv)
{
  uint64_t n = 1000;
  if (argv[1])
    n = std::atol(argv[1]);

  uint64_t nth_prime = primesieve::nth_prime(n);
  std::cout << n << "th prime = " << nth_prime << std::endl;

  return 0;
}
```

9.6 previous_prime.c

Iterate backwards over primes using primesieve_iterator.

```
#include <primesieve.h>
#include <inttypes.h>
#include <stdio.h>

int main()
{
  primesieve_iterator pi;
  primesieve_init(&pi);
```

```
  /* primesieve_skipto(primesieve_iterator, start_number, stop_hint) */
  primesieve_skipto(&pi, 2000, 1000);
  uint64_t prime;

  /* iterate backwards over the primes between 2000 and 1000 */
  while ((prime = primesieve_previous_prime(&pi)) >= 1000)
    printf("%" PRIu64 "\n", prime);

  primesieve_free_iterator(&pi);
  return 0;
}
```

9.7 previous_prime.cpp

This example shows how to iterate backwards over primes.

```
#include <primesieve.hpp>
#include <iostream>

int main()
{
  primesieve::iterator pi;
  pi.skipto(2000);

  uint64_t prime;

  // iterate backwards over the primes between 2000 and 1000
  while ((prime = pi.previous_prime()) >= 1000)
    std::cout << prime << std::endl;

  return 0;
}
```

9.8 primesieve_iterator.c

Iterate over primes using C primesieve_iterator.

```
#include <primesieve.h>
#include <inttypes.h>
#include <stdio.h>

int main()
{
  primesieve_iterator pi;
  primesieve_init(&pi);

  uint64_t sum = 0;
  uint64_t prime = 0;

  /* iterate over the primes below 10^10 */
  while ((prime = primesieve_next_prime(&pi)) < 10000000000ull)
    sum += prime;

  primesieve_free_iterator(&pi);
  printf("Sum of the primes below 10^10 = %" PRIu64 "\n", sum);
  return 0;
}
```

9.9 primesieve_iterator.cpp

Iterate over primes using a primesieve::iterator object.

```
#include <primesieve.hpp>
#include <iostream>

int main()
{
```

```
  primesieve::iterator pi;
  uint64_t sum = 0;
  uint64_t prime;

  // iterate over primes below 10^10
  while ((prime = pi.next_prime()) < 10000000000ull)
    sum += prime;

  std::cout << "Sum of the primes below 10^10 = " << sum << std::endl;
  return 0;
}
```

9.10 store_primes_in_array.c

Store primes in a C array.

```
#include <primesieve.h>
#include <stdio.h>

int main()
{
  uint64_t start = 0;
  uint64_t stop = 1000;
  size_t i;
  size_t size;

  /* store the primes below 1000 */
  int* primes = (int*) primesieve_generate_primes(start, stop, &size,
      INT_PRIMES);

  for (i = 0; i < size; i++)
    printf("%i\n", primes[i]);

  primesieve_free(primes);

  uint64_t n = 1000;
  /* store the first 1000 primes */
  primes = (int*) primesieve_generate_n_primes(n, start,
      INT_PRIMES);

  for (i = 0; i < n; i++)
    printf("%i\n", primes[i]);

  primesieve_free(primes);
  return 0;
}
```

9.11 store_primes_in_vector.cpp

Store primes in a std::vector using primesieve.

```
#include <primesieve.hpp>
#include <vector>

int main()
{
  std::vector<int> primes;

  // Store the primes below 1000
  primesieve::generate_primes(1000, &primes);

  // Store the primes within the interval [1000, 2000]
  primes.clear();
  primesieve::generate_primes(1000, 2000, &primes);

  // Store first 1000 primes
  primes.clear();
  primesieve::generate_n_primes(1000, &primes);

  return 0;
}
```

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