Boost.Container

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Introduction

Boost.Container library implements several well-known containers, including STL containers. The aim of the library is to offers advanced features not present in standard containers or to offer the latest standard draft features for compilers that comply with C++03.

In short, what does **Boost.Container** offer?

- Move semantics are implemented, including move emulation for pre-C++11 compilers.
- New advanced features (e.g. placement insertion, recursive containers) are present.
- Containers support stateful allocators and are compatible with **Boost.Interprocess** (they can be safely placed in shared memory).
- The library offers new useful containers:
  - `flat_map`, `flat_set`, `flat_multimap` and `flat_multiset`: drop-in replacements for standard associative containers but more memory friendly and with faster searches.
  - `stable_vector`: a std::list and std::vector hybrid container: vector-like random-access iterators and list-like iterator stability in insertions and erasures.
  - `slist`: the classic pre-standard singly linked list implementation offering constant-time `size()`. Note that C++11 `forward_list` has no `size()`.

Building Boost.Container

There is no need to compile **Boost.Container**, since it's a header only library. Just include your Boost header directory in your compiler include path.

Tested compilers

Boost.Container requires a decent C++98 compatibility. Some compilers known to work are:

- Visual C++ >= 7.1.
- GCC >= 4.1.
- Intel C++ >= 9.0

Efficient insertion

Move semantics and placement insertion are two features brought by C++11 containers that can have a very positive impact in your C++ applications. Boost.Container implements both techniques both for C++11 and C++03 compilers.

Move-aware containers

All containers offered by **Boost.Container** can store movable-only types and actual requirements for `value_type` depend on each container operations. Following C++11 requirements even for C++03 compilers, many operations now require movable or default constructible types instead of just copy constructible types.

Containers themselves are also movable, with no-throw guarantee if allocator or predicate (if present) copy operations are no-throw. This allows high performance operations when transferring data between vectors. Let's see an example:

```
#include <boost/container/vector.hpp>
#include <boost/move/utility.hpp>
#include <cassert>

//Non-copyable class
class non_copyable
{
   BOOST_MOVABLE_BUT_NOT_COPYABLE(non_copyable)

   public:
   non_copyable(){}
   non_copyable(BOOST_RV_REF(non_copyable)) {}
   non_copyable& operator=(BOOST_RV_REF(non_copyable)) { return *this; }
};

int main ()
{
   using namespace boost::container;

   //Store non-copyable objects in a vector
   vector<non_copyable> v;
   non_copyable nc;
   v.push_back(boost::move(nc));
   assert(v.size() == 1);

   //Reserve no longer needs copy-constructible
   v.reserve(100);
   assert(v.capacity() >= 100);

   //This resize overload only needs movable and default constructible
   v.resize(200);
   assert(v.size() == 200);

   //Containers are also movable
   vector<non_copyable> v_other(boost::move(v));
   assert(v_other.size() == 200);
   assert(v.empty());

   return 0;
}
```

Emplace: Placement insertion

All containers offered by **Boost.Container** implement placement insertion, which means that objects can be built directly into the container from user arguments without creating any temporary object. For compilers without variadic templates support placement insertion is emulated up to a finite (10) number of arguments.

Expensive to move types are perfect candidates emplace functions and in case of node containers (`list`, `set`, ...) emplace allows storing non-movable and non-copyable types in containers! Let's see an example:

```
#include <boost/container/list.hpp>
#include <cassert>

//Non-copyable and non-movable class
class non_copy_movable
{
   non_copy_movable(const non_copy_movable &);
   non_copy_movable& operator=(const non_copy_movable &);

   public:
   non_copy_movable(int = 0) {}
};

int main ()
{
   using namespace boost::container;

   //Store non-copyable and non-movable objects in a list
   list<non_copy_movable> l;
   non_copy_movable ncm;

   //A new element will be built calling non_copy_movable(int) contructor
   l.emplace(l.begin(), 0);
   assert(l.size() == 1);

   //A new element will be built calling the default constructor
   l.emplace(l.begin());
   assert(l.size() == 2);
   return 0;
}
```

Containers of Incomplete Types

Incomplete types allow **type erasure** and **recursive data types**, and C and C++ programmers have been using it for years to build complex data structures, like tree structures where a node may have an arbitrary number of children.

What about standard containers? Containers of incomplete types have been under discussion for a long time, as explained in Matt Austern's great article (**The Standard Librarian: Containers of Incomplete Types**):

"*Unlike most of my columns, this one is about something you can't do with the C++ Standard library: put incomplete types in one of the standard containers. This column explains why you might want to do this, why the standardization committee banned it even though they knew it was useful, and what you might be able to do to get around the restriction.*"

"*In 1997, shortly before the C++ Standard was completed, the standardization committee received a query: Is it possible to create standard containers with incomplete types? It took a while for the committee to understand the question. What would such a thing even mean, and why on earth would you ever want to do it? The committee eventually worked it out and came up with an answer to the question. (Just so you don't have to skip ahead to the end, the answer is "no.") But the question is much more interesting than the answer: it points to a useful, and insufficiently discussed, programming technique. The standard library doesn't directly support that technique, but the two can be made to coexist.*"

"*In a future revision of C++, it might make sense to relax the restriction on instantiating standard library templates with incomplete types. Clearly, the general prohibition should stay in place - instantiating templates with incomplete types is a delicate business, and there are too many classes in the standard library where it would make no sense. But perhaps it should be relaxed on a case-by-case basis, and `vector` looks like a good candidate for such special-case treatment: it's the one standard container class where there are good reasons to instantiate it with an incomplete type and where Standard Library implementors want to make it work. As of today, in fact, implementors would have to go out of their way to prohibit it!*"

C++11 standard is also cautious about incomplete types and STL: "*17.6.4.8 Other functions (...) 2. the effects are undefined in the following cases: (...) In particular - if an incomplete type (3.9) is used as a template argument when instantiating a template component, unless specifically allowed for that component*". Fortunately **Boost.Container** containers are designed to support type erasure and recursive types, so let's see some examples:

Recursive containers

All containers offered by **Boost.Container** can be used to define recursive containers:

```
#include <boost/container/vector.hpp>
#include <boost/container/list.hpp>
#include <boost/container/map.hpp>
#include <boost/container/stable_vector.hpp>
#include <boost/container/string.hpp>

using namespace boost::container;

struct data
{
   int               i_;
   //A vector holding still undefined class 'data'
   vector<data>      v_;
   //A list holding still undefined 'data'
   list<data>        l_;
   //A map holding still undefined 'data'
   map<data, data>   m_;

   friend bool operator <(const data &l, const data &r)
   { return l.i_ < r.i_; }
};

struct tree_node
{
   string name;
   string value;

   //children nodes of this node
   list<tree_node>        children_;
};



int main()
{
   //a container holding a recursive data type
   stable_vector<data> sv;
   sv.resize(100);

   //Let's build a tree based in
   //a recursive data type
   tree_node root;
   root.name  = "root";
   root.value = "root_value";
   root.children_.resize(7);
   return 0;
}
```

Type Erasure

Containers of incomplete types are useful to break header file dependencies and improve compilation types. With Boost.Container, you can write a header file defining a class with containers of incomplete types as data members, if you carefully put all the implementation details that require knowing the size of the `value_type` in your implementation file:

In this header file we define a class (`MyClassHolder)` that holds a `vector` of an incomplete type (`MyClass`) that it's only forward declared.

```
#include <boost/container/vector.hpp>

//MyClassHolder.h

//We don't need to include "MyClass.h"
//to store vector<MyClass>
class MyClass;

class MyClassHolder
{
   public:

   void AddNewObject(const MyClass &o);
   const MyClass & GetLastObject() const;

   private:
   ::boost::container::vector<MyClass> vector_;
};
```

Then we can define `MyClass` in its own header file.

```
//MyClass.h

class MyClass
{
   private:
   int value_;

   public:
   MyClass(int val = 0) : value_(val){}

   friend bool operator==(const MyClass &l, const MyClass &r)
   {  return l.value_ == r.value_;  }
   //...
};
```

And include it only in the implementation file of `MyClassHolder`

```
//MyClassHolder.cpp

#include "MyClassHolder.h"

//In the implementation MyClass must be a complete
//type so we include the appropriate header
#include "MyClass.h"

void MyClassHolder::AddNewObject(const MyClass &o)
{  vector_.push_back(o);  }

const MyClass & MyClassHolder::GetLastObject() const
{  return vector_.back();  }
```

Finally, we can just compile, link, and run!

```
//Main.cpp

#include "MyClassHolder.h"
#include "MyClass.h"

#include <cassert>

int main()
{
   MyClass mc(7);
   MyClassHolder myclassholder;
   myclassholder.AddNewObject(mc);
   return myclassholder.GetLastObject() == mc ? 0 : 1;
}
```

Boost.Container and C++ exceptions

In some environments, such as game development or embedded systems, C++ exceptions are disabled or a customized error handling is needed. According to document N2271 EASTL -- Electronic Arts Standard Template Library exceptions can be disabled for several reasons:

- “*Exception handling incurs some kind of cost in all compiler implementations, including those that avoid the cost during normal execution. However, in some cases this cost may arguably offset the cost of the code that it is replacing.*”
- “*Exception handling is often agreed to be a superior solution for handling a large range of function return values. However, avoiding the creation of functions that need large ranges of return values is superior to using exception handling to handle such values.*”
- “*Using exception handling correctly can be difficult in the case of complex software.*”
- “*The execution of throw and catch can be significantly expensive with some implementations.*”
- “*Exception handling violates the don't-pay-for-what-you-don't-use design of C++, as it incurs overhead in any non-leaf function that has destructible stack objects regardless of whether they use exception handling.*”
- “*The approach that game software usually takes is to avoid the need for exception handling where possible; avoid the possibility of circumstances that may lead to exceptions. For example, verify up front that there is enough memory for a subsystem to do its job instead of trying to deal with the problem via exception handling or any other means after it occurs.*”
- “*However, some game libraries may nevertheless benefit from the use of exception handling. It's best, however, if such libraries keep the exception handling internal lest they force their usage of exception handling on the rest of the application.*”

In order to support environments without C++ exception support or environments with special error handling needs, **Boost.Container** changes error signalling behaviour when `BOOST_CONTAINER_USER_DEFINED_THROW_CALLBACKS` or `BOOST_NO_EXCEPTIONS` is defined. The former shall be defined by the user and the latter can be either defined by the user or implicitly defined by **Boost.Confg** when the compiler has been invoked with the appropriate flag (like `-fno-exceptions` in GCC).

When dealing with user-defined classes, (e.g. when constructing user-defined classes):

- If `BOOST_NO_EXCEPTIONS` is defined, the library avoids using `try`/`catch`/`throw` statements. The class writer must handle and propagate error situations internally as no error will be propagated through **Boost.Container**.
- If `BOOST_NO_EXCEPTIONS` is **not** defined, the library propagates exceptions offering the exception guarantees detailed in the documentation.

When the library needs to throw an exception (such as `out_of_range` when an incorrect index is used in `vector::at`)], the library calls a throw callback declared in `<boost/container/throw_exception.hpp>`:

- If `BOOST_CONTAINER_USER_DEFINED_THROW_CALLBACKS` is defined, then the programmer must provide its own definition for all `throw_xxx` functions. Those functions can't return, they must throw an exception or call `std::exit` or `std::abort`.
- Else if `BOOST_NO_EXCEPTIONS` is defined, a `BOOST_ASSERT_MSG` assertion is triggered (see Boost.Assert for more information). If this assertion returns, then `std::abort` is called.
- Else, an appropriate standard library exception is thrown (like `std::out_of_range`).

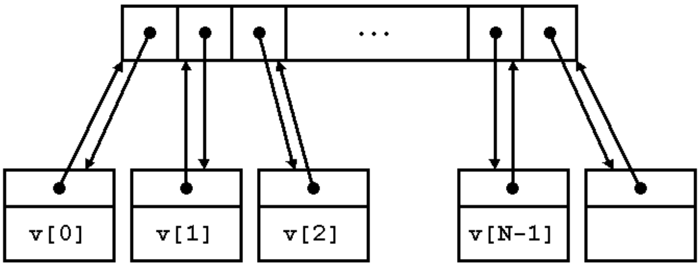
Non-standard containers

stable_vector

This useful, fully STL-compliant stable container designed by Joaquín M. López Muñoz is an hybrid between `vector` and `list`, providing most of the features of `vector` except element contiguity.

Extremely convenient as they are, `vector`s have a limitation that many novice C++ programmers frequently stumble upon: iterators and references to an element of an `vector` are invalidated when a preceding element is erased or when the vector expands and needs to migrate its internal storage to a wider memory region (i.e. when the required size exceeds the vector's capacity). We say then that `vector`s are unstable: by contrast, stable containers are those for which references and iterators to a given element remain valid as long as the element is not erased: examples of stable containers within the C++ standard library are `list` and the standard associative containers (`set`, `map`, etc.).

Sometimes stability is too precious a feature to live without, but one particular property of `vector`s, element contiguity, makes it impossible to add stability to this container. So, provided we sacrifice element contiguity, how much can a stable design approach the behavior of `vector` (random access iterators, amortized constant time end insertion/deletion, minimal memory overhead, etc.)? The following image describes the layout of a possible data structure upon which to base the design of a stable vector:



Each element is stored in its own separate node. All the nodes are referenced from a contiguous array of pointers, but also every node contains an "up" pointer referring back to the associated array cell. This up pointer is the key element to implementing stability and random accessibility:

Iterators point to the nodes rather than to the pointer array. This ensures stability, as it is only the pointer array that needs to be shifted or relocated upon insertion or deletion. Random access operations can be implemented by using the pointer array as a convenient intermediate zone. For instance, if the iterator it holds a node pointer `it.p` and we want to advance it by n positions, we simply do:

```
it.p = *(it.p->up+n);
```

That is, we go "up" to the pointer array, add n there and then go "down" to the resulting node.

General properties. `stable_vector` satisfies all the requirements of a container, a reversible container and a sequence and provides all the optional operations present in vector. Like vector, iterators are random access. `stable_vector` does not provide element contiguity; in exchange for this absence, the container is stable, i.e. references and iterators to an element of a `stable_vector` remain valid as long as the element is not erased, and an iterator that has been assigned the return value of end() always remain valid until the destruction of the associated `stable_vector`.

Operation complexity. The big-O complexities of `stable_vector` operations match exactly those of vector. In general, insertion/deletion is constant time at the end of the sequence and linear elsewhere. Unlike vector, `stable_vector` does not internally perform any value_type destruction, copy/move construction/assignment operations other than those exactly corresponding to the insertion of new elements or deletion of stored elements, which can sometimes compensate in terms of performance for the extra burden of doing more pointer manipulation and an additional allocation per element.

Exception safety. (according to Abrahams' terminology) As `stable_vector` does not internally copy/move elements around, some operations provide stronger exception safety guarantees than in vector:

Table 1. Exception safety

operation	exception safety for vector<T>	exception safety for stable_vector<T>
insert	strong unless copy/move construction/assignment of T throw (basic)	strong
erase	no-throw unless copy/move construction/assignment of T throw (basic)	no-throw

Memory overhead. The C++ standard does not specifiy requirements on memory consumption, but virtually any implementation of `vector` has the same behavior wih respect to memory usage: the memory allocated by a `vector` v with n elements of type T is

$m_v = c \cdot e$,

where c is `v.capacity()` and e is `sizeof(T)`. c can be as low as n if the user has explicitly reserved the exact capacity required; otherwise, the average value c for a growing `vector` oscillates between 1.25·n and 1.5·n for typical resizing policies. For `stable_vector`, the memory usage is

$m_{sv} = (c + 1)p + (n + 1)(e + p)$,

where p is the size of a pointer. We have c + 1 and n + 1 rather than c and n because a dummy node is needed at the end of the sequence. If we call f the capacity to size ratio c/n and assume that n is large enough, we have that

m_{sv}/m_v $(fp + e + p)/fe$.

So, `stable_vector` uses less memory than `vector` only when e > p and the capacity to size ratio exceeds a given threshold:

$m_{sv} < m_v$ <-> $f > (e + p)/(e - p)$. (provided $e > p$)

This threshold approaches typical values of f below 1.5 when e > 5p; in a 32-bit architecture, when e > 20 bytes.

Summary. `stable_vector` is a drop-in replacement for `vector` providing stability of references and iterators, in exchange for missing element contiguity and also some performance and memory overhead. When the element objects are expensive to move around, the performance overhead can turn into a net performance gain for `stable_vector` if many middle insertions or deletions are performed or if resizing is very frequent. Similarly, if the elements are large there are situations when the memory used by `stable_vector` can actually be less than required by vector.

Note: Text and explanations taken from Joaquín's blog

flat_(multi)map/set associative containers

Using sorted vectors instead of tree-based associative containers is a well-known technique in C++ world. Matt Austern's classic article Why You Shouldn't Use set, and What You Should Use Instead (C++ Report 12:4, April 2000) was enlightening:

"*Red-black trees aren't the only way to organize data that permits lookup in logarithmic time. One of the basic algorithms of computer science is binary search, which works by successively dividing a range in half. Binary search is log N and it doesn't require any fancy data structures, just a sorted collection of elements. (...) You can use whatever data structure is convenient, so long as it provides STL iterator; usually it's easiest to use a C array, or a vector.*"

"*Both std::lower_bound and set::find take time proportional to log N, but the constants of proportionality are very different. Using g++ (...) it takes X seconds to perform a million lookups in a sorted vector<double> of a million elements, and almost twice as long (...) using a set. Moreover, the set uses almost three times as much memory (48 million bytes) as the vector (16.8 million).*"

"*Using a sorted vector instead of a set gives you faster lookup and much faster iteration, but at the cost of slower insertion. Insertion into a set, using set::insert, is proportional to log N, but insertion into a sorted vector, (...) , is proportional to N. Whenever you insert something into a vector, vector::insert has to make room by shifting all of the elements that follow it. On average, if you're equally likely to insert a new element anywhere, you'll be shifting N/2 elements.*"

“It may sometimes be convenient to bundle all of this together into a small container adaptor. This class does not satisfy the requirements of a Standard Associative Container, since the complexity of insert is O(N) rather than O(log N), but otherwise it is almost a drop-in replacement for set.”

Following Matt Austern's indications, Andrei Alexandrescu's Modern C++ Design showed `AssocVector`, a `std::map` drop-in replacement designed in his Loki library:

“It seems as if we're better off with a sorted vector. The disadvantages of a sorted vector are linear-time insertions and linear-time deletions (...). In exchange, a vector offers about twice the lookup speed and a much smaller working set (...). Loki saves the trouble of maintaining a sorted vector by hand by defining an AssocVector class template. AssocVector is a drop-in replacement for std::map (it supports the same set of member functions), implemented on top of std::vector. AssocVector differs from a map in the behavior of its erase functions (AssocVector::erase invalidates all iterators into the object) and in the complexity guarantees of insert and erase (linear as opposed to constant). ”

Boost.Container `flat_[multi]map/set` containers are ordered-vector based associative containers based on Austern's and Alexandrescu's guidelines. These ordered vector containers have also benefited recently with the addition of `move semantics` to C++, speeding up insertion and erasure times considerably. Flat associative containers have the following attributes:

- Faster lookup than standard associative containers
- Much faster iteration than standard associative containers
- Less memory consumption for small objects (and for big objects if `shrink_to_fit` is used)
- Improved cache performance (data is stored in contiguous memory)
- Non-stable iterators (iterators are invalidated when inserting and erasing elements)
- Non-copyable and non-movable values types can't be stored
- Weaker exception safety than standard associative containers (copy/move constructors can throw when shifting values in erasures and insertions)
- Slower insertion and erasure than standard associative containers (specially for non-movable types)

slist

When the standard template library was designed, it contained a singly linked list called `slist`. Unfortunately, this container was not standardized and remained as an extension for many standard library implementations until C++11 introduced `forward_list`, which is a bit different from the the original SGI `slist`. According to SGI STL documentation:

“An `slist` is a singly linked list: a list where each element is linked to the next element, but not to the previous element. That is, it is a Sequence that supports forward but not backward traversal, and (amortized) constant time insertion and removal of elements. Slists, like lists, have the important property that insertion and splicing do not invalidate iterators to list elements, and that even removal invalidates only the iterators that point to the elements that are removed. The ordering of iterators may be changed (that is, slist<T>::iterator might have a different predecessor or successor after a list operation than it did before), but the iterators themselves will not be invalidated or made to point to different elements unless that invalidation or mutation is explicit.”

“The main difference between `slist` and list is that list's iterators are bidirectional iterators, while slist's iterators are forward iterators. This means that `slist` is less versatile than list; frequently, however, bidirectional iterators are unnecessary. You should usually use `slist` unless you actually need the extra functionality of list, because singly linked lists are smaller and faster than double linked lists.”

“Important performance note: like every other Sequence, `slist` defines the member functions insert and erase. Using these member functions carelessly, however, can result in disastrously slow programs. The problem is that insert's first argument is an iterator pos, and that it inserts the new element(s) before pos. This means that insert must find the iterator just before pos; this is a constant-time operation for list, since list has bidirectional iterators, but for `slist` it must find that iterator by traversing the list from the beginning up to pos. In other words: insert and erase are slow operations anywhere but near the beginning of the slist.”

"*Slist provides the member functions insert_after and erase_after, which are constant time operations: you should always use insert_after and erase_after whenever possible. If you find that insert_after and erase_after aren't adequate for your needs, and that you often need to use insert and erase in the middle of the list, then you should probably use list instead of slist.*"

Boost.Container updates the classic `slist` container with C++11 features like move semantics and placement insertion and implements it a bit differently than the standard C++ `forward_list`. `forward_list` has no `size()` method, so it's been designed to allow (or in practice, encourage) implementations without tracking list size with every insertion/erasure, allowing constant-time `splice_after(iterator, forward_list &, iterator, iterator)`-based list merging. On the other hand `slist` offers constant-time `size()` for those that don't care about linear-time `splice_after(iterator, slist &, iterator, iterator)` `size()` and offers an additional `splice_after(iterator, slist &, iterator, iterator, size_type)` method that can speed up `slist` merging when the programmer already knows the size. `slist` and `forward_list` are therefore complementary.

static_vector

`static_vector` is an hybrid between `vector` and `array`: like `vector`, it's a sequence container with contiguous storage that can change in size, along with the static allocation, low overhead, and fixed capacity of `array`. `static_vector` is based on Adam Wulkiewicz and Andrew Hundt's high-performance varray class.

The number of elements in a `static_vector` may vary dynamically up to a fixed capacity because elements are stored within the object itself similarly to an array. However, objects are initialized as they are inserted into `static_vector` unlike C arrays or `std::array` which must construct all elements on instantiation. The behavior of `static_vector` enables the use of statically allocated elements in cases with complex object lifetime requirements that would otherwise not be trivially possible. Some other properties:

- Random access to elements
- Constant time insertion and removal of elements at the end
- Linear time insertion and removal of elements at the beginning or in the middle.

`static_vector` is well suited for use in a buffer, the internal implementation of other classes, or use cases where there is a fixed limit to the number of elements that must be stored. Embedded and realtime applications where allocation either may not be available or acceptable are a particular case where `static_vector` can be beneficial.

C++11 Conformance

Boost.Container aims for full C++11 conformance except reasoned deviations, backporting as much as possible for C++03. Obviously, this conformance is a work in progress so this section explains what C++11 features are implemented and which of them have been backported to C++03 compilers.

Move and Emplace

For compilers with rvalue references and for those C++03 types that use Boost.Move rvalue reference emulation **Boost.Container** supports all C++11 features related to move semantics: containers are movable, requirements for `value_type` are those specified for C++11 containers.

For compilers with variadic templates, **Boost.Container** supports placement insertion (`emplace`, ...) functions from C++11. For those compilers without variadic templates support **Boost.Container** uses the preprocessor to create a set of overloads up to a finite (10) number of parameters.

Stateful allocators

C++03 was not stateful-allocator friendly. For compactness of container objects and for simplicity, it did not require containers to support allocators with state: Allocator objects need not be stored in container objects. It was not possible to store an allocator with state, say an allocator that holds a pointer to an arena from which to allocate. C++03 allowed implementors to suppose two allocators of the same type always compare equal (that means that memory allocated by one allocator object could be deallocated by another instance of the same type) and allocators were not swapped when the container was swapped.

C++11 further improves stateful allocator support through `std::allocator_traits`. `std::allocator_traits` is the protocol between a container and an allocator, and an allocator writer can customize its behaviour (should the container propagate it in move constructor, swap, etc.?) following `allocator_traits` requirements. **Boost.Container** not only supports this model with C++11 but also **backports it to C++03**.

If possible, a single allocator is hold to construct `value_type`. If the container needs an auxiliary allocator (e.g. a array allocator used by `deque` or `stable_vector`), that allocator is also constructed from the user-supplied allocator when the container is constructed (i.e. it's not constructed on the fly when auxiliary memory is needed).

Scoped allocators

C++11 improves stateful allocators with the introduction of `std::scoped_allocator_adaptor` class template. `scoped_allocator_adaptor` is instantiated with one outer allocator and zero or more inner allocators.

A scoped allocator is a mechanism to automatically propagate the state of the allocator to the subobjects of a container in a controlled way. If instantiated with only one allocator type, the inner allocator becomes the `scoped_allocator_adaptor` itself, thus using the same allocator resource for the container and every element within the container and, if the elements themselves are containers, each of their elements recursively. If instantiated with more than one allocator, the first allocator is the outer allocator for use by the container, the second allocator is passed to the constructors of the container's elements, and, if the elements themselves are containers, the third allocator is passed to the elements' elements, and so on.

Boost.Container implements its own `scoped_allocator_adaptor` class and **backports this feature also to C++03 compilers**. Due to C++03 limitations, in those compilers the allocator propagation implemented by `scoped_allocator_adaptor::construct` functions will be based on traits(`constructible_with_allocator_suffix` and `constructible_with_allocator_prefix`) proposed in N2554: The Scoped Allocator Model (Rev 2) proposal. In conforming C++11 compilers or compilers supporting SFINAE expressions (when `BOOST_NO_SFINAE_EXPR` is NOT defined), traits are ignored and C++11 rules (`is_constructible<T, Args..., inner_allocator_type>::value` and `is_constructible<T, allocator_arg_t, inner_allocator_type, Args...>::value`) will be used to detect if the allocator must be propagated with suffix or prefix allocator arguments.

Initializer lists

Boost.Container does not support initializer lists when constructing or assigning containers but it will support it for compilers with initialized-list support. This feature won't be backported to C++03 compilers.

`forward_list<T>`

Boost.Container does not offer C++11 `forward_list` container yet, but it will be available in future versions.

`vector<bool>`

`vector<bool>` specialization has been quite problematic, and there have been several unsuccessful tries to deprecate or remove it from the standard. **Boost.Container** does not implement it as there is a superior Boost.DynamicBitset solution. For issues with `vector<bool>` see papers vector<bool>: N1211: More Problems, Better Solutions, N2160: Library Issue 96: Fixing vector<bool>, N2204 A Specification to deprecate vector<bool>.

- "*In 1998, admitting that the committee made a mistake was controversial. Since then Java has had to deprecate such significant portions of their libraries that the idea C++ would be ridiculed for deprecating a single minor template specialization seems quaint.*"
- "*`vector<bool>` is not a container and `vector<bool>::iterator` is not a random-access iterator (or even a forward or bidirectional iterator either, for that matter). This has already broken user code in the field in mysterious ways.*"
- "*`vector<bool>` forces a specific (and potentially bad) optimization choice on all users by enshrining it in the standard. The optimization is premature; different users have different requirements. This too has already hurt users who have been forced to implement workarounds to disable the 'optimization' (e.g., by using a vector<char> and manually casting to/from bool).*"

So `boost::container::vector<bool>::iterator` returns real `bool` references and works as a fully compliant container. If you need a memory optimized version of `boost::container::vector<bool>` functionalities, please use Boost.DynamicBitset.

Other features

- Default constructors don't allocate memory which improves performance and usually implies a no-throw guarantee (if predicate's or allocator's default constructor doesn't throw).
- Small string optimization for `basic_string`, with an internal buffer of 11/23 bytes (32/64 bit systems) **without** increasing the usual `sizeof` of the string (3 words).
- `[multi]set/map` containers are size optimized embedding the color bit of the red-black tree nodes in the parent pointer.
- `[multi]set/map` containers use no recursive functions so stack problems are avoided.

History and reasons to use Boost.Container

Boost.Container history

Boost.Container is a product of a long development effort that started in 2004 with the experimental Shmem library, which pioneered the use of standard containers in shared memory. Shmem included modified SGI STL container code tweaked to support non-raw `allocator::pointer` types and stateful allocators. Once reviewed, Shmem was accepted as Boost.Interprocess and this library continued to refine and improve those containers.

In 2007, container code from node containers (`map`, `list`, `slist`) was rewritten, refactored and expanded to build the intrusive container library Boost.Intrusive. **Boost.Interprocess** containers were refactored to take advantage of **Boost.Intrusive** containers and code duplication was minimized. Both libraries continued to gain support and bug fixes for years. They introduced move semantics, emplacement insertion and more features of then unreleased C++0x standard.

Boost.Interprocess containers were always standard compliant, and those containers and new containers like `stable_vector` and `flat_[multi]set/map` were used outside **Boost.Interprocess** with success. As containers were mature enough to get their own library, it was a natural step to collect them containers and build **Boost.Container**, a library targeted to a wider audience.

Why Boost.Container?

With so many high quality standard library implementations out there, why would you want to use **Boost.Container**? There are several reasons for that:

- If you have a C++03 compiler, you can have access to C++11 features and have an easy code migration when you change your compiler.
- It's compatible with **Boost.Interprocess** shared memory allocators.
- You have extremely useful new containers like `stable_vector` and `flat_[multi]set/map`.
- If you work on multiple platforms, you'll have a portable behaviour without depending on the std-lib implementation conformance of each platform. Some examples:
  - Default constructors don't allocate memory at all, which improves performance and usually implies a no-throw guarantee (if predicate's or allocator's default constructor doesn't throw).
  - Small string optimization for `basic_string`.
- New extensions beyond the standard based on user feedback to improve code performance.
- You need a portable implementation that works when compiling without exceptions support or you need to customize the error handling when a container needs to signall an exceptional error.

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Boost.Container Header Reference

Header <boost/container/allocator_traits.hpp>

```
template<typename Alloc> struct allocator_traits;
```

Struct template allocator_traits

allocator_traits

Synopsis

```
// In header: <boost/container/allocator_traits.hpp>

template<typename Alloc> 
struct allocator_traits {
  // types
  typedef Alloc                                         allocator_type;                        
  typedef Alloc::value_type                             value_type;                            
  typedef unspecified                                   pointer;                               
  typedef see_documentation                             const_pointer;                         
  typedef see_documentation                             reference;                             
  typedef see_documentation                             const_reference;                       
  typedef see_documentation                             void_pointer;                          
  typedef see_documentation                             const_void_pointer;                    
  typedef see_documentation                             difference_type;                       
  typedef see_documentation                             size_type;                             
  typedef see_documentation                             propagate_on_container_copy_assignment;
  typedef see_documentation                             propagate_on_container_move_assignment;
  typedef see_documentation                             propagate_on_container_swap;           
  typedef see_documentation                             rebind_alloc;                          
  typedef allocator_traits< rebind_alloc< T > >         rebind_traits;                         

  // member classes/structs/unions
  template<typename T> 
  struct portable_rebind_alloc {
    // types
    typedef see_documentation type;
  };

  // public static functions
  static pointer allocate(Alloc &, size_type);
  static void deallocate(Alloc &, pointer, size_type);
  static pointer allocate(Alloc &, size_type, const_void_pointer);
  template<typename T> static void destroy(Alloc &, T *);
  static size_type max_size(const Alloc &);
  static Alloc select_on_container_copy_construction(const Alloc &);
  template<typename T, class... Args> 
    static void construct(Alloc &, T *, Args &&...);
};
```

Description

The class template allocator_traits supplies a uniform interface to all allocator types. This class is a C++03-compatible implementation of std::allocator_traits

`allocator_traits` public types

1. typedef unspecified pointer;

   Alloc::pointer if such a type exists; otherwise, value_type*

2. typedef see_documentation const_pointer;

   Alloc::const_pointer if such a type exists ; otherwise, pointer_traits<pointer>::rebind<const

3. typedef see_documentation reference;

   Non-standard extension Alloc::reference if such a type exists; otherwise, value_type&

4. typedef see_documentation const_reference;

   Non-standard extension Alloc::const_reference if such a type exists ; otherwise, const value_type&

5. typedef see_documentation void_pointer;

   Alloc::void_pointer if such a type exists ; otherwise, pointer_traits<pointer>::rebind<void>.

6. typedef see_documentation const_void_pointer;

   Alloc::const_void_pointer if such a type exists ; otherwis e, pointer_traits<pointer>::rebind<const

7. typedef see_documentation difference_type;

   Alloc::difference_type if such a type exists ; otherwise, pointer_traits<pointer>::difference_type.

8. typedef see_documentation size_type;

   Alloc::size_type if such a type exists ; otherwise, make_unsigned<difference_type>::type

9. typedef see_documentation propagate_on_container_copy_assignment;

   Alloc::propagate_on_container_copy_assignment if such a type exists, otherwise an integral_constant type with internal constant static member `value` == false.

10. typedef see_documentation propagate_on_container_move_assignment;

    Alloc::propagate_on_container_move_assignment if such a type exists, otherwise an integral_constant type with internal constant static member `value` == false.

11. typedef see_documentation propagate_on_container_swap;

    Alloc::propagate_on_container_swap if such a type exists, otherwise an integral_constant type with internal constant static member `value` == false.

12. typedef see_documentation rebind_alloc;

    Defines an allocator: Alloc::rebind<T>::other if such a type exists; otherwise, Alloc<T, Args> if Alloc is a class template instantiation of the form Alloc<U, Args>, where Args is zero or more type arguments ; otherwise, the instantiation of rebind_alloc is ill-formed.

    In C++03 compilers `rebind_alloc` is a struct derived from an allocator deduced by previously detailed rules.

13. typedef allocator_traits< rebind_alloc< T > > rebind_traits;

    In C++03 compilers `rebind_traits` is a struct derived from `allocator_traits<OtherAlloc>`, where `OtherAlloc` is the allocator deduced by rules explained in `rebind_alloc`.

`allocator_traits` public static functions

1.
```
static pointer allocate(Alloc & a, size_type n);
```

Returns: `a.allocate(n)`

2.
```
static void deallocate(Alloc & a, pointer p, size_type n);
```

Returns: `a.deallocate(p, n)`

Throws: Nothing

3.
```
static pointer allocate(Alloc & a, size_type n, const_void_pointer p);
```

Effects: calls `a.allocate(n, p)` if that call is well-formed; otherwise, invokes `a.allocate(n)`

4.
```
template<typename T> static void destroy(Alloc & a, T * p);
```

Effects: calls `a.destroy(p)` if that call is well-formed; otherwise, invokes `p->~T()`.

5.
```
static size_type max_size(const Alloc & a);
```

Returns: `a.max_size()` if that expression is well-formed; otherwise, `numeric_limits<size_type>::max()`.

6.
```
static Alloc select_on_container_copy_construction(const Alloc & a);
```

Returns: `a.select_on_container_copy_construction()` if that expression is well-formed; otherwise, a.

7.
```
template<typename T, class... Args>
  static void construct(Alloc & a, T * p, Args &&... args);
```

Effects: calls `a.construct(p, std::forward<Args>(args)...)` if that call is well-formed; otherwise, invokes `::new (static_cast<void*>(p)) T(std::forward<Args>(args)...)`

Struct template portable_rebind_alloc

allocator_traits::portable_rebind_alloc

Synopsis

```
// In header: <boost/container/allocator_traits.hpp>


template<typename T>
struct portable_rebind_alloc {
  // types
  typedef see_documentation type;
};
```

Description

Non-standard extension: Portable allocator rebind for C++03 and C++11 compilers. `type` is an allocator related to Alloc deduced deduced by rules explained in `rebind_alloc`.

Header <boost/container/container_fwd.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator = std::allocator<T> > class vector;
    template<typename T, typename Allocator = std::allocator<T> > 
      class stable_vector;
    template<typename T, typename Allocator = std::allocator<T> > class deque;
    template<typename T, typename Allocator = std::allocator<T> > class list;
    template<typename T, typename Allocator = std::allocator<T> > class slist;
    template<typename Key, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<Key> > 
      class set;
    template<typename Key, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<Key> > 
      class multiset;
    template<typename Key, typename T, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<std::pair<const Key, T> > > 
      class map;
    template<typename Key, typename T, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<std::pair<const Key, T> > > 
      class multimap;
    template<typename Key, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<Key> > 
      class flat_set;
    template<typename Key, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<Key> > 
      class flat_multiset;
    template<typename Key, typename T, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<std::pair<Key, T> > > 
      class flat_map;
    template<typename Key, typename T, typename Compare = std::less<Key>, 
             typename Allocator = std::allocator<std::pair<Key, T> > > 
      class flat_multimap;
    template<typename CharT, typename Traits = std::char_traits<CharT>, 
             typename Allocator = std::allocator<CharT> > 
      class basic_string;

    struct ordered_range_t;
    struct ordered_unique_range_t;

    static const ordered_range_t ordered_range;
    static const ordered_unique_range_t ordered_unique_range;
  }
}
```

Class template vector

boost::container::vector

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename T, typename Allocator = std::allocator<T> >
class vector {
public:
  // construct/copy/destruct
  vector();
  explicit vector(const Allocator &);
  explicit vector(size_type);
  vector(size_type, const T &);
  vector(size_type, const T &, const allocator_type &);
  template<typename InIt> vector(InIt, InIt);
  template<typename InIt> vector(InIt, InIt, const allocator_type &);
  vector(const vector &);
  vector(vector &&);
  vector(const vector &, const allocator_type &);
  vector(vector &&, const allocator_type &);
  vector& operator=(const vector &);
  vector& operator=(vector &&);
  ~vector();

  // public member functions
  template<typename InIt> void assign(InIt, InIt);
  void assign(size_type, const value_type &);
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  void resize(size_type);
  void resize(size_type, const T &);
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  reference front();
  const_reference front() const;
  reference back();
  const_reference back() const;
  reference operator[](size_type);
  const_reference operator[](size_type) const;
  reference at(size_type);
  const_reference at(size_type) const;
  T * data();
  const T * data() const;
  template<class... Args> void emplace_back(Args &&...);
  template<class... Args> iterator emplace(const_iterator, Args &&...);
  void push_back(const T &);
```

```
  void push_back(T &&);
  iterator insert(const_iterator, const T &);
  iterator insert(const_iterator, T &&);
  iterator insert(const_iterator, size_type, const T &);
  template<typename InIt> iterator insert(const_iterator, InIt, InIt);
  void pop_back();
  iterator erase(const_iterator);
  iterator erase(const_iterator, const_iterator);
  void swap(vector &);
  void clear();
};
```

Description

A vector is a sequence that supports random access to elements, constant time insertion and removal of elements at the end, and linear time insertion and removal of elements at the beginning or in the middle. The number of elements in a vector may vary dynamically; memory management is automatic. boost::container::vector is similar to std::vector but it's compatible with shared memory and memory mapped files.

`vector` public construct/copy/destruct

1.
```
vector();
```

   Effects: Constructs a vector taking the allocator as parameter.

   Throws: If allocator_type's default constructor throws.

   Complexity: Constant.

2.
```
explicit vector(const Allocator & a);
```

   Effects: Constructs a vector taking the allocator as parameter.

   Throws: Nothing

   Complexity: Constant.

3.
```
explicit vector(size_type n);
```

   Effects: Constructs a vector that will use a copy of allocator a and inserts n default contructed values.

   Throws: If allocator_type's default constructor or allocation throws or T's default constructor throws.

   Complexity: Linear to n.

4.
```
vector(size_type n, const T & value);
```

   Effects: Constructs a vector and inserts n copies of value.

   Throws: If allocator_type's default constructor or allocation throws or T's copy constructor throws.

   Complexity: Linear to n.

5.
```
vector(size_type n, const T & value, const allocator_type & a);
```

   Effects: Constructs a vector that will use a copy of allocator a and inserts n copies of value.

Throws: If allocation throws or T's copy constructor throws.

Complexity: Linear to n.

6.
```
template<typename InIt> vector(InIt first, InIt last);
```

Effects: Constructs a vector and inserts a copy of the range [first, last) in the vector.

Throws: If allocator_type's default constructor or allocation throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

7.
```
template<typename InIt>
  vector(InIt first, InIt last, const allocator_type & a);
```

Effects: Constructs a vector that will use a copy of allocator a and inserts a copy of the range [first, last) in the vector.

Throws: If allocator_type's default constructor or allocation throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

8.
```
vector(const vector & x);
```

Effects: Copy constructs a vector.

Postcondition: x == *this.

Throws: If allocator_type's default constructor or allocation throws or T's copy constructor throws.

Complexity: Linear to the elements x contains.

9.
```
vector(vector && mx);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: Nothing

Complexity: Constant.

10.
```
vector(const vector & x, const allocator_type & a);
```

defined(BOOST_CONTAINER_DOXYGEN_INVOKED)

Effects: Copy constructs a vector using the specified allocator.

Postcondition: x == *this.

Throws: If allocation throws or T's copy constructor throws.

Complexity: Linear to the elements x contains.

11.
```
vector(vector && mx, const allocator_type & a);
```

Effects: Move constructor using the specified allocator. Moves mx's resources to *this if a == allocator_type(). Otherwise copies values from x to *this.

Throws: If allocation or T's copy constructor throws.

Complexity: Constant if a == mx.get_allocator(), linear otherwise.

12.
```
vector& operator=(const vector & x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy/move constructor/assignment throws.

Complexity: Linear to the number of elements in x.

13.
```
vector& operator=(vector && x);
```

Effects: Move assignment. All mx's values are transferred to *this.

Postcondition: x.empty(). *this contains a the elements x had before the function.

Throws: Nothing

Complexity: Linear.

14.
```
~vector();
```

Effects: Destroys the vector. All stored values are destroyed and used memory is deallocated.

Throws: Nothing.

Complexity: Linear to the number of elements.

`vector` public member functions

1.
```
template<typename InIt> void assign(InIt first, InIt last);
```

Effects: Assigns the the range [first, last) to *this.

Throws: If memory allocation throws or T's copy/move constructor/assignment or T's constructor/assignment from dereferencing InpIt throws.

Complexity: Linear to n.

2.
```
void assign(size_type n, const value_type & val);
```

Effects: Assigns the n copies of val to *this.

Throws: If memory allocation throws or T's copy/move constructor/assignment throws.

Complexity: Linear to n.

3.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

4.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

5.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

6.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

8.
```
iterator end();
```

Effects: Returns an iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

12.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

13.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

14.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

15.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

16.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

17.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

18.
```
bool empty() const;
```

Effects: Returns true if the vector contains no elements.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the vector.

Throws: Nothing.

Complexity: Constant.

20.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the vector.

Throws: Nothing.

Complexity: Constant.

21.
```
void resize(size_type new_size);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

22.
```
void resize(size_type new_size, const T & x);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

23.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

24.
```
void reserve(size_type new_cap);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws or T's copy/move constructor throws.

25.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created with previous allocations. The size of the vector is unchanged

Throws: If memory allocation throws, or T's copy/move constructor throws.

Complexity: Linear to size().

26.
```
reference front();
```

Requires: !empty()

Effects: Returns a reference to the first element of the container.

Throws: Nothing.

Complexity: Constant.

27.
```
const_reference front() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element of the container.

Throws: Nothing.

Complexity: Constant.

28.
```
reference back();
```

Requires: !empty()

Effects: Returns a reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

29.
```
const_reference back() const;
```

Requires: !empty()

Effects: Returns a const reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

30.
```
reference operator[](size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

31.
```
const_reference operator[](size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

32.
```
reference at(size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

33.
```
const_reference at(size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

34.
```
T * data();
```

Returns: Allocator pointer such that [data(),data() + size()) is a valid range. For a non-empty vector, data() == &front().

Throws: Nothing.

Complexity: Constant.

35.
```
const T * data() const;
```

Returns: Allocator pointer such that [data(),data() + size()) is a valid range. For a non-empty vector, data() == &front().

Throws: Nothing.

Complexity: Constant.

36.
```
template<class... Args> void emplace_back(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the end of the vector.

Throws: If memory allocation throws or the in-place constructor throws or T's move constructor throws.

Complexity: Amortized constant time.

37.
```
template<class... Args>
  iterator emplace(const_iterator position, Args &&... args);
```

Requires: position must be a valid iterator of *this.

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... before position

Throws: If memory allocation throws or the in-place constructor throws or T's move constructor/assignment throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

38.
```
void push_back(const T & x);
```

Effects: Inserts a copy of x at the end of the vector.

Throws: If memory allocation throws or T's copy/move constructor throws.

Complexity: Amortized constant time.

39.
```
void push_back(T && x);
```

Effects: Constructs a new element in the end of the vector and moves the resources of mx to this new element.

Throws: If memory allocation throws or T's move constructor throws.

Complexity: Amortized constant time.

40.
```
iterator insert(const_iterator position, const T & x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a copy of x before position.

Throws: If memory allocation throws or T's copy/move constructor/assignment throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

41.
```
iterator insert(const_iterator position, T && x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a new element before position with mx's resources.

Throws: If memory allocation throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

42.
```
iterator insert(const_iterator p, size_type n, const T & x);
```

Requires: p must be a valid iterator of *this.

Effects: Insert n copies of x before pos.

Returns: an iterator to the first inserted element or p if n is 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

43.
```
template<typename InIt>
  iterator insert(const_iterator pos, InIt first, InIt last);
```

Requires: p must be a valid iterator of *this.

Effects: Insert a copy of the [first, last) range before pos.

Returns: an iterator to the first inserted element or pos if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InpIt throws or T's copy/move constructor/assignment throws.

Complexity: Linear to std::distance [first, last).

44.
```
void pop_back();
```

Effects: Removes the last element from the vector.

Throws: Nothing.

Complexity: Constant time.

45.
```
iterator erase(const_iterator position);
```

Effects: Erases the element at position pos.

Throws: Nothing.

Complexity: Linear to the elements between pos and the last element. Constant if pos is the last element.

46.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases the elements pointed by [first, last).

Throws: Nothing.

Complexity: Linear to the distance between first and last plus linear to the elements between pos and the last element.

47.
```
void swap(vector & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

48.
```
void clear();
```

Effects: Erases all the elements of the vector.

Throws: Nothing.

Complexity: Linear to the number of elements in the vector.

Class template stable_vector

boost::container::stable_vector

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename T, typename Allocator = std::allocator<T> >
class stable_vector {
public:
  // construct/copy/destruct
  stable_vector();
  explicit stable_vector(const allocator_type &);
  explicit stable_vector(size_type);
  stable_vector(size_type, const T &,
                const allocator_type & = allocator_type());
  template<typename InputIterator>
    stable_vector(InputIterator, InputIterator,
                  const allocator_type & = allocator_type());
  stable_vector(const stable_vector &);
  stable_vector(stable_vector &&);
  stable_vector(const stable_vector &, const allocator_type &);
  stable_vector(stable_vector &&, const allocator_type &);
  stable_vector& operator=(const stable_vector &);
  stable_vector& operator=(stable_vector &&);
  ~stable_vector();

  // public member functions
  void assign(size_type, const T &);
  template<typename InputIterator> void assign(InputIterator, InputIterator);
  allocator_type get_allocator() const;
  const stored_allocator_type & get_stored_allocator() const;
  stored_allocator_type & get_stored_allocator();
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  void resize(size_type);
  void resize(size_type, const T &);
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  reference front();
  const_reference front() const;
  reference back();
  const_reference back() const;
  reference operator[](size_type);
```

```
  const_reference operator[](size_type) const;
  reference at(size_type);
  const_reference at(size_type) const;
  template<class... Args> void emplace_back(Args &&...);
  template<class... Args> iterator emplace(const_iterator, Args &&...);
  void push_back(const T &);
  void push_back(T &&);
  iterator insert(const_iterator, const T &);
  iterator insert(const_iterator, T &&);
  iterator insert(const_iterator, size_type, const T &);
  template<typename InputIterator> 
    iterator insert(const_iterator, InputIterator, InputIterator);
  void pop_back();
  iterator erase(const_iterator);
  iterator erase(const_iterator, const_iterator);
  void swap(stable_vector &);
  void clear();
};
```

Description

Originally developed by Joaquin M. Lopez Munoz, stable_vector is a std::vector drop-in replacement implemented as a node container, offering iterator and reference stability.

Here are the details taken from the author's blog (Introducing stable_vector):

We present stable_vector, a fully STL-compliant stable container that provides most of the features of std::vector except element contiguity.

General properties: stable_vector satisfies all the requirements of a container, a reversible container and a sequence and provides all the optional operations present in std::vector. Like std::vector, iterators are random access. stable_vector does not provide element contiguity; in exchange for this absence, the container is stable, i.e. references and iterators to an element of a stable_vector remain valid as long as the element is not erased, and an iterator that has been assigned the return value of end() always remain valid until the destruction of the associated stable_vector.

Operation complexity: The big-O complexities of stable_vector operations match exactly those of std::vector. In general, insertion/deletion is constant time at the end of the sequence and linear elsewhere. Unlike std::vector, stable_vector does not internally perform any value_type destruction, copy or assignment operations other than those exactly corresponding to the insertion of new elements or deletion of stored elements, which can sometimes compensate in terms of performance for the extra burden of doing more pointer manipulation and an additional allocation per element.

Exception safety: As stable_vector does not internally copy elements around, some operations provide stronger exception safety guarantees than in std::vector.

`stable_vector` public construct/copy/destruct

1.
```
stable_vector();
```

   Effects: Default constructs a `stable_vector`.

   Throws: If allocator_type's default constructor throws.

   Complexity: Constant.

2.
```
explicit stable_vector(const allocator_type & al);
```

   Effects: Constructs a `stable_vector` taking the allocator as parameter.

   Throws: Nothing

Complexity: Constant.

3.
```
explicit stable_vector(size_type n);
```

Effects: Constructs a `stable_vector` that will use a copy of allocator a and inserts n default contructed values.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

4.
```
stable_vector(size_type n, const T & t,
              const allocator_type & al = allocator_type());
```

Effects: Constructs a `stable_vector` that will use a copy of allocator a and inserts n copies of value.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

5.
```
template<typename InputIterator>
  stable_vector(InputIterator first, InputIterator last,
                const allocator_type & al = allocator_type());
```

Effects: Constructs a `stable_vector` that will use a copy of allocator a and inserts a copy of the range [first, last) in the `stable_vector`.

Throws: If allocator_type's default constructor or copy constructor throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

6.
```
stable_vector(const stable_vector & x);
```

Effects: Copy constructs a `stable_vector`.

Postcondition: x == *this.

Complexity: Linear to the elements x contains.

7.
```
stable_vector(stable_vector && x);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

8.
```
stable_vector(const stable_vector & x, const allocator_type & a);
```

Effects: Copy constructs a `stable_vector` using the specified allocator.

Postcondition: x == *this.

Complexity: Linear to the elements x contains.

9.
```
stable_vector(stable_vector && x, const allocator_type & a);
```

Effects: Move constructor using the specified allocator. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant if a == x.get_allocator(), linear otherwise

10.
```
stable_vector& operator=(const stable_vector & x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to the number of elements in x.

11.
```
stable_vector& operator=(stable_vector && x);
```

Effects: Move assignment. All mx's values are transferred to *this.

Postcondition: x.empty(). *this contains a the elements x had before the function.

Throws: If allocator_type's copy constructor throws.

Complexity: Linear.

12.
```
~stable_vector();
```

Effects: Destroys the `stable_vector`. All stored values are destroyed and used memory is deallocated.

Throws: Nothing.

Complexity: Linear to the number of elements.

`stable_vector` public member functions

1.
```
void assign(size_type n, const T & t);
```

Effects: Assigns the n copies of val to *this.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

2.
```
template<typename InputIterator> 
  void assign(InputIterator first, InputIterator last);
```

Effects: Assigns the the range [first, last) to *this.

Throws: If memory allocation throws or T's constructor from dereferencing InpIt throws.

Complexity: Linear to n.

3.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

4.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

5.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

6.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

8.
```
iterator end();
```

Effects: Returns an iterator to the end of the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

12.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

13.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

14.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

15.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

16.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

17.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed `stable_vector`.

Throws: Nothing.

Complexity: Constant.

18.
```
bool empty() const;
```

Effects: Returns true if the `stable_vector` contains no elements.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

20.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the `stable_vector`.

Throws: Nothing.

Complexity: Constant.

21.
```
void resize(size_type n);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

22.
```
void resize(size_type n, const T & t);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

23.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

24.
```
void reserve(size_type n);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws.

25.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created with previous allocations. The size of the `stable_vector` is unchanged

Throws: If memory allocation throws.

Complexity: Linear to size().

26.
```
reference front();
```

Requires: !empty()

Effects: Returns a reference to the first element of the container.

Throws: Nothing.

Complexity: Constant.

27.
```
const_reference front() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element of the container.

Throws: Nothing.

Complexity: Constant.

28.
```
reference back();
```

Requires: !empty()

Effects: Returns a reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

29.
```
const_reference back() const;
```

Requires: !empty()

Effects: Returns a const reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

30.
```
reference operator[](size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

31.
```
const_reference operator[](size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

32.
```
reference at(size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

33.
```
const_reference at(size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

34.
```
template<class... Args> void emplace_back(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the end of the `stable_vector`.

Throws: If memory allocation throws or the in-place constructor throws.

Complexity: Amortized constant time.

35.
```
template<class... Args>
  iterator emplace(const_iterator position, Args &&... args);
```

Requires: position must be a valid iterator of *this.

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... before position

Throws: If memory allocation throws or the in-place constructor throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

36.
```
void push_back(const T & x);
```

Effects: Inserts a copy of x at the end of the `stable_vector`.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

37.
```
void push_back(T && x);
```

Effects: Constructs a new element in the end of the `stable_vector` and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

38.
```
iterator insert(const_iterator position, const T & x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a copy of x before position.

Returns: An iterator to the inserted element.

Throws: If memory allocation throws or x's copy constructor throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

39.
```
iterator insert(const_iterator position, T && x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a new element before position with mx's resources.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

40.
```
iterator insert(const_iterator position, size_type n, const T & t);
```

Requires: pos must be a valid iterator of *this.

Effects: Insert n copies of x before position.

Returns: an iterator to the first inserted element or position if n is 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

41.
```
template<typename InputIterator> 
  iterator insert(const_iterator position, InputIterator first, 
                  InputIterator last);
```

Requires: pos must be a valid iterator of *this.

Effects: Insert a copy of the [first, last) range before pos.

Returns: an iterator to the first inserted element or position if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InpIt throws or T's copy constructor throws.

Complexity: Linear to std::distance [first, last).

42.
```
void pop_back();
```

Effects: Removes the last element from the stable_vector.

Throws: Nothing.

Complexity: Constant time.

43.
```
iterator erase(const_iterator position);
```

Effects: Erases the element at position pos.

Throws: Nothing.

Complexity: Linear to the elements between pos and the last element. Constant if pos is the last element.

44.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases the elements pointed by [first, last).

Throws: Nothing.

Complexity: Linear to the distance between first and last plus linear to the elements between pos and the last element.

45.
```
void swap(stable_vector & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

46.
```
void clear();
```

Effects: Erases all the elements of the stable_vector.

Throws: Nothing.

Complexity: Linear to the number of elements in the stable_vector.

Class template deque

boost::container::deque

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename T, typename Allocator = std::allocator<T> >
class deque : protected deque_base< T, Allocator > {
public:
  // construct/copy/destruct
  deque();
  explicit deque(const allocator_type &);
  explicit deque(size_type);
  deque(size_type, const value_type &,
        const allocator_type & = allocator_type());
  template<typename InIt>
    deque(InIt, InIt, const allocator_type & = allocator_type());
  deque(const deque &);
  deque(deque &&);
  deque(const deque &, const allocator_type &);
  deque(deque &&, const allocator_type &);
  deque& operator=(const deque &);
  deque& operator=(deque &&);
  ~deque();

  // public member functions
  void assign(size_type, const T &);
  template<typename InIt> void assign(InIt, InIt);
  allocator_type get_allocator() const;
  const stored_allocator_type & get_stored_allocator() const;
  stored_allocator_type & get_stored_allocator();
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  void resize(size_type);
  void resize(size_type, const value_type &);
  void shrink_to_fit();
  reference front();
  const_reference front() const;
  reference back();
  const_reference back() const;
  reference operator[](size_type);
  const_reference operator[](size_type) const;
  reference at(size_type);
  const_reference at(size_type) const;
  template<class... Args> void emplace_front(Args &&...);
  template<class... Args> void emplace_back(Args &&...);
  template<class... Args> iterator emplace(const_iterator, Args &&...);
  void push_front(const T &);
  void push_front(T &&);
  void push_back(const T &);
  void push_back(T &&);
```

```
  iterator insert(const_iterator, const T &);
  iterator insert(const_iterator, T &&);
  iterator insert(const_iterator, size_type, const value_type &);
  template<typename InIt> iterator insert(const_iterator, InIt, InIt);
  void pop_front();
  void pop_back();
  iterator erase(const_iterator);
  iterator erase(const_iterator, const_iterator);
  void swap(deque &);
  void clear();
};
```

Description

Deque class

deque public construct/copy/destruct

1.
```
deque();
```

Effects: Default constructors a deque.

Throws: If allocator_type's default constructor throws.

Complexity: Constant.

2.
```
explicit deque(const allocator_type & a);
```

Effects: Constructs a deque taking the allocator as parameter.

Throws: Nothing

Complexity: Constant.

3.
```
explicit deque(size_type n);
```

Effects: Constructs a deque that will use a copy of allocator a and inserts n default contructed values.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

4.
```
deque(size_type n, const value_type & value,
      const allocator_type & a = allocator_type());
```

Effects: Constructs a deque that will use a copy of allocator a and inserts n copies of value.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

5.
```
template<typename InIt>
  deque(InIt first, InIt last, const allocator_type & a = allocator_type());
```

Effects: Constructs a deque that will use a copy of allocator a and inserts a copy of the range [first, last) in the deque.

Throws: If allocator_type's default constructor or copy constructor throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

6.
```
deque(const deque & x);
```

Effects: Copy constructs a deque.

Postcondition: x == *this.

Complexity: Linear to the elements x contains.

7.
```
deque(deque && x);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

8.
```
deque(const deque & x, const allocator_type & a);
```

Effects: Copy constructs a vector using the specified allocator.

Postcondition: x == *this.

Throws: If allocation throws or T's copy constructor throws.

Complexity: Linear to the elements x contains.

9.
```
deque(deque && mx, const allocator_type & a);
```

Effects: Move constructor using the specified allocator. Moves mx's resources to *this if a == allocator_type(). Otherwise copies values from x to *this.

Throws: If allocation or T's copy constructor throws.

Complexity: Constant if a == mx.get_allocator(), linear otherwise.

10.
```
deque& operator=(const deque & x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to the number of elements in x.

11.
```
deque& operator=(deque && x);
```

Effects: Move assignment. All mx's values are transferred to *this.

Postcondition: x.empty(). *this contains a the elements x had before the function.

Throws: If allocator_type's copy constructor throws.

Complexity: Linear.

12.
```
~deque();
```

Effects: Destroys the deque. All stored values are destroyed and used memory is deallocated.

Throws: Nothing.

Complexity: Linear to the number of elements.

deque public member functions

1.
```
void assign(size_type n, const T & val);
```

Effects: Assigns the n copies of val to *this.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

2.
```
template<typename InIt> void assign(InIt first, InIt last);
```

Effects: Assigns the the range [first, last) to *this.

Throws: If memory allocation throws or T's constructor from dereferencing InIt throws.

Complexity: Linear to n.

3.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

4.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

5.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

6.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the deque.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the deque.

Throws: Nothing.

Complexity: Constant.

8.
```
iterator end();
```

Effects: Returns an iterator to the end of the deque.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the deque.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed deque.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed deque.

Throws: Nothing.

Complexity: Constant.

12.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed deque.

Throws: Nothing.

Complexity: Constant.

13.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed deque.

Throws: Nothing.

Complexity: Constant.

14.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the deque.

Throws: Nothing.

Complexity: Constant.

15.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the deque.

Throws: Nothing.

Complexity: Constant.

16.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed deque.

Throws: Nothing.

Complexity: Constant.

17.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed deque.

Throws: Nothing.

Complexity: Constant.

18.
```
bool empty() const;
```

Effects: Returns true if the deque contains no elements.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the deque.

Throws: Nothing.

Complexity: Constant.

20.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the deque.

Throws: Nothing.

Complexity: Constant.

21.
```
void resize(size_type new_size);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

22.
```
void resize(size_type new_size, const value_type & x);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

23.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created with previous allocations. The size of the deque is unchanged

Throws: If memory allocation throws.

Complexity: Constant.

24.
```
reference front();
```

Requires: !empty()

Effects: Returns a reference to the first element of the container.

Throws: Nothing.

Complexity: Constant.

25.
```
const_reference front() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

26.
```
reference back();
```

Requires: !empty()

Effects: Returns a reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

27.
```
const_reference back() const;
```

Requires: !empty()

Effects: Returns a const reference to the last element of the container.

Throws: Nothing.

Complexity: Constant.

28.
```
reference operator[](size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

29.
```
const_reference operator[](size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

30.
```
reference at(size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

31.
```
const_reference at(size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

32.
```
template<class... Args> void emplace_front(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the beginning of the deque.

Throws: If memory allocation throws or the in-place constructor throws.

Complexity: Amortized constant time

33.
```
template<class... Args> void emplace_back(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the end of the deque.

Throws: If memory allocation throws or the in-place constructor throws.

Complexity: Amortized constant time

34.
```
template<class... Args> iterator emplace(const_iterator p, Args &&... args);
```

Requires: position must be a valid iterator of *this.

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... before position

Throws: If memory allocation throws or the in-place constructor throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

35.
```
void push_front(const T & x);
```

Effects: Inserts a copy of x at the front of the deque.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

36.
```
void push_front(T && x);
```

Effects: Constructs a new element in the front of the deque and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

37.
```
void push_back(const T & x);
```

Effects: Inserts a copy of x at the end of the deque.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

38.
```
void push_back(T && x);
```

Effects: Constructs a new element in the end of the deque and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

39.
```
iterator insert(const_iterator position, const T & x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a copy of x before position.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws or x's copy constructor throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

40.
```
iterator insert(const_iterator position, T && x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a new element before position with mx's resources.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws.

Complexity: If position is end(), amortized constant time Linear time otherwise.

41.
```
iterator insert(const_iterator pos, size_type n, const value_type & x);
```

Requires: pos must be a valid iterator of *this.

Effects: Insert n copies of x before pos.

Returns: an iterator to the first inserted element or pos if n is 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

42.
```
template<typename InIt>
  iterator insert(const_iterator pos, InIt first, InIt last);
```

Requires: pos must be a valid iterator of *this.

Effects: Insert a copy of the [first, last) range before pos.

Returns: an iterator to the first inserted element or pos if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InIt throws or T's copy constructor throws.

Complexity: Linear to std::distance [first, last).

43.
```
void pop_front();
```

Effects: Removes the first element from the deque.

Throws: Nothing.

Complexity: Constant time.

44.
```
void pop_back();
```

Effects: Removes the last element from the deque.

Throws: Nothing.

Complexity: Constant time.

45.
```
iterator erase(const_iterator pos);
```

Effects: Erases the element at position pos.

Throws: Nothing.

Complexity: Linear to the elements between pos and the last element (if pos is near the end) or the first element if(pos is near the beginning). Constant if pos is the first or the last element.

46.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases the elements pointed by [first, last).

Throws: Nothing.

Complexity: Linear to the distance between first and last plus the elements between pos and the last element (if pos is near the end) or the first element if(pos is near the beginning).

47.
```
void swap(deque & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

48.
```
void clear();
```

Effects: Erases all the elements of the deque.

Throws: Nothing.

Complexity: Linear to the number of elements in the deque.

Class template list

boost::container::list

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename T, typename Allocator = std::allocator<T> >
class list {
public:
  // construct/copy/destruct
  list();
  explicit list(const allocator_type &);
  explicit list(size_type);
  list(size_type, const T &, const Allocator & = Allocator());
  list(const list &);
  list(list &&);
  list(const list &, const allocator_type &);
  list(list &&, const allocator_type &);
  template<typename InpIt> list(InpIt, InpIt, const Allocator & = Allocator());
  list& operator=(const list &);
  list& operator=(list &&);
  ~list();

  // public member functions
  void assign(size_type, const T &);
  template<typename InpIt> void assign(InpIt, InpIt);
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  void resize(size_type);
  void resize(size_type, const T &);
  reference front();
  const_reference front() const;
  reference back();
  const_reference back() const;
  template<class... Args> void emplace_back(Args &&...);
  template<class... Args> void emplace_front(Args &&...);
  template<class... Args> iterator emplace(const_iterator, Args &&...);
  void push_front(const T &);
  void push_front(T &&);
  void push_back(const T &);
  void push_back(T &&);
  iterator insert(const_iterator, const T &);
  iterator insert(const_iterator, T &&);
  iterator insert(const_iterator, size_type, const T &);
  template<typename InpIt> iterator insert(const_iterator, InpIt, InpIt);
  void pop_front();
  void pop_back();
  iterator erase(const_iterator);
```

```
  iterator erase(const_iterator, const_iterator);
  void swap(list &);
  void clear();
  void splice(const_iterator, list &);
  void splice(const_iterator, list &&);
  void splice(const_iterator, list &, const_iterator);
  void splice(const_iterator, list &&, const_iterator);
  void splice(const_iterator, list &, const_iterator, const_iterator);
  void splice(const_iterator, list &&, const_iterator, const_iterator);
  void splice(const_iterator, list &, const_iterator, const_iterator,
              size_type);
  void splice(const_iterator, list &&, const_iterator, const_iterator,
              size_type);
  void remove(const T &);
  template<typename Pred> void remove_if(Pred);
  void unique();
  template<typename BinaryPredicate> void unique(BinaryPredicate);
  void merge(list &);
  void merge(list &&);
  template<typename StrictWeakOrdering>
    void merge(list &, const StrictWeakOrdering &);
  template<typename StrictWeakOrdering>
    void merge(list &&, StrictWeakOrdering);
  void sort();
  template<typename StrictWeakOrdering> void sort(StrictWeakOrdering);
  void reverse();
};
```

Description

A list is a doubly linked list. That is, it is a Sequence that supports both forward and backward traversal, and (amortized) constant time insertion and removal of elements at the beginning or the end, or in the middle. Lists have the important property that insertion and splicing do not invalidate iterators to list elements, and that even removal invalidates only the iterators that point to the elements that are removed. The ordering of iterators may be changed (that is, list<T>::iterator might have a different predecessor or successor after a list operation than it did before), but the iterators themselves will not be invalidated or made to point to different elements unless that invalidation or mutation is explicit.

`list` public construct/copy/destruct

1.
```
list();
```

Effects: Default constructs a list.

Throws: If allocator_type's default constructor throws.

Complexity: Constant.

2.
```
explicit list(const allocator_type & a);
```

Effects: Constructs a list taking the allocator as parameter.

Throws: Nothing

Complexity: Constant.

3.
```
explicit list(size_type n);
```

Effects: Constructs a list that will use a copy of allocator a and inserts n copies of value.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

4.
```
list(size_type n, const T & value, const Allocator & a = Allocator());
```

Effects: Constructs a list that will use a copy of allocator a and inserts n copies of value.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

5.
```
list(const list & x);
```

Effects: Copy constructs a list.

Postcondition: x == *this.

Throws: If allocator_type's default constructor or copy constructor throws.

Complexity: Linear to the elements x contains.

6.
```
list(list && x);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

7.
```
list(const list & x, const allocator_type & a);
```

Effects: Copy constructs a list using the specified allocator.

Postcondition: x == *this.

Throws: If allocator_type's default constructor or copy constructor throws.

Complexity: Linear to the elements x contains.

8.
```
list(list && x, const allocator_type & a);
```

Effects: Move constructor sing the specified allocator. Moves mx's resources to *this.

Throws: If allocation or value_type's copy constructor throws.

Complexity: Constant if a == x.get_allocator(), linear otherwise.

9.
```
template<typename InpIt>
  list(InpIt first, InpIt last, const Allocator & a = Allocator());
```

Effects: Constructs a list that will use a copy of allocator a and inserts a copy of the range [first, last) in the list.

Throws: If allocator_type's default constructor or copy constructor throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

10.
```
list& operator=(const list & x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to the number of elements in x.

11.
```
list& operator=(list && x);
```

Effects: Move assignment. All mx's values are transferred to *this.

Postcondition: x.empty(). *this contains a the elements x had before the function.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

12.
```
~list();
```

Effects: Destroys the list. All stored values are destroyed and used memory is deallocated.

Throws: Nothing.

Complexity: Linear to the number of elements.

`list` public member functions

1.
```
void assign(size_type n, const T & val);
```

Effects: Assigns the n copies of val to *this.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

2.
```
template<typename InpIt> void assign(InpIt first, InpIt last);
```

Effects: Assigns the the range [first, last) to *this.

Throws: If memory allocation throws or T's constructor from dereferencing InpIt throws.

Complexity: Linear to n.

3.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

4.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

5.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

6.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

8.
```
iterator end();
```

Effects: Returns an iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed list.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed list.

Throws: Nothing.

Complexity: Constant.

12.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed list.

Throws: Nothing.

Complexity: Constant.

13.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed list.

Throws: Nothing.

Complexity: Constant.

14.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

15.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

16.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed list.

Throws: Nothing.

Complexity: Constant.

17.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed list.

Throws: Nothing.

Complexity: Constant.

18.
```
bool empty() const;
```

Effects: Returns true if the list contains no elements.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the list.

Throws: Nothing.

Complexity: Constant.

20.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the list.

Throws: Nothing.

Complexity: Constant.

21.
```
void resize(size_type new_size);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

22.
```
void resize(size_type new_size, const T & x);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

23.
```
reference front();
```

Requires: !empty()

Effects: Returns a reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

24.
```
const_reference front() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

25.
```
reference back();
```

Requires: !empty()

Effects: Returns a reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

26.
```
const_reference back() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

27.
```
template<class... Args> void emplace_back(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the end of the list.

Throws: If memory allocation throws or T's in-place constructor throws.

Complexity: Constant

28.
```
template<class... Args> void emplace_front(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the beginning of the list.

Throws: If memory allocation throws or T's in-place constructor throws.

Complexity: Constant

29.
```
template<class... Args> iterator emplace(const_iterator p, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... before p.

Throws: If memory allocation throws or T's in-place constructor throws.

Complexity: Constant

30.
```
void push_front(const T & x);
```

Effects: Inserts a copy of x at the beginning of the list.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

31.
```
void push_front(T && x);
```

Effects: Constructs a new element in the beginning of the list and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

32.
```
void push_back(const T & x);
```

Effects: Inserts a copy of x at the end of the list.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

33.
```
void push_back(T && x);
```

Effects: Constructs a new element in the end of the list and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

34.
```
iterator insert(const_iterator position, const T & x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a copy of x before position.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws or x's copy constructor throws.

Complexity: Amortized constant time.

35.
```
iterator insert(const_iterator position, T && x);
```

Requires: position must be a valid iterator of *this.

Effects: Insert a new element before position with mx's resources.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

36.
```
iterator insert(const_iterator p, size_type n, const T & x);
```

Requires: p must be a valid iterator of *this.

Effects: Inserts n copies of x before p.

Returns: an iterator to the first inserted element or p if n is 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

37.
```
template<typename InpIt>
  iterator insert(const_iterator p, InpIt first, InpIt last);
```

Requires: p must be a valid iterator of *this.

Effects: Insert a copy of the [first, last) range before p.

Returns: an iterator to the first inserted element or p if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InpIt throws.

Complexity: Linear to std::distance [first, last).

38.
```
void pop_front();
```

Effects: Removes the first element from the list.

Throws: Nothing.

Complexity: Amortized constant time.

39.
```
void pop_back();
```

Effects: Removes the last element from the list.

Throws: Nothing.

Complexity: Amortized constant time.

40.
```
iterator erase(const_iterator p);
```

Requires: p must be a valid iterator of *this.

Effects: Erases the element at p p.

Throws: Nothing.

Complexity: Amortized constant time.

41.
```
iterator erase(const_iterator first, const_iterator last);
```

Requires: first and last must be valid iterator to elements in *this.

Effects: Erases the elements pointed by [first, last).

Throws: Nothing.

Complexity: Linear to the distance between first and last.

42.
```
void swap(list & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

43.
```
void clear();
```

Effects: Erases all the elements of the list.

Throws: Nothing.

Complexity: Linear to the number of elements in the list.

44.
```
void splice(const_iterator p, list & x);
```

Requires: p must point to an element contained by the list. x != *this. this' allocator and x's allocator shall compare equal

Effects: Transfers all the elements of list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

45.
```
void splice(const_iterator p, list && x);
```

Requires: p must point to an element contained by the list. x != *this. this' allocator and x's allocator shall compare equal

Effects: Transfers all the elements of list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

46.
```
void splice(const_iterator p, list & x, const_iterator i);
```

Requires: p must point to an element contained by this list. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal

Effects: Transfers the value pointed by i, from list x to this list, before the the element pointed by p. No destructors or copy constructors are called. If p == i or p == ++i, this function is a null operation.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

47.
```
void splice(const_iterator p, list && x, const_iterator i);
```

Requires: p must point to an element contained by this list. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal.

Effects: Transfers the value pointed by i, from list x to this list, before the the element pointed by p. No destructors or copy constructors are called. If p == i or p == ++i, this function is a null operation.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

48.
```
void splice(const_iterator p, list & x, const_iterator first,
            const_iterator last);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x. this' allocator and x's allocator shall compare equal

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Linear to the number of elements transferred.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

49.
```
void splice(const_iterator p, list && x, const_iterator first,
            const_iterator last);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x. this' allocator and x's allocator shall compare equal.

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Linear to the number of elements transferred.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

50.
```
void splice(const_iterator p, list & x, const_iterator first,
            const_iterator last, size_type n);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x. n == std::distance(first, last). this' allocator and x's allocator shall compare equal

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

Note: Non-standard extension

51.
```
void splice(const_iterator p, list && x, const_iterator first,
            const_iterator last, size_type n);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x. n == std::distance(first, last). this' allocator and x's allocator shall compare equal

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

Note: Non-standard extension

52.
```
void remove(const T & value);
```

Effects: Removes all the elements that compare equal to value.

Throws: If comparison throws.

Complexity: Linear time. It performs exactly size() comparisons for equality.

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

53.
```
template<typename Pred> void remove_if(Pred pred);
```

Effects: Removes all the elements for which a specified predicate is satisfied.

Throws: If pred throws.

Complexity: Linear time. It performs exactly size() calls to the predicate.

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

54.
```
void unique();
```

Effects: Removes adjacent duplicate elements or adjacent elements that are equal from the list.

Throws: If comparison throws.

Complexity: Linear time (size()-1 comparisons equality comparisons).

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

55.
```
template<typename BinaryPredicate> void unique(BinaryPredicate binary_pred);
```

Effects: Removes adjacent duplicate elements or adjacent elements that satisfy some binary predicate from the list.

Throws: If pred throws.

Complexity: Linear time (size()-1 comparisons calls to pred()).

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

56.
```
void merge(list & x);
```

Requires: The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this according to std::less<value_type>. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comparison throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

57.
```
void merge(list && x);
```

Requires: The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this according to std::less<value_type>. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comparison throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

58.
```
template<typename StrictWeakOrdering> 
  void merge(list & x, const StrictWeakOrdering & comp);
```

Requires: p must be a comparison function that induces a strict weak ordering and both *this and x must be sorted according to that ordering The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comp throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

Note: Iterators and references to *this are not invalidated.

59.
```
template<typename StrictWeakOrdering> 
  void merge(list && x, StrictWeakOrdering comp);
```

Requires: p must be a comparison function that induces a strict weak ordering and both *this and x must be sorted according to that ordering The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comp throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

Note: Iterators and references to *this are not invalidated.

60.
```
void sort();
```

Effects: This function sorts the list *this according to std::less<value_type>. The sort is stable, that is, the relative order of equivalent elements is preserved.

Throws: If comparison throws.

Notes: Iterators and references are not invalidated.

Complexity: The number of comparisons is approximately N log N, where N is the list's size.

61.
```
template<typename StrictWeakOrdering> void sort(StrictWeakOrdering comp);
```

Effects: This function sorts the list *this according to std::less<value_type>. The sort is stable, that is, the relative order of equivalent elements is preserved.

Throws: If comp throws.

Notes: Iterators and references are not invalidated.

Complexity: The number of comparisons is approximately N log N, where N is the list's size.

62.
```
void reverse();
```

Effects: Reverses the order of elements in the list.

Throws: Nothing.

Complexity: This function is linear time.

Note: Iterators and references are not invalidated

Class template slist

boost::container::slist

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename T, typename Allocator = std::allocator<T> >
class slist {
public:
  // construct/copy/destruct
  slist();
  explicit slist(const allocator_type &);
  explicit slist(size_type);
  explicit slist(size_type, const value_type &,
                 const allocator_type & = allocator_type());
  template<typename InpIt>
    slist(InpIt, InpIt, const allocator_type & = allocator_type());
  slist(const slist &);
  slist(slist &&);
  slist(const slist &, const allocator_type &);
  slist(slist &&, const allocator_type &);
  slist& operator=(const slist &);
  slist& operator=(slist &&);
  ~slist();

  // public member functions
  void assign(size_type, const T &);
  template<typename InpIt> void assign(InpIt, InpIt);
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator before_begin();
  const_iterator before_begin() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  const_iterator cbefore_begin() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  iterator previous(iterator);
  const_iterator previous(const_iterator);
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  void resize(size_type);
  void resize(size_type, const T &);
  reference front();
  const_reference front() const;
  template<class... Args> void emplace_front(Args &&...);
  template<class... Args> iterator emplace_after(const_iterator, Args &&...);
  void push_front(const T &);
  void push_front(T &&);
  iterator insert_after(const_iterator, const T &);
  iterator insert_after(const_iterator, T &&);
  iterator insert_after(const_iterator, size_type, const value_type &);
  template<typename InpIt> iterator insert_after(const_iterator, InpIt, InpIt);
  void pop_front();
  iterator erase_after(const_iterator);
  iterator erase_after(const_iterator, const_iterator);
  void swap(slist &);
  void clear();
  void splice_after(const_iterator, slist &);
  void splice_after(const_iterator, slist &&);
```

```
  void splice_after(const_iterator, slist &, const_iterator);
  void splice_after(const_iterator, slist &&, const_iterator);
  void splice_after(const_iterator, slist &, const_iterator, const_iterator);
  void splice_after(const_iterator, slist &&, const_iterator, const_iterator);
  void splice_after(const_iterator, slist &, const_iterator, const_iterator, 
                    size_type);
  void splice_after(const_iterator, slist &&, const_iterator, const_iterator, 
                    size_type);
  void remove(const T &);
  template<typename Pred> void remove_if(Pred);
  void unique();
  template<typename Pred> void unique(Pred);
  void merge(slist &);
  void merge(slist &&);
  template<typename StrictWeakOrdering> 
    void merge(slist &, StrictWeakOrdering);
  template<typename StrictWeakOrdering> 
    void merge(slist &&, StrictWeakOrdering);
  void sort();
  template<typename StrictWeakOrdering> void sort(StrictWeakOrdering);
  void reverse();
  template<class... Args> iterator emplace(const_iterator, Args &&...);
  iterator insert(const_iterator, const T &);
  iterator insert(const_iterator, T &&);
  iterator insert(const_iterator, size_type, const value_type &);
  template<typename InIter> iterator insert(const_iterator, InIter, InIter);
  iterator erase(const_iterator);
  iterator erase(const_iterator, const_iterator);
  void splice(const_iterator, slist &);
  void splice(const_iterator, slist &&);
  void splice(const_iterator, slist &, const_iterator);
  void splice(const_iterator, slist &&, const_iterator);
  void splice(const_iterator, slist &, const_iterator, const_iterator);
  void splice(const_iterator, slist &&, const_iterator, const_iterator);
};
```

Description

An slist is a singly linked list: a list where each element is linked to the next element, but not to the previous element. That is, it is a Sequence that supports forward but not backward traversal, and (amortized) constant time insertion and removal of elements. Slists, like lists, have the important property that insertion and splicing do not invalidate iterators to list elements, and that even removal invalidates only the iterators that point to the elements that are removed. The ordering of iterators may be changed (that is, slist<T>::iterator might have a different predecessor or successor after a list operation than it did before), but the iterators themselves will not be invalidated or made to point to different elements unless that invalidation or mutation is explicit.

The main difference between slist and list is that list's iterators are bidirectional iterators, while slist's iterators are forward iterators. This means that slist is less versatile than list; frequently, however, bidirectional iterators are unnecessary. You should usually use slist unless you actually need the extra functionality of list, because singly linked lists are smaller and faster than double linked lists.

Important performance note: like every other Sequence, slist defines the member functions insert and erase. Using these member functions carelessly, however, can result in disastrously slow programs. The problem is that insert's first argument is an iterator p, and that it inserts the new element(s) before p. This means that insert must find the iterator just before p; this is a constant-time operation for list, since list has bidirectional iterators, but for slist it must find that iterator by traversing the list from the beginning up to p. In other words: insert and erase are slow operations anywhere but near the beginning of the slist.

Slist provides the member functions insert_after and erase_after, which are constant time operations: you should always use insert_after and erase_after whenever possible. If you find that insert_after and erase_after aren't adequate for your needs, and that you often need to use insert and erase in the middle of the list, then you should probably use list instead of slist.

`slist` public construct/copy/destruct

1.
```
slist();
```

Effects: Constructs a list taking the allocator as parameter.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

2.
```
explicit slist(const allocator_type & a);
```

Effects: Constructs a list taking the allocator as parameter.

Throws: Nothing

Complexity: Constant.

3.
```
explicit slist(size_type n);
```

4.
```
explicit slist(size_type n, const value_type & x,
               const allocator_type & a = allocator_type());
```

Effects: Constructs a list that will use a copy of allocator a and inserts n copies of value.

Throws: If allocator_type's default constructor or copy constructor throws or T's default or copy constructor throws.

Complexity: Linear to n.

5.
```
template<typename InpIt>
  slist(InpIt first, InpIt last, const allocator_type & a = allocator_type());
```

Effects: Constructs a list that will use a copy of allocator a and inserts a copy of the range [first, last) in the list.

Throws: If allocator_type's default constructor or copy constructor throws or T's constructor taking an dereferenced InIt throws.

Complexity: Linear to the range [first, last).

6.
```
slist(const slist & x);
```

Effects: Copy constructs a list.

Postcondition: x == *this.

Throws: If allocator_type's default constructor or copy constructor throws.

Complexity: Linear to the elements x contains.

7.
```
slist(slist && x);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

8.
```
slist(const slist & x, const allocator_type & a);
```

Effects: Copy constructs a list using the specified allocator.

Postcondition: x == *this.

Throws: If allocator_type's default constructor or copy constructor throws.

Complexity: Linear to the elements x contains.

9.
```
slist(slist && x, const allocator_type & a);
```

Effects: Move constructor using the specified allocator. Moves x's resources to *this.

Throws: If allocation or value_type's copy constructor throws.

Complexity: Constant if a == x.get_allocator(), linear otherwise.

10.
```
slist& operator=(const slist & x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to the number of elements in x.

11.
```
slist& operator=(slist && x);
```

Effects: Makes *this contain the same elements as x.

Postcondition: this->size() == x.size(). *this contains a copy of each of x's elements.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to the number of elements in x.

12.
```
~slist();
```

Effects: Destroys the list. All stored values are destroyed and used memory is deallocated.

Throws: Nothing.

Complexity: Linear to the number of elements.

`slist` public member functions

1.
```
void assign(size_type n, const T & val);
```

Effects: Assigns the n copies of val to *this.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

2.
```
template<typename InpIt> void assign(InpIt first, InpIt last);
```

Effects: Assigns the range [first, last) to *this.

Throws: If memory allocation throws or T's constructor from dereferencing InpIt throws.

Complexity: Linear to n.

3.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

4.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

5.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

6.
```
iterator before_begin();
```

Effects: Returns a non-dereferenceable iterator that, when incremented, yields begin(). This iterator may be used as the argument to insert_after, erase_after, etc.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator before_begin() const;
```

Effects: Returns a non-dereferenceable const_iterator that, when incremented, yields begin(). This iterator may be used as the argument to insert_after, erase_after, etc.

Throws: Nothing.

Complexity: Constant.

8.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

10.
```
iterator end();
```

Effects: Returns an iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

11.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbefore_begin() const;
```

Effects: Returns a non-dereferenceable const_iterator that, when incremented, yields begin(). This iterator may be used as the argument to insert_after, erase_after, etc.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the list.

Throws: Nothing.

Complexity: Constant.

14.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the list.

Throws: Nothing.

Complexity: Constant.

15.
```
iterator previous(iterator p);
```

Returns: The iterator to the element before i in the sequence. Returns the end-iterator, if either i is the begin-iterator or the sequence is empty.

Throws: Nothing.

Complexity: Linear to the number of elements before i.

Note: Non-standard extension.

16.
```
const_iterator previous(const_iterator p);
```

Returns: The const_iterator to the element before i in the sequence. Returns the end-const_iterator, if either i is the begin-const_iterator or the sequence is empty.

Throws: Nothing.

Complexity: Linear to the number of elements before i.

Note: Non-standard extension.

17.
```
bool empty() const;
```

Effects: Returns true if the list contains no elements.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the list.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the list.

Throws: Nothing.

Complexity: Constant.

20.
```
void resize(size_type new_size);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

21.
```
void resize(size_type new_size, const T & x);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to the difference between size() and new_size.

22.
```
reference front();
```

Requires: !empty()

Effects: Returns a reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

23.
```
const_reference front() const;
```

Requires: !empty()

Effects: Returns a const reference to the first element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

24.
```
template<class... Args> void emplace_front(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the front of the list

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

25.
```
template<class... Args>
  iterator emplace_after(const_iterator prev, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... after prev

Throws: If memory allocation throws or T's in-place constructor throws.

Complexity: Constant

26.
```
void push_front(const T & x);
```

Effects: Inserts a copy of x at the beginning of the list.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

27.
```
void push_front(T && x);
```

Effects: Constructs a new element in the beginning of the list and moves the resources of mx to this new element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

28.
```
iterator insert_after(const_iterator prev_pos, const T & x);
```

Requires: p must be a valid iterator of *this.

Effects: Inserts a copy of the value after the position pointed by prev_p.

Returns: An iterator to the inserted element.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Amortized constant time.

Note: Does not affect the validity of iterators and references of previous values.

29.
```
iterator insert_after(const_iterator prev_pos, T && x);
```

Requires: prev_pos must be a valid iterator of *this.

Effects: Inserts a move constructed copy object from the value after the p pointed by prev_pos.

Returns: An iterator to the inserted element.

Throws: If memory allocation throws.

Complexity: Amortized constant time.

Note: Does not affect the validity of iterators and references of previous values.

30.
```
iterator insert_after(const_iterator prev_pos, size_type n,
                      const value_type & x);
```

Requires: prev_pos must be a valid iterator of *this.

Effects: Inserts n copies of x after prev_pos.

Returns: an iterator to the last inserted element or prev_pos if n is 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n.

Note: Does not affect the validity of iterators and references of previous values.

31.
```
template<typename InpIt>
  iterator insert_after(const_iterator prev_pos, InpIt first, InpIt last);
```

Requires: prev_pos must be a valid iterator of *this.

Effects: Inserts the range pointed by [first, last) after the position prev_pos.

Returns: an iterator to the last inserted element or prev_pos if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InpIt throws.

Complexity: Linear to the number of elements inserted.

Note: Does not affect the validity of iterators and references of previous values.

32.
```
void pop_front();
```

Effects: Removes the first element from the list.

Throws: Nothing.

Complexity: Amortized constant time.

33.
```
iterator erase_after(const_iterator prev_pos);
```

Effects: Erases the element after the element pointed by prev_pos of the list.

Returns: the first element remaining beyond the removed elements, or end() if no such element exists.

Throws: Nothing.

Complexity: Constant.

Note: Does not invalidate iterators or references to non erased elements.

34.
```
iterator erase_after(const_iterator before_first, const_iterator last);
```

Effects: Erases the range (before_first, last) from the list.

Returns: the first element remaining beyond the removed elements, or end() if no such element exists.

Throws: Nothing.

Complexity: Linear to the number of erased elements.

Note: Does not invalidate iterators or references to non erased elements.

35.
```
void swap(slist & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Linear to the number of elements on *this and x.

36.
```
void clear();
```

Effects: Erases all the elements of the list.

Throws: Nothing.

Complexity: Linear to the number of elements in the list.

37.
```
void splice_after(const_iterator prev_pos, slist & x);
```

Requires: p must point to an element contained by the list. x != *this

Effects: Transfers all the elements of list x to this list, after the the element pointed by p. No destructors or copy constructors are called.

Throws: std::runtime_error if this' allocator and x's allocator are not equal.

Complexity: Linear to the elements in x.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

38.
```
void splice_after(const_iterator prev_pos, slist && x);
```

Requires: p must point to an element contained by the list. x != *this

Effects: Transfers all the elements of list x to this list, after the the element pointed by p. No destructors or copy constructors are called.

Throws: std::runtime_error if this' allocator and x's allocator are not equal.

Complexity: Linear to the elements in x.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

39.
```
void splice_after(const_iterator prev_pos, slist & x, const_iterator prev);
```

Requires: prev_pos must be a valid iterator of this. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal.

Effects: Transfers the value pointed by i, from list x to this list, after the element pointed by prev_pos. If prev_pos == prev or prev_pos == ++prev, this function is a null operation.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

40.
```
void splice_after(const_iterator prev_pos, slist && x, const_iterator prev);
```

Requires: prev_pos must be a valid iterator of this. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal.

Effects: Transfers the value pointed by i, from list x to this list, after the element pointed by prev_pos. If prev_pos == prev or prev_pos == ++prev, this function is a null operation.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

41.
```
void splice_after(const_iterator prev_pos, slist & x,
                  const_iterator before_first, const_iterator before_last);
```

Requires: prev_pos must be a valid iterator of this. before_first and before_last must be valid iterators of x. prev_pos must not be contained in [before_first, before_last) range. this' allocator and x's allocator shall compare equal.

Effects: Transfers the range [before_first + 1, before_last + 1) from list x to this list, after the element pointed by prev_pos.

Throws: Nothing

Complexity: Linear to the number of transferred elements.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

42.
```
void splice_after(const_iterator prev_pos, slist && x,
                  const_iterator before_first, const_iterator before_last);
```

Requires: prev_pos must be a valid iterator of this. before_first and before_last must be valid iterators of x. prev_pos must not be contained in [before_first, before_last) range. this' allocator and x's allocator shall compare equal.

Effects: Transfers the range [before_first + 1, before_last + 1) from list x to this list, after the element pointed by prev_pos.

Throws: Nothing

Complexity: Linear to the number of transferred elements.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

43.
```
void splice_after(const_iterator prev_pos, slist & x,
                  const_iterator before_first, const_iterator before_last,
                  size_type n);
```

Requires: prev_pos must be a valid iterator of this. before_first and before_last must be valid iterators of x. prev_pos must not be contained in [before_first, before_last) range. n == std::distance(before_first, before_last). this' allocator and x's allocator shall compare equal.

Effects: Transfers the range [before_first + 1, before_last + 1) from list x to this list, after the element pointed by prev_pos.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

44.
```
void splice_after(const_iterator prev_pos, slist && x,
                  const_iterator before_first, const_iterator before_last,
                  size_type n);
```

Requires: prev_pos must be a valid iterator of this. before_first and before_last must be valid iterators of x. prev_pos must not be contained in [before_first, before_last) range. n == std::distance(before_first, before_last). this' allocator and x's allocator shall compare equal.

Effects: Transfers the range [before_first + 1, before_last + 1) from list x to this list, after the element pointed by prev_pos.

Throws: Nothing

Complexity: Constant.

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

45.
```
void remove(const T & value);
```

Effects: Removes all the elements that compare equal to value.

Throws: Nothing.

Complexity: Linear time. It performs exactly size() comparisons for equality.

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

46.
```
template<typename Pred> void remove_if(Pred pred);
```

Effects: Removes all the elements for which a specified predicate is satisfied.

Throws: If pred throws.

Complexity: Linear time. It performs exactly size() calls to the predicate.

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

47.
```
void unique();
```

Effects: Removes adjacent duplicate elements or adjacent elements that are equal from the list.

Throws: If comparison throws.

Complexity: Linear time (size()-1 comparisons equality comparisons).

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

48.
```
template<typename Pred> void unique(Pred pred);
```

Effects: Removes adjacent duplicate elements or adjacent elements that satisfy some binary predicate from the list.

Throws: If pred throws.

Complexity: Linear time (size()-1 comparisons calls to pred()).

Note: The relative order of elements that are not removed is unchanged, and iterators to elements that are not removed remain valid.

49.
```
void merge(slist & x);
```

Requires: The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this according to std::less<value_type>. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comparison throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

50.
```
void merge(slist && x);
```

Requires: The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this according to std::less<value_type>. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comparison throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

51.
```
template<typename StrictWeakOrdering>
  void merge(slist & x, StrictWeakOrdering comp);
```

Requires: p must be a comparison function that induces a strict weak ordering and both *this and x must be sorted according to that ordering The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comp throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

Note: Iterators and references to *this are not invalidated.

52.
```
template<typename StrictWeakOrdering>
  void merge(slist && x, StrictWeakOrdering comp);
```

Requires: p must be a comparison function that induces a strict weak ordering and both *this and x must be sorted according to that ordering The lists x and *this must be distinct.

Effects: This function removes all of x's elements and inserts them in order into *this. The merge is stable; that is, if an element from *this is equivalent to one from x, then the element from *this will precede the one from x.

Throws: If comp throws.

Complexity: This function is linear time: it performs at most size() + x.size() - 1 comparisons.

Note: Iterators and references to *this are not invalidated.

53.
```
void sort();
```

Effects: This function sorts the list *this according to std::less<value_type>. The sort is stable, that is, the relative order of equivalent elements is preserved.

Throws: If comparison throws.

Notes: Iterators and references are not invalidated.

Complexity: The number of comparisons is approximately N log N, where N is the list's size.

54.
```
template<typename StrictWeakOrdering> void sort(StrictWeakOrdering comp);
```

Effects: This function sorts the list *this according to std::less<value_type>. The sort is stable, that is, the relative order of equivalent elements is preserved.

Throws: If comp throws.

Notes: Iterators and references are not invalidated.

Complexity: The number of comparisons is approximately N log N, where N is the list's size.

55.
```
void reverse();
```

Effects: Reverses the order of elements in the list.

Throws: Nothing.

Complexity: This function is linear time.

Note: Iterators and references are not invalidated

56.
```
template<class... Args> iterator emplace(const_iterator p, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... before p

Throws: If memory allocation throws or T's in-place constructor throws.

Complexity: Linear to the elements before p

57.
```
iterator insert(const_iterator position, const T & x);
```

Requires: p must be a valid iterator of *this.

Effects: Insert a copy of x before p.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws or x's copy constructor throws.

Complexity: Linear to the elements before p.

58.
```
iterator insert(const_iterator prev_pos, T && x);
```

Requires: p must be a valid iterator of *this.

Effects: Insert a new element before p with mx's resources.

Returns: an iterator to the inserted element.

Throws: If memory allocation throws.

Complexity: Linear to the elements before p.

59.
```
iterator insert(const_iterator p, size_type n, const value_type & x);
```

Requires: p must be a valid iterator of *this.

Effects: Inserts n copies of x before p.

Returns: an iterator to the first inserted element or p if n == 0.

Throws: If memory allocation throws or T's copy constructor throws.

Complexity: Linear to n plus linear to the elements before p.

60.
```
template<typename InIter>
  iterator insert(const_iterator p, InIter first, InIter last);
```

Requires: p must be a valid iterator of *this.

Effects: Insert a copy of the [first, last) range before p.

Returns: an iterator to the first inserted element or p if first == last.

Throws: If memory allocation throws, T's constructor from a dereferenced InpIt throws.

Complexity: Linear to std::distance [first, last) plus linear to the elements before p.

61.
```
iterator erase(const_iterator p);
```

Requires: p must be a valid iterator of *this.

Effects: Erases the element at p p.

Throws: Nothing.

Complexity: Linear to the number of elements before p.

62.
```
iterator erase(const_iterator first, const_iterator last);
```

Requires: first and last must be valid iterator to elements in *this.

Effects: Erases the elements pointed by [first, last).

Throws: Nothing.

Complexity: Linear to the distance between first and last plus linear to the elements before first.

63.
```
void splice(const_iterator p, slist & x);
```

Requires: p must point to an element contained by the list. x != *this. this' allocator and x's allocator shall compare equal

Effects: Transfers all the elements of list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Linear in distance(begin(), p), and linear in x.size().

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

64.
```
void splice(const_iterator p, slist && x);
```

Requires: p must point to an element contained by the list. x != *this. this' allocator and x's allocator shall compare equal

Effects: Transfers all the elements of list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Linear in distance(begin(), p), and linear in x.size().

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

65.
```
void splice(const_iterator p, slist & x, const_iterator i);
```

Requires: p must point to an element contained by this list. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal

Effects: Transfers the value pointed by i, from list x to this list, before the the element pointed by p. No destructors or copy constructors are called. If p == i or p == ++i, this function is a null operation.

Throws: Nothing

Complexity: Linear in distance(begin(), p), and in distance(x.begin(), i).

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

66.
```
void splice(const_iterator p, slist && x, const_iterator i);
```

Requires: p must point to an element contained by this list. i must point to an element contained in list x. this' allocator and x's allocator shall compare equal.

Effects: Transfers the value pointed by i, from list x to this list, before the the element pointed by p. No destructors or copy constructors are called. If p == i or p == ++i, this function is a null operation.

Throws: Nothing

Complexity: Linear in distance(begin(), p), and in distance(x.begin(), i).

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

67.
```
void splice(const_iterator p, slist & x, const_iterator first,
            const_iterator last);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x.

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called. this' allocator and x's allocator shall compare equal.

Throws: Nothing

Complexity: Linear in distance(begin(), p), in distance(x.begin(), first), and in distance(first, last).

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

68.
```
void splice(const_iterator p, slist && x, const_iterator first,
            const_iterator last);
```

Requires: p must point to an element contained by this list. first and last must point to elements contained in list x. this' allocator and x's allocator shall compare equal

Effects: Transfers the range pointed by first and last from list x to this list, before the the element pointed by p. No destructors or copy constructors are called.

Throws: Nothing

Complexity: Linear in distance(begin(), p), in distance(x.begin(), first), and in distance(first, last).

Note: Iterators of values obtained from list x now point to elements of this list. Iterators of this list and all the references are not invalidated.

Class template set

boost::container::set

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<Key> >
class set {
public:
  // construct/copy/destruct
  set();
  explicit set(const Compare &, const allocator_type & = allocator_type());
  template<typename InputIterator>
    set(InputIterator, InputIterator, const Compare & = Compare(),
        const allocator_type & = allocator_type());
  template<typename InputIterator>
    set(ordered_unique_range_t, InputIterator, InputIterator,
        const Compare & = Compare(),
        const allocator_type & = allocator_type());
  set(const set &);
  set(set &&);
  set(const set &, const allocator_type &);
  set(set &&, const allocator_type &);
  set& operator=(const set &);
  set& operator=(set &&);

  // public member functions
  allocator_type get_allocator() const;
  const stored_allocator_type & get_stored_allocator() const;
  stored_allocator_type & get_stored_allocator();
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  template<class... Args> std::pair< iterator, bool > emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  std::pair< iterator, bool > insert(const value_type &);
  std::pair< iterator, bool > insert(value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  iterator erase(const_iterator);
```

```
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(set &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator > 
  equal_range(const key_type &) const;
};
```

Description

A set is a kind of associative container that supports unique keys (contains at most one of each key value) and provides for fast retrieval of the keys themselves. Class set supports bidirectional iterators.

A set satisfies all of the requirements of a container and of a reversible container , and of an associative container. A set also provides most operations described in for unique keys.

`set` public construct/copy/destruct

1.
```
set();
```

   Effects: Default constructs an empty set.

   Complexity: Constant.

2.
```
explicit set(const Compare & comp, 
             const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty set using the specified comparison object and allocator.

   Complexity: Constant.

3.
```
template<typename InputIterator> 
  set(InputIterator first, InputIterator last, 
      const Compare & comp = Compare(), 
      const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty set using the specified comparison object and allocator, and inserts elements from the range [first ,last).

   Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator> 
  set(ordered_unique_range_t, InputIterator first, InputIterator last, 
      const Compare & comp = Compare(), 
      const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty set using the specified comparison object and allocator, and inserts elements from the ordered unique range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate and must be unique values.

Complexity: Linear in N.

5.
```
set(const set & x);
```

Effects: Copy constructs a set.

Complexity: Linear in x.size().

6.
```
set(set && x);
```

Effects: Move constructs a set. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
set(const set & x, const allocator_type & a);
```

Effects: Copy constructs a set using the specified allocator.

Complexity: Linear in x.size().

8.
```
set(set && x, const allocator_type & a);
```

Effects: Move constructs a set using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if a == x.get_allocator(), linear otherwise.

9.
```
set& operator=(const set & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
set& operator=(set && x);
```

Effects: this->swap(x.get()).

Complexity: Constant.

`set` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
template<class... Args> std::pair< iterator, bool > emplace(Args &&... args);
```

Effects: Inserts an object x of type Key constructed with std::forward<Args>(args)... if and only if there is no element in the container with equivalent value. and returns the iterator pointing to the newly inserted element.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Throws: If memory allocation throws or Key's in-place constructor throws.

Complexity: Logarithmic.

20.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)... if and only if there is no element in the container with equivalent value. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic.

21.
```
std::pair< iterator, bool > insert(const value_type & x);
```

Effects: Inserts x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

22.
```
std::pair< iterator, bool > insert(value_type && x);
```

Effects: Move constructs a new value from x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

23.
```
iterator insert(const_iterator p, const value_type & x);
```

Effects: Inserts a copy of x in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

24.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts an element move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic.

25.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element.

Complexity: At most N log(size()+N) (N is the distance from first to last)

26.
```
iterator erase(const_iterator p);
```

Effects: Erases the element pointed to by p.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Amortized constant time

27.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: log(size()) + count(k)

28.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: log(size())+N where N is the distance from first to last.

29.
```
void swap(set & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

30.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

31.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

32.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

33.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

34.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

35.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

36.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

37.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

38.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

39.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

40.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

41.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template multiset

boost::container::multiset

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<Key> >
class multiset {
public:
  // construct/copy/destruct
  multiset();
  explicit multiset(const Compare &,
                    const allocator_type & = allocator_type());
  template<typename InputIterator>
    multiset(InputIterator, InputIterator, const Compare & = Compare(),
             const allocator_type & = allocator_type());
  template<typename InputIterator>
    multiset(ordered_range_t, InputIterator, InputIterator,
             const Compare & = Compare(),
             const allocator_type & = allocator_type());
  multiset(const multiset &);
  multiset(multiset &&);
  multiset(const multiset &, const allocator_type &);
  multiset(multiset &&, const allocator_type &);
  multiset& operator=(const multiset &);
  multiset& operator=(multiset &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  template<class... Args> iterator emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  iterator insert(const value_type &);
  iterator insert(value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(multiset &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
```

```
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator >
  equal_range(const key_type &) const;
};
```

Description

A multiset is a kind of associative container that supports equivalent keys (possibly contains multiple copies of the same key value) and provides for fast retrieval of the keys themselves. Class multiset supports bidirectional iterators.

A multiset satisfies all of the requirements of a container and of a reversible container, and of an associative container). multiset also provides most operations described for duplicate keys.

`multiset` public construct/copy/destruct

1.

```
multiset();
```

Effects: Constructs an empty multiset using the specified comparison object and allocator.

Complexity: Constant.

2.

```
explicit multiset(const Compare & comp,
                  const allocator_type & a = allocator_type());
```

Effects: Constructs an empty multiset using the specified comparison object and allocator.

Complexity: Constant.

3.

```
template<typename InputIterator>
  multiset(InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty multiset using the specified comparison object and allocator, and inserts elements from the range [first ,last).

Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.

```
template<typename InputIterator>
  multiset(ordered_range_t, InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty multiset using the specified comparison object and allocator, and inserts elements from the ordered range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate.

Complexity: Linear in N.

5.

```
multiset(const multiset & x);
```

Effects: Copy constructs a multiset.

Complexity: Linear in x.size().

6.
```
multiset(multiset && x);
```

Effects: Move constructs a multiset. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
multiset(const multiset & x, const allocator_type & a);
```

Effects: Copy constructs a multiset using the specified allocator.

Complexity: Linear in x.size().

8.
```
multiset(multiset && x, const allocator_type & a);
```

Effects: Move constructs a multiset using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if a == x.get_allocator(), linear otherwise.

Postcondition: x is emptied.

9.
```
multiset& operator=(const multiset & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
multiset& operator=(multiset && x);
```

Effects: this->swap(x.get()).

Complexity: Constant.

`multiset` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
template<class... Args> iterator emplace(Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)... and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

20.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)...

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

21.
```
iterator insert(const value_type & x);
```

Effects: Inserts x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

22.
```
iterator insert(value_type && x);
```

Effects: Inserts a copy of x in the container.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

23.
```
iterator insert(const_iterator p, const value_type & x);
```

Effects: Inserts a copy of x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

24.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts a value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

25.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) .

Complexity: At most N log(size()+N) (N is the distance from first to last)

26.
```
iterator erase(const_iterator p);
```

Effects: Erases the element pointed to by p.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Amortized constant time

27.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: log(size()) + count(k)

28.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: log(size())+N where N is the distance from first to last.

29.
```
void swap(multiset & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

30.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

31.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

32.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

33.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

34.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

35.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

36.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

37.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

38.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

39.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

40.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

41.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template map

boost::container::map

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename T, typename Compare = std::less<Key>, 
         typename Allocator = std::allocator<std::pair<const Key, T> > > 
class map {
public:
  // construct/copy/destruct
  map();
  explicit map(const Compare &, const allocator_type & = allocator_type());
  template<typename InputIterator> 
    map(InputIterator, InputIterator, const Compare & = Compare(), 
        const allocator_type & = allocator_type());
  template<typename InputIterator> 
    map(ordered_unique_range_t, InputIterator, InputIterator, 
        const Compare & = Compare(), 
        const allocator_type & = allocator_type());
  map(const map &);
  map(map &&);
  map(const map &, const allocator_type &);
  map(map &&, const allocator_type &);
  map& operator=(const map &);
  map& operator=(map &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  mapped_type & operator[](const key_type &);
  mapped_type & operator[](key_type &&);
  T & at(const key_type &);
  const T & at(const key_type &) const;
  std::pair< iterator, bool > insert(const value_type &);
  std::pair< iterator, bool > insert(const nonconst_value_type &);
  std::pair< iterator, bool > insert(nonconst_value_type &&);
  std::pair< iterator, bool > insert(movable_value_type &&);
  std::pair< iterator, bool > insert(value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, nonconst_value_type &&);
  iterator insert(const_iterator, movable_value_type &&);
  iterator insert(const_iterator, const nonconst_value_type &);
  iterator insert(const_iterator, value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  template<class... Args> std::pair< iterator, bool > emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  iterator erase(const_iterator);
```

```
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(map &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator > 
  equal_range(const key_type &) const;
};
```

Description

A map is a kind of associative container that supports unique keys (contains at most one of each key value) and provides for fast retrieval of values of another type T based on the keys. The map class supports bidirectional iterators.

A map satisfies all of the requirements of a container and of a reversible container and of an associative container. For a map<Key,T> the key_type is Key and the value_type is std::pair<const Key,T>.

Compare is the ordering function for Keys (e.g. *std::less<Key>*).

Allocator is the allocator to allocate the value_types (e.g. *allocator< std::pair<const Key, T> >*).

`map` public construct/copy/destruct

1.
```
map();
```

   Effects: Default constructs an empty map.

   Complexity: Constant.

2.
```
explicit map(const Compare & comp, 
             const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty map using the specified comparison object and allocator.

   Complexity: Constant.

3.
```
template<typename InputIterator> 
  map(InputIterator first, InputIterator last, 
      const Compare & comp = Compare(), 
      const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty map using the specified comparison object and allocator, and inserts elements from the range [first ,last).

   Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator>
  map(ordered_unique_range_t, InputIterator first, InputIterator last,
      const Compare & comp = Compare(),
      const allocator_type & a = allocator_type());
```

Effects: Constructs an empty map using the specified comparison object and allocator, and inserts elements from the ordered unique range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate and must be unique values.

Complexity: Linear in N.

5.
```
map(const map & x);
```

Effects: Copy constructs a map.

Complexity: Linear in x.size().

6.
```
map(map && x);
```

Effects: Move constructs a map. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
map(const map & x, const allocator_type & a);
```

Effects: Copy constructs a map using the specified allocator.

Complexity: Linear in x.size().

8.
```
map(map && x, const allocator_type & a);
```

Effects: Move constructs a map using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if x == x.get_allocator(), linear otherwise.

Postcondition: x is emptied.

9.
```
map& operator=(const map & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
map& operator=(map && x);
```

Effects: this->swap(x.get()).

Complexity: Constant.

`map` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
mapped_type & operator[](const key_type & k);
```

Effects: If there is no key equivalent to x in the map, inserts value_type(x, T()) into the map.

Returns: Allocator reference to the mapped_type corresponding to x in *this.

Complexity: Logarithmic.

20.
```
mapped_type & operator[](key_type && k);
```

Effects: If there is no key equivalent to x in the map, inserts value_type(boost::move(x), T()) into the map (the key is move-constructed)

Returns: Allocator reference to the mapped_type corresponding to x in *this.

Complexity: Logarithmic.

21.
```
T & at(const key_type & k);
```

Returns: Allocator reference to the element whose key is equivalent to x. Throws: An exception object of type out_of_range if no such element is present. Complexity: logarithmic.

22.
```
const T & at(const key_type & k) const;
```

Returns: Allocator reference to the element whose key is equivalent to x. Throws: An exception object of type out_of_range if no such element is present. Complexity: logarithmic.

23.
```
std::pair< iterator, bool > insert(const value_type & x);
```

Effects: Inserts x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

24.
```
std::pair< iterator, bool > insert(const nonconst_value_type & x);
```

Effects: Inserts a new value_type created from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

25.
```
std::pair< iterator, bool > insert(nonconst_value_type && x);
```

Effects: Inserts a new value_type move constructed from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

26.
```
std::pair< iterator, bool > insert(movable_value_type && x);
```

Effects: Inserts a new value_type move constructed from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

27.
```
std::pair< iterator, bool > insert(value_type && x);
```

Effects: Move constructs a new value from x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic.

28.
```
iterator insert(const_iterator position, const value_type & x);
```

Effects: Inserts a copy of x in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

29.
```
iterator insert(const_iterator position, nonconst_value_type && x);
```

Effects: Move constructs a new value from x if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

30.
```
iterator insert(const_iterator position, movable_value_type && x);
```

Effects: Move constructs a new value from x if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

31.
```
iterator insert(const_iterator position, const nonconst_value_type & x);
```

Effects: Inserts a copy of x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic.

32.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts an element move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic.

33.
```
template<typename InputIterator> 
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element.

Complexity: At most N log(size()+N) (N is the distance from first to last)

34.
```
template<class... Args> std::pair< iterator, bool > emplace(Args &&... args);
```

Effects: Inserts an object x of type T constructed with std::forward<Args>(args)... in the container if and only if there is no element in the container with an equivalent key. p is a hint pointing to where the insert should start to search.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

35.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the container if and only if there is no element in the container with an equivalent key. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

36.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Amortized constant time

37.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: log(size()) + count(k)

38.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: log(size())+N where N is the distance from first to last.

39.
```
void swap(map & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

40.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

41.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

42.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

43.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

44.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

45.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

46.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

47.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

48.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

49.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

50.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

51.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template multimap

boost::container::multimap

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename T, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<std::pair<const Key, T> > >
class multimap {
public:
  // construct/copy/destruct
  multimap();
  explicit multimap(const Compare &,
                    const allocator_type & = allocator_type());
  template<typename InputIterator>
    multimap(InputIterator, InputIterator, const Compare & = Compare(),
             const allocator_type & = allocator_type());
  template<typename InputIterator>
    multimap(ordered_range_t, InputIterator, InputIterator,
             const Compare & = Compare(),
             const allocator_type & = allocator_type());
  multimap(const multimap &);
  multimap(multimap &&);
  multimap(const multimap &, const allocator_type &);
  multimap(multimap &&, const allocator_type &);
  multimap& operator=(const multimap &);
  multimap& operator=(multimap &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
```

```
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  template<class... Args> iterator emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  iterator insert(const value_type &);
  iterator insert(const nonconst_value_type &);
  iterator insert(nonconst_value_type &&);
  iterator insert(movable_value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, const nonconst_value_type &);
  iterator insert(const_iterator, nonconst_value_type &&);
  iterator insert(const_iterator, movable_value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(multimap &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator > 
  equal_range(const key_type &) const;
};
```

Description

A multimap is a kind of associative container that supports equivalent keys (possibly containing multiple copies of the same key value) and provides for fast retrieval of values of another type T based on the keys. The multimap class supports bidirectional iterators.

A multimap satisfies all of the requirements of a container and of a reversible container and of an associative container. For a map<Key,T> the key_type is Key and the value_type is std::pair<const Key,T>.

Compare is the ordering function for Keys (e.g. *std::less<Key>*).

Allocator is the allocator to allocate the value_types (e.g. *allocator< std::pair<**const** Key, T> >*).

`multimap` public construct/copy/destruct

1.
```
multimap();
```

   Effects: Default constructs an empty multimap.

   Complexity: Constant.

2.
```
explicit multimap(const Compare & comp, 
                  const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty multimap using the specified comparison object and allocator.

   Complexity: Constant.

3.
```
template<typename InputIterator>
  multimap(InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty multimap using the specified comparison object and allocator, and inserts elements from the range [first ,last).

Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator>
  multimap(ordered_range_t, InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty multimap using the specified comparison object and allocator, and inserts elements from the ordered range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate.

Complexity: Linear in N.

5.
```
multimap(const multimap & x);
```

Effects: Copy constructs a multimap.

Complexity: Linear in x.size().

6.
```
multimap(multimap && x);
```

Effects: Move constructs a multimap. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
multimap(const multimap & x, const allocator_type & a);
```

Effects: Copy constructs a multimap.

Complexity: Linear in x.size().

8.
```
multimap(multimap && x, const allocator_type & a);
```

Effects: Move constructs a multimap using the specified allocator. Constructs *this using x's resources. **Complexity**: Constant if a == x.get_allocator(), linear otherwise.

Postcondition: x is emptied.

9.
```
multimap& operator=(const multimap & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
multimap& operator=(multimap && x);
```

Effects: this->swap(x.get()).

Complexity: Constant.

`multimap` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
template<class... Args> iterator emplace(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

20.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

21.
```
iterator insert(const value_type & x);
```

Effects: Inserts x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

22.
```
iterator insert(const nonconst_value_type & x);
```

Effects: Inserts a new value constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

23.
```
iterator insert(nonconst_value_type && x);
```

Effects: Inserts a new value move-constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

24.
```
iterator insert(movable_value_type && x);
```

Effects: Inserts a new value move-constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic.

25.
```
iterator insert(const_iterator position, const value_type & x);
```

Effects: Inserts a copy of x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

26.
```
iterator insert(const_iterator position, const nonconst_value_type & x);
```

Effects: Inserts a new value constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

27.
```
iterator insert(const_iterator position, nonconst_value_type && x);
```

Effects: Inserts a new value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

28.
```
iterator insert(const_iterator position, movable_value_type && x);
```

Effects: Inserts a new value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic in general, but amortized constant if t is inserted right before p.

29.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) .

Complexity: At most N log(size()+N) (N is the distance from first to last)

30.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Amortized constant time

31.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: log(size()) + count(k)

32.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: log(size())+N where N is the distance from first to last.

33.
```
void swap(multimap & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

34.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

35.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

36.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

37.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

38.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

39.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

40.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

41.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

42.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

43.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

44.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

45.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template flat_set

boost::container::flat_set

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<Key> >
class flat_set {
public:
  // construct/copy/destruct
  explicit flat_set();
  explicit flat_set(const Compare &,
                    const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_set(InputIterator, InputIterator, const Compare & = Compare(),
             const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_set(ordered_unique_range_t, InputIterator, InputIterator,
             const Compare & = Compare(),
             const allocator_type & = allocator_type());
  flat_set(const flat_set &);
  flat_set(flat_set &&);
  flat_set(const flat_set &, const allocator_type &);
  flat_set(flat_set &&, const allocator_type &);
  flat_set& operator=(const flat_set &);
  flat_set& operator=(flat_set &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  template<class... Args> std::pair< iterator, bool > emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  std::pair< iterator, bool > insert(const value_type &);
  std::pair< iterator, bool > insert(value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  template<typename InputIterator>
    void insert(ordered_unique_range_t, InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(flat_set &);
  void clear();
```

```
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< const_iterator, const_iterator >
  equal_range(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
};
```

Description

flat_set is a Sorted Associative Container that stores objects of type Key. flat_set is a Simple Associative Container, meaning that its value type, as well as its key type, is Key. It is also a Unique Associative Container, meaning that no two elements are the same.

flat_set is similar to std::set but it's implemented like an ordered vector. This means that inserting a new element into a flat_set invalidates previous iterators and references

Erasing an element of a flat_set invalidates iterators and references pointing to elements that come after (their keys are bigger) the erased element.

`flat_set` public construct/copy/destruct

1.
```
explicit flat_set();
```

Effects: Default constructs an empty `flat_set`.

Complexity: Constant.

2.
```
explicit flat_set(const Compare & comp,
                  const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_set` using the specified comparison object and allocator.

Complexity: Constant.

3.
```
template<typename InputIterator>
  flat_set(InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty set using the specified comparison object and allocator, and inserts elements from the range [first ,last).

Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator>
  flat_set(ordered_unique_range_t, InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_set` using the specified comparison object and allocator, and inserts elements from the ordered unique range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate and must be unique values.

Complexity: Linear in N.

Note: Non-standard extension.

5.
```
flat_set(const flat_set & x);
```

Effects: Copy constructs a set.

Complexity: Linear in x.size().

6.
```
flat_set(flat_set && mx);
```

Effects: Move constructs a set. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
flat_set(const flat_set & x, const allocator_type & a);
```

Effects: Copy constructs a set using the specified allocator.

Complexity: Linear in x.size().

8.
```
flat_set(flat_set && mx, const allocator_type & a);
```

Effects: Move constructs a set using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if a == mx.get_allocator(), linear otherwise

9.
```
flat_set& operator=(const flat_set & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
flat_set& operator=(flat_set && mx);
```

Effects: Makes *this a copy of the previous value of xx.

Complexity: Linear in x.size().

`flat_set` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

20.
```
void reserve(size_type cnt);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws or Key's copy constructor throws.

Note: If capacity() is less than "cnt", iterators and references to to values might be invalidated.

21.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created

Throws: If memory allocation throws, or Key's copy constructor throws.

Complexity: Linear to size().

22.
```
template<class... Args> std::pair< iterator, bool > emplace(Args &&... args);
```

Effects: Inserts an object x of type Key constructed with std::forward<Args>(args)... if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

23.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)... in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

24.
```
std::pair< iterator, bool > insert(const value_type & x);
```

Effects: Inserts x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

25.
```
std::pair< iterator, bool > insert(value_type && x);
```

Effects: Inserts a new value_type move constructed from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

26.
```
iterator insert(const_iterator p, const value_type & x);
```

Effects: Inserts a copy of x in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

27.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts an element move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

28.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

29.
```
template<typename InputIterator>
  void insert(ordered_unique_range_t, InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this and must be ordered according to the predicate and must be unique values.

Effects: inserts each element from the range [first,last) .This function is more efficient than the normal range creation for ordered ranges.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: Non-standard extension. If an element is inserted it might invalidate elements.

30.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Linear to the elements with keys bigger than position

Note: Invalidates elements with keys not less than the erased element.

31.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

32.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: size()*N where N is the distance from first to last.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

33.
```
void swap(flat_set & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

34.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

35.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

36.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

37.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

38.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.s

39.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

40.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

41.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

42.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

43.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

44.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

45.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template flat_multiset

boost::container::flat_multiset

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<Key> >
class flat_multiset {
public:
  // construct/copy/destruct
  explicit flat_multiset();
  explicit flat_multiset(const Compare &,
                         const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_multiset(InputIterator, InputIterator, const Compare & = Compare(),
                  const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_multiset(ordered_range_t, InputIterator, InputIterator,
                  const Compare & = Compare(),
                  const allocator_type & = allocator_type());
  flat_multiset(const flat_multiset &);
  flat_multiset(flat_multiset &&);
  flat_multiset(const flat_multiset &, const allocator_type &);
  flat_multiset(flat_multiset &&, const allocator_type &);
  flat_multiset& operator=(const flat_multiset &);
  flat_multiset& operator=(flat_multiset &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  const_iterator cbegin() const;
  iterator end();
  const_iterator end() const;
  const_iterator cend() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  const_reverse_iterator crbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  template<class... Args> iterator emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  iterator insert(const value_type &);
  iterator insert(value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  template<typename InputIterator>
    void insert(ordered_range_t, InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(flat_multiset &);
  void clear();
```

```
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< const_iterator, const_iterator >
  equal_range(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
};
```

Description

flat_multiset is a Sorted Associative Container that stores objects of type Key. flat_multiset is a Simple Associative Container, meaning that its value type, as well as its key type, is Key. flat_Multiset can store multiple copies of the same key value.

flat_multiset is similar to std::multiset but it's implemented like an ordered vector. This means that inserting a new element into a flat_multiset invalidates previous iterators and references

Erasing an element of a flat_multiset invalidates iterators and references pointing to elements that come after (their keys are equal or bigger) the erased element.

`flat_multiset` public construct/copy/destruct

1.
```
explicit flat_multiset();
```

   Effects: Default constructs an empty `flat_multiset`.

   Complexity: Constant.

2.
```
explicit flat_multiset(const Compare & comp,
                       const allocator_type & a = allocator_type());
```

3.
```
template<typename InputIterator>
  flat_multiset(InputIterator first, InputIterator last,
                const Compare & comp = Compare(),
                const allocator_type & a = allocator_type());
```

4.
```
template<typename InputIterator>
  flat_multiset(ordered_range_t, InputIterator first, InputIterator last,
                const Compare & comp = Compare(),
                const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty `flat_multiset` using the specified comparison object and allocator, and inserts elements from the ordered range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

   Requires: [first ,last) must be ordered according to the predicate.

   Complexity: Linear in N.

   Note: Non-standard extension.

5.
```
flat_multiset(const flat_multiset & x);
```

Effects: Copy constructs a `flat_multiset`.

Complexity: Linear in x.size().

6.
```
flat_multiset(flat_multiset && mx);
```

Effects: Move constructs a `flat_multiset`. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
flat_multiset(const flat_multiset & x, const allocator_type & a);
```

Effects: Copy constructs a `flat_multiset` using the specified allocator.

Complexity: Linear in x.size().

8.
```
flat_multiset(flat_multiset && mx, const allocator_type & a);
```

Effects: Move constructs a `flat_multiset` using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if a == mx.get_allocator(), linear otherwise

9.
```
flat_multiset& operator=(const flat_multiset & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
flat_multiset& operator=(flat_multiset && mx);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

`flat_multiset` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

7.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

13.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

20.
```
void reserve(size_type cnt);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws or Key's copy constructor throws.

Note: If capacity() is less than "cnt", iterators and references to to values might be invalidated.

21.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created

Throws: If memory allocation throws, or Key's copy constructor throws.

Complexity: Linear to size().

22.
```
template<class... Args> iterator emplace(Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)... and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

23.
```
template<class... Args> 
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type Key constructed with std::forward<Args>(args)... in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

24.
```
iterator insert(const value_type & x);
```

Effects: Inserts x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

25.
```
iterator insert(value_type && x);
```

Effects: Inserts a new value_type move constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

26.
```
iterator insert(const_iterator p, const value_type & x);
```

Effects: Inserts a copy of x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

27.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts a new value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

28.
```
template<typename InputIterator> 
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) .

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

29.
```
template<typename InputIterator>
  void insert(ordered_range_t, InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this and must be ordered according to the predicate.

Effects: inserts each element from the range [first,last) .This function is more efficient than the normal range creation for ordered ranges.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: Non-standard extension. If an element is inserted it might invalidate elements.

30.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Linear to the elements with keys bigger than position

Note: Invalidates elements with keys not less than the erased element.

31.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

32.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: size()*N where N is the distance from first to last.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

33.
```
void swap(flat_multiset & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

34.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

35.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

36.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

37.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

38.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.s

39.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

40.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

41.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

42.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

43.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

44.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

45.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template flat_map

boost::container::flat_map

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename T, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<std::pair<Key, T> > >
class flat_map {
public:
  // construct/copy/destruct
  flat_map();
  explicit flat_map(const Compare &,
                    const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_map(InputIterator, InputIterator, const Compare & = Compare(),
             const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_map(ordered_unique_range_t, InputIterator, InputIterator,
             const Compare & = Compare(),
             const allocator_type & = allocator_type());
  flat_map(const flat_map &);
  flat_map(flat_map &&);
  flat_map(const flat_map &, const allocator_type &);
  flat_map(flat_map &&, const allocator_type &);
  flat_map& operator=(const flat_map &);
  flat_map& operator=(flat_map &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  mapped_type & operator[](const key_type &);
  mapped_type & operator[](key_type &&);
  T & at(const key_type &);
  const T & at(const key_type &) const;
  template<class... Args> std::pair< iterator, bool > emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  std::pair< iterator, bool > insert(const value_type &);
  std::pair< iterator, bool > insert(value_type &&);
  std::pair< iterator, bool > insert(movable_value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  iterator insert(const_iterator, movable_value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  template<typename InputIterator>
```

```
    void insert(ordered_unique_range_t, InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
  void swap(flat_map &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator >
  equal_range(const key_type &) const;
};
```

Description

A flat_map is a kind of associative container that supports unique keys (contains at most one of each key value) and provides for fast retrieval of values of another type T based on the keys. The flat_map class supports random-access iterators.

A flat_map satisfies all of the requirements of a container and of a reversible container and of an associative container. A flat_map also provides most operations described for unique keys. For a flat_map<Key,T> the key_type is Key and the value_type is std::pair<Key,T> (unlike std::map<Key, T> which value_type is std::pair<**const** Key, T>).

Compare is the ordering function for Keys (e.g. *std::less<Key>*).

Allocator is the allocator to allocate the value_types (e.g. *allocator< std::pair<Key, T> >*).

flat_map is similar to std::map but it's implemented like an ordered vector. This means that inserting a new element into a flat_map invalidates previous iterators and references

Erasing an element of a flat_map invalidates iterators and references pointing to elements that come after (their keys are bigger) the erased element.

`flat_map` public construct/copy/destruct

1.
```
flat_map();
```

   Effects: Default constructs an empty `flat_map`.

   Complexity: Constant.

2.
```
explicit flat_map(const Compare & comp,
                  const allocator_type & a = allocator_type());
```

   Effects: Constructs an empty `flat_map` using the specified comparison object and allocator.

   Complexity: Constant.

3.
```
template<typename InputIterator>
  flat_map(InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_map` using the specified comparison object and allocator, and inserts elements from the range [first ,last).

Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator>
  flat_map(ordered_unique_range_t, InputIterator first, InputIterator last,
           const Compare & comp = Compare(),
           const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_map` using the specified comparison object and allocator, and inserts elements from the ordered unique range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate and must be unique values.

Complexity: Linear in N.

Note: Non-standard extension.

5.
```
flat_map(const flat_map & x);
```

Effects: Copy constructs a `flat_map`.

Complexity: Linear in x.size().

6.
```
flat_map(flat_map && x);
```

Effects: Move constructs a `flat_map`. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
flat_map(const flat_map & x, const allocator_type & a);
```

Effects: Copy constructs a `flat_map` using the specified allocator.

Complexity: Linear in x.size().

8.
```
flat_map(flat_map && x, const allocator_type & a);
```

Effects: Move constructs a `flat_map` using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if x.get_allocator() == a, linear otherwise.

9.
```
flat_map& operator=(const flat_map & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
flat_map& operator=(flat_map && mx);
```

Effects: Move constructs a `flat_map`. Constructs *this using x's resources.

Complexity: Construct.

Postcondition: x is emptied.

`flat_map` public member functions

1.
```
allocator_type get_allocator() const;
```

   Effects: Returns a copy of the Allocator that was passed to the object's constructor.

   Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

   Effects: Returns a reference to the internal allocator.

   Throws: Nothing

   Complexity: Constant.

   Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

   Effects: Returns a reference to the internal allocator.

   Throws: Nothing

   Complexity: Constant.

   Note: Non-standard extension.

4.
```
iterator begin();
```

   Effects: Returns an iterator to the first element contained in the container.

   Throws: Nothing.

   Complexity: Constant.

5.
```
const_iterator begin() const;
```

   Effects: Returns a const_iterator to the first element contained in the container.

   Throws: Nothing.

   Complexity: Constant.

6.
```
iterator end();
```

   Effects: Returns an iterator to the end of the container.

   Throws: Nothing.

   Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

20.
```
void reserve(size_type cnt);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws or T's copy constructor throws.

Note: If capacity() is less than "cnt", iterators and references to to values might be invalidated.

21.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to size().

22.
```
mapped_type & operator[](const key_type & k);
```

Effects: If there is no key equivalent to x in the `flat_map`, inserts value_type(x, T()) into the `flat_map`.

Returns: Allocator reference to the mapped_type corresponding to x in *this.

Complexity: Logarithmic.

23.
```
mapped_type & operator[](key_type && k);
```

Effects: If there is no key equivalent to x in the `flat_map`, inserts value_type(move(x), T()) into the `flat_map` (the key is move-constructed)

Returns: Allocator reference to the mapped_type corresponding to x in *this.

Complexity: Logarithmic.

24.
```
T & at(const key_type & k);
```

Returns: Allocator reference to the element whose key is equivalent to x.

Throws: An exception object of type out_of_range if no such element is present.

Complexity: logarithmic.

25.
```
const T & at(const key_type & k) const;
```

Returns: Allocator reference to the element whose key is equivalent to x.

Throws: An exception object of type out_of_range if no such element is present.

Complexity: logarithmic.

26.
```
template<class... Args> std::pair< iterator, bool > emplace(Args &&... args);
```

Effects: Inserts an object x of type T constructed with std::forward<Args>(args)... if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

27.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

28.
```
std::pair< iterator, bool > insert(const value_type & x);
```

Effects: Inserts x if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

29.
```
std::pair< iterator, bool > insert(value_type && x);
```

Effects: Inserts a new value_type move constructed from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

30.
```
std::pair< iterator, bool > insert(movable_value_type && x);
```

Effects: Inserts a new value_type move constructed from the pair if and only if there is no element in the container with key equivalent to the key of x.

Returns: The bool component of the returned pair is true if and only if the insertion takes place, and the iterator component of the pair points to the element with key equivalent to the key of x.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

31.
```
iterator insert(const_iterator position, const value_type & x);
```

Effects: Inserts a copy of x in the container if and only if there is no element in the container with key equivalent to the key of x. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

32.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts an element move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

33.
```
iterator insert(const_iterator position, movable_value_type && x);
```

Effects: Inserts an element move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant if x is inserted right before p) plus insertion linear to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

34.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

35.
```
template<typename InputIterator>
  void insert(ordered_unique_range_t, InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Requires: [first ,last) must be ordered according to the predicate and must be unique values.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element. This function is more efficient than the normal range creation for ordered ranges.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

36.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Linear to the elements with keys bigger than position

Note: Invalidates elements with keys not less than the erased element.

37.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

38.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: size()*N where N is the distance from first to last.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

39.
```
void swap(flat_map & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

40.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

41.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

42.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

43.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

44.
```
const_iterator find(const key_type & x) const;
```

Returns: Allocator const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.s

45.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

46.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

47.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

48.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

49.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

50.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

51.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template flat_multimap

boost::container::flat_multimap

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename Key, typename T, typename Compare = std::less<Key>,
         typename Allocator = std::allocator<std::pair<Key, T> > >
class flat_multimap {
public:
  // construct/copy/destruct
  flat_multimap();
  explicit flat_multimap(const Compare &,
                         const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_multimap(InputIterator, InputIterator, const Compare & = Compare(),
                  const allocator_type & = allocator_type());
  template<typename InputIterator>
    flat_multimap(ordered_range_t, InputIterator, InputIterator,
                  const Compare & = Compare(),
                  const allocator_type & = allocator_type());
  flat_multimap(const flat_multimap &);
  flat_multimap(flat_multimap &&);
  flat_multimap(const flat_multimap &, const allocator_type &);
  flat_multimap(flat_multimap &&, const allocator_type &);
  flat_multimap& operator=(const flat_multimap &);
  flat_multimap& operator=(flat_multimap &&);

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type max_size() const;
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  template<class... Args> iterator emplace(Args &&...);
  template<class... Args> iterator emplace_hint(const_iterator, Args &&...);
  iterator insert(const value_type &);
  iterator insert(value_type &&);
  iterator insert(impl_value_type &&);
  iterator insert(const_iterator, const value_type &);
  iterator insert(const_iterator, value_type &&);
  iterator insert(const_iterator, impl_value_type &&);
  template<typename InputIterator> void insert(InputIterator, InputIterator);
  template<typename InputIterator>
    void insert(ordered_range_t, InputIterator, InputIterator);
  iterator erase(const_iterator);
  size_type erase(const key_type &);
  iterator erase(const_iterator, const_iterator);
```

```
  void swap(flat_multimap &);
  void clear();
  key_compare key_comp() const;
  value_compare value_comp() const;
  iterator find(const key_type &);
  const_iterator find(const key_type &) const;
  size_type count(const key_type &) const;
  iterator lower_bound(const key_type &);
  const_iterator lower_bound(const key_type &) const;
  iterator upper_bound(const key_type &);
  const_iterator upper_bound(const key_type &) const;
  std::pair< iterator, iterator > equal_range(const key_type &);
  std::pair< const_iterator, const_iterator >
  equal_range(const key_type &) const;
};
```

Description

A flat_multimap is a kind of associative container that supports equivalent keys (possibly containing multiple copies of the same key value) and provides for fast retrieval of values of another type T based on the keys. The flat_multimap class supports random-access iterators.

A flat_multimap satisfies all of the requirements of a container and of a reversible container and of an associative container. For a flat_multimap<Key,T> the key_type is Key and the value_type is std::pair<Key,T> (unlike std::multimap<Key, T> which value_type is std::pair<**const** Key, T>).

Compare is the ordering function for Keys (e.g. *std::less<Key>*).

Allocator is the allocator to allocate the value_types (e.g. *allocator< std::pair<Key, T> >*).

`flat_multimap` public construct/copy/destruct

1.
```
flat_multimap();
```

Effects: Default constructs an empty `flat_map`.

Complexity: Constant.

2.
```
explicit flat_multimap(const Compare & comp,
                       const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_multimap` using the specified comparison object and allocator.

Complexity: Constant.

3.
```
template<typename InputIterator>
  flat_multimap(InputIterator first, InputIterator last,
                const Compare & comp = Compare(),
                const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_multimap` using the specified comparison object and allocator, and inserts elements from the range [first ,last).

Complexity: Linear in N if the range [first ,last) is already sorted using comp and otherwise N logN, where N is last - first.

4.
```
template<typename InputIterator>
  flat_multimap(ordered_range_t, InputIterator first, InputIterator last,
                const Compare & comp = Compare(),
                const allocator_type & a = allocator_type());
```

Effects: Constructs an empty `flat_multimap` using the specified comparison object and allocator, and inserts elements from the ordered range [first ,last). This function is more efficient than the normal range creation for ordered ranges.

Requires: [first ,last) must be ordered according to the predicate.

Complexity: Linear in N.

Note: Non-standard extension.

5.
```
flat_multimap(const flat_multimap & x);
```

Effects: Copy constructs a `flat_multimap`.

Complexity: Linear in x.size().

6.
```
flat_multimap(flat_multimap && x);
```

Effects: Move constructs a `flat_multimap`. Constructs *this using x's resources.

Complexity: Constant.

Postcondition: x is emptied.

7.
```
flat_multimap(const flat_multimap & x, const allocator_type & a);
```

Effects: Copy constructs a `flat_multimap` using the specified allocator.

Complexity: Linear in x.size().

8.
```
flat_multimap(flat_multimap && x, const allocator_type & a);
```

Effects: Move constructs a `flat_multimap` using the specified allocator. Constructs *this using x's resources.

Complexity: Constant if a == x.get_allocator(), linear otherwise.

9.
```
flat_multimap& operator=(const flat_multimap & x);
```

Effects: Makes *this a copy of x.

Complexity: Linear in x.size().

10.
```
flat_multimap& operator=(flat_multimap && mx);
```

Effects: this->swap(x.get()).

Complexity: Constant.

`flat_multimap` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the Allocator that was passed to the object's constructor.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the container.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the container.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed container.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed container.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the container contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the container.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the container.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

20.
```
void reserve(size_type cnt);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws or T's copy constructor throws.

Note: If capacity() is less than "cnt", iterators and references to to values might be invalidated.

21.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created

Throws: If memory allocation throws, or T's copy constructor throws.

Complexity: Linear to size().

22.
```
template<class... Args> iterator emplace(Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

23.
```
template<class... Args>
  iterator emplace_hint(const_iterator hint, Args &&... args);
```

Effects: Inserts an object of type T constructed with std::forward<Args>(args)... in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant time if the value is to be inserted before p) plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

24.
```
iterator insert(const value_type & x);
```

Effects: Inserts x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

25.
```
iterator insert(value_type && x);
```

Effects: Inserts a new value move-constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

26.
```
iterator insert(impl_value_type && x);
```

Effects: Inserts a new value move-constructed from x and returns the iterator pointing to the newly inserted element.

Complexity: Logarithmic search time plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

27.
```
iterator insert(const_iterator position, const value_type & x);
```

Effects: Inserts a copy of x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant time if the value is to be inserted before p) plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

28.
```
iterator insert(const_iterator position, value_type && x);
```

Effects: Inserts a value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant time if the value is to be inserted before p) plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

29.
```
iterator insert(const_iterator position, impl_value_type && x);
```

Effects: Inserts a value move constructed from x in the container. p is a hint pointing to where the insert should start to search.

Returns: An iterator pointing to the element with key equivalent to the key of x.

Complexity: Logarithmic search time (constant time if the value is to be inserted before p) plus linear insertion to the elements with bigger keys than x.

Note: If an element is inserted it might invalidate elements.

30.
```
template<typename InputIterator>
  void insert(InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Effects: inserts each element from the range [first,last) .

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

31.
```
template<typename InputIterator>
  void insert(ordered_range_t, InputIterator first, InputIterator last);
```

Requires: first, last are not iterators into *this.

Requires: [first ,last) must be ordered according to the predicate.

Effects: inserts each element from the range [first,last) if and only if there is no element with key equivalent to the key of that element. This function is more efficient than the normal range creation for ordered ranges.

Complexity: At most N log(size()+N) (N is the distance from first to last) search time plus N*size() insertion time.

Note: If an element is inserted it might invalidate elements.

32.
```
iterator erase(const_iterator position);
```

Effects: Erases the element pointed to by position.

Returns: Returns an iterator pointing to the element immediately following q prior to the element being erased. If no such element exists, returns end().

Complexity: Linear to the elements with keys bigger than position

Note: Invalidates elements with keys not less than the erased element.

33.
```
size_type erase(const key_type & x);
```

Effects: Erases all elements in the container with key equivalent to x.

Returns: Returns the number of erased elements.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

34.
```
iterator erase(const_iterator first, const_iterator last);
```

Effects: Erases all the elements in the range [first, last).

Returns: Returns last.

Complexity: size()*N where N is the distance from first to last.

Complexity: Logarithmic search time plus erasure time linear to the elements with bigger keys.

35.
```
void swap(flat_multimap & x);
```

Effects: Swaps the contents of *this and x.

Throws: Nothing.

Complexity: Constant.

36.
```
void clear();
```

Effects: erase(a.begin(),a.end()).

Postcondition: size() == 0.

Complexity: linear in size().

37.
```
key_compare key_comp() const;
```

Effects: Returns the comparison object out of which a was constructed.

Complexity: Constant.

38.
```
value_compare value_comp() const;
```

Effects: Returns an object of value_compare constructed out of the comparison object.

Complexity: Constant.

39.
```
iterator find(const key_type & x);
```

Returns: An iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

40.
```
const_iterator find(const key_type & x) const;
```

Returns: An const_iterator pointing to an element with the key equivalent to x, or end() if such an element is not found.

Complexity: Logarithmic.

41.
```
size_type count(const key_type & x) const;
```

Returns: The number of elements with key equivalent to x.

Complexity: log(size())+count(k)

42.
```
iterator lower_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

43.
```
const_iterator lower_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than k, or a.end() if such an element is not found.

Complexity: Logarithmic

44.
```
iterator upper_bound(const key_type & x);
```

Returns: An iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

45.
```
const_iterator upper_bound(const key_type & x) const;
```

Returns: Allocator const iterator pointing to the first element with key not less than x, or end() if such an element is not found.

Complexity: Logarithmic

46.
```
std::pair< iterator, iterator > equal_range(const key_type & x);
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

47.
```
std::pair< const_iterator, const_iterator >
equal_range(const key_type & x) const;
```

Effects: Equivalent to std::make_pair(this->lower_bound(k), this->upper_bound(k)).

Complexity: Logarithmic

Class template basic_string

boost::container::basic_string

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

template<typename CharT, typename Traits = std::char_traits<CharT>,
         typename Allocator = std::allocator<CharT> >
class basic_string {
public:
  // construct/copy/destruct
  basic_string();
  explicit basic_string(const allocator_type &);
  basic_string(const basic_string &);
  basic_string(basic_string &&);
  basic_string(const basic_string &, const allocator_type &);
  basic_string(basic_string &&, const allocator_type &);
  basic_string(const basic_string &, size_type, size_type = npos,
               const allocator_type & = allocator_type());
  basic_string(const CharT *, size_type,
               const allocator_type & = allocator_type());
  basic_string(const CharT *, const allocator_type & = allocator_type());
  basic_string(size_type, CharT, const allocator_type & = allocator_type());
  template<typename InputIterator>
    basic_string(InputIterator, InputIterator,
                 const allocator_type & = allocator_type());
  basic_string& operator=(const basic_string &);
  basic_string& operator=(basic_string &&);
  basic_string& operator=(const CharT *);
  basic_string& operator=(CharT);
  ~basic_string();

  // public member functions
  allocator_type get_allocator() const;
  stored_allocator_type & get_stored_allocator();
  const stored_allocator_type & get_stored_allocator() const;
  iterator begin();
  const_iterator begin() const;
  iterator end();
  const_iterator end() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_iterator cbegin() const;
  const_iterator cend() const;
  const_reverse_iterator crbegin() const;
  const_reverse_iterator crend() const;
  bool empty() const;
  size_type size() const;
  size_type length() const;
  size_type max_size() const;
  void resize(size_type, CharT);
  void resize(size_type);
  size_type capacity() const;
  void reserve(size_type);
  void shrink_to_fit();
  reference operator[](size_type);
  const_reference operator[](size_type) const;
  reference at(size_type);
  const_reference at(size_type) const;
  basic_string & operator+=(const basic_string &);
  basic_string & operator+=(const CharT *);
  basic_string & operator+=(CharT);
```

```
basic_string & append(const basic_string &);
basic_string & append(const basic_string &, size_type, size_type);
basic_string & append(const CharT *, size_type);
basic_string & append(const CharT *);
basic_string & append(size_type, CharT);
template<typename InputIter> basic_string & append(InputIter, InputIter);
void push_back(CharT);
basic_string & assign(const basic_string &);
basic_string & assign(basic_string &&);
basic_string & assign(const basic_string &, size_type, size_type);
basic_string & assign(const CharT *, size_type);
basic_string & assign(const CharT *);
basic_string & assign(size_type, CharT);
template<typename InputIter> basic_string & assign(InputIter, InputIter);
basic_string & insert(size_type, const basic_string &);
basic_string & insert(size_type, const basic_string &, size_type, size_type);
basic_string & insert(size_type, const CharT *, size_type);
basic_string & insert(size_type, const CharT *);
basic_string & insert(size_type, size_type, CharT);
iterator insert(const_iterator, CharT);
iterator insert(const_iterator, size_type, CharT);
template<typename InputIter>
  iterator insert(const_iterator, InputIter, InputIter);
basic_string & erase(size_type = 0, size_type = npos);
iterator erase(const_iterator);
iterator erase(const_iterator, const_iterator);
void pop_back();
void clear();
basic_string & replace(size_type, size_type, const basic_string &);
basic_string &
replace(size_type, size_type, const basic_string &, size_type, size_type);
basic_string & replace(size_type, size_type, const CharT *, size_type);
basic_string & replace(size_type, size_type, const CharT *);
basic_string & replace(size_type, size_type, size_type, CharT);
basic_string & replace(const_iterator, const_iterator, const basic_string &);
basic_string &
replace(const_iterator, const_iterator, const CharT *, size_type);
basic_string & replace(const_iterator, const_iterator, const CharT *);
basic_string & replace(const_iterator, const_iterator, size_type, CharT);
template<typename InputIter>
  basic_string &
  replace(const_iterator, const_iterator, InputIter, InputIter);
size_type copy(CharT *, size_type, size_type = 0) const;
void swap(basic_string &);
const CharT * c_str() const;
const CharT * data() const;
size_type find(const basic_string &, size_type = 0) const;
size_type find(const CharT *, size_type, size_type) const;
size_type find(const CharT *, size_type = 0) const;
size_type find(CharT, size_type = 0) const;
size_type rfind(const basic_string &, size_type = npos) const;
size_type rfind(const CharT *, size_type, size_type) const;
size_type rfind(const CharT *, size_type = npos) const;
size_type rfind(CharT, size_type = npos) const;
size_type find_first_of(const basic_string &, size_type = 0) const;
size_type find_first_of(const CharT *, size_type, size_type) const;
size_type find_first_of(const CharT *, size_type = 0) const;
size_type find_first_of(CharT, size_type = 0) const;
size_type find_last_of(const basic_string &, size_type = npos) const;
size_type find_last_of(const CharT *, size_type, size_type) const;
size_type find_last_of(const CharT *, size_type = npos) const;
size_type find_last_of(CharT, size_type = npos) const;
size_type find_first_not_of(const basic_string &, size_type = 0) const;
```

```
  size_type find_first_not_of(const CharT *, size_type, size_type) const;
  size_type find_first_not_of(const CharT *, size_type = 0) const;
  size_type find_first_not_of(CharT, size_type = 0) const;
  size_type find_last_not_of(const basic_string &, size_type = npos) const;
  size_type find_last_not_of(const CharT *, size_type, size_type) const;
  size_type find_last_not_of(const CharT *, size_type = npos) const;
  size_type find_last_not_of(CharT, size_type = npos) const;
  basic_string substr(size_type = 0, size_type = npos) const;
  int compare(const basic_string &) const;
  int compare(size_type, size_type, const basic_string &) const;
  int compare(size_type, size_type, const basic_string &, size_type, 
              size_type) const;
  int compare(const CharT *) const;
  int compare(size_type, size_type, const CharT *, size_type) const;
  int compare(size_type, size_type, const CharT *) const;
};
```

Description

The basic_string class represents a Sequence of characters. It contains all the usual operations of a Sequence, and, additionally, it contains standard string operations such as search and concatenation.

The basic_string class is parameterized by character type, and by that type's Character Traits.

This class has performance characteristics very much like vector<>, meaning, for example, that it does not perform reference-count or copy-on-write, and that concatenation of two strings is an O(N) operation.

Some of basic_string's member functions use an unusual method of specifying positions and ranges. In addition to the conventional method using iterators, many of basic_string's member functions use a single value pos of type size_type to represent a position (in which case the position is begin() + pos, and many of basic_string's member functions use two values, pos and n, to represent a range. In that case pos is the beginning of the range and n is its size. That is, the range is [begin() + pos, begin() + pos + n).

Note that the C++ standard does not specify the complexity of basic_string operations. In this implementation, basic_string has performance characteristics very similar to those of vector: access to a single character is O(1), while copy and concatenation are O(N).

In this implementation, begin(), end(), rbegin(), rend(), operator[], c_str(), and data() do not invalidate iterators. In this implementation, iterators are only invalidated by member functions that explicitly change the string's contents.

`basic_string` public construct/copy/destruct

1.
```
basic_string();
```

   Effects: Default constructs a `basic_string`.

   Throws: If allocator_type's default constructor throws.

2.
```
explicit basic_string(const allocator_type & a);
```

   Effects: Constructs a `basic_string` taking the allocator as parameter.

   Throws: Nothing

3.
```
basic_string(const basic_string & s);
```

   Effects: Copy constructs a `basic_string`.

   Postcondition: x == *this.

Throws: If allocator_type's default constructor throws.

4.
```
basic_string(basic_string && s);
```

Effects: Move constructor. Moves s's resources to *this.

Throws: Nothing.

Complexity: Constant.

5.
```
basic_string(const basic_string & s, const allocator_type & a);
```

Effects: Copy constructs a basic_string using the specified allocator.

Postcondition: x == *this.

Throws: If allocation throws.

6.
```
basic_string(basic_string && s, const allocator_type & a);
```

Effects: Move constructor using the specified allocator. Moves s's resources to *this.

Throws: If allocation throws.

Complexity: Constant if a == s.get_allocator(), linear otherwise.

7.
```
basic_string(const basic_string & s, size_type pos, size_type n = npos,
             const allocator_type & a = allocator_type());
```

Effects: Constructs a basic_string taking the allocator as parameter, and is initialized by a specific number of characters of the s string.

8.
```
basic_string(const CharT * s, size_type n,
             const allocator_type & a = allocator_type());
```

Effects: Constructs a basic_string taking the allocator as parameter, and is initialized by a specific number of characters of the s c-string.

9.
```
basic_string(const CharT * s, const allocator_type & a = allocator_type());
```

Effects: Constructs a basic_string taking the allocator as parameter, and is initialized by the null-terminated s c-string.

10.
```
basic_string(size_type n, CharT c,
             const allocator_type & a = allocator_type());
```

Effects: Constructs a basic_string taking the allocator as parameter, and is initialized by n copies of c.

11.
```
template<typename InputIterator>
  basic_string(InputIterator f, InputIterator l,
               const allocator_type & a = allocator_type());
```

Effects: Constructs a basic_string taking the allocator as parameter, and a range of iterators.

12.
```
basic_string& operator=(const basic_string & x);
```

Effects: Copy constructs a string.

Postcondition: x == *this.

Complexity: Linear to the elements x contains.

13.
```
basic_string& operator=(basic_string && x);
```

Effects: Move constructor. Moves mx's resources to *this.

Throws: If allocator_type's copy constructor throws.

Complexity: Constant.

14.
```
basic_string& operator=(const CharT * s);
```

Effects: Assignment from a null-terminated c-string.

15.
```
basic_string& operator=(CharT c);
```

Effects: Assignment from character.

16.
```
~basic_string();
```

Effects: Destroys the `basic_string`. All used memory is deallocated.

Throws: Nothing.

Complexity: Constant.

`basic_string` public member functions

1.
```
allocator_type get_allocator() const;
```

Effects: Returns a copy of the internal allocator.

Throws: If allocator's copy constructor throws.

Complexity: Constant.

2.
```
stored_allocator_type & get_stored_allocator();
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

3.
```
const stored_allocator_type & get_stored_allocator() const;
```

Effects: Returns a reference to the internal allocator.

Throws: Nothing

Complexity: Constant.

Note: Non-standard extension.

4.
```
iterator begin();
```

Effects: Returns an iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

5.
```
const_iterator begin() const;
```

Effects: Returns a const_iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

6.
```
iterator end();
```

Effects: Returns an iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

7.
```
const_iterator end() const;
```

Effects: Returns a const_iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

8.
```
reverse_iterator rbegin();
```

Effects: Returns a reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

9.
```
const_reverse_iterator rbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

10.
```
reverse_iterator rend();
```

Effects: Returns a reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

11.
```
const_reverse_iterator rend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

12.
```
const_iterator cbegin() const;
```

Effects: Returns a const_iterator to the first element contained in the vector.

Throws: Nothing.

Complexity: Constant.

13.
```
const_iterator cend() const;
```

Effects: Returns a const_iterator to the end of the vector.

Throws: Nothing.

Complexity: Constant.

14.
```
const_reverse_iterator crbegin() const;
```

Effects: Returns a const_reverse_iterator pointing to the beginning of the reversed vector.

Throws: Nothing.

Complexity: Constant.

15.
```
const_reverse_iterator crend() const;
```

Effects: Returns a const_reverse_iterator pointing to the end of the reversed vector.

Throws: Nothing.

Complexity: Constant.

16.
```
bool empty() const;
```

Effects: Returns true if the vector contains no elements.

Throws: Nothing.

Complexity: Constant.

17.
```
size_type size() const;
```

Effects: Returns the number of the elements contained in the vector.

Throws: Nothing.

Complexity: Constant.

18.
```
size_type length() const;
```

Effects: Returns the number of the elements contained in the vector.

Throws: Nothing.

Complexity: Constant.

19.
```
size_type max_size() const;
```

Effects: Returns the largest possible size of the vector.

Throws: Nothing.

Complexity: Constant.

20.
```
void resize(size_type n, CharT c);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are copy constructed from x.

Throws: If memory allocation throws

Complexity: Linear to the difference between size() and new_size.

21.
```
void resize(size_type n);
```

Effects: Inserts or erases elements at the end such that the size becomes n. New elements are default constructed.

Throws: If memory allocation throws

Complexity: Linear to the difference between size() and new_size.

22.
```
size_type capacity() const;
```

Effects: Number of elements for which memory has been allocated. capacity() is always greater than or equal to size().

Throws: Nothing.

Complexity: Constant.

23.
```
void reserve(size_type res_arg);
```

Effects: If n is less than or equal to capacity(), this call has no effect. Otherwise, it is a request for allocation of additional memory. If the request is successful, then capacity() is greater than or equal to n; otherwise, capacity() is unchanged. In either case, size() is unchanged.

Throws: If memory allocation allocation throws

24.
```
void shrink_to_fit();
```

Effects: Tries to deallocate the excess of memory created with previous allocations. The size of the string is unchanged

Throws: Nothing

Complexity: Linear to size().

25.
```
reference operator[](size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

26.
```
const_reference operator[](size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: Nothing.

Complexity: Constant.

27.
```
reference at(size_type n);
```

Requires: size() > n.

Effects: Returns a reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

28.
```
const_reference at(size_type n) const;
```

Requires: size() > n.

Effects: Returns a const reference to the nth element from the beginning of the container.

Throws: std::range_error if n >= size()

Complexity: Constant.

29.
```
basic_string & operator+=(const basic_string & s);
```

Effects: Calls append(str.data, str.size()).

Returns: *this

30.
```
basic_string & operator+=(const CharT * s);
```

Effects: Calls append(s).

Returns: *this

31.
```
basic_string & operator+=(CharT c);
```

Effects: Calls append(1, c).

Returns: *this

32.
```
basic_string & append(const basic_string & s);
```

Effects: Calls append(str.data(), str.size()).

Returns: *this

33.
```
basic_string & append(const basic_string & s, size_type pos, size_type n);
```

Requires: pos <= str.size()

Effects: Determines the effective length rlen of the string to append as the smaller of n and str.size() - pos and calls append(str.data() + pos, rlen).

Throws: If memory allocation throws and out_of_range if pos > str.size()

Returns: *this

34.
```
basic_string & append(const CharT * s, size_type n);
```

Requires: s points to an array of at least n elements of CharT.

Effects: The function replaces the string controlled by *this with a string of length size() + n whose irst size() elements are a copy of the original string controlled by *this and whose remaining elements are a copy of the initial n elements of s.

Throws: If memory allocation throws length_error if size() + n > max_size().

Returns: *this

35.
```
basic_string & append(const CharT * s);
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Effects: Calls append(s, traits::length(s)).

Returns: *this

36.
```
basic_string & append(size_type n, CharT c);
```

Effects: Equivalent to append(basic_string(n, c)).

Returns: *this

37.
```
template<typename InputIter>
  basic_string & append(InputIter first, InputIter last);
```

Requires: [first,last) is a valid range.

Effects: Equivalent to append(basic_string(first, last)).

Returns: *this

38.
```
void push_back(CharT c);
```

Effects: Equivalent to append(static_cast<size_type>(1), c).

39.
```
basic_string & assign(const basic_string & s);
```

Effects: Equivalent to assign(str, 0, npos).

Returns: *this

40.
```
basic_string & assign(basic_string && ms);
```

Effects: The function replaces the string controlled by *this with a string of length str.size() whose elements are a copy of the string controlled by str. Leaves str in a valid but unspecified state.

Throws: Nothing

Returns: *this

41.
```
basic_string & assign(const basic_string & s, size_type pos, size_type n);
```

Requires: pos <= str.size()

Effects: Determines the effective length rlen of the string to assign as the smaller of n and str.size() - pos and calls assign(str.data() + pos rlen).

Throws: If memory allocation throws or out_of_range if pos > str.size().

Returns: *this

42.
```
basic_string & assign(const CharT * s, size_type n);
```

Requires: s points to an array of at least n elements of CharT.

Effects: Replaces the string controlled by *this with a string of length n whose elements are a copy of those pointed to by s.

Throws: If memory allocation throws or length_error if n > max_size().

Returns: *this

43.
```
basic_string & assign(const CharT * s);
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Effects: Calls assign(s, traits::length(s)).

Returns: *this

44.
```
basic_string & assign(size_type n, CharT c);
```

Effects: Equivalent to assign(basic_string(n, c)).

Returns: *this

45.
```
template<typename InputIter>
  basic_string & assign(InputIter first, InputIter last);
```

Effects: Equivalent to assign(basic_string(first, last)).

Returns: *this

46.
```
basic_string & insert(size_type pos, const basic_string & s);
```

Requires: pos <= size().

Effects: Calls insert(pos, str.data(), str.size()).

Throws: If memory allocation throws or out_of_range if pos > size().

Returns: *this

47.
```
basic_string &
insert(size_type pos1, const basic_string & s, size_type pos2, size_type n);
```

Requires: pos1 <= size() and pos2 <= str.size()

Effects: Determines the effective length rlen of the string to insert as the smaller of n and str.size() - pos2 and calls insert(pos1, str.data() + pos2, rlen).

Throws: If memory allocation throws or out_of_range if pos1 > size() or pos2 > str.size().

Returns: *this

48.
```
basic_string & insert(size_type pos, const CharT * s, size_type n);
```

Requires: s points to an array of at least n elements of CharT and pos <= size().

Effects: Replaces the string controlled by *this with a string of length size() + n whose first pos elements are a copy of the initial elements of the original string controlled by *this and whose next n elements are a copy of the elements in s and whose remaining elements are a copy of the remaining elements of the original string controlled by *this.

Throws: If memory allocation throws, out_of_range if pos > size() or length_error if size() + n > max_size().

Returns: *this

49.
```
basic_string & insert(size_type pos, const CharT * s);
```

Requires: pos <= size() and s points to an array of at least traits::length(s) + 1 elements of CharT

Effects: Calls insert(pos, s, traits::length(s)).

Throws: If memory allocation throws, out_of_range if pos > size() length_error if size() > max_size() - Traits::length(s)

Returns: *this

50.
```
basic_string & insert(size_type pos, size_type n, CharT c);
```

Effects: Equivalent to insert(pos, basic_string(n, c)).

Throws: If memory allocation throws, out_of_range if pos > size() length_error if size() > max_size() - n

Returns: *this

51.
```
iterator insert(const_iterator p, CharT c);
```

Requires: p is a valid iterator on *this.

Effects: inserts a copy of c before the character referred to by p.

Returns: An iterator which refers to the copy of the inserted character.

52.
```
iterator insert(const_iterator p, size_type n, CharT c);
```

Requires: p is a valid iterator on *this.

Effects: Inserts n copies of c before the character referred to by p.

Returns: an iterator to the first inserted element or p if n is 0.

53.
```
template<typename InputIter>
  iterator insert(const_iterator p, InputIter first, InputIter last);
```

Requires: p is a valid iterator on *this. [first,last) is a valid range.

Effects: Equivalent to insert(p - begin(), basic_string(first, last)).

Returns: an iterator to the first inserted element or p if first == last.

54.
```
basic_string & erase(size_type pos = 0, size_type n = npos);
```

Requires: pos <= size()

Effects: Determines the effective length xlen of the string to be removed as the smaller of n and size() - pos. The function then replaces the string controlled by *this with a string of length size() - xlen whose first pos elements are a copy of the initial elements of the original string controlled by *this, and whose remaining elements are a copy of the elements of the original string controlled by *this beginning at position pos + xlen.

Throws: out_of_range if pos > size().

Returns: *this

55.
```
iterator erase(const_iterator p);
```

Effects: Removes the character referred to by p.

Throws: Nothing

Returns: An iterator which points to the element immediately following p prior to the element being erased. If no such element exists, end() is returned.

56.
```
iterator erase(const_iterator first, const_iterator last);
```

Requires: first and last are valid iterators on *this, defining a range [first,last).

Effects: Removes the characters in the range [first,last).

Throws: Nothing

Returns: An iterator which points to the element pointed to by last prior to the other elements being erased. If no such element exists, end() is returned.

57.
```
void pop_back();
```

Requires: !empty()

Throws: Nothing

Effects: Equivalent to erase(size() - 1, 1).

58.
```
void clear();
```

Effects: Erases all the elements of the vector.

Throws: Nothing.

Complexity: Linear to the number of elements in the vector.

59.
```
basic_string & replace(size_type pos1, size_type n1, const basic_string & str);
```

Requires: pos1 <= size().

Effects: Calls replace(pos1, n1, str.data(), str.size()).

Throws: if memory allocation throws or out_of_range if pos1 > size().

Returns: *this

60.
```
basic_string & 
replace(size_type pos1, size_type n1, const basic_string & str, 
        size_type pos2, size_type n2);
```

Requires: pos1 <= size() and pos2 <= str.size().

Effects: Determines the effective length rlen of the string to be inserted as the smaller of n2 and str.size() - pos2 and calls replace(pos1, n1, str.data() + pos2, rlen).

Throws: if memory allocation throws, out_of_range if pos1 > size() or pos2 > str.size().

Returns: *this

61.
```
basic_string & 
replace(size_type pos1, size_type n1, const CharT * s, size_type n2);
```

Requires: pos1 <= size() and s points to an array of at least n2 elements of CharT.

Effects: Determines the effective length xlen of the string to be removed as the smaller of n1 and size() - pos1. If size() - xlen >= max_size() - n2 throws length_error. Otherwise, the function replaces the string controlled by *this with a string of length size() - xlen + n2 whose first pos1 elements are a copy of the initial elements of the original string controlled by *this, whose next n2 elements are a copy of the initial n2 elements of s, and whose remaining elements are a copy of the elements of the original string controlled by *this beginning at position pos + xlen.

Throws: if memory allocation throws, out_of_range if pos1 > size() or length_error if the length of the resulting string would exceed max_size()

Returns: *this

62.
```
basic_string & replace(size_type pos, size_type n1, const CharT * s);
```

Requires: pos1 <= size() and s points to an array of at least n2 elements of CharT.

Effects: Determines the effective length xlen of the string to be removed as the smaller of n1 and size() - pos1. If size() - xlen >= max_size() - n2 throws length_error. Otherwise, the function replaces the string controlled by *this with a string of length size() - xlen + n2 whose first pos1 elements are a copy of the initial elements of the original string controlled by *this, whose next n2 elements are a copy of the initial n2 elements of s, and whose remaining elements are a copy of the elements of the original string controlled by *this beginning at position pos + xlen.

Throws: if memory allocation throws, out_of_range if pos1 > size() or length_error if the length of the resulting string would exceed max_size()

Returns: *this

63.
```
basic_string & replace(size_type pos1, size_type n1, size_type n2, CharT c);
```

Requires: pos1 <= size().

Effects: Equivalent to replace(pos1, n1, basic_string(n2, c)).

Throws: if memory allocation throws, out_of_range if pos1 > size() or length_error if the length of the resulting string would exceed max_size()

Returns: *this

64.
```
basic_string &
replace(const_iterator i1, const_iterator i2, const basic_string & str);
```

Requires: [begin(),i1) and [i1,i2) are valid ranges.

Effects: Calls replace(i1 - begin(), i2 - i1, str).

Throws: if memory allocation throws

Returns: *this

65.
```
basic_string &
replace(const_iterator i1, const_iterator i2, const CharT * s, size_type n);
```

Requires: [begin(),i1) and [i1,i2) are valid ranges and s points to an array of at least n elements

Effects: Calls replace(i1 - begin(), i2 - i1, s, n).

Throws: if memory allocation throws

Returns: *this

66.
```
basic_string & replace(const_iterator i1, const_iterator i2, const CharT * s);
```

Requires: [begin(),i1) and [i1,i2) are valid ranges and s points to an array of at least traits::length(s) + 1 elements of CharT.

Effects: Calls replace(i1 - begin(), i2 - i1, s, traits::length(s)).

Throws: if memory allocation throws

Returns: *this

67.
```
basic_string &
replace(const_iterator i1, const_iterator i2, size_type n, CharT c);
```

Requires: [begin(),i1) and [i1,i2) are valid ranges.

Effects: Calls replace(i1 - begin(), i2 - i1, basic_string(n, c)).

Throws: if memory allocation throws

Returns: *this

68.
```
template<typename InputIter>
  basic_string &
  replace(const_iterator i1, const_iterator i2, InputIter j1, InputIter j2);
```

Requires: [begin(),i1), [i1,i2) and [j1,j2) are valid ranges.

Effects: Calls replace(i1 - begin(), i2 - i1, basic_string(j1, j2)).

Throws: if memory allocation throws

Returns: *this

69.
```
size_type copy(CharT * s, size_type n, size_type pos = 0) const;
```

Requires: pos <= size()

Effects: Determines the effective length rlen of the string to copy as the smaller of n and size() - pos. s shall designate an array of at least rlen elements. The function then replaces the string designated by s with a string of length rlen whose elements are a copy of the string controlled by *this beginning at position pos. The function does not append a null object to the string designated by s.

Throws: if memory allocation throws, out_of_range if pos > size().

Returns: rlen

70.
```
void swap(basic_string & x);
```

Effects: *this contains the same sequence of characters that was in s, s contains the same sequence of characters that was in *this.

Throws: Nothing

71.
```
const CharT * c_str() const;
```

Requires: The program shall not alter any of the values stored in the character array.

Returns: Allocator pointer p such that p + i == &operator[](i) for each i in [0,size()].

Complexity: constant time.

72.
```
const CharT * data() const;
```

Requires: The program shall not alter any of the values stored in the character array.

Returns: Allocator pointer p such that p + i == &operator[](i) for each i in [0,size()].

Complexity: constant time.

73.
```
size_type find(const basic_string & s, size_type pos = 0) const;
```

Effects: Determines the lowest position xpos, if possible, such that both of the following conditions obtain: 19 pos <= xpos and xpos + str.size() <= size(); 2) traits::eq(at(xpos+I), str.at(I)) for all elements I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

74.
```
size_type find(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least n elements of CharT.

Throws: Nothing

Returns: find(basic_string<CharT,traits,Allocator>(s,n),pos).

75.
```
size_type find(const CharT * s, size_type pos = 0) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find(basic_string(s), pos).

76.
```
size_type find(CharT c, size_type pos = 0) const;
```

Throws: Nothing

Returns: find(basic_string<CharT,traits,Allocator>(1,c), pos).

77.
```
size_type rfind(const basic_string & str, size_type pos = npos) const;
```

Effects: Determines the highest position xpos, if possible, such that both of the following conditions obtain: a) xpos <= pos and xpos + str.size() <= size(); b) traits::eq(at(xpos+I), str.at(I)) for all elements I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

78.
```
size_type rfind(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least n elements of CharT.

Throws: Nothing

Returns: rfind(basic_string(s, n), pos).

79.
```
size_type rfind(const CharT * s, size_type pos = npos) const;
```

Requires: pos <= size() and s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: rfind(basic_string(s), pos).

80.
```
size_type rfind(CharT c, size_type pos = npos) const;
```

Throws: Nothing

Returns: rfind(basic_string<CharT,traits,Allocator>(1,c),pos).

81.
```
size_type find_first_of(const basic_string & s, size_type pos = 0) const;
```

Effects: Determines the lowest position xpos, if possible, such that both of the following conditions obtain: a) pos <= xpos and xpos < size(); b) traits::eq(at(xpos), str.at(I)) for some element I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

82.
```
size_type find_first_of(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least n elements of CharT.

Throws: Nothing

Returns: find_first_of(basic_string(s, n), pos).

83.
```
size_type find_first_of(const CharT * s, size_type pos = 0) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_first_of(basic_string(s), pos).

84.
```
size_type find_first_of(CharT c, size_type pos = 0) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_first_of(basic_string<CharT,traits,Allocator>(1,c), pos).

85.
```
size_type find_last_of(const basic_string & str, size_type pos = npos) const;
```

Effects: Determines the highest position xpos, if possible, such that both of the following conditions obtain: a) xpos <= pos and xpos < size(); b) traits::eq(at(xpos), str.at(I)) for some element I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

86.
```
size_type find_last_of(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least n elements of CharT.

Throws: Nothing

Returns: find_last_of(basic_string(s, n), pos).

87.
```
size_type find_last_of(const CharT * s, size_type pos = npos) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_last_of(basic_string<CharT,traits,Allocator>(1,c),pos).

88.
```
size_type find_last_of(CharT c, size_type pos = npos) const;
```

Throws: Nothing

Returns: find_last_of(basic_string(s), pos).

89.
```
size_type find_first_not_of(const basic_string & str, size_type pos = 0) const;
```

Effects: Determines the lowest position xpos, if possible, such that both of the following conditions obtain: a) pos <= xpos and xpos < size(); b) traits::eq(at(xpos), str.at(I)) for no element I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

90.
```
size_type find_first_not_of(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_first_not_of(basic_string(s, n), pos).

91.
```
size_type find_first_not_of(const CharT * s, size_type pos = 0) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_first_not_of(basic_string(s), pos).

92.
```
size_type find_first_not_of(CharT c, size_type pos = 0) const;
```

Throws: Nothing

Returns: find_first_not_of(basic_string(1, c), pos).

93.
```
size_type find_last_not_of(const basic_string & str, size_type pos = npos) const;
```

Effects: Determines the highest position xpos, if possible, such that both of the following conditions obtain: a) xpos <= pos and xpos < size(); b) traits::eq(at(xpos), str.at(I)) for no element I of the string controlled by str.

Throws: Nothing

Returns: xpos if the function can determine such a value for xpos. Otherwise, returns npos.

94.
```
size_type find_last_not_of(const CharT * s, size_type pos, size_type n) const;
```

Requires: s points to an array of at least n elements of CharT.

Throws: Nothing

Returns: find_last_not_of(basic_string(s, n), pos).

95.
```
size_type find_last_not_of(const CharT * s, size_type pos = npos) const;
```

Requires: s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: Nothing

Returns: find_last_not_of(basic_string(s), pos).

96.
```
size_type find_last_not_of(CharT c, size_type pos = npos) const;
```

Throws: Nothing

Returns: find_last_not_of(basic_string(1, c), pos).

97.
```
basic_string substr(size_type pos = 0, size_type n = npos) const;
```

Requires: Requires: pos <= size()

Effects: Determines the effective length rlen of the string to copy as the smaller of n and size() - pos.

Throws: If memory allocation throws or out_of_range if pos > size().

Returns: basic_string<CharT,traits,Allocator>(data()+pos,rlen).

98.
```
int compare(const basic_string & str) const;
```

Effects: Determines the effective length rlen of the string to copy as the smaller of size() and str.size(). The function then compares the two strings by calling traits::compare(data(), str.data(), rlen).

Throws: Nothing

Returns: The nonzero result if the result of the comparison is nonzero. Otherwise, returns a value < 0 if size() < str.size(), a 0 value if size() == str.size(), and value > 0 if size() > str.size()

99.
```
int compare(size_type pos1, size_type n1, const basic_string & str) const;
```

Requires: pos1 <= size()

Effects: Determines the effective length rlen of the string to copy as the smaller of

Throws: out_of_range if pos1 > size()

Returns:basic_string(*this,pos1,n1).compare(str).

100.
```
int compare(size_type pos1, size_type n1, const basic_string & str,
            size_type pos2, size_type n2) const;
```

Requires: pos1 <= size() and pos2 <= str.size()

Effects: Determines the effective length rlen of the string to copy as the smaller of

Throws: out_of_range if pos1 > size() or pos2 > str.size()

Returns: basic_string(*this, pos1, n1).compare(basic_string(str, pos2, n2)).

101.
```
int compare(const CharT * s) const;
```

Throws: Nothing

Returns: compare(basic_string(s)).

102.
```
int compare(size_type pos1, size_type n1, const CharT * s, size_type n2) const;
```

Requires: pos1 > size() and s points to an array of at least n2 elements of CharT.

Throws: out_of_range if pos1 > size()

Returns: basic_string(*this, pos, n1).compare(basic_string(s, n2)).

103.
```
int compare(size_type pos1, size_type n1, const CharT * s) const;
```

Requires: pos1 > size() and s points to an array of at least traits::length(s) + 1 elements of CharT.

Throws: out_of_range if pos1 > size()

Returns: basic_string(*this, pos, n1).compare(basic_string(s, n2)).

Struct ordered_range_t

boost::container::ordered_range_t

Synopsis

```
// In header: <boost/container/container_fwd.hpp>


struct ordered_range_t {
};
```

Description

Type used to tag that the input range is guaranteed to be ordered

Struct ordered_unique_range_t

boost::container::ordered_unique_range_t

Synopsis

```
// In header: <boost/container/container_fwd.hpp>


struct ordered_unique_range_t : public boost::container::ordered_range_t {
};
```

Description

Type used to tag that the input range is guaranteed to be ordered and unique

Global ordered_range

boost::container::ordered_range

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

static const ordered_range_t ordered_range;
```

Description

Value used to tag that the input range is guaranteed to be ordered

Global ordered_unique_range

boost::container::ordered_unique_range

Synopsis

```
// In header: <boost/container/container_fwd.hpp>

static const ordered_unique_range_t ordered_unique_range;
```

Description

Value used to tag that the input range is guaranteed to be ordered and unique

Header <boost/container/deque.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator>
      bool operator==(const deque< T, Allocator > & x,
                      const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<(const deque< T, Allocator > & x,
                     const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator!=(const deque< T, Allocator > & x,
                      const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>(const deque< T, Allocator > & x,
                     const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>=(const deque< T, Allocator > & x,
                      const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<=(const deque< T, Allocator > & x,
                      const deque< T, Allocator > & y);
    template<typename T, typename Allocator>
      void swap(deque< T, Allocator > & x, deque< T, Allocator > & y);
  }
}
```

Header <boost/container/flat_map.hpp>

```
namespace boost {
  namespace container {
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator==(const flat_map< Key, T, Compare, Allocator > & x,
                      const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<(const flat_map< Key, T, Compare, Allocator > & x,
                     const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator!=(const flat_map< Key, T, Compare, Allocator > & x,
                      const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>(const flat_map< Key, T, Compare, Allocator > & x,
                     const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<=(const flat_map< Key, T, Compare, Allocator > & x,
                      const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>=(const flat_map< Key, T, Compare, Allocator > & x,
                      const flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      void swap(flat_map< Key, T, Compare, Allocator > & x,
                flat_map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator==(const flat_multimap< Key, T, Compare, Allocator > & x,
                      const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<(const flat_multimap< Key, T, Compare, Allocator > & x,
                     const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator!=(const flat_multimap< Key, T, Compare, Allocator > & x,
                      const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>(const flat_multimap< Key, T, Compare, Allocator > & x,
                     const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<=(const flat_multimap< Key, T, Compare, Allocator > & x,
                      const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>=(const flat_multimap< Key, T, Compare, Allocator > & x,
                      const flat_multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      void swap(flat_multimap< Key, T, Compare, Allocator > & x,
                flat_multimap< Key, T, Compare, Allocator > & y);
  }
}
```

Header <boost/container/flat_set.hpp>

```
namespace boost {
  namespace container {
    template<typename Key, typename Compare, typename Allocator>
      bool operator==(const flat_set< Key, Compare, Allocator > & x,
                      const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator<(const flat_set< Key, Compare, Allocator > & x,
                     const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator!=(const flat_set< Key, Compare, Allocator > & x,
                      const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator>(const flat_set< Key, Compare, Allocator > & x,
                     const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator<=(const flat_set< Key, Compare, Allocator > & x,
                      const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator>=(const flat_set< Key, Compare, Allocator > & x,
                      const flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      void swap(flat_set< Key, Compare, Allocator > & x,
                flat_set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator==(const flat_multiset< Key, Compare, Allocator > & x,
                      const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator<(const flat_multiset< Key, Compare, Allocator > & x,
                     const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator!=(const flat_multiset< Key, Compare, Allocator > & x,
                      const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator>(const flat_multiset< Key, Compare, Allocator > & x,
                     const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator<=(const flat_multiset< Key, Compare, Allocator > & x,
                      const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      bool operator>=(const flat_multiset< Key, Compare, Allocator > & x,
                      const flat_multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator>
      void swap(flat_multiset< Key, Compare, Allocator > & x,
                flat_multiset< Key, Compare, Allocator > & y);
  }
}
```

Header <boost/container/list.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator>
      bool operator==(const list< T, Allocator > & x,
                      const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<(const list< T, Allocator > & x,
                     const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator!=(const list< T, Allocator > & x,
                      const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>(const list< T, Allocator > & x,
                     const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<=(const list< T, Allocator > & x,
                      const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>=(const list< T, Allocator > & x,
                      const list< T, Allocator > & y);
    template<typename T, typename Allocator>
      void swap(list< T, Allocator > & x, list< T, Allocator > & y);
  }
}
```

Header <boost/container/map.hpp>

```
namespace boost {
  namespace container {
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator==(const map< Key, T, Compare, Allocator > & x,
                      const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<(const map< Key, T, Compare, Allocator > & x,
                     const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator!=(const map< Key, T, Compare, Allocator > & x,
                      const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>(const map< Key, T, Compare, Allocator > & x,
                     const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<=(const map< Key, T, Compare, Allocator > & x,
                      const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>=(const map< Key, T, Compare, Allocator > & x,
                      const map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      void swap(map< Key, T, Compare, Allocator > & x,
                map< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator==(const multimap< Key, T, Compare, Allocator > & x,
                      const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<(const multimap< Key, T, Compare, Allocator > & x,
                     const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator!=(const multimap< Key, T, Compare, Allocator > & x,
                      const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>(const multimap< Key, T, Compare, Allocator > & x,
                     const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator<=(const multimap< Key, T, Compare, Allocator > & x,
                      const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      bool operator>=(const multimap< Key, T, Compare, Allocator > & x,
                      const multimap< Key, T, Compare, Allocator > & y);
    template<typename Key, typename T, typename Compare, typename Allocator>
      void swap(multimap< Key, T, Compare, Allocator > & x,
                multimap< Key, T, Compare, Allocator > & y);
  }
}
```

Header <boost/container/scoped_allocator.hpp>

```
namespace boost {
  namespace container {
    template<typename T> struct constructible_with_allocator_suffix;
    template<typename T> struct constructible_with_allocator_prefix;
    template<typename T, typename Alloc> struct uses_allocator;

    template<typename OuterAlloc, typename... InnerAllocs>
      class scoped_allocator_adaptor;
    template<typename OuterA1, typename OuterA2, typename... InnerAllocs>
      bool operator==(const scoped_allocator_adaptor< OuterA1, InnerAllocs... > & a,
                      const scoped_allocator_adaptor< OuterA2, InnerAllocs... > & b);
    template<typename OuterA1, typename OuterA2, typename... InnerAllocs>
      bool operator!=(const scoped_allocator_adaptor< OuterA1, InnerAllocs... > & a,
                      const scoped_allocator_adaptor< OuterA2, InnerAllocs... > & b);
  }
}
```

Struct template constructible_with_allocator_suffix

boost::container::constructible_with_allocator_suffix

Synopsis

```
// In header: <boost/container/scoped_allocator.hpp>

template<typename T>
struct constructible_with_allocator_suffix : public false_type {
};
```

Description

Remark: if a specialization is derived from true_type, indicates that T may be constructed with an allocator as its last constructor argument. Ideally, all constructors of T (including the copy and move constructors) should have a variant that accepts a final argument of allocator_type.

Requires: if a specialization is derived from true_type, T must have a nested type, allocator_type and at least one constructor for which allocator_type is the last parameter. If not all constructors of T can be called with a final allocator_type argument, and if T is used in a context where a container must call such a constructor, then the program is ill-formed.

[Example: template <class T, class Allocator = allocator<T> > class Z { public: typedef Allocator allocator_type;

// Default constructor with optional allocator suffix Z(const allocator_type& a = allocator_type());

// Copy constructor and allocator-extended copy constructor Z(const Z& zz); Z(const Z& zz, const allocator_type& a); };

// Specialize trait for class template Z template <class T, class Allocator = allocator<T> > struct constructible_with_allocator_suffix<Z<T,Allocator> > : ::boost::true_type { };
<ndash></ndash>
end example]

Note: This trait is a workaround inspired by "N2554: The Scoped Allocator Model (Rev 2)" (Pablo Halpern, 2008-02-29) to backport the scoped allocator model to C++03, as in C++03 there is no mechanism to detect if a type can be constructed from arbitrary arguments. Applications aiming portability with several compilers should always define this trait.

In conforming C++11 compilers or compilers supporting SFINAE expressions (when BOOST_NO_SFINAE_EXPR is NOT defined), this trait is ignored and C++11 rules will be used to detect if a type should be constructed with suffix or prefix allocator arguments.

Struct template constructible_with_allocator_prefix

boost::container::constructible_with_allocator_prefix

Synopsis

```
// In header: <boost/container/scoped_allocator.hpp>

template<typename T>
struct constructible_with_allocator_prefix : public false_type {
};
```

Description

Remark: if a specialization is derived from true_type, indicates that T may be constructed with allocator_arg and T::allocator_type as its first two constructor arguments. Ideally, all constructors of T (including the copy and move constructors) should have a variant that accepts these two initial arguments.

Requires: if a specialization is derived from true_type, T must have a nested type, allocator_type and at least one constructor for which allocator_arg_t is the first parameter and allocator_type is the second parameter. If not all constructors of T can be called with these initial arguments, and if T is used in a context where a container must call such a constructor, then the program is ill-formed.

[Example: template <class T, class Allocator = allocator<T> > class Y { public: typedef Allocator allocator_type;

// Default constructor with and allocator-extended default constructor Y(); Y(allocator_arg_t, const allocator_type& a);

// Copy constructor and allocator-extended copy constructor Y(const Y& yy); Y(allocator_arg_t, const allocator_type& a, const Y& yy);

// Variadic constructor and allocator-extended variadic constructor template<class ...Args> Y(Args&& args...); template<class ...Args> Y(allocator_arg_t, const allocator_type& a, Args&&... args); };

// Specialize trait for class template Y template <class T, class Allocator = allocator<T> > struct constructible_with_allocator_prefix<Y<T,Allocator> > : ::boost::true_type { };

<ndash></ndash>
end example]

Note: This trait is a workaround inspired by "N2554: The Scoped Allocator Model (Rev 2)" (Pablo Halpern, 2008-02-29) to backport the scoped allocator model to C++03, as in C++03 there is no mechanism to detect if a type can be constructed from arbitrary arguments. Applications aiming portability with several compilers should always define this trait.

In conforming C++11 compilers or compilers supporting SFINAE expressions (when BOOST_NO_SFINAE_EXPR is NOT defined), this trait is ignored and C++11 rules will be used to detect if a type should be constructed with suffix or prefix allocator arguments.

Struct template uses_allocator

boost::container::uses_allocator

Synopsis

```
// In header: <boost/container/scoped_allocator.hpp>

template<typename T, typename Alloc>
struct uses_allocator {
};
```

Description

Remark: Automatically detects if T has a nested allocator_type that is convertible from Alloc. Meets the BinaryTypeTrait requirements ([meta.rqmts] 20.4.1). A program may specialize this type to derive from true_type for a T of user-defined type if T does not have a nested allocator_type but is nonetheless constructible using the specified Alloc.

Result: derived from true_type if Convertible<Alloc,T::allocator_type> and derived from false_type otherwise.

Class template scoped_allocator_adaptor

boost::container::scoped_allocator_adaptor

Synopsis

```
// In header: <boost/container/scoped_allocator.hpp>

template<typename OuterAlloc, typename... InnerAllocs>
class scoped_allocator_adaptor {
public:
  // types
  typedef OuterAlloc                                          outer_allocator_type;          ↵

  typedef allocator_traits< OuterAlloc >                      outer_traits_type;             ↵

  typedef base_type::inner_allocator_type                     inner_allocator_type;          ↵

  typedef allocator_traits< inner_allocator_type >            inner_traits_type;             ↵

  typedef outer_traits_type::value_type                       value_type;                    ↵

  typedef outer_traits_type::size_type                        size_type;                     ↵

  typedef outer_traits_type::difference_type                  difference_type;               ↵

  typedef outer_traits_type::pointer                          pointer;                       ↵

  typedef outer_traits_type::const_pointer                    const_pointer;                 ↵

  typedef outer_traits_type::void_pointer                     void_pointer;                  ↵

  typedef outer_traits_type::const_void_pointer               const_void_pointer;            ↵

  typedef base_type::propagate_on_container_copy_assignment propagate_on_container_copy_assignment;
  typedef base_type::propagate_on_container_move_assignment propagate_on_container_move_assignment;
  typedef base_type::propagate_on_container_swap              propagate_on_container_swap;   ↵


  // member classes/structs/unions
  template<typename U>
  struct rebind {
    // types
    typedef scoped_allocator_adaptor< typename outer_traits_type::template portable_rebind_al↵
loc< U >::type, InnerAllocs... > other;
  };

  // construct/copy/destruct
  scoped_allocator_adaptor();
  scoped_allocator_adaptor(const scoped_allocator_adaptor &);
  scoped_allocator_adaptor(scoped_allocator_adaptor &&);
  template<typename OuterA2>
    scoped_allocator_adaptor(OuterA2 &&, const InnerAllocs &...);
  template<typename OuterA2>
    scoped_allocator_adaptor(const scoped_allocator_adaptor< OuterA2, InnerAllocs... > &);
  template<typename OuterA2>
    scoped_allocator_adaptor(scoped_allocator_adaptor< OuterA2, InnerAllocs... > &&);
  scoped_allocator_adaptor& operator=(const scoped_allocator_adaptor &);
  scoped_allocator_adaptor& operator=(scoped_allocator_adaptor &&);
  ~scoped_allocator_adaptor();

  // public member functions
  void swap(scoped_allocator_adaptor &);
  outer_allocator_type & outer_allocator();
  const outer_allocator_type & outer_allocator() const;
  inner_allocator_type & inner_allocator();
```

```
  inner_allocator_type const & inner_allocator() const;
  size_type max_size() const;
  template<typename T> void destroy(T *);
  pointer allocate(size_type);
  pointer allocate(size_type, const_void_pointer);
  void deallocate(pointer, size_type);
  scoped_allocator_adaptor select_on_container_copy_construction() const;
  template<typename T, class... Args> void construct(T *, Args &&...);
  template<typename T1, typename T2> void construct(std::pair< T1, T2 > *);
  template<typename T1, typename T2> void construct(unspecified);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(std::pair< T1, T2 > *, U &&, V &&);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(unspecified, U &&, V &&);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(std::pair< T1, T2 > *, const std::pair< U, V > &);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(unspecified, unspecified);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(std::pair< T1, T2 > *, std::pair< U, V > &&);
  template<typename T1, typename T2, typename U, typename V> 
    void construct(unspecified, unspecified);

  // friend functions
  friend void swap(scoped_allocator_adaptor &, scoped_allocator_adaptor &);
};
```

Description

This class is a C++03-compatible implementation of std::scoped_allocator_adaptor. The class template scoped_allocator_adaptor is an allocator template that specifies the memory resource (the outer allocator) to be used by a container (as any other allocator does) and also specifies an inner allocator resource to be passed to the constructor of every element within the container.

This adaptor is instantiated with one outer and zero or more inner allocator types. If instantiated with only one allocator type, the inner allocator becomes the scoped_allocator_adaptor itself, thus using the same allocator resource for the container and every element within the container and, if the elements themselves are containers, each of their elements recursively. If instantiated with more than one allocator, the first allocator is the outer allocator for use by the container, the second allocator is passed to the constructors of the container's elements, and, if the elements themselves are containers, the third allocator is passed to the elements' elements, and so on. If containers are nested to a depth greater than the number of allocators, the last allocator is used repeatedly, as in the single-allocator case, for any remaining recursions.

[**Note**: The scoped_allocator_adaptor is derived from the outer allocator type so it can be substituted for the outer allocator type in most expressions. -end note]

In the construct member functions, `OUTERMOST(x)` is x if x does not have an `outer_allocator()` member function and `OUTERMOST(x.outer_allocator())` otherwise; `OUTERMOST_ALLOC_TRAITS(x)` is `allocator_traits<decltype(OUTERMOST(x))>`.

[**Note**: `OUTERMOST(x)` and `OUTERMOST_ALLOC_TRAITS(x)` are recursive operations. It is incumbent upon the definition of `outer_allocator()` to ensure that the recursion terminates. It will terminate for all instantiations of scoped_allocator_adaptor. -end note]

`scoped_allocator_adaptor` public types

1. typedef allocator_traits< OuterAlloc > outer_traits_type;

   Type: For exposition only

2. typedef base_type::inner_allocator_type inner_allocator_type;

   Type: `scoped_allocator_adaptor<OuterAlloc>` if `sizeof...(InnerAllocs)` is zero; otherwise, `scoped_allocator_adaptor<InnerAllocs...>`.

3. typedef base_type::propagate_on_container_copy_assignment propagate_on_container_copy_assignment;

   Type: `true_type` if `allocator_traits<Allocator>::propagate_on_container_copy_assignment::value` is true for any `Allocator` in the set of `OuterAlloc` and `InnerAllocs...`; otherwise, false_type.

4. typedef base_type::propagate_on_container_move_assignment propagate_on_container_move_assignment;

   Type: `true_type` if `allocator_traits<Allocator>::propagate_on_container_move_assignment::value` is true for any `Allocator` in the set of `OuterAlloc` and `InnerAllocs...`; otherwise, false_type.

5. typedef base_type::propagate_on_container_swap propagate_on_container_swap;

   Type: `true_type` if `allocator_traits<Allocator>::propagate_on_container_swap::value` is true for any `Allocator` in the set of `OuterAlloc` and `InnerAllocs...`; otherwise, false_type.

`scoped_allocator_adaptor` public construct/copy/destruct

1.
```
scoped_allocator_adaptor();
```

   Effects: value-initializes the OuterAlloc base class and the inner allocator object.

2.
```
scoped_allocator_adaptor(const scoped_allocator_adaptor & other);
```

   Effects: initializes each allocator within the adaptor with the corresponding allocator from other.

3.
```
scoped_allocator_adaptor(scoped_allocator_adaptor && other);
```

   Effects: move constructs each allocator within the adaptor with the corresponding allocator from other.

4.
```
template<typename OuterA2> 
  scoped_allocator_adaptor(OuterA2 && outerAlloc, 
                           const InnerAllocs &... innerAllocs);
```

   Requires: OuterAlloc shall be constructible from OuterA2.

   Effects: initializes the OuterAlloc base class with boost::forward<OuterA2>(outerAlloc) and inner with innerAllocs...(hence recursively initializing each allocator within the adaptor with the corresponding allocator from the argument list).

5.
```
template<typename OuterA2> 
  scoped_allocator_adaptor(const scoped_allocator_adaptor< OuterA2, InnerAllocs... > & other);
```

   Requires: OuterAlloc shall be constructible from OuterA2.

   Effects: initializes each allocator within the adaptor with the corresponding allocator from other.

6.
```
template<typename OuterA2> 
  scoped_allocator_adaptor(scoped_allocator_adaptor< OuterA2, InnerAllocs... > && other);
```

   Requires: OuterAlloc shall be constructible from OuterA2.

   Effects: initializes each allocator within the adaptor with the corresponding allocator rvalue from other.

7.
```
scoped_allocator_adaptor& operator=(const scoped_allocator_adaptor & other);
```

8.
```
scoped_allocator_adaptor& operator=(scoped_allocator_adaptor && other);
```

9.
```
~scoped_allocator_adaptor();
```

`scoped_allocator_adaptor` public member functions

1.
```
void swap(scoped_allocator_adaptor & r);
```

Effects: swaps *this with r.

2.
```
outer_allocator_type & outer_allocator();
```

Returns: `static_cast<OuterAlloc&>(*this)`.

3.
```
const outer_allocator_type & outer_allocator() const;
```

Returns: `static_cast<const OuterAlloc&>(*this)`.

4.
```
inner_allocator_type & inner_allocator();
```

Returns: *this if `sizeof...(InnerAllocs)` is zero; otherwise, inner.

5.
```
inner_allocator_type const & inner_allocator() const;
```

Returns: *this if `sizeof...(InnerAllocs)` is zero; otherwise, inner.

6.
```
size_type max_size() const;
```

Returns: `allocator_traits<OuterAlloc>::max_size(outer_allocator())`.

7.
```
template<typename T> void destroy(T * p);
```

Effects: calls `OUTERMOST_ALLOC_TRAITS(*this)::destroy(OUTERMOST(*this), p)`.

8.
```
pointer allocate(size_type n);
```

Returns: `allocator_traits<OuterAlloc>::allocate(outer_allocator(), n)`.

9.
```
pointer allocate(size_type n, const_void_pointer hint);
```

Returns: `allocator_traits<OuterAlloc>::allocate(outer_allocator(), n, hint)`.

10.
```
void deallocate(pointer p, size_type n);
```

Effects: `allocator_traits<OuterAlloc>::deallocate(outer_allocator(), p, n)`.

11.
```
scoped_allocator_adaptor select_on_container_copy_construction() const;
```

Returns: Allocator new scoped_allocator_adaptor object where each allocator A in the adaptor is initialized from the result of calling allocator_traits<Allocator>::select_on_container_copy_construction() on the corresponding allocator in *this.

12.
```
template<typename T, class... Args> void construct(T * p, Args &&... args);
```

Effects: 1) If uses_allocator<T, inner_allocator_type>::value is false calls OUTERMOST_ALLOC_TRAITS(*this)::construct (OUTERMOST(*this), p, std::forward<Args>(args)...).

2) Otherwise, if uses_allocator<T, inner_allocator_type>::value is true and is_constructible<T, allocator_arg_t, inner_allocator_type, Args...>::value is true, calls OUTERMOST_ALLOC_TRAITS(*this)::construct(OUTERMOST(*this), p, allocator_arg, inner_allocator(), std::forward<Args>(args)...).

[**Note**: In compilers without advanced decltype SFINAE support, is_constructible can't be implemented so that condition will be replaced by constructible_with_allocator_prefix<T>::value. -end note]

3) Otherwise, if uses_allocator<T, inner_allocator_type>::value is true and is_constructible<T, Args..., inner_allocator_type>::value is true, calls OUTERMOST_ALLOC_TRAITS(*this)::construct(OUTERMOST(*this), p, std::forward<Args>(args)..., inner_allocator()).

[**Note**: In compilers without advanced decltype SFINAE support, is_constructible can't be implemented so that condition will be replaced by constructible_with_allocator_suffix<T>::value. -end note]

4) Otherwise, the program is ill-formed.

[**Note**: An error will result if uses_allocator evaluates to true but the specific constructor does not take an allocator. This definition prevents a silent failure to pass an inner allocator to a contained element. -end note]

13.
```
template<typename T1, typename T2> void construct(std::pair< T1, T2 > * p);
```

14.
```
template<typename T1, typename T2> void construct(unspecified p);
```

15.
```
template<typename T1, typename T2, typename U, typename V> 
  void construct(std::pair< T1, T2 > * p, U && x, V && y);
```

16.
```
template<typename T1, typename T2, typename U, typename V> 
  void construct(unspecified p, U && x, V && y);
```

17.
```
template<typename T1, typename T2, typename U, typename V> 
  void construct(std::pair< T1, T2 > * p, const std::pair< U, V > & x);
```

18.
```
template<typename T1, typename T2, typename U, typename V> 
  void construct(unspecified p, unspecified x);
```

19.
```
template<typename T1, typename T2, typename U, typename V> 
  void construct(std::pair< T1, T2 > * p, std::pair< U, V > && x);
```

20.
```
template<typename T1, typename T2, typename U, typename V>
  void construct(unspecified p, unspecified x);
```

`scoped_allocator_adaptor` friend functions

1.
```
friend void swap(scoped_allocator_adaptor & l, scoped_allocator_adaptor & r);
```

Effects: swaps *this with r.

Struct template rebind

boost::container::scoped_allocator_adaptor::rebind

Synopsis

```
// In header: <boost/container/scoped_allocator.hpp>


template<typename U>
struct rebind {
  // types
  typedef scoped_allocator_adaptor< typename outer_traits_type::template portable_rebind_al↵
loc< U >::type, InnerAllocs... > other;
};
```

Description

Type: Rebinds scoped allocator to `typedef scoped_allocator_adaptor < typename outer_traits_type::template portable_rebind_alloc<U>::type , InnerAllocs... >`

Header <boost/container/scoped_allocator_fwd.hpp>

```
namespace boost {
  namespace container {
    struct allocator_arg_t;

    static const allocator_arg_t allocator_arg;
  }
}
```

Struct allocator_arg_t

boost::container::allocator_arg_t

Synopsis

```
// In header: <boost/container/scoped_allocator_fwd.hpp>


struct allocator_arg_t {
};
```

Description

The allocator_arg_t struct is an empty structure type used as a unique type to disambiguate constructor and function overloading. Specifically, several types have constructors with allocator_arg_t as the first argument, immediately followed by an argument of a type that satisfies the Allocator requirements

Global allocator_arg

boost::container::allocator_arg

Synopsis

```
// In header: <boost/container/scoped_allocator_fwd.hpp>

static const allocator_arg_t allocator_arg;
```

Description

A instance of type allocator_arg_t

Header <boost/container/set.hpp>

```
namespace boost {
  namespace container {
    template<typename Key, typename Compare, typename Allocator> 
      bool operator==(const set< Key, Compare, Allocator > & x, 
                      const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator<(const set< Key, Compare, Allocator > & x, 
                     const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator!=(const set< Key, Compare, Allocator > & x, 
                      const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator>(const set< Key, Compare, Allocator > & x, 
                     const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator<=(const set< Key, Compare, Allocator > & x, 
                      const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator>=(const set< Key, Compare, Allocator > & x, 
                      const set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      void swap(set< Key, Compare, Allocator > & x, 
                set< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator==(const multiset< Key, Compare, Allocator > & x, 
                      const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator<(const multiset< Key, Compare, Allocator > & x, 
                     const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator!=(const multiset< Key, Compare, Allocator > & x, 
                      const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator>(const multiset< Key, Compare, Allocator > & x, 
                     const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator<=(const multiset< Key, Compare, Allocator > & x, 
                      const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      bool operator>=(const multiset< Key, Compare, Allocator > & x, 
                      const multiset< Key, Compare, Allocator > & y);
    template<typename Key, typename Compare, typename Allocator> 
      void swap(multiset< Key, Compare, Allocator > & x, 
                multiset< Key, Compare, Allocator > & y);
  }
}
```

Header <boost/container/slist.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator>
      bool operator==(const slist< T, Allocator > & x,
                      const slist< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<(const slist< T, Allocator > & sL1,
                     const slist< T, Allocator > & sL2);
    template<typename T, typename Allocator>
      bool operator!=(const slist< T, Allocator > & sL1,
                      const slist< T, Allocator > & sL2);
    template<typename T, typename Allocator>
      bool operator>(const slist< T, Allocator > & sL1,
                     const slist< T, Allocator > & sL2);
    template<typename T, typename Allocator>
      bool operator<=(const slist< T, Allocator > & sL1,
                      const slist< T, Allocator > & sL2);
    template<typename T, typename Allocator>
      bool operator>=(const slist< T, Allocator > & sL1,
                      const slist< T, Allocator > & sL2);
    template<typename T, typename Allocator>
      void swap(slist< T, Allocator > & x, slist< T, Allocator > & y);
  }
}
```

Header <boost/container/stable_vector.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator>
      bool operator==(const stable_vector< T, Allocator > & x,
                      const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<(const stable_vector< T, Allocator > & x,
                     const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator!=(const stable_vector< T, Allocator > & x,
                      const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>(const stable_vector< T, Allocator > & x,
                     const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator>=(const stable_vector< T, Allocator > & x,
                      const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<=(const stable_vector< T, Allocator > & x,
                      const stable_vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      void swap(stable_vector< T, Allocator > & x,
                stable_vector< T, Allocator > & y);
  }
}
```

Header <boost/container/static_vector.hpp>

```
namespace boost {
  namespace container {
    template<typename Value, std::size_t Capacity> class static_vector;
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator==(static_vector< V, C1 > const &, 
                      static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator!=(static_vector< V, C1 > const &, 
                      static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator<(static_vector< V, C1 > const &, 
                     static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator>(static_vector< V, C1 > const &, 
                     static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator<=(static_vector< V, C1 > const &, 
                      static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      bool operator>=(static_vector< V, C1 > const &, 
                      static_vector< V, C2 > const &);
    template<typename V, std::size_t C1, std::size_t C2> 
      void swap(static_vector< V, C1 > &, static_vector< V, C2 > &);
  }
}
```

Class template static_vector

boost::container::static_vector — A variable-size array container with fixed capacity.

Synopsis

```
// In header: <boost/container/static_vector.hpp>

template<typename Value, std::size_t Capacity>
class static_vector {
public:
  // types
  typedef base_t::value_type              value_type;              // The type of elements stored ↵
in the container.
  typedef base_t::size_type               size_type;               // The unsigned integral type ↵
used by the container.
  typedef base_t::difference_type         difference_type;         // The pointers difference type.
  typedef base_t::pointer                 pointer;                 // The pointer type.
  typedef base_t::const_pointer           const_pointer;           // The const pointer type.
  typedef base_t::reference               reference;               // The value reference type.
  typedef base_t::const_reference         const_reference;         // The value const reference ↵
type.
  typedef base_t::iterator                iterator;                // The iterator type.
  typedef base_t::const_iterator          const_iterator;          // The const iterator type.
  typedef base_t::reverse_iterator        reverse_iterator;        // The reverse iterator type.
  typedef base_t::const_reverse_iterator const_reverse_iterator;  // The const reverse iterator.

  // construct/copy/destruct
  static_vector();
  explicit static_vector(size_type);
  static_vector(size_type, value_type const &);
  template<typename Iterator> static_vector(Iterator, Iterator);
  static_vector(static_vector const &);
  template<std::size_t C>
    static_vector(static_vector< value_type, C > const &);
  static_vector(static_vector &&);
  template<std::size_t C> static_vector(static_vector< value_type, C > &&);
  static_vector& operator=(const static_vector &);
  template<std::size_t C>
    static_vector& operator=(static_vector< value_type, C > const &);
  static_vector& operator=(static_vector &&);
  template<std::size_t C>
    static_vector& operator=(static_vector< value_type, C > &&);
  ~static_vector();

  // public member functions
  void swap(static_vector &);
  template<std::size_t C> void swap(static_vector< value_type, C > &);
  void resize(size_type);
  void resize(size_type, value_type const &);
  void reserve(size_type);
  void push_back(value_type const &);
  void push_back(value_type &&);
  void pop_back();
  iterator insert(iterator, value_type const &);
  iterator insert(iterator, value_type &&);
  iterator insert(iterator, size_type, value_type const &);
  template<typename Iterator> iterator insert(iterator, Iterator, Iterator);
  iterator erase(iterator);
  iterator erase(iterator, iterator);
  template<typename Iterator> void assign(Iterator, Iterator);
  void assign(size_type, value_type const &);
  template<class... Args> void emplace_back(Args &&...);
  template<class... Args> iterator emplace(iterator, Args &&...);
  void clear();
  reference at(size_type);
```

```
  const_reference at(size_type) const;
  reference operator[](size_type);
  const_reference operator[](size_type) const;
  reference front();
  const_reference front() const;
  reference back();
  const_reference back() const;
  Value * data();
  const Value * data() const;
  iterator begin();
  const_iterator begin() const;
  const_iterator cbegin() const;
  iterator end();
  const_iterator end() const;
  const_iterator cend() const;
  reverse_iterator rbegin();
  const_reverse_iterator rbegin() const;
  const_reverse_iterator crbegin() const;
  reverse_iterator rend();
  const_reverse_iterator rend() const;
  const_reverse_iterator crend() const;
  size_type size() const;
  bool empty() const;

  // public static functions
  static size_type capacity();
  static size_type max_size();
};
```

Description

static_vector is a sequence container like boost::container::vector with contiguous storage that can change in size, along with the static allocation, low overhead, and fixed capacity of boost::array.

A static_vector is a sequence that supports random access to elements, constant time insertion and removal of elements at the end, and linear time insertion and removal of elements at the beginning or in the middle. The number of elements in a static_vector may vary dynamically up to a fixed capacity because elements are stored within the object itself similarly to an array. However, objects are initialized as they are inserted into static_vector unlike C arrays or std::array which must construct all elements on instantiation. The behavior of static_vector enables the use of statically allocated elements in cases with complex object lifetime requirements that would otherwise not be trivially possible.

Error Handling. Insertion beyond the capacity and out of bounds errors results in calling throw_bad_alloc(). The reason for this is because unlike vectors, static_vector does not perform allocation.

Template Parameters

1.
```
typename Value
```

   The type of element that will be stored.

2.
```
std::size_t Capacity
```

   The maximum number of elements `static_vector` can store, fixed at compile time.

`static_vector` public construct/copy/destruct

1.
```
static_vector();
```

Constructs an empty `static_vector`.

Throws. Nothing.

Complexity. Constant O(1).

2.
```
explicit static_vector(size_type count);
```

Constructs a `static_vector` containing count default constructed Values.

Throws. If Value's default constructor throws.

Complexity. Linear O(N).
Parameters: `count` The number of values which will be contained in the container.
Requires: `count <= capacity()`

3.
```
static_vector(size_type count, value_type const & value);
```

Constructs a `static_vector` containing count copies of value.

Throws. If Value's copy constructor throws.

Complexity. Linear O(N).
Parameters: `count` The number of copies of a values that will be contained in the container.
`value` The value which will be used to copy construct values.
Requires: `count <= capacity()`

4.
```
template<typename Iterator> static_vector(Iterator first, Iterator last);
```

Constructs a `static_vector` containing copy of a range `[first, last)`.

Throws. If Value's constructor taking a dereferenced Iterator throws.

Complexity. Linear O(N).
Parameters: `first` The iterator to the first element in range.
`last` The iterator to the one after the last element in range.
Requires:
- `distance(first, last) <= capacity()`
- Iterator must meet the `ForwardTraversalIterator` concept.

5.
```
static_vector(static_vector const & other);
```

Constructs a copy of other `static_vector`.

Throws. If Value's copy constructor throws.

Complexity. Linear O(N).
Parameters: `other` The `static_vector` which content will be copied to this one.

6.
```
template<std::size_t C>
  static_vector(static_vector< value_type, C > const & other);
```

Constructs a copy of other `static_vector`.

Throws. If Value's copy constructor throws.

Complexity. Linear O(N).

Parameters: `other` The `static_vector` which content will be copied to this one.
Requires: `other.size() <= capacity()`.

7.
```
static_vector(static_vector && other);
```

Move constructor. Moves Values stored in the other `static_vector` to this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor throws.
- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor throws.

Complexity. Linear O(N).
Parameters: `other` The `static_vector` which content will be moved to this one.

8.
```
template<std::size_t C> static_vector(static_vector< value_type, C > && other);
```

Move constructor. Moves Values stored in the other `static_vector` to this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor throws.
- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor throws.

Complexity. Linear O(N).
Parameters: `other` The `static_vector` which content will be moved to this one.
Requires: `other.size() <= capacity()`

9.
```
static_vector& operator=(const static_vector & other);
```

Copy assigns Values stored in the other `static_vector` to this one.

Throws. If Value's copy constructor or copy assignment throws.

Complexity. Linear O(N).
Parameters: `other` The `static_vector` which content will be copied to this one.

10.
```
template<std::size_t C> 
  static_vector& operator=(static_vector< value_type, C > const & other);
```

Copy assigns Values stored in the other `static_vector` to this one.

Throws. If Value's copy constructor or copy assignment throws.

Complexity. Linear O(N).
Parameters: `other` The `static_vector` which content will be copied to this one.
Requires: `other.size() <= capacity()`

11.
```
static_vector& operator=(static_vector && other);
```

Move assignment. Moves Values stored in the other `static_vector` to this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor or move assignment throws.

- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor or copy assignment throws.

Complexity. Linear O(N).

Parameters: `other` The `static_vector` which content will be moved to this one.

12.
```
template<std::size_t C>
  static_vector& operator=(static_vector< value_type, C > && other);
```

Move assignment. Moves Values stored in the other `static_vector` to this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor or move assignment throws.
- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor or copy assignment throws.

Complexity. Linear O(N).

Parameters: `other` The `static_vector` which content will be moved to this one.

Requires: `other.size() <= capacity()`

13.
```
~static_vector();
```

Destructor. Destroys Values stored in this container.

Throws. Nothing

Complexity. Linear O(N).

`static_vector` public member functions

1.
```
void swap(static_vector & other);
```

Swaps contents of the other `static_vector` and this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor or move assignment throws,
- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor or copy assignment throws,

Complexity. Linear O(N).

Parameters: `other` The `static_vector` which content will be swapped with this one's content.

2.
```
template<std::size_t C> void swap(static_vector< value_type, C > & other);
```

Swaps contents of the other `static_vector` and this one.

Throws.

- If `boost::has_nothrow_move<Value>::value` is `true` and Value's move constructor or move assignment throws,
- If `boost::has_nothrow_move<Value>::value` is `false` and Value's copy constructor or copy assignment throws,

Complexity. Linear O(N).

Parameters: `other` The `static_vector` which content will be swapped with this one's content.

Requires: `other.size() <= capacity() && size() <= other.capacity()`

3.
```
void resize(size_type count);
```

Inserts or erases elements at the end such that the size becomes count. New elements are default constructed.

Throws. If Value's default constructor throws.

Complexity. Linear O(N).
Parameters: `count` The number of elements which will be stored in the container.
Requires: `count <= capacity()`

4.
```
void resize(size_type count, value_type const & value);
```

Inserts or erases elements at the end such that the size becomes count. New elements are copy constructed from value.

Throws. If Value's copy constructor throws.

Complexity. Linear O(N).
Parameters: `count` The number of elements which will be stored in the container.
`value` The value used to copy construct the new element.
Requires: `count <= capacity()`

5.
```
void reserve(size_type count);
```

This call has no effect because the Capacity of this container is constant.

Throws. Nothing.

Complexity. Linear O(N).
Parameters: `count` The number of elements which the container should be able to contain.
Requires: `count <= capacity()`

6.
```
void push_back(value_type const & value);
```

Adds a copy of value at the end.

Throws. If Value's copy constructor throws.

Complexity. Constant O(1).
Parameters: `value` The value used to copy construct the new element.
Requires: `size() < capacity()`

7.
```
void push_back(value_type && value);
```

Moves value to the end.

Throws. If Value's move constructor throws.

Complexity. Constant O(1).
Parameters: `value` The value to move construct the new element.
Requires: `size() < capacity()`

8.
```
void pop_back();
```

Destroys last value and decreases the size.

Throws. Nothing by default.

Complexity. Constant O(1).
Requires: `!empty()`

9.
```
iterator insert(iterator position, value_type const & value);
```

Inserts a copy of element at position.

Throws.

- If Value's copy constructor or copy assignment throws
- If Value's move constructor or move assignment throws.

Complexity. Constant or linear.

Parameters:	`position`	The position at which the new value will be inserted.
	`value`	The value used to copy construct the new element.
Requires:	• `position` must be a valid iterator of `*this` in range `[begin(), end()]`. • `size() < capacity()`	

10.
```
iterator insert(iterator position, value_type && value);
```

Inserts a move-constructed element at position.

Throws. If Value's move constructor or move assignment throws.

Complexity. Constant or linear.

Parameters:	`position`	The position at which the new value will be inserted.
	`value`	The value used to move construct the new element.
Requires:	• `position` must be a valid iterator of `*this` in range `[begin(), end()]`. • `size() < capacity()`	

11.
```
iterator insert(iterator position, size_type count, value_type const & value);
```

Inserts a count copies of value at position.

Throws.

- If Value's copy constructor or copy assignment throws.
- If Value's move constructor or move assignment throws.

Complexity. Linear O(N).

Parameters:	`count`	The number of new elements which will be inserted.
	`position`	The position at which new elements will be inserted.
	`value`	The value used to copy construct new elements.
Requires:	• `position` must be a valid iterator of `*this` in range `[begin(), end()]`. • `size() + count <= capacity()`	

12.
```
template<typename Iterator> 
  iterator insert(iterator position, Iterator first, Iterator last);
```

Inserts a copy of a range `[first, last)` at position.

Throws.

- If Value's constructor and assignment taking a dereferenced `Iterator`.
- If Value's move constructor or move assignment throws.

Complexity. Linear O(N).

Parameters:
`first` The iterator to the first element of a range used to construct new elements.
`last` The iterator to the one after the last element of a range used to construct new elements.
`position` The position at which new elements will be inserted.

Requires:
- `position` must be a valid iterator of `*this` in range `[begin(), end()]`.
- `distance(first, last) <= capacity()`
- `Iterator` must meet the `ForwardTraversalIterator` concept.

13.
```
iterator erase(iterator position);
```

Erases Value from position.

Throws. If Value's move assignment throws.

Complexity. Linear O(N).

Parameters:
`position` The position of the element which will be erased from the container.

Requires:
`position` must be a valid iterator of `*this` in range `[begin(), end())`

14.
```
iterator erase(iterator first, iterator last);
```

Erases Values from a range `[first, last)`.

Throws. If Value's move assignment throws.

Complexity. Linear O(N).

Parameters:
`first` The position of the first element of a range which will be erased from the container.
`last` The position of the one after the last element of a range which will be erased from the container.

Requires:
- `first` and `last` must define a valid range
- iterators must be in range `[begin(), end()]`

15.
```
template<typename Iterator> void assign(Iterator first, Iterator last);
```

Assigns a range `[first, last)` of Values to this container.

Throws. If Value's copy constructor or copy assignment throws,

Complexity. Linear O(N).

Parameters:
`first` The iterator to the first element of a range used to construct new content of this container.
`last` The iterator to the one after the last element of a range used to construct new content of this container.

Requires:
`distance(first, last) <= capacity()`

16.
```
void assign(size_type count, value_type const & value);
```

Assigns a count copies of value to this container.

Throws. If Value's copy constructor or copy assignment throws.

Complexity. Linear O(N).

Parameters:
`count` The new number of elements which will be container in the container.
`value` The value which will be used to copy construct the new content.

Requires:
`count <= capacity()`

17.
```
template<class... Args> void emplace_back(Args &&... args);
```

Inserts a Value constructed with `std::forward<Args>(args)`... in the end of the container.

Throws. If in-place constructor throws or Value's move constructor throws.

Complexity. Constant O(1).

Parameters: `args` The arguments of the constructor of the new element which will be created at the end of the container.

Requires: `size() < capacity()`

18.
```
template<class... Args> iterator emplace(iterator position, Args &&... args);
```

Inserts a Value constructed with `std::forward<Args>(args)`... before position.

Throws. If in-place constructor throws or if Value's move constructor or move assignment throws.

Complexity. Constant or linear.

Parameters:
- `args` The arguments of the constructor of the new element.
- `position` The position at which new elements will be inserted.

Requires:
- `position` must be a valid iterator of `*this` in range `[begin(), end()]`
- `size() < capacity()`

19.
```
void clear();
```

Removes all elements from the container.

Throws. Nothing.

Complexity. Constant O(1).

20.
```
reference at(size_type i);
```

Returns reference to the i-th element.

Throws. `std::out_of_range` exception by default.

Complexity. Constant O(1).

Parameters: `i` The element's index.

Requires: `i < size()`

Returns: reference to the i-th element from the beginning of the container.

21.
```
const_reference at(size_type i) const;
```

Returns const reference to the i-th element.

Throws. `std::out_of_range` exception by default.

Complexity. Constant O(1).

Parameters: `i` The element's index.

Requires: `i < size()`

Returns: const reference to the i-th element from the beginning of the container.

22.
```
reference operator[](size_type i);
```

Returns reference to the i-th element.

Throws. Nothing by default.

Complexity. Constant O(1).
Parameters: `i` The element's index.
Requires: `i < size()`
Returns: reference to the i-th element from the beginning of the container.

23.
```
const_reference operator[](size_type i) const;
```

Returns const reference to the i-th element.

Throws. Nothing by default.

Complexity. Constant O(1).
Parameters: `i` The element's index.
Requires: `i < size()`
Returns: const reference to the i-th element from the beginning of the container.

24.
```
reference front();
```

Returns reference to the first element.

Throws. Nothing by default.

Complexity. Constant O(1).
Requires: `!empty()`
Returns: reference to the first element from the beginning of the container.

25.
```
const_reference front() const;
```

Returns const reference to the first element.

Throws. Nothing by default.

Complexity. Constant O(1).
Requires: `!empty()`
Returns: const reference to the first element from the beginning of the container.

26.
```
reference back();
```

Returns reference to the last element.

Throws. Nothing by default.

Complexity. Constant O(1).
Requires: `!empty()`
Returns: reference to the last element from the beginning of the container.

27.
```
const_reference back() const;
```

Returns const reference to the first element.

Throws. Nothing by default.

Complexity. Constant O(1).
Requires: `!empty()`
Returns: const reference to the last element from the beginning of the container.

28.
```
Value * data();
```

Pointer such that `[data(), data() + size())` is a valid range. For a non-empty vector `data() == &front()`.

Throws. Nothing.

Complexity. Constant O(1).

29.
```
const Value * data() const;
```

Const pointer such that `[data(), data() + size())` is a valid range. For a non-empty vector `data() == &front()`.

Throws. Nothing.

Complexity. Constant O(1).

30.
```
iterator begin();
```

Returns iterator to the first element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: iterator to the first element contained in the vector.

31.
```
const_iterator begin() const;
```

Returns const iterator to the first element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_iterator to the first element contained in the vector.

32.
```
const_iterator cbegin() const;
```

Returns const iterator to the first element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_iterator to the first element contained in the vector.

33.
```
iterator end();
```

Returns iterator to the one after the last element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: iterator pointing to the one after the last element contained in the vector.

34.
```
const_iterator end() const;
```

Returns const iterator to the one after the last element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_iterator pointing to the one after the last element contained in the vector.

35.
```
const_iterator cend() const;
```

Returns const iterator to the one after the last element.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_iterator pointing to the one after the last element contained in the vector.

36.
```
reverse_iterator rbegin();
```

Returns reverse iterator to the first element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).
Returns: reverse_iterator pointing to the beginning of the reversed static_vector.

37.
```
const_reverse_iterator rbegin() const;
```

Returns const reverse iterator to the first element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_reverse_iterator pointing to the beginning of the reversed static_vector.

38.
```
const_reverse_iterator crbegin() const;
```

Returns const reverse iterator to the first element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_reverse_iterator pointing to the beginning of the reversed static_vector.

39.
```
reverse_iterator rend();
```

Returns reverse iterator to the one after the last element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).
Returns: reverse_iterator pointing to the one after the last element of the reversed static_vector.

40.
```
const_reverse_iterator rend() const;
```

Returns const reverse iterator to the one after the last element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).

Returns: const_reverse_iterator pointing to the one after the last element of the reversed static_vector.

41.
```
const_reverse_iterator crend() const;
```

Returns const reverse iterator to the one after the last element of the reversed container.

Throws. Nothing.

Complexity. Constant O(1).
Returns: const_reverse_iterator pointing to the one after the last element of the reversed static_vector.

42.
```
size_type size() const;
```

Returns the number of stored elements.

Throws. Nothing.

Complexity. Constant O(1).
Returns: Number of elements contained in the container.

43.
```
bool empty() const;
```

Queries if the container contains elements.

Throws. Nothing.

Complexity. Constant O(1).
Returns: true if the number of elements contained in the container is equal to 0.

`static_vector` public static functions

1.
```
static size_type capacity();
```

Returns container's capacity.

Throws. Nothing.

Complexity. Constant O(1).
Returns: container's capacity.

2.
```
static size_type max_size();
```

Returns container's capacity.

Throws. Nothing.

Complexity. Constant O(1).
Returns: container's capacity.

Function template operator==

boost::container::operator== — Checks if contents of two static_vectors are equal.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2> 
  bool operator==(static_vector< V, C1 > const & x, 
                  static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters: `x` The first `static_vector`.
`y` The second `static_vector`.
Returns: `true` if containers have the same size and elements in both containers are equal.

Function template operator!=

boost::container::operator!= — Checks if contents of two static_vectors are not equal.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2> 
  bool operator!=(static_vector< V, C1 > const & x, 
                  static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters: `x` The first `static_vector`.
`y` The second `static_vector`.
Returns: `true` if containers have different size or elements in both containers are not equal.

Function template operator<

boost::container::operator< — Lexicographically compares static_vectors.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2> 
  bool operator<(static_vector< V, C1 > const & x, 
                 static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters: x The first `static_vector`.
y The second `static_vector`.
Returns: `true` if x compares lexicographically less than y.

Function template operator>

boost::container::operator> — Lexicographically compares static_vectors.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2>
  bool operator>(static_vector< V, C1 > const & x,
                 static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters: x The first `static_vector`.
y The second `static_vector`.
Returns: `true` if y compares lexicographically less than x.

Function template operator<=

boost::container::operator<= — Lexicographically compares static_vectors.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2>
  bool operator<=(static_vector< V, C1 > const & x,
                  static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters: x The first `static_vector`.
y The second `static_vector`.
Returns: `true` if y don't compare lexicographically less than x.

Function template operator>=

boost::container::operator>= — Lexicographically compares static_vectors.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2>
  bool operator>=(static_vector< V, C1 > const & x,
                  static_vector< V, C2 > const & y);
```

Description

Complexity. Linear O(N).

Parameters:
- x The first `static_vector`.
- y The second `static_vector`.

Returns: `true` if x don't compare lexicographically less than y.

Function template swap

boost::container::swap — Swaps contents of two static_vectors.

Synopsis

```
// In header: <boost/container/static_vector.hpp>


template<typename V, std::size_t C1, std::size_t C2>
  void swap(static_vector< V, C1 > & x, static_vector< V, C2 > & y);
```

Description

This function calls static_vector::swap().

Complexity. Linear O(N).

Parameters:
- x The first `static_vector`.
- y The second `static_vector`.

Header <boost/container/string.hpp>

```
namespace boost {
  namespace container {
    typedef basic_string< char,std::char_traits< char >,std::allocator< char > > string;
    typedef basic_string< wchar_t,std::char_traits< wchar_t >,std::allocator< wchar_t > > wstring;
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(const basic_string< CharT, Traits, Allocator > & x, 
                const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(basic_string< CharT, Traits, Allocator > && mx, 
                basic_string< CharT, Traits, Allocator > && my);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(basic_string< CharT, Traits, Allocator > && mx, 
                const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(const basic_string< CharT, Traits, Allocator > & x, 
                basic_string< CharT, Traits, Allocator > && my);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(const CharT * s, basic_string< CharT, Traits, Allocator > y);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(basic_string< CharT, Traits, Allocator > x, const CharT * s);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(CharT c, basic_string< CharT, Traits, Allocator > y);
    template<typename CharT, typename Traits, typename Allocator> 
      basic_string< CharT, Traits, Allocator > 
      operator+(basic_string< CharT, Traits, Allocator > x, const CharT c);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator==(const basic_string< CharT, Traits, Allocator > & x, 
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator==(const CharT * s, 
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator==(const basic_string< CharT, Traits, Allocator > & x, 
                      const CharT * s);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator!=(const basic_string< CharT, Traits, Allocator > & x, 
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator!=(const CharT * s, 
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator!=(const basic_string< CharT, Traits, Allocator > & x, 
                      const CharT * s);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator<(const basic_string< CharT, Traits, Allocator > & x, 
                     const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator<(const CharT * s, 
                     const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator> 
      bool operator<(const basic_string< CharT, Traits, Allocator > & x, 
                     const CharT * s);
    template<typename CharT, typename Traits, typename Allocator> 
```

```
      bool operator>(const basic_string< CharT, Traits, Allocator > & x,
                     const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator>(const CharT * s,
                     const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator>(const basic_string< CharT, Traits, Allocator > & x,
                     const CharT * s);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator<=(const basic_string< CharT, Traits, Allocator > & x,
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator<=(const CharT * s,
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator<=(const basic_string< CharT, Traits, Allocator > & x,
                      const CharT * s);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator>=(const basic_string< CharT, Traits, Allocator > & x,
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator>=(const CharT * s,
                      const basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      bool operator>=(const basic_string< CharT, Traits, Allocator > & x,
                      const CharT * s);
    template<typename CharT, typename Traits, typename Allocator>
      void swap(basic_string< CharT, Traits, Allocator > & x,
                basic_string< CharT, Traits, Allocator > & y);
    template<typename CharT, typename Traits, typename Allocator>
      std::basic_ostream< CharT, Traits > &
      operator<<(std::basic_ostream< CharT, Traits > & os,
                 const basic_string< CharT, Traits, Allocator > & s);
    template<typename CharT, typename Traits, typename Allocator>
      std::basic_istream< CharT, Traits > &
      operator>>(std::basic_istream< CharT, Traits > & is,
                 basic_string< CharT, Traits, Allocator > & s);
    template<typename CharT, typename Traits, typename Allocator>
      std::basic_istream< CharT, Traits > &
      getline(std::istream & is, basic_string< CharT, Traits, Allocator > & s,
              CharT delim);
    template<typename CharT, typename Traits, typename Allocator>
      std::basic_istream< CharT, Traits > &
      getline(std::basic_istream< CharT, Traits > & is,
              basic_string< CharT, Traits, Allocator > & s);
    template<typename Ch, typename Allocator>
      std::size_t hash_value(basic_string< Ch, std::char_traits< Ch >, Allocator > const & v);
  }
}
```

Type definition string

string

Synopsis

```
// In header: <boost/container/string.hpp>


typedef basic_string< char,std::char_traits< char >,std::allocator< char > > string;
```

Description

Typedef for a basic_string of narrow characters

Type definition wstring

wstring

Synopsis

```
// In header: <boost/container/string.hpp>


typedef basic_string< wchar_t,std::char_traits< wchar_t >,std::allocator< wchar_t > > wstring;
```

Description

Typedef for a basic_string of narrow characters

Header <boost/container/throw_exception.hpp>

```
namespace boost {
  namespace container {
    void throw_bad_alloc();
    void throw_out_of_range(const char * str);
    void throw_length_error(const char * str);
    void throw_logic_error(const char * str);
    void throw_runtime_error(const char * str);
  }
}
```

Header <boost/container/vector.hpp>

```
namespace boost {
  namespace container {
    template<typename T, typename Allocator>
      bool operator==(const vector< T, Allocator > & x,
                      const vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator!=(const vector< T, Allocator > & x,
                      const vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      bool operator<(const vector< T, Allocator > & x,
                     const vector< T, Allocator > & y);
    template<typename T, typename Allocator>
      void swap(vector< T, Allocator > & x, vector< T, Allocator > & y);
  }
}
```

Acknowledgements, notes and links

- Original standard container code comes from SGI STL library, which enhanced the original HP STL code. Most of this code was rewritten for **Boost.Interprocess** and moved to **Boost.Intrusive**. `deque` and `string` containers still have fragments of the original SGI code. Many thanks to Alexander Stepanov, Meng Lee, David Musser, Matt Austern... and all HP and SGI STL developers.
- `flat_[multi]_map/set` containers were originally based on Loki's AssocVector class. Code was rewritten and expanded for **Boost.Interprocess**, so thanks to Andrei Alexandrescu.
- `stable_vector` was invented and coded by Joaquín M. López Muñoz, then adapted for **Boost.Interprocess**. Thanks for such a great container.
- `static_vector` was based on Andrew Hundt's and Adam Wulkiewicz's high-performance `varray` class. Many performance improvements of `vector` were also inspired in their implementation. Thanks!
- Howard Hinnant's help and advices were essential when implementing move semantics, improving allocator support or implementing small string optimization. Thanks Howard for your wonderful standard library implementations.
- And finally thanks to all Boosters who helped all these years, improving, fixing and reviewing all my libraries.

Release Notes

Boost 1.54 Release

- Added experimental `static_vector` class, based on Andrew Hundt's and Adam Wulkiewicz's high performance `varray` class.
- Speed improvements in `vector` constructors/copy/move/swap, dispatching to memcpy when possible.
- Support for `BOOST_NO_EXCEPTIONS` #7227.
- Fixed bugs #7921, #7969, #8118, #8294, #8553, #8724.

Boost 1.53 Release

- Fixed bug #7650.
- Improved `vector`'s insertion performance.
- Changed again experimental multiallocation interface for better performance (still experimental).
- Added no exception support for those willing to disable exceptions in their compilers.
- Fixed GCC -Wshadow warnings.
- Replaced deprecated BOOST_NO_XXXX with newer BOOST_NO_CXX11_XXX macros.

Boost 1.52 Release

- Improved `stable_vector`'s template code bloat and type safety.
- Changed typedefs and reordered functions of sequence containers to improve doxygen documentation.
- Fixed bugs #6615, #7139, #7215, #7232, #7269, #7439.
- Implemented LWG Issue #149 (range insertion now returns an iterator) & cleaned up insertion code in most containers
- Corrected aliasing errors.

Boost 1.51 Release

- Fixed bugs #6763, #6803, #7114, #7103. #7123,

Boost 1.50 Release

- Added Scoped Allocator Model support.
- Fixed bugs #6606, #6533, #6536, #6566, #6575,

Boost 1.49 Release

- Fixed bugs #6540, #6499, #6336, #6335, #6287, #6205, #4383.
- Added `allocator_traits` support for both C++11 and C++03 compilers through an internal `allocator_traits` clone.

Boost 1.48 Release

- First release. Container code from **Boost.Interprocess** was deleted and redirected to **Boost.Container** via using directives.