

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

Introduction to STL

TA

CST, THU

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Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

What is STL?

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

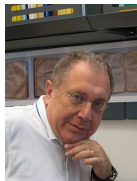
Bitset

Algorithm

Beyond STL

Summary

- Full Name: Standard Template Library
- Author: Alexander Stepanov



What is STL?

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

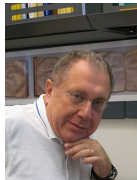
Bitset

Algorithm

Beyond STL

Summary

- Full Name: Standard Template Library
- Author: Alexander Stepanov
- Idea: Generic Programming



History

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

- 1979: work out
- 1983: Ada
- 1987: An Ada Library
- 1993-1994: C++ Standard
- 1994: HP(Original), Stepanov & Lee
- 1997: SGI-STL, Stepanov & Lee
- Present: libstdc++(g++), Microsoft STL(Visual C++),
...

Framework

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

Components: Container, Algorithm, Iterator, Functor, Adaptor, Allocator

Framework

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

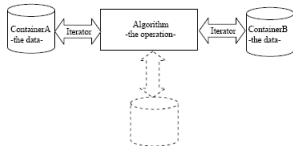
Bitset

Algorithm

Beyond STL

Summary

Components: Container, Algorithm, Iterator, Functor, Adaptor, Allocator



Framework

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

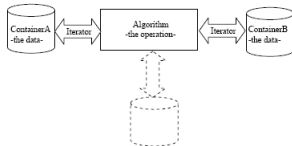
Bitset

Algorithm

Beyond STL

Summary

Components: Container, Algorithm, Iterator, Functor, Adaptor, Allocator



```
#include<vector>
int main(){
    vector<int> a(10);
    for(vector<int>::iterator it=a.begin();
        it!=a.end();++it)
        ++*it;
}
```

Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

Container

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

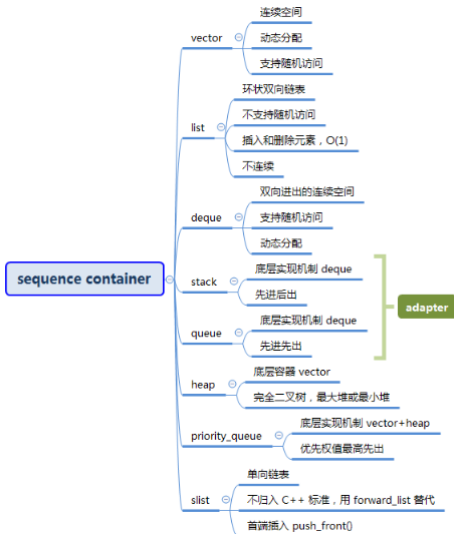
Bitset

Algorithm

Beyond STL

Summary

- Basic: **pair**
- Sequence container:
array, **vector**,
priority_queue,
list, *deque*,
stack, *queue*



Container

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

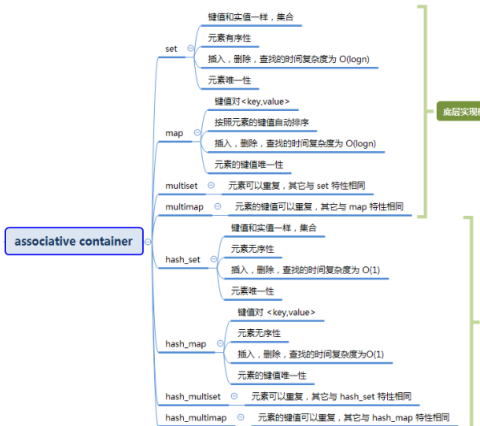
Algorithm

Beyond STL

Summary

- Associative:
RB-tree, set, map, multiset, multimap

- Associative(c++11):
unordered_set,
unordered_map,
unordered_multiset,
un-
ordered_multimap



Pair

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template <class T1, class T2> struct pair;
```

Member variables: first, second

Relative Function: make_pair

```
pair<int, double> p(1, 2.0);  
cout << p.first + p.second << endl;  
p = make_pair(2.3, 3);  
cout << p.first + p.second << endl;
```

Vector: Dynamic Array

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template < class T,  
          class Alloc = allocator<T> > class vector;
```

Functions

- Specialization: `vector<bool>`
- Element access: `operator[]`, `front`, `back`
- Iterators: `begin`, `end`, `rbegin`, `rend`
- Capacity: `empty`, `size`, `max_size`
- Modifiers: `clear`, `insert`, `erase`, `push_back`, `pop_back`,
- Non-member functions: `operator==`, `operator!=`,
`operator<`, `operator<=`, `operator>`, `operator>=`

Principle

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

How to implement a dynamic array?

Requirement: random access + push/pop back

- $O(n)$

Principle

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

How to implement a dynamic array?

Requirement: random access + push/pop back

- $O(n)$
- amortized $O(1)$

Principle

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

How to implement a dynamic array?

Requirement: random access + push/pop back

- $O(n)$
- amortized $O(1)$
- $O(\log n)$

Application

- Adjacency list

Notice

- Double memory
- Speed
- Iterator

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长度为 n 的整数数组，支持如下两种操作：

- 将位置 i 的值改为 x （不超过 m_1 个）
- 查询时刻 t 位置 i 的值（不超过 m_2 个）

其中， $n \leq 10^5$ 。

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长度为 n 的整数数组，支持如下两种操作：

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其中， $n \leq 10^5$ 。

- 允许离线？（ $m_1, m_2 \leq 10^6$, $m_1, m_2 \leq 10^7$ ）

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长度为 n 的整数数组，支持如下两种操作：

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- 允许离线？（ $m_1, m_2 \leq 10^6$, $m_1, m_2 \leq 10^7$ ）
- 要求 $O(\log n)$ 的操作？（ $m_1, m_2 \leq 10^6$ ）

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长度为 n 的整数数组，支持如下两种操作：

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- 允许离线？（ $m_1, m_2 \leq 10^6$, $m_1, m_2 \leq 10^7$ ）
- 要求 $O(\log n)$ 的操作？（ $m_1, m_2 \leq 10^6$ ）
- 要求 $O(1)$ 修改？（ $m_1 \leq 10^7, m_2 \leq 10^6$ ）

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长度为 n 的整数数组，支持如下两种操作：

- 将位置 i 的值改为 x （不超过 m_1 个）
- 查询时刻 t 位置 i 的值（不超过 m_2 个）

其中， $n \leq 10^5$ 。

- 允许离线？（ $m_1, m_2 \leq 10^6$, $m_1, m_2 \leq 10^7$ ）
- 要求 $O(\log n)$ 的操作？（ $m_1, m_2 \leq 10^6$ ）
- 要求 $O(1)$ 修改？（ $m_1 \leq 10^7, m_2 \leq 10^6$ ）
- 要求 $O(1)$ 查询？（ $m_1 \leq 10^5, m_2 \leq 10^7$ ）

Priority_queue

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template<
    class T,
    class Container = std::vector<T>,
    class Compare = std::less<
        typename Container::value_type>
> class priority_queue;
```

Functions

- Element Access: top
- Capacity: empty, size
- Modifiers: push, pop

Principle: Binary Heap

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

- Storage
- Insert: $O(\log n)$
- Delete: $O(\log n)$
- Build: $O(n)$

Exercise 1

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

有 n 件商品，第 i 件商品在第 d_i ($d_i \leq m$) 天及之前卖出会获得收益 p_i ，每天只能卖出一件商品，求最大收益。

$$1 \leq n, m \leq 10^6$$

Exercise 2

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

一个 $n \times n$ 的二维数组 a , $a[x][y] = x^3 + xy + y^2 (0 \leq x, y < n)$,
求 a 中最小的 k 个数的和。
 $n, k \leq 10^6$

Set/Multiset

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template<
    class Key,
    class Compare = std::less<Key>,
    class Allocator = std::allocator<Key>
> class multiset;
```

Functions

- Iterators: begin, end
- Capacity: empty, size
- Modifiers: clear, insert, erase
- Lookup: count, find, lower_bound, upper_bound, equal_range

Map

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template<
    class Key,
    class T,
    class Compare = std::less<Key>,
    class Allocator = std::allocator<
        std::pair<const Key, T> >
> class map;
```

Functions

- Element access: operator[]
- Iterators: begin, end, rbegin, rend
- Capacity: empty, size
- Modifiers: clear, insert, erase
- Lookup: find, lower_bound, upper_bound

Principle: RB-tree

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

Properties

- Each node is either red or black.
- If a node is red, then both its children are black.
- Every path from a given node to any of its descendant leaves contains the same number of black nodes.

Time Complexity

- Height: $O(\log n)$
- Insertion: $O(\log n)$
- Removal: $O(\log n)$

Exercise

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

维护一个长为 n 的正整数序列，支持：

- 在初始序列中位置 i 的后面插入一个值为 x 的数，如果已经有多个，放到最后面。
- 查询相邻两个元素最小的差
- 查询任意两个元素最小的差

Bitset

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

```
template< std::size_t N >  
class bitset;
```

Functions

- Element access: operator[], count
- Capacity: size
- Modifiers: operator=..., set, reset, flip

Exercise 1

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

给你 n 个数字 a_i , 问 $1-m$ 中有多少个数字可以表示为任意多个数字 a_i 的和?

$$1 \leq n, m \leq 10^5$$

Exercise 2

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

一张 n 个点, m 条边的 DAG, 问每个点能到达多少节点?
 $1 \leq n, m \leq 10^5$

Exercise 3

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

d 维空间中 n 个点, 给出 q 个询问点, 对于每个询问点你需要回答有多少个点是每一维都比它小的。

$$1 \leq d \leq 5, 1 \leq n, q \leq 3 * 10^5$$

Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

Algorithm

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

- min_element, max_element
- sort
- nth_element
- lower_bound, upper_bound
- next_permutation
- random_shuffle
- valarray

Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

Beyond STL

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

- `rope<T>`
- `__gnu_pbds::priority_queue<T>` modify, erase, join
- `__gnu_pbds::tree<key, T>` split, join, rank, k-th

Contents

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

1 Introduction

2 Container

- Vector
- Priority_queue
- Set/Map
- Bitset

3 Algorithm

4 Beyond STL

5 Summary

Summary

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

- Standard Template Library
- Vector
- Priority_queue
- Set/Map
- Bitset
- Others

Reference

Introduction
to STL

TA

Introduction

Container

Vector

Priority_queue

Set/Map

Bitset

Algorithm

Beyond STL

Summary

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- 侯捷. STL 源码剖析.
- https://en.wikipedia.org/wiki/Standard_Template_Library#History
- <http://www.tenouk.com/Module27.html>
- https://en.wikipedia.org/wiki/Alexander_Stepanov
- <http://www.cplusplus.com>
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- <https://www.zhihu.com/question/49238475>