# STL Algorithms

Cristian Cibils
(ccibils@stanford.edu)

# Annoucements

Assignment two is out!

- We're going to write a hangman program
- Due: Sunday May 11, 11:59 PM
- I recommend doing it
  - You must do it if you did not do GraphViz
- There's no starter code whatsoever, so all you have to download is the dictionary file

# STL Algorithms

Road Map for Today

- Abstraction in C++
- STL <algorithm>
- Iterator adapters

# STL Iterators

Let's introduce a different picture of the STL, in terms of **abstraction**

# Abstraction in the STL

**abstraction** allows us to express the general structure of a problem instead of the particulars of implementation

# Abstraction in the STL

- We began by talking about **basic types**.
- **char**, **int**, **double**, **string**, others.
- Each of these types held what was conceptually a "single value"

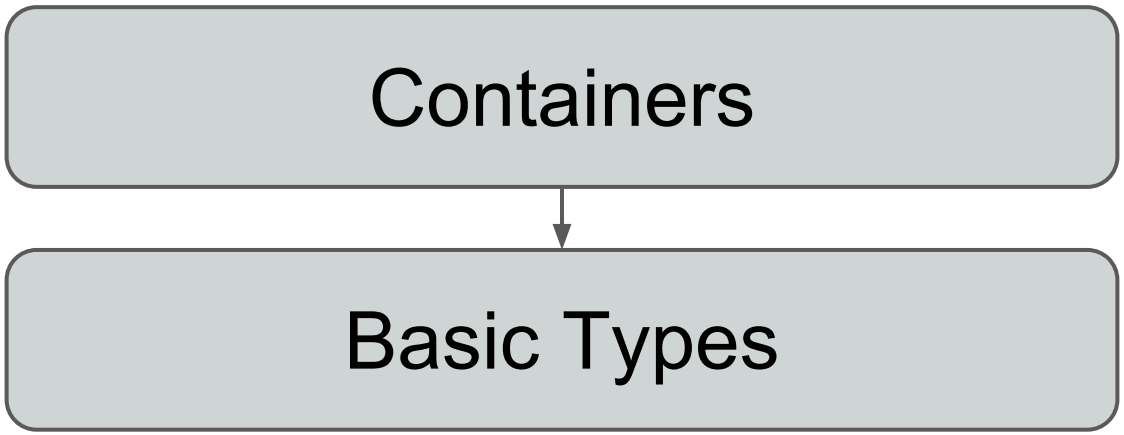
# Abstraction in the STL

Basic Types

# Abstraction in the STL

- Many programs require a number of variables of the same basic type
  - A vector of integers representing student's ages
  - A mapping translating between names and addresses
- **Containers** allow a programmer to use the same collection regardless of the underlying basic type
- The same `<vector>` implementation can be used for `ints` as well as `strings`

# Abstraction in the STL



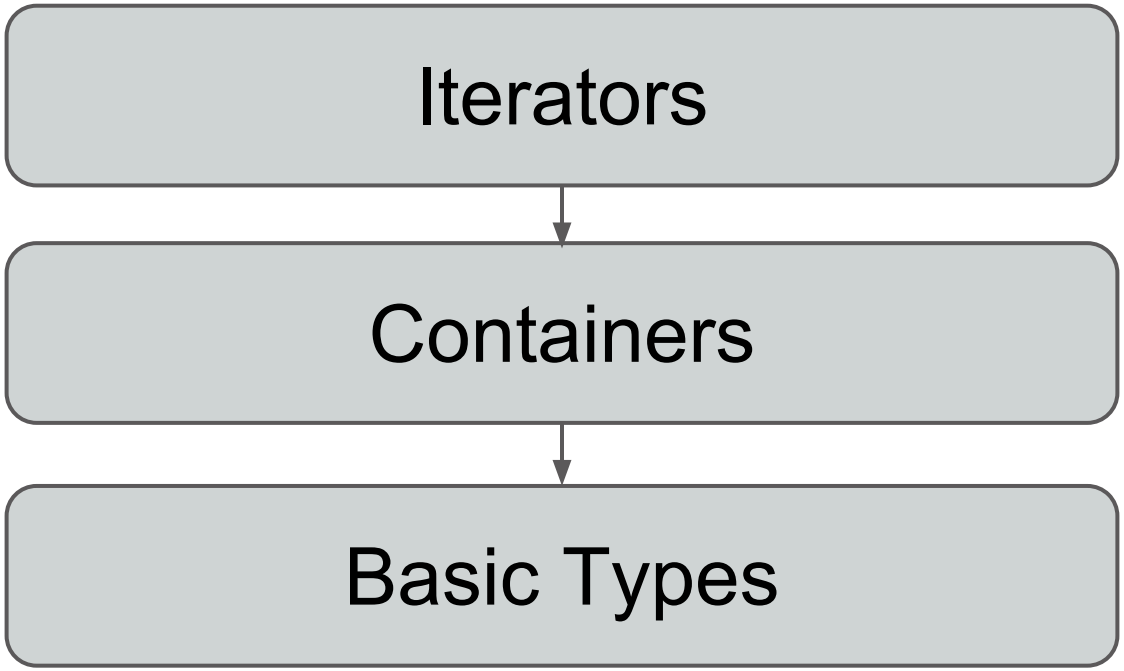
# Abstraction in the STL

- The same `<vector>` implementation can be used for `ints` as well as `strings`
- This means we can use containers to perform various operations on **basic types**, regardless of what the basic type is
- Is it possible to perform various operations on **containers** regardless of what the container is?

# Abstraction in the STL

- Iterators allow us to abstract away which container was used
  - Similar to how containers allow us to abstract away which basic type was used

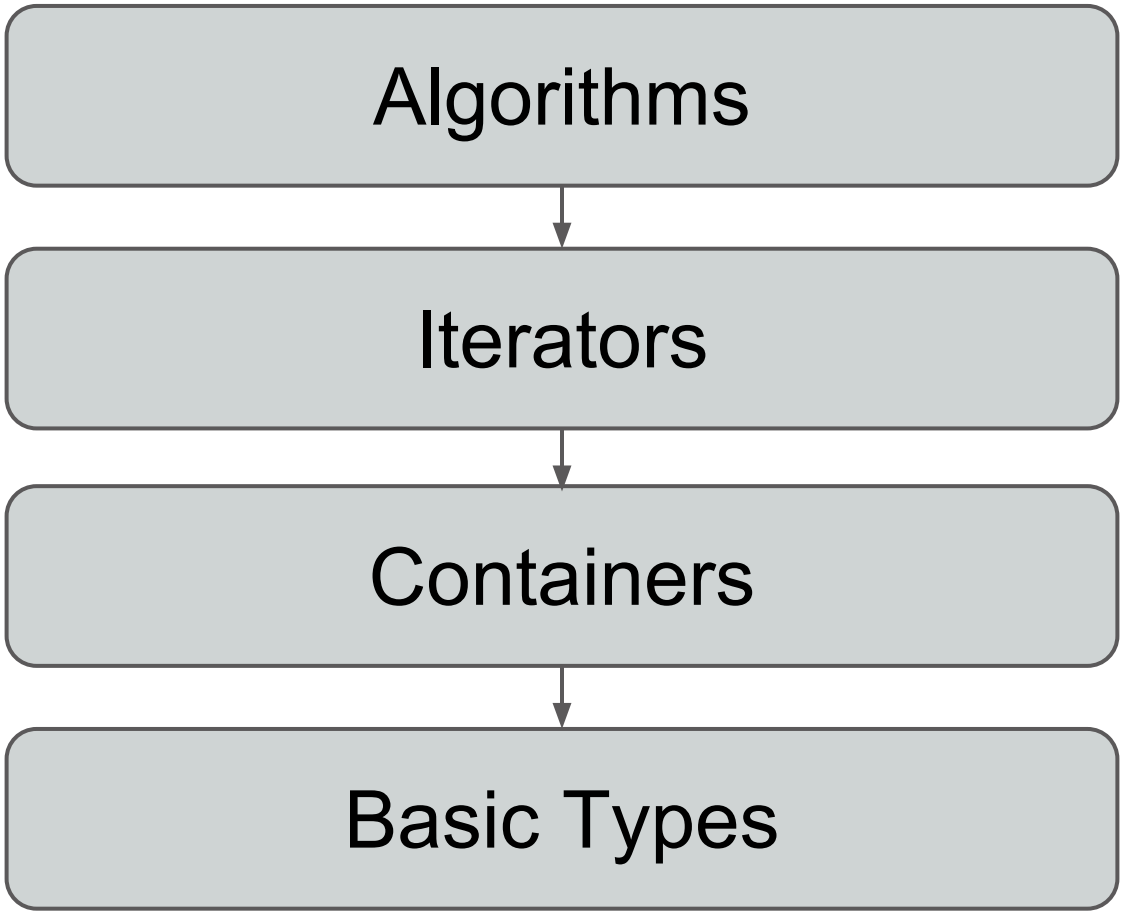
# Abstraction in the STL



# Abstraction in the STL

- Operations like sorting, partitioning, filtering, searching, etc., can be written to work with a **vector**, **deque**, **set**, or any other data type.
- We call these operations the STL **algorithms**
- Rely heavily on **templates**

# Abstraction in the STL



# Examples of Algorithms

Let's take a look at why this is cool.

See AlgorithmFun.pro

# Why Algorithm

Why do we need this complex model of abstraction?

- Don't **duplicate** code

# Why Algorithm

Why do we need this complex model of abstraction?

- Don't **duplicate** code
- Write **correct** code
- Write **efficient** code
- Write **clear** code

# Why Algorithm

To take a look at what's possible with <algorithm>, let's write a quick magic square solver.

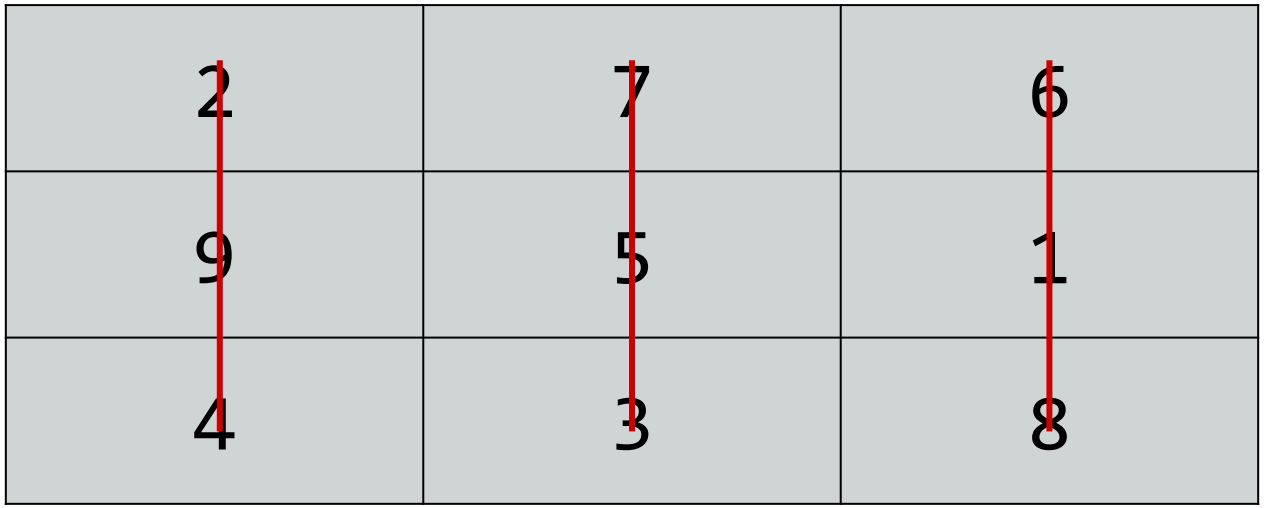
# Why Algorithm

A "magic square" is a 3x3 grid in which all rows, columns, and 3-element diagonals sum to the same number.

| | | |
|---|---|---|
| 2 | 7 | 6 |
| 9 | 5 | 1 |
| 4 | 3 | 8 |

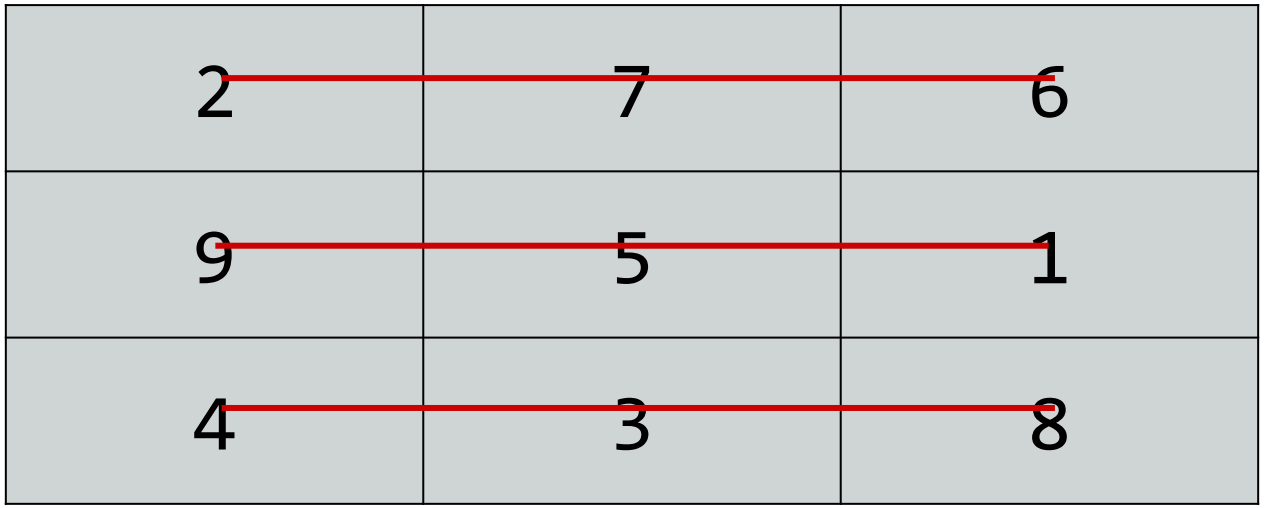
# Why Algorithm

A "magic square" is a 3x3 grid in which all rows, columns, and 3-element diagonals sum to the same number.



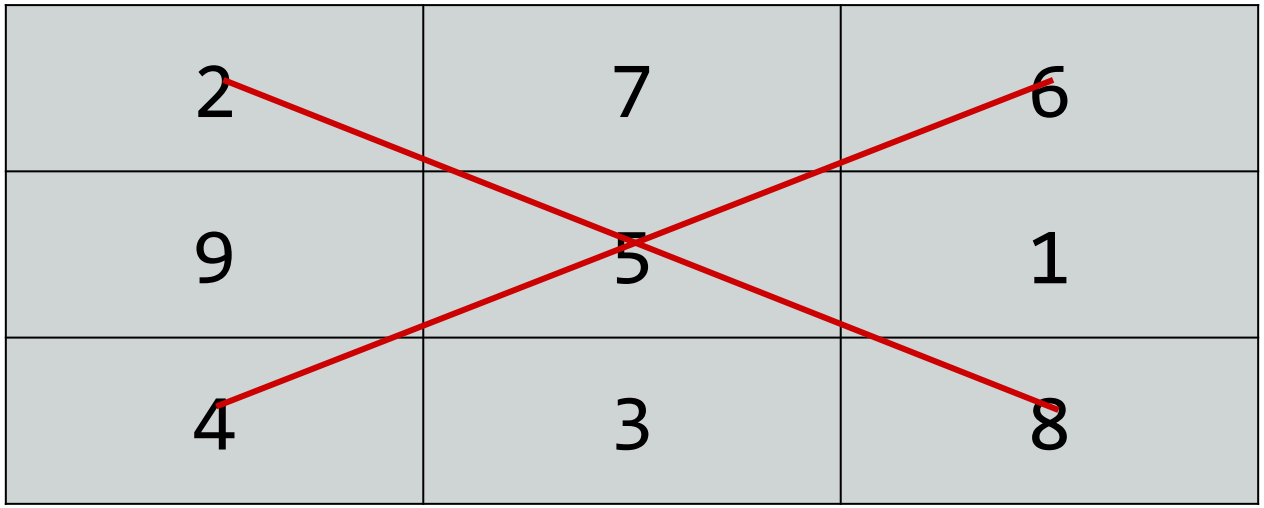
# Why Algorithm

A "magic square" is a 3x3 grid in which all rows, columns, and 3-element diagonals sum to the same number.



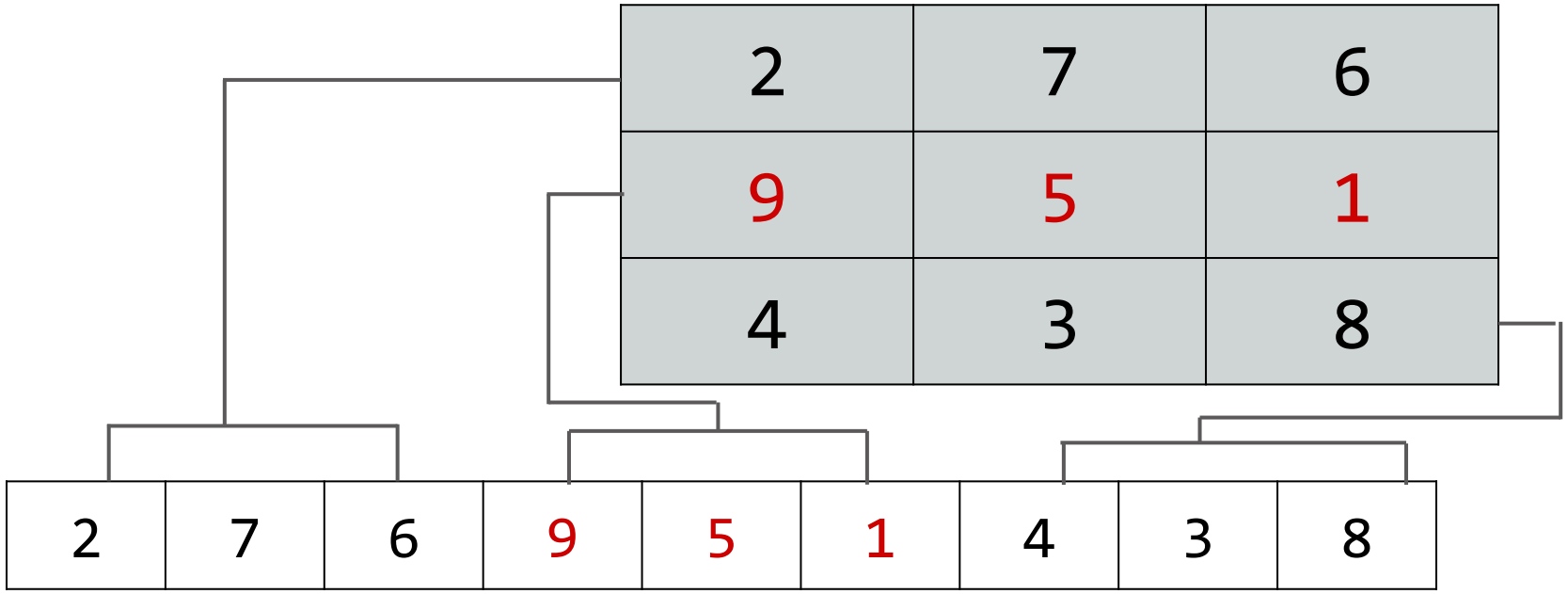
# Why Algorithm

A "magic square" is a 3x3 grid in which all rows, columns, and 3-element diagonals sum to the same number.



# Why Algorithm

We'll represent a magic square as a linear vector of elements



# Why Algorithm

If we could enumerate through every permutation of the numbers 1-9 in a vector, we could find every magic square which uses only the numbers 1-9...

If only we had an **`<algorithm>`** to do that...

# Why Algorithm

Let's take a look at some code to solve this in MagicSquares.pro

# In-depth: std::copy

To understand iterators and algorithms a bit better, let's take a look at the copy algorithm we wrote last time

```
vector<int> v;
v.push_back(1);
v.push_back(650);
v.push_back(867);
v.push_back(5309);

vector<int> vcopy(4);

copy(v.begin(), v.end(), vcopy.begin());
```

# In-depth: std::copy

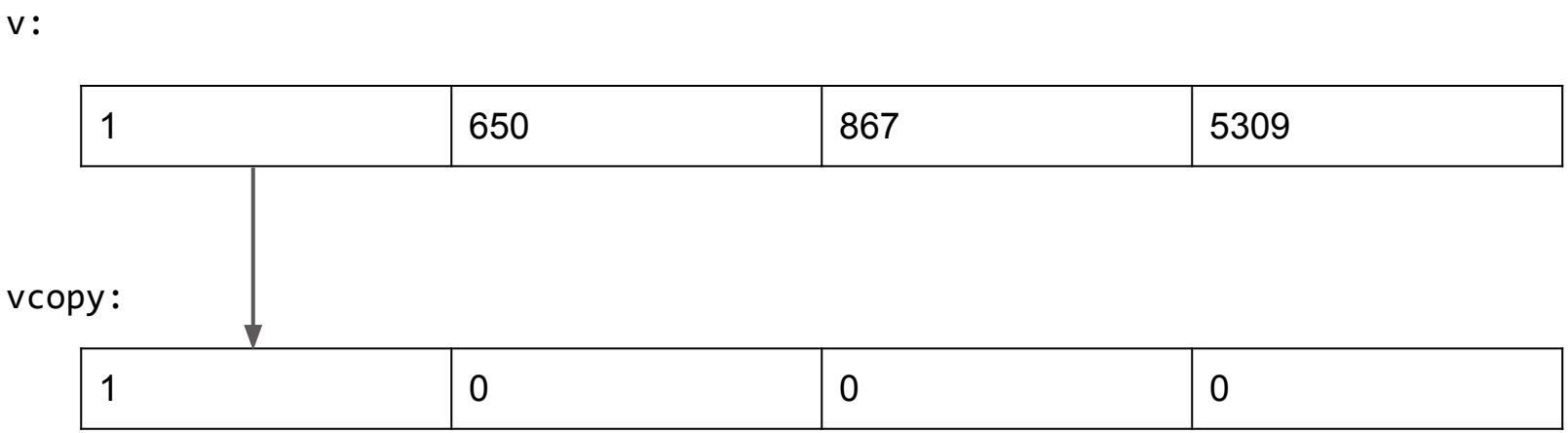
v:

| | | | |
|---|---|---|---|
| 1 | 650 | 867 | 5309 |

vcopy:

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

# In-depth: std::copy



# In-depth: std::copy

v:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

vcopy:

| 1 | 650 | 0 | 0 |
|---|---|---|---|

# In-depth: std::copy

v:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

vcopy:

| 1 | 650 | 867 | 0 |
|---|---|---|---|

# In-depth: std::copy

v:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

vcopy:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

# In-depth std::copy

What happens if we didn't allocate enough space?

# In-depth: std::copy

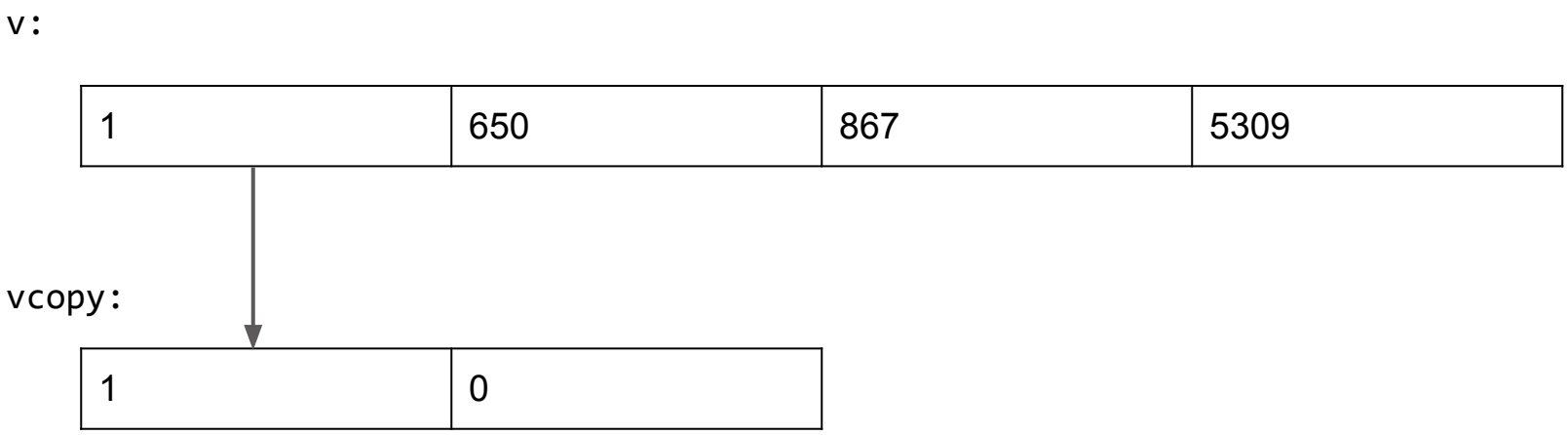
v:

| | | | |
|---|---|---|---|
| 1 | 650 | 867 | 5309 |

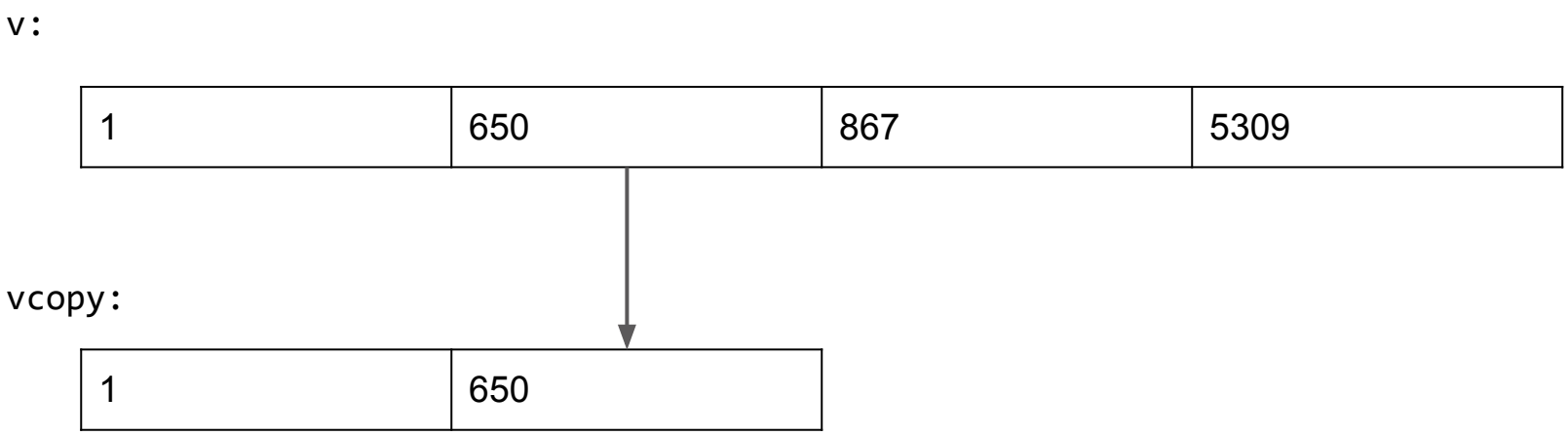
vcopy:

| | |
|---|---|
| 0 | 0 |

# In-depth: std::copy



# In-depth: std::copy



# In-depth: std::copy

v:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

vcopy:

| 1 | 650 |
|---|---|

# In-depth: std::copy

How can we avoid running into this problem?

# Iterator Adapters

Sometimes we need to form "weird" iterators.

- We don't just want to iterate over elements, we want to retrieve them from an istream
- We don't just want to iterate over elements we want to add them to a vector

# Iterator Adapters

Stream iterators are a fun way to simplify code.

When you want to repeatedly read values from an input streams, you can form iterators which write values to a stream for you.

It's easiest to explain these with a quick bit of code demonstrating how they work.

# Iterator Adapters

See code in Sum.pro

# Iterator Adapters

**Inserters** create an iterator which inserts values into a container for you.

These are useful when using something like std::copy.

# Iterator Adapters

Using a **back_inserter** will push the elements to the end of vcopy, so you don't have to worry about vcopy not having enough space.

```
vector<int> v;
v.push_back(1);
v.push_back(650);
v.push_back(867);
v.push_back(5309);

vector<int> vcopy;

copy(v.begin(), v.end(), back_inserter(vcopy));
```

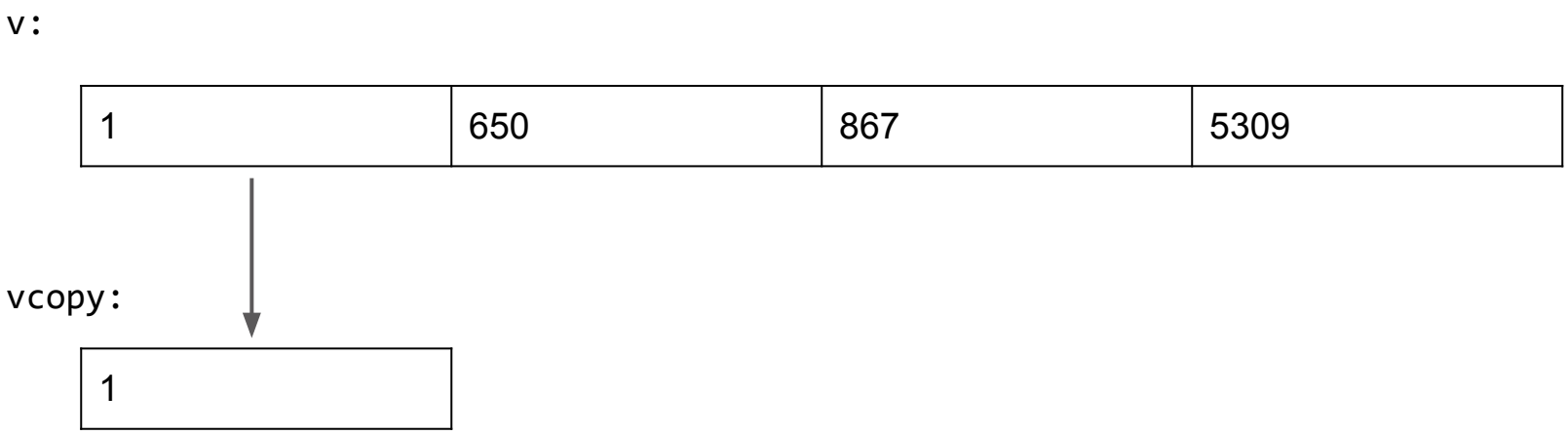
# Iterator Adapters

v:

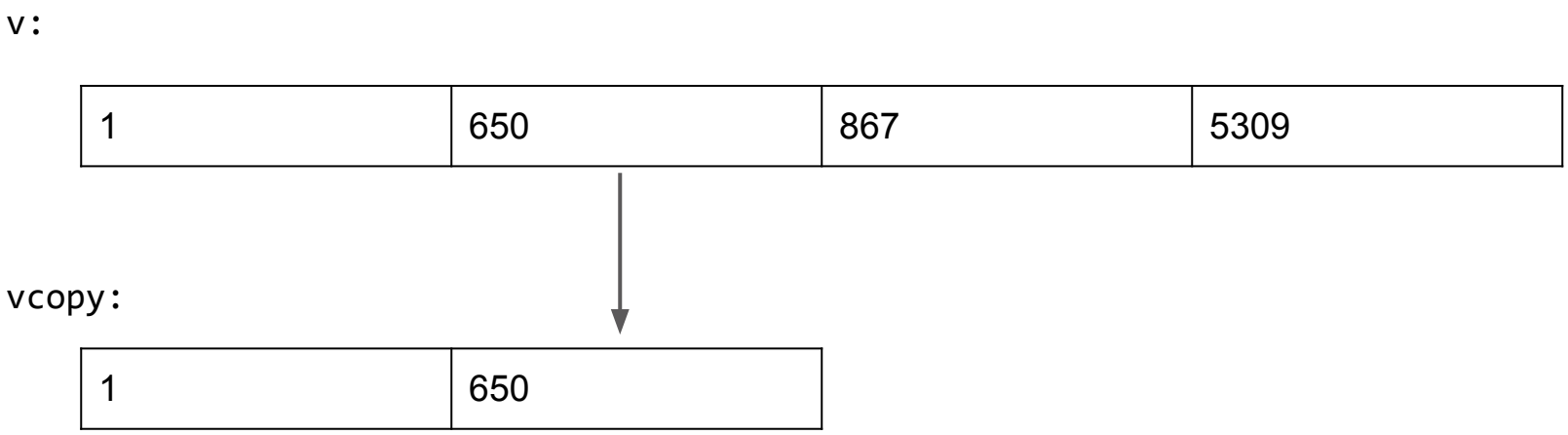
| | | | |
|---|---|---|---|
| 1 | 650 | 867 | 5309 |

vcopy:

# Iterator Adapters

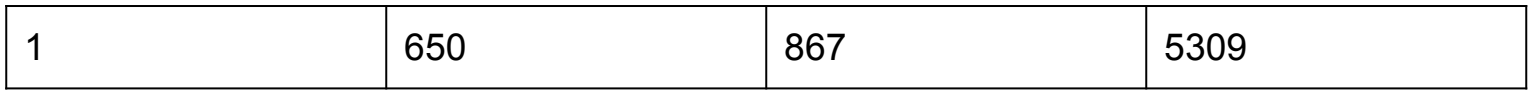


# Iterator Adapters



# Iterator Adapters

v:




vcopy:

# Iterator Adapters

v:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

vcopy:

| 1 | 650 | 867 | 5309 |
|---|---|---|---|

# Iterator Adapters

- Similar to **back_inserter**, there is also a **front_inserter** for structures like a deque, and just plain **inserter** for structures like sets and maps
- dereferencing a back_inserter calls push_back
- dereferencing a front_inserter calls push_front
- dereferencing an inserter calls insert

# Closing Notes

- There are many more algorithms than what we have covered today
- To see the full list of all 85 algorithms, see http://www.cplusplus.com/reference/algorithm