Associative Containers and Iterators

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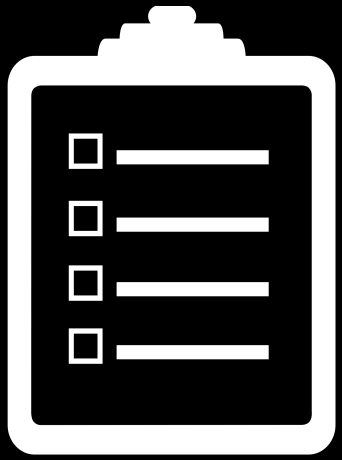
Game Plan



- Recap
- Associative Containers
- Iterators
- Map Iterators
- The `auto` keyword (maybe)
- Range-Based `for` Loops (maybe)

Recap

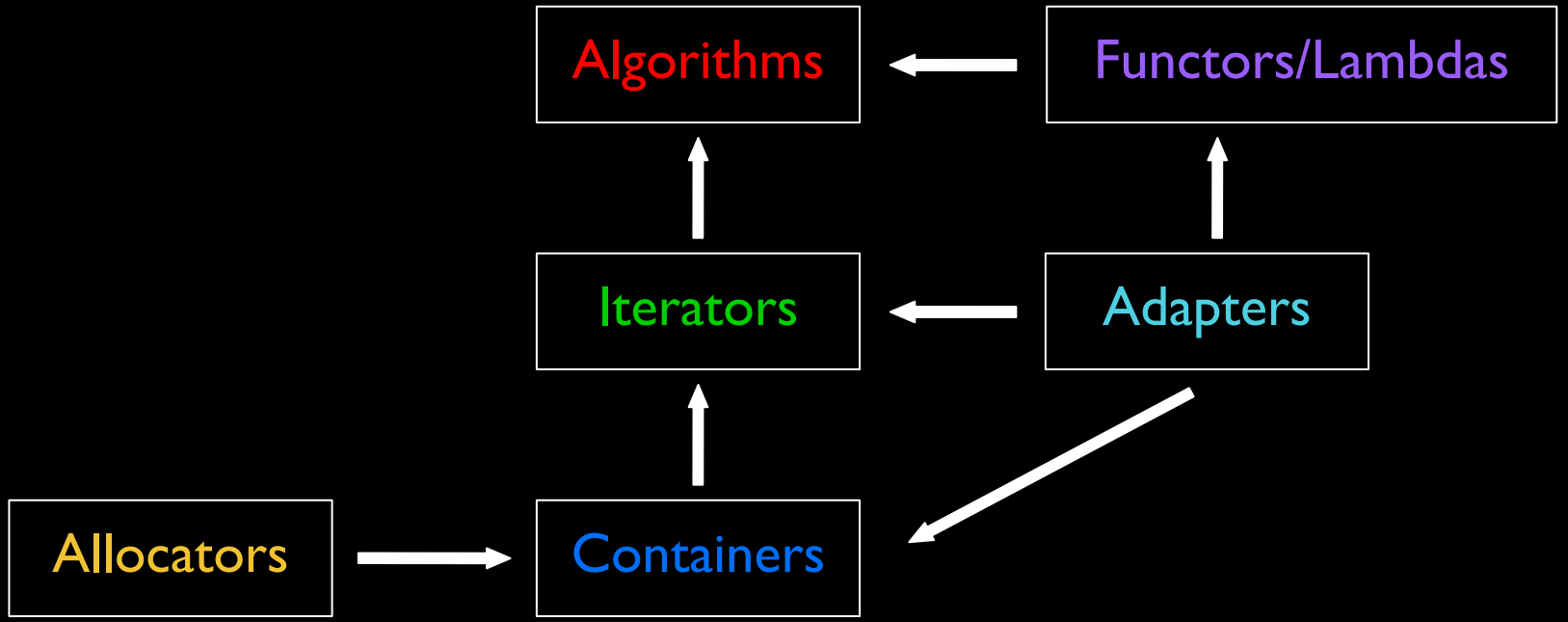
Structs

You can define your own mini-types that bundle multiple variables together:

```
struct point {
    int x;
    int y;
};
```


Useful for Assignment 1

Overview of STL



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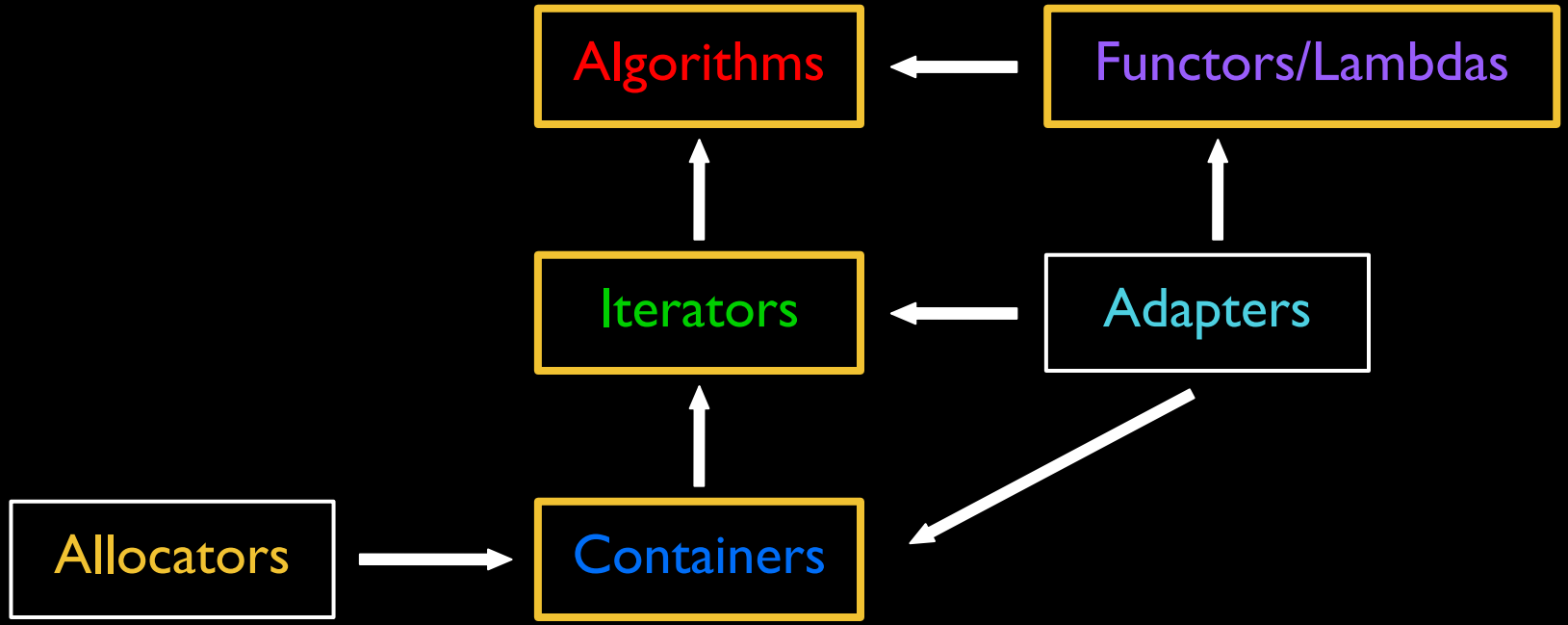

Sequence Containers

Provides access to sequences of elements.

Examples:

- `std::vector<T>`
- `std::list<T>`
- `std::deque<T>`

std::vector<T>

Some new stuff there:

```
const int kNumInts = 5;

using vecsz_t = std::vector<int>::size_type;

std::sort(vec.begin(), vec.end());
```

This let's us use `vecsz_t` as an alias/synonym for the type `std::vector<int>::size_type;`

`std::deque<T>`

A deque (pronounced “deck”) is a double ended queue.

Can do everything a vector can do

and also...

Unlike a vector, it is possible (and fast) to `push_front` and `pop_front`.

Container Adapters

How can we implement stack and queue using the containers we have?

Stack:

Just limit the functionality of a vector/deque to only allow `push_back` and `pop_back`.

Queue:

Just limit the functionality of a deque to only allow `push_back` and `pop_front`.

Plus only allow access to top element

Associative Containers

Associative Container

Scenario:

You want to count the frequency of words in a file.

What do you use?

- `vector<string>`, `vector<int>`

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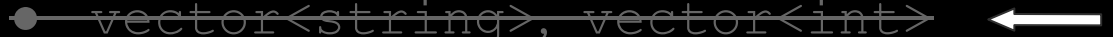
~~`vector<string>, vector<int>`~~ 

We would need to keep two vectors with indexes denoting pairs

Associative Container

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Associative Container

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No quick way to lookup based on word

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- `std::map<string, int>`

Associative Container

It is useful to have a data structure that can associate values.

Associative containers do exactly that!

Associative Container

Have no idea of a sequence.

Data is accessed using the key instead of indexes.

- `std::map<T1, T2>`
- `std::set<T>`
- `std::unordered_map<T1, T2>`
- `std::unordered_set<T>`

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Based on ordering property of keys.

Keys need to be comparable using `<` (less than) operator.

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Based on hash function. You need to define how the key can be hashed.

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You can define < and hash function operators for your own classes!

`std::map<T1, T2>`

Methods mostly same as Stanford map.

Check documentation for full list of methods.

We can do a small example, counting frequency of words in a file:

Map Example
(`MapExample.pro`)

std::set<T>

Methods mostly same as Stanford map.

Check documentation for full list of methods.

Key point:

A set is just a specific case of a map that doesn't have a value.

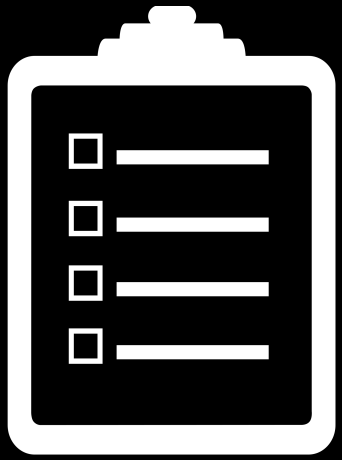
We can do a small example of adding and removing stuff:

Set Example

(SetExample.pro)

Announcements

Game Plan



- Recap
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- Iterators
- Map Iterator
- The `auto` keyword
- Range-Based `for` Loops

Iterators

How do we iterate over associative containers?

Remember:

Assoc. containers have no notion of a sequence/indexing

```
for(int i = umm?; i < uhh?; i++ maybe?) {
```

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Iterators

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~~`for(int i = umm?; i < uhh?; i++ maybe?) {`~~

C++ has a solution!

Iterators

First: A note

A note

We are going on a journey.

A note


FORODWAITH
ERED MITHRIN
IRON HILLS
RHÛN
Withered Heath
The Lost Realm of Arnor
Here was of old the Witch-realm of Angmar
Carn Dûm
Icebay of Forochel
Himling
ERED LUIN
ERIADOR
Forlindon
Forlond
Gulf of Lhûn
Mithlond
Harlond
Harlindon
(Blue Mountains)
Nenuial
North Downs
Fornost
Weather Hills
Weathertop (Amon Sûl)
Ettenmoors
RHUDAUR
Trollshaws
Rivendell
High Pass
Carrock
Old Ford
Old Forest Road
Mountains of Mirkwood
Erebor
The Lonely Mountain
Esgaroth
The Long Lake
Wood Elves
Celduin (River Running)
Carnen (Redwater)
Sea of Rhûn
THE SHIRE
Hobbiton
Bree
South Downs
East-West Road
Sarn Ford
CARDOLAN
MINHIRIATH
Tharbad
Nîn-in-Eilph (Swanfleet)
Eregion (Hollin)
Moria Gate
Dimrill Dale
Gladden River
Gladden Fields
LÓRIEN
Glanduin
Baranduin (Brandywine)
Eryn Vorn
Gwathló (Greyflood)
Lond Daer
ENEDWAITH
Dunland
Isengard
North-South Road
FANGORN
ROHAN
The Wold
Field of Celebrant
Limlight
North Undeep
South Undeep
The BROWN LANDS
East Bight
MIRKWOOD
RHOVANION
DOL GULDUR
Anduin (The Great River)
East Emnet
West Emnet
WESTFOLD
Helm's Deep
Fords of Isen
Angren (Isen)
Adorn
Sarn Gebir
Falls of Rauros
Dead Marshes
EMYN MUIL
Dagorlad (Battle Plain)
Morannon
ERED LITHUI (Ash Mountains)
Barad-dûr
Plateau of Gorgoroth
MORDOR
NURN
Sea of Núrnen
EPHEL DUATH
Osgiliath
Minas Tirith
Minas Morgul
Anórien
EASTFOLD
ERED NIMRAIS
GONDOR
Pinnath Gelin
Anfalas (Langstrand)
Andrast (Ras Morthil)
Edhellond
Dol Amroth
Belfalas
Lebennin
Ithilien
Crossings of Poros
Poros
Tolfalas
Ethir Anduin
South Gondor (now a debatable and desert land)
Harad Road
Harnen
NEAR HARAD
N
The Realm of Middle Earth
Miles
50 100 150 200

A note

We could in theory fly to the end destination.

A note


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ERED MITHRIN
(Grey Mountains)
Withered Heath
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RHÛN
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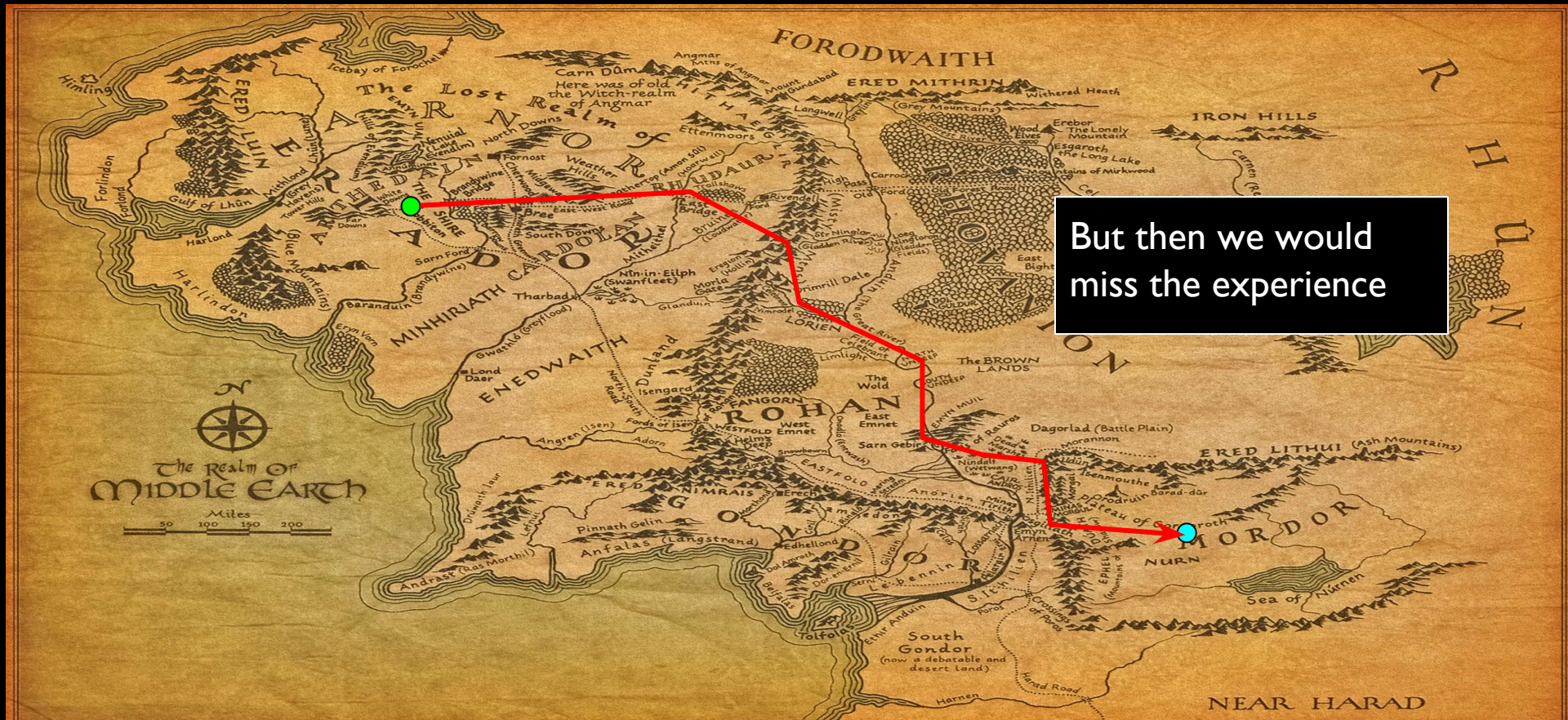
A note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We are going on a journey.

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At the end lies simplicity, but if we jump to it we miss out on understanding.

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At the end lies simplicity, but if we jump to it we miss out on understanding.

So we will walk to it.

Iterators

Iterators

Iterators allow iteration over any container,

whether it is ordered or not.

Iterators

Let’s try and get a mental model of iterators:

Say we have a `std::set<int> mySet`

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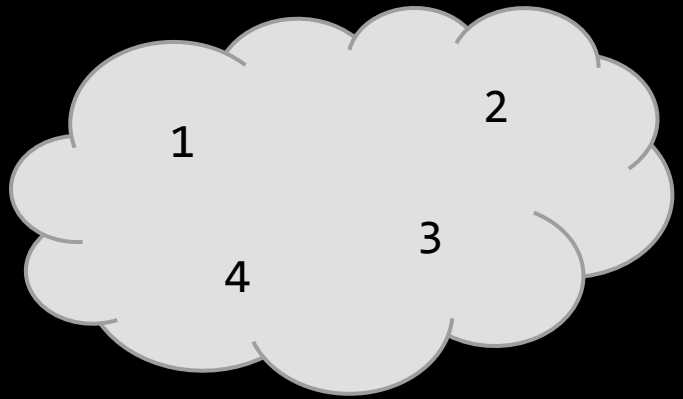

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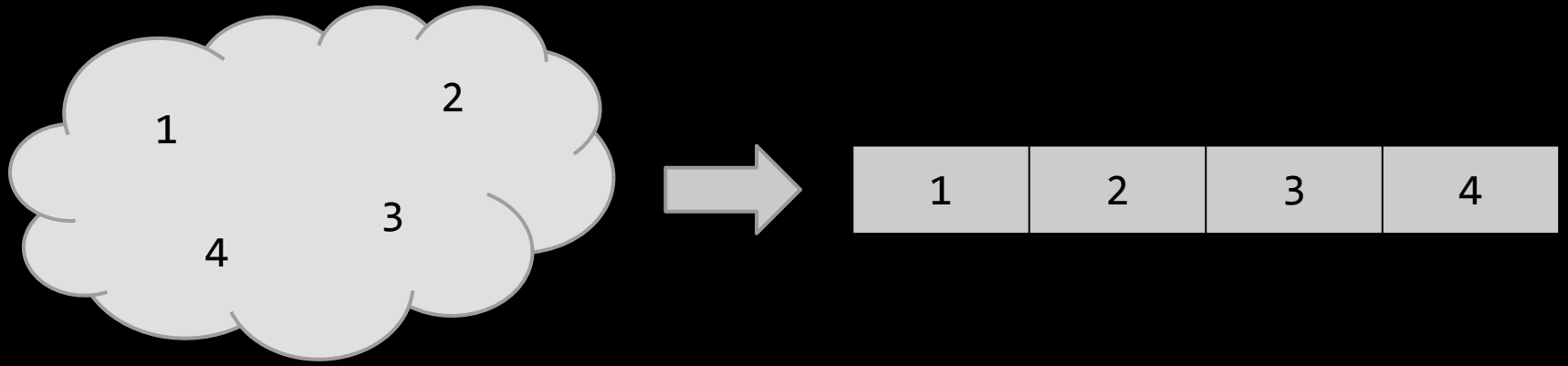

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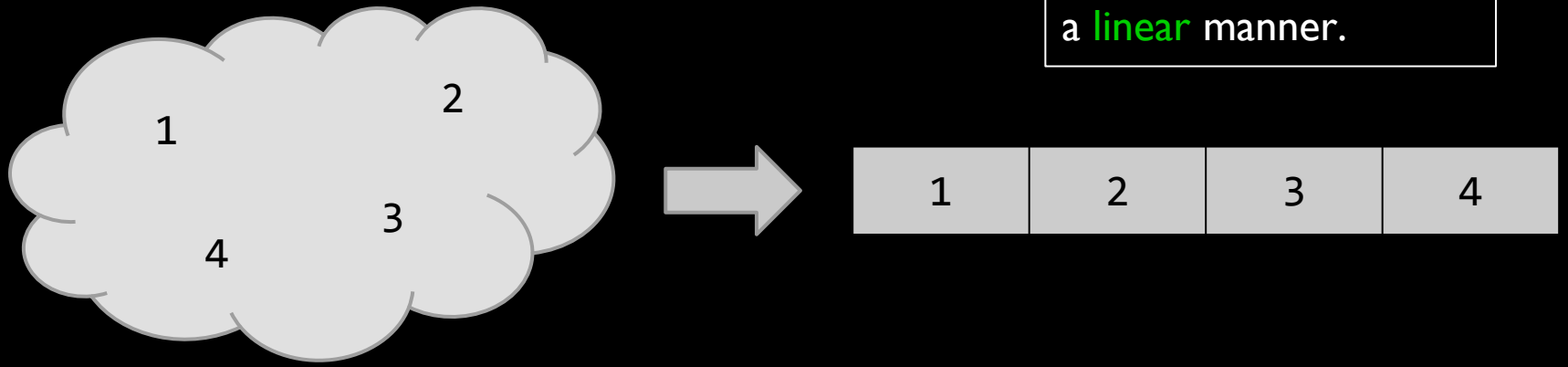
Say we have a `std::set<int> mySet`

Iterators let us view a non-linear collection in a linear manner.



Iterators

How do they work?

We don’t care right now.

We will just use them like any other thing - assume they just work somehow.

Iterators - Usage

Let’s try and get a mental model of iterators:

Iterators - Usage

Let’s try and get a mental model of iterators:

We can get an iterator pointing to the “start” of the sequence by calling `mySet.begin()`


```
mySet.begin();
```

Iterators - Usage

Let’s try and get a mental model of iterators: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```

Iterators - Usage

Let’s try and get a mental model of iterators:

How do we store it in a variable?

```
mySet.begin();
```

Iterators - Usage

Let’s try and get a mental model of iterators:


```
??? iter = mySet.begin();
```

Iterators - Usage

Let’s try and get a mental model of iterators:

What is the type of the iterator?

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Iterators - Usage

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What is the type of the iterator?

```
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```

```
set<int> mySet;
mySet.beg
    begin   iterator begin()
```

Iterators - Usage

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```
??? iter = mySet.begin();
```

Iterators - Usage

Let’s try and get a mental model of iterators:


```
set<int>::iterator iter = mySet.begin();
```

Iterators - Usage

Let's try and get a mental model of iterators:

It is the `iterator` type defined in the `set<int>` class!


```
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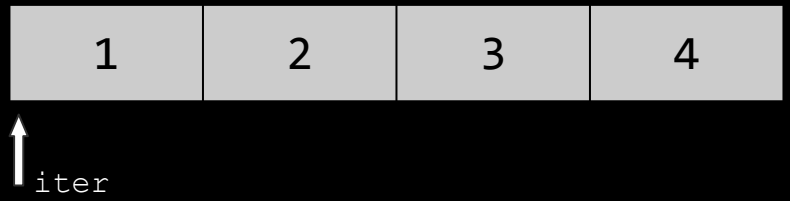

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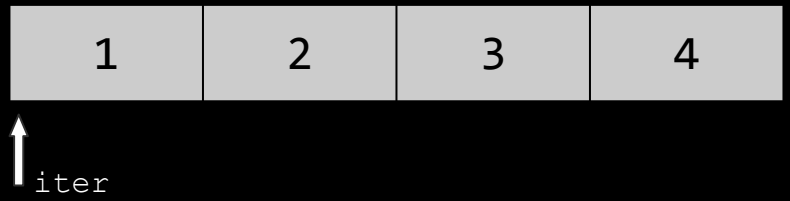
Let’s try and get a mental model of iterators:

We can get the value of an iterator by using the dereference * operator.



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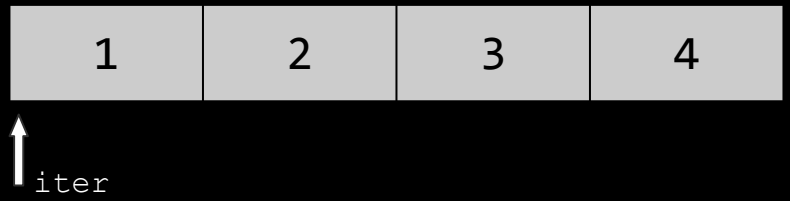


```
cout << *iter << endl;     // prints 1
```

Iterators - Usage

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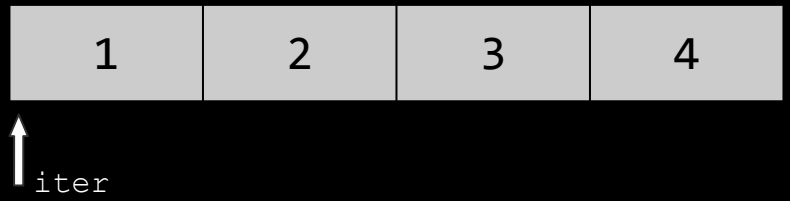
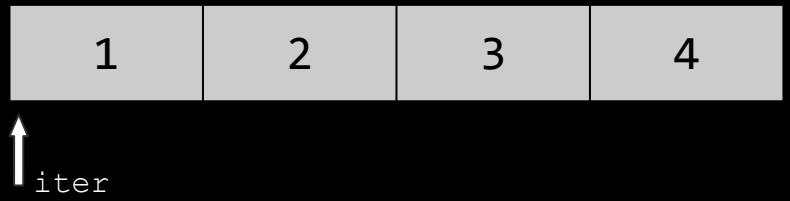


Iterators - Usage

Let’s try and get a mental model of iterators:

We can advance the iterator one by using the ++ operator (prefix)



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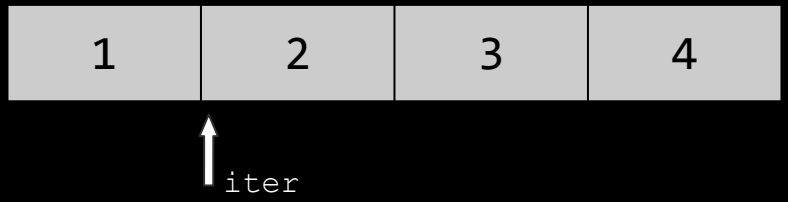


```
++iter;        // advances iterator
```

Iterators - Usage

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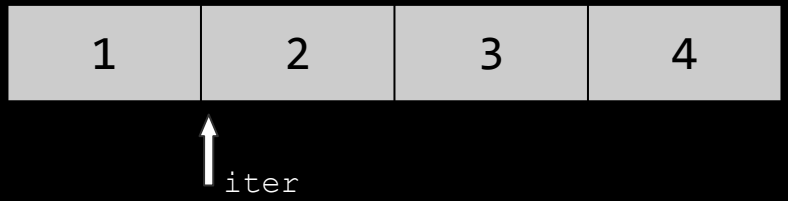

And so on...

Iterators - Usage

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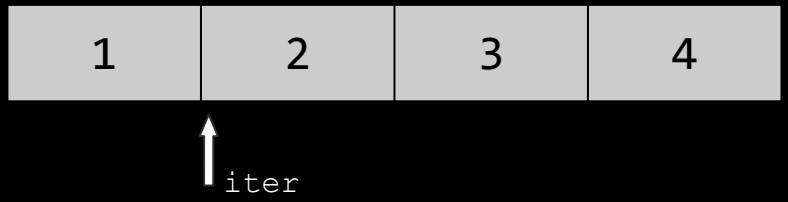
And so on...




```
cout << *iter << endl;     // prints 2
```

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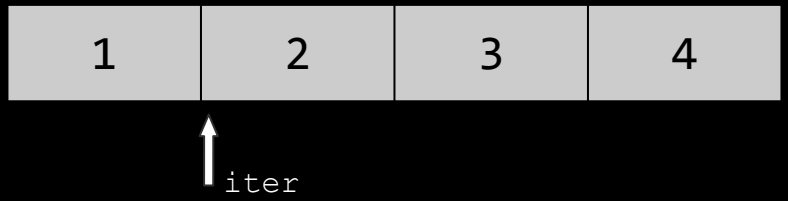

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Iterators - Usage

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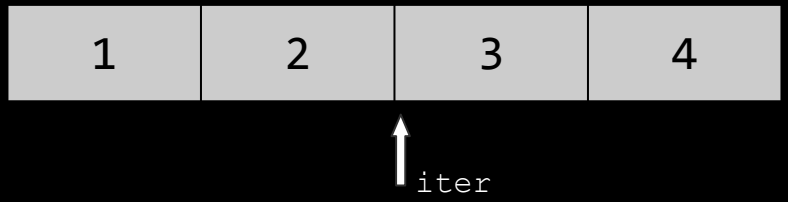

And so on...

```
++iter;        // advances iterator
```

Iterators - Usage

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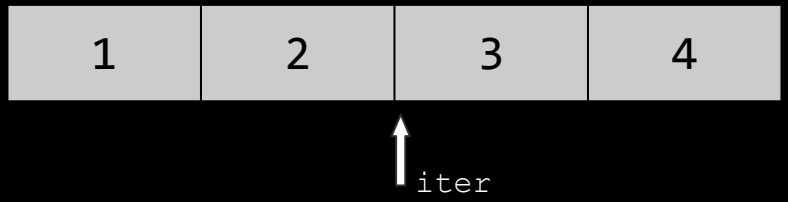

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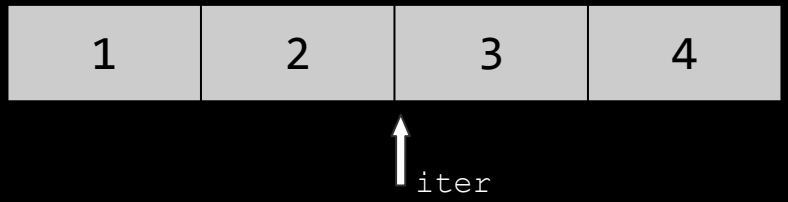


```
cout << *iter << endl;      // prints 3
```

Iterators - Usage

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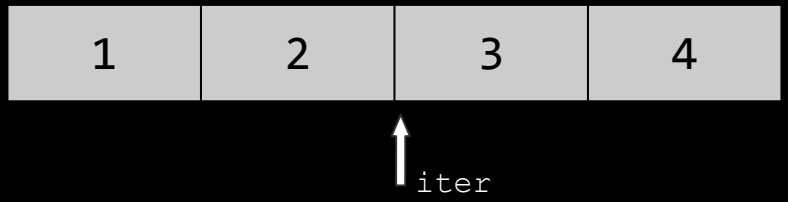

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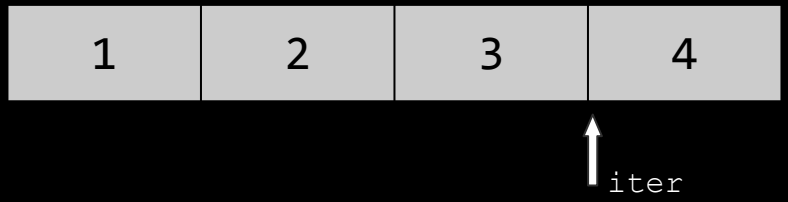


```
++iter;        // advances iterator
```

Iterators - Usage

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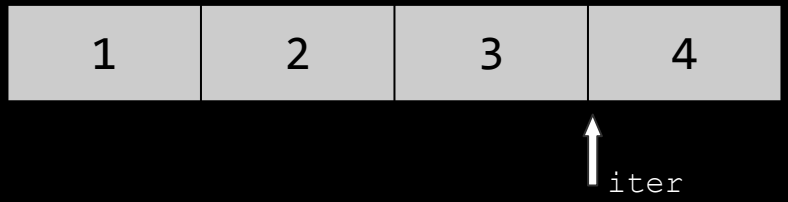

And so on...

Iterators - Usage

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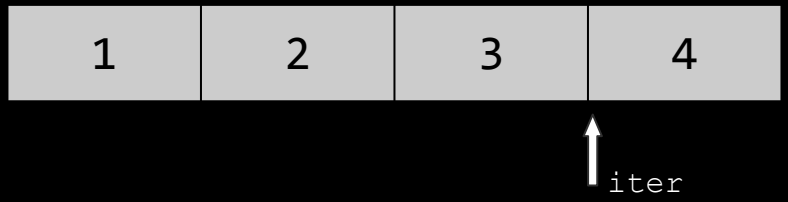
And so on...




```
cout << *iter << endl;     // prints 4
```

Iterators - Usage

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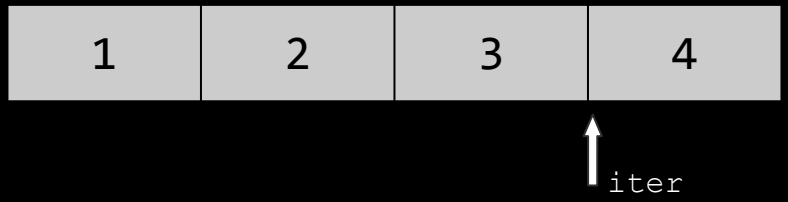

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Iterators - Usage

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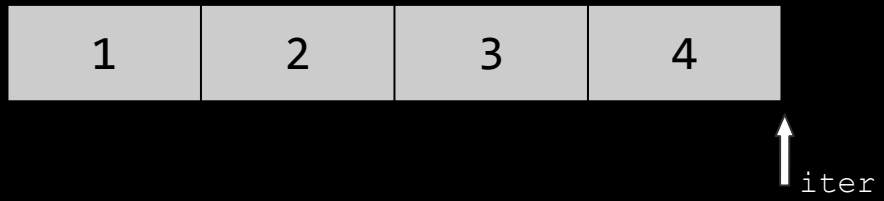
And so on...




```
++iter;       // advances iterator
```

Iterators - Usage

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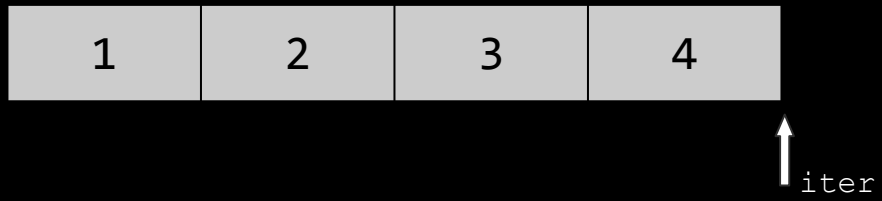
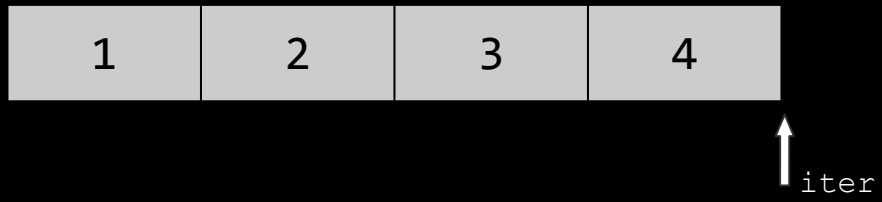


Iterators - Usage

Let’s try and get a mental model of iterators:

We can check if we have hit the end by comparing to `mySet.end()`



Iterators - Usage

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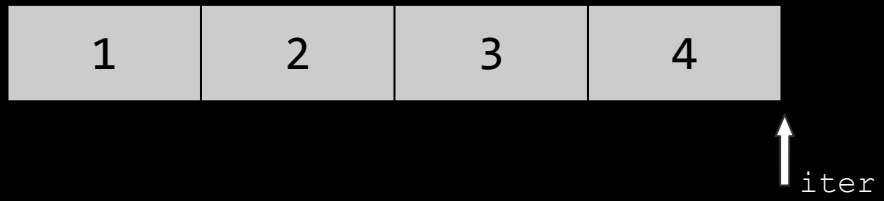


```
if(iter == mySet.end()) return;
```

Iterators - Usage

A summary of the essential iterator operations:

- Create iterator
- Dereference iterator to read value currently pointed to
- Advance iterator
- Compare against another iterator (especially `.end()` iterator)

Iterators - Usage

Let’s do some examples:

Basic Iterator

(`BasicIter.pro`)

Iterators

Our examples have used sets, but (almost) all C++ containers have iterators.

Why is this powerful?

- Many scenarios require looking at elements, regardless of what type of container is storing those elements.
- Iterators let us go through sequences of elements in a standardised way.

Iterators

Example (find number occurrences):

```
int numOccurences(vector<int>& cont, int elemToCount) {
    int counter = 0;
    vector<int>::iterator iter;
    for(iter = cont.begin(); iter != cont.end(); ++iter) {
        if(*iter == elemToCount)
            ++counter;
    }
    return counter;
}
```

Iterators

Example (find number occurrences):

Can I make this work for `std::list<int>`?

```
int numOccurences(vector<int>& cont, int elemToCount) {
    int counter = 0;
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Iterators

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Iterators

Example (find number occurrences):

```
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        if(*iter == elemToCount)
            ++counter;
    }
    return counter;
}
```

Iterators

This standard interface for looping through things is going to be really powerful.

We will cover it sometime this week or next week!

Map Iterators

Map Iterators

Map iterators are slightly different because we have both keys and values.

The iterator of a `map<string, int>` points to a `std::pair<string, int>`.

The `std::pair` Class

A pair is simply two objects bundled together.

Syntax:

```
std::pair<string, int> p;
p.first = "Phone number";
p.second = 6504550404;
```

Map Iterators

Example:

```
map<int, int> m;
map<int, int>::iterator i = m.begin();
map<int, int>::iterator end = m.end();
while(i != end) {
    cout << (*i).first << (*i).second << endl;
    ++i;
}
```

Next Time

Templates and Iterators