



 <http://web.stanford.edu/class/cs106l/>



Iterators and Pointers

How do we access elements in a container in order?
How do we reference existing data in our code?

CS106L - Fall 22

Attendance!

<https://bit.ly/3CTGyyM>





Agenda



01. Recap: Containers

02. Iterators

How to access container elements

03. Pointers

Accessing objects by address

04. Iterators + Pointers demo





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Containers

- Containers are ways to collect related data together and work with it logically
- Two types of containers: **sequence** and **associative**
- Container adaptors wrap existing containers to permit new/restrict access to the interface for the clients.

There are two types of containers:

Sequence:

- Containers that can be accessed sequentially
- Anything with an inherent order goes here!

Associative

- Containers that don't necessarily have a sequential order
- More easily searched
- Maps and sets go here!

Sequence Containers: Summary

- Sequence containers are for when you need to enforce some order on your information!
- Can usually use an **std::vector** for most anything
- If you need particularly fast inserts in the front, consider an **std::deque**
- For joining/working with multiple lists, consider an **std::list** (very rarely)

Choosing associative containers

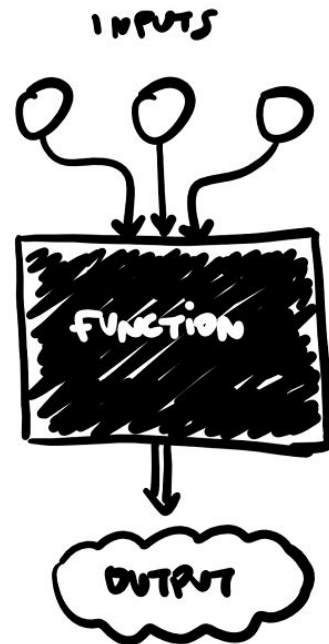
Lots of similarities between maps/sets! Broad tips:

- Unordered containers are **faster**, but can be difficult to get to work with nested containers/collections
- If using **complicated data types**/unfamiliar with hash functions, use an ordered container

Container Adaptors

Container adaptors are “wrappers” to existing containers!

- Wrappers **modify the interface** to sequence containers and change what the client is allowed to do/how they can interact with the container.



The STL

```
template <class T, class Container = deque<T> > class queue;
```

queues are implemented as **containers adaptors**, which are classes that use an encapsulated object of a specific container class as its **underlying container**, providing a specific set of member functions to access its elements. Elements are **pushed** into the **"back"** of the specific container and **popped** from its **"front"**.

The underlying container may be one of the standard container class template or some other specifically designed container class. This underlying container shall support at least the following operations:

empty

size

front

back

push_back

pop_front



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So how do we access those objects?

- What if we want to print out everything in a vector?
- Or loop until we find a certain object in a set?

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How is this done in the STL?

遍历



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something...++???

Guess we're done!

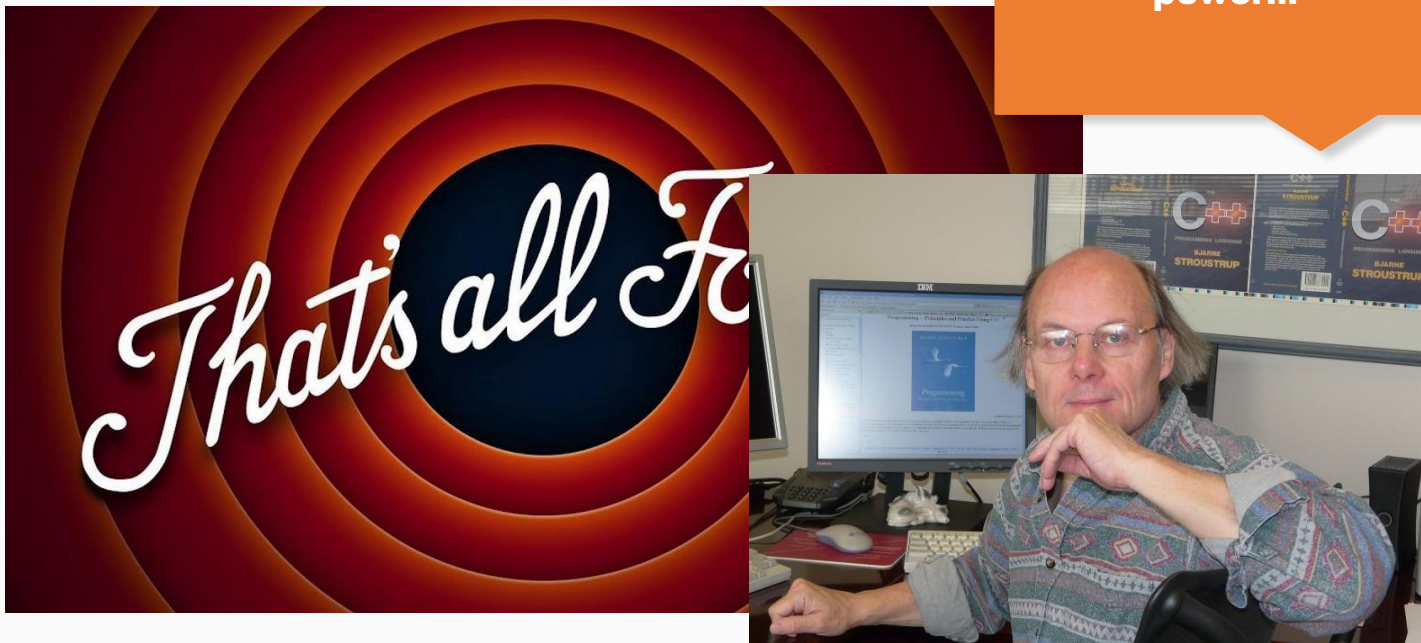


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You underestimate my
power...





Introducing Iterators!

Containers all implement something called an iterator to do this!



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- Iterators let you access **all** data in containers programmatically!
- An iterator has a certain **order**; it “knows” what element will come next
 - Not necessarily the same each time you iterate!

Think of your container as a file cabinet!



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- You can move your finger from one to the next, because you kept your place.
- You can take out any file you've your hand on, and read/write whatever you'd like in it.
- You can compare the relative location of any two files just by looking at where they are in the cabinet.





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begin() and **end()**
return iterators!

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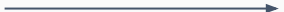

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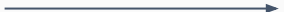

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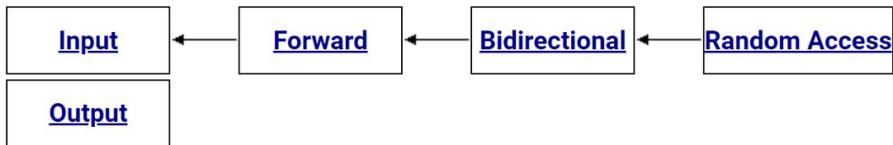
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What other behaviors can iterators have?

That depends!

Let's check out the docs:

Iterators are classified into five categories depending on the functionality they implement:



[Input](#) and [output](#) iterators are the most limited types of iterators: they can perform sequential single-pass input or output operations.

[Forward iterators](#) have all the functionality of [input iterators](#) and -if they are not **constant iterators**- also the functionality of [output iterators](#), although they are limited to one direction in which to iterate through a range (forward). All [standard containers](#) support at least forward iterator types.

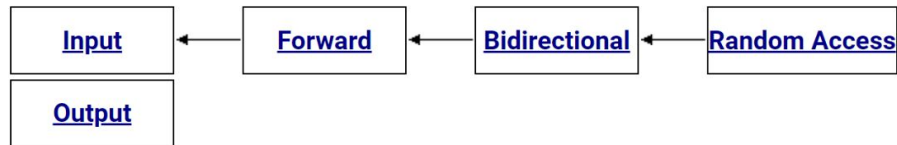
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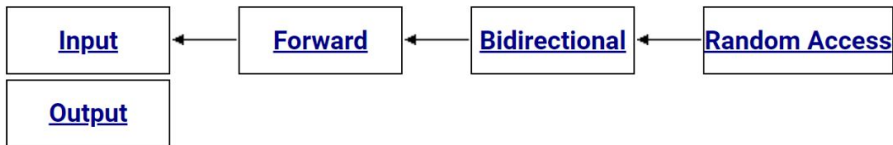
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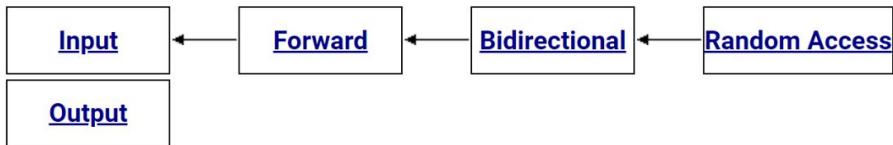
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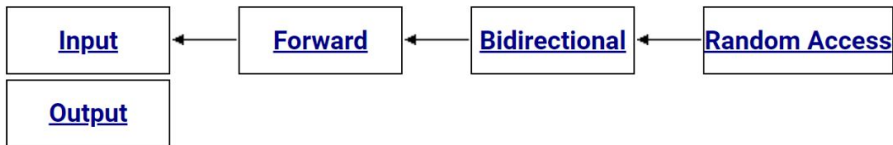
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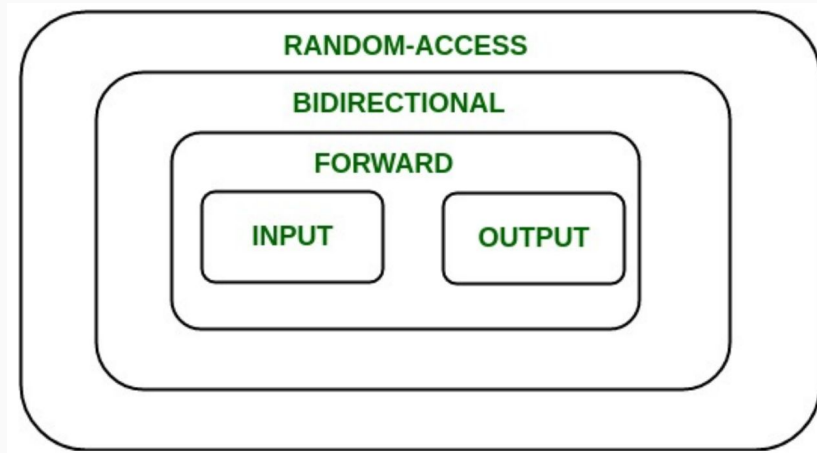
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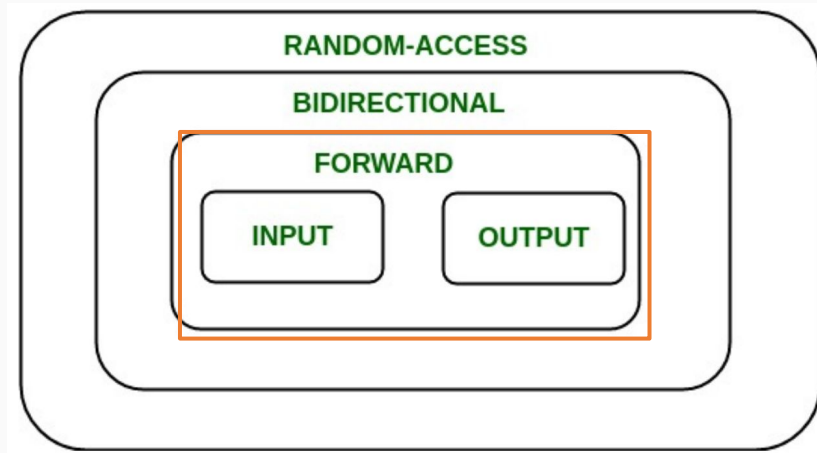
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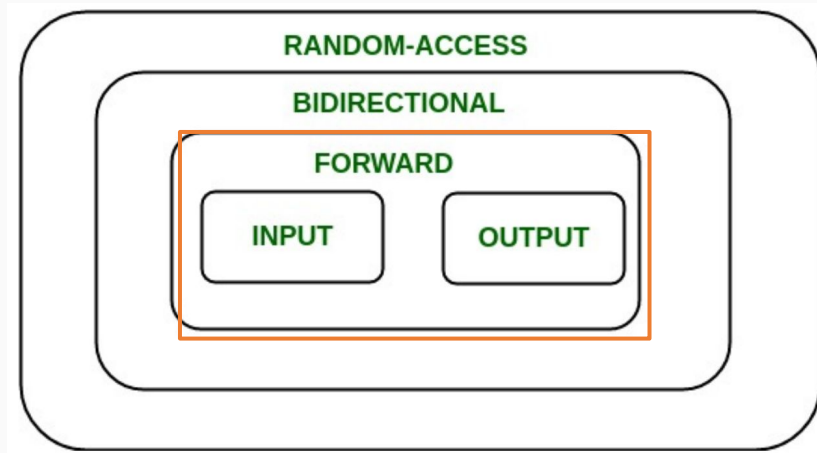
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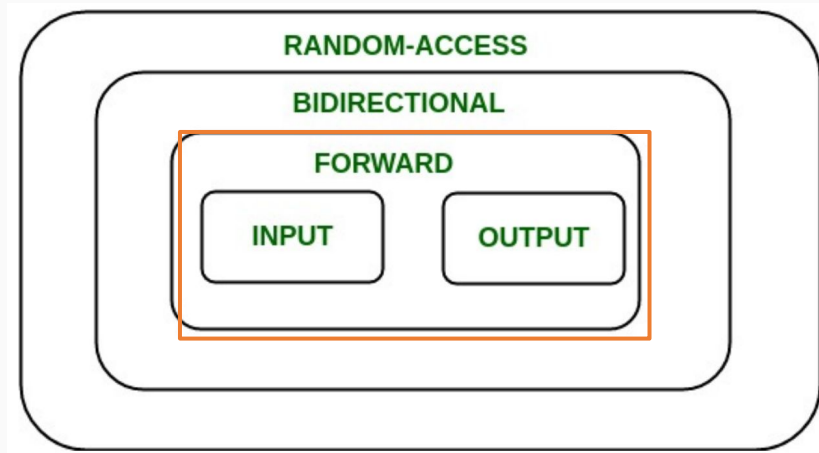


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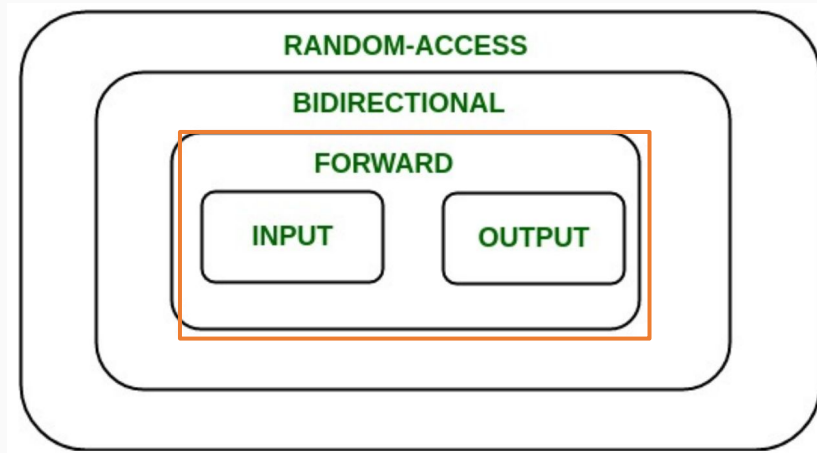
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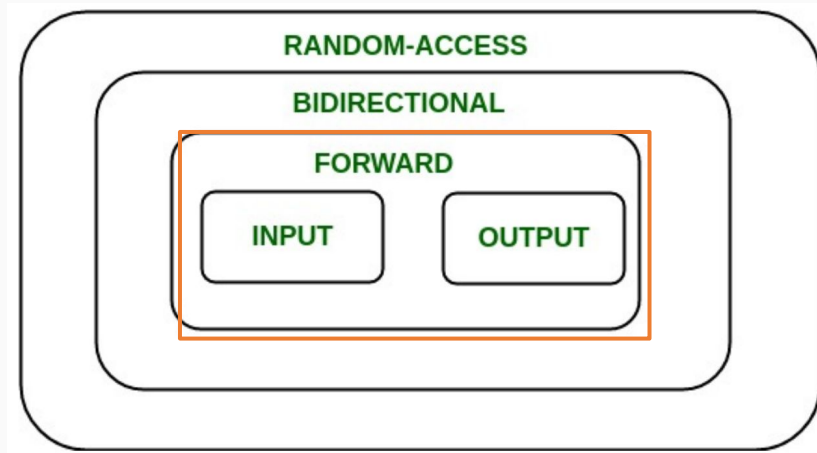
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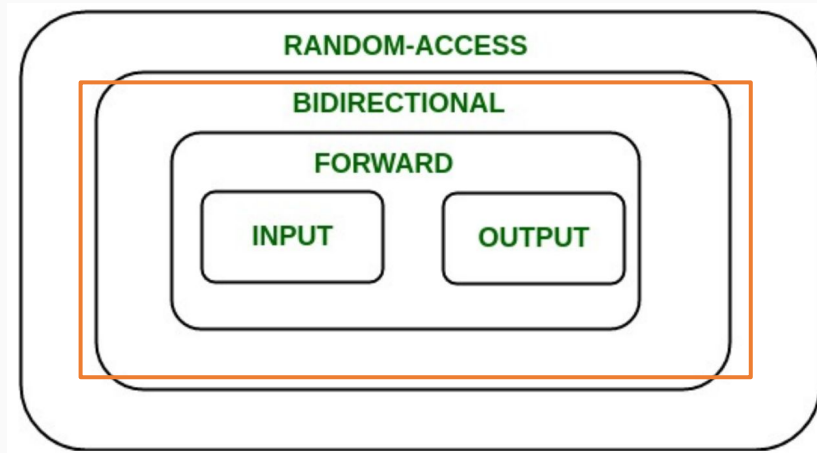
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```
*elem = value;
```



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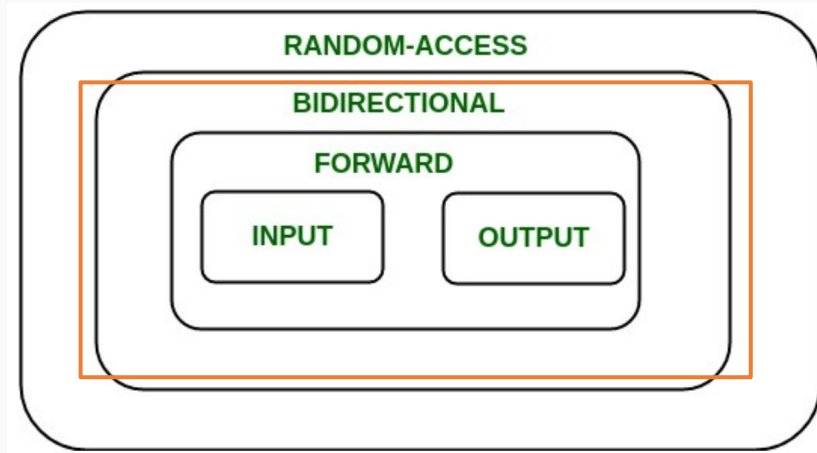
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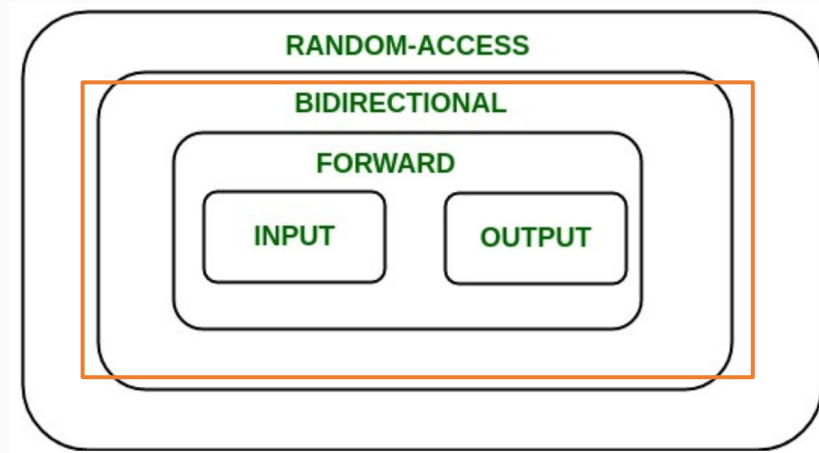
backward!

backward

- ~~iter;~~

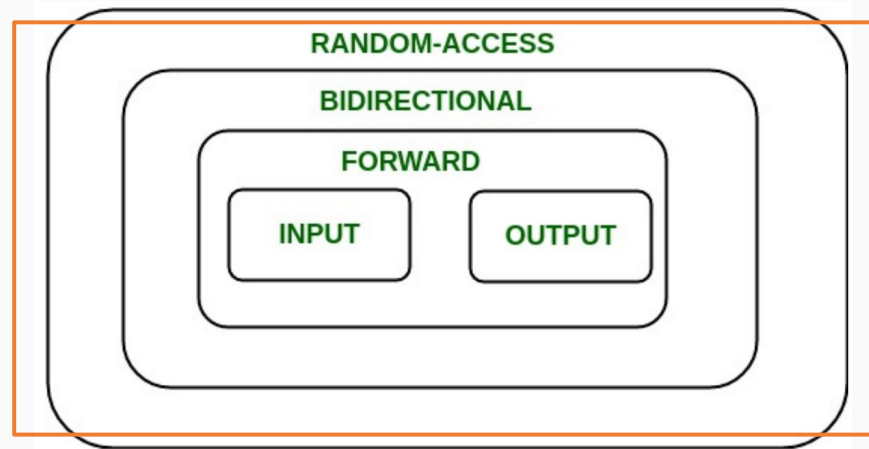
filter *forward*

- Still has the same functionality of forward iterators!



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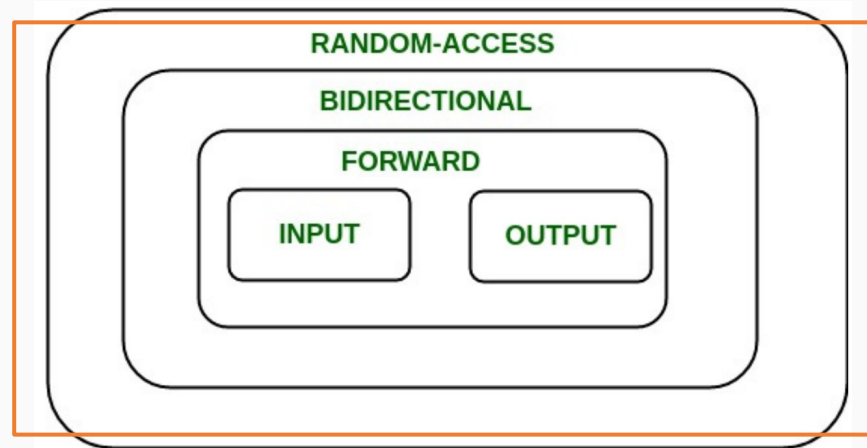
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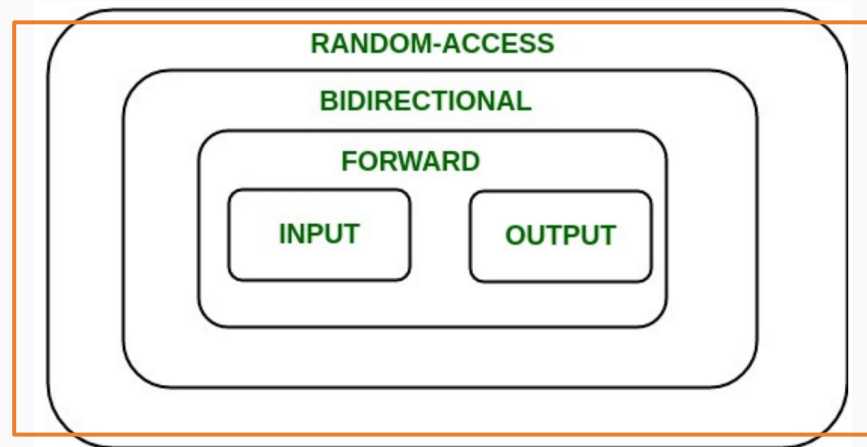
- `iter += 5;`



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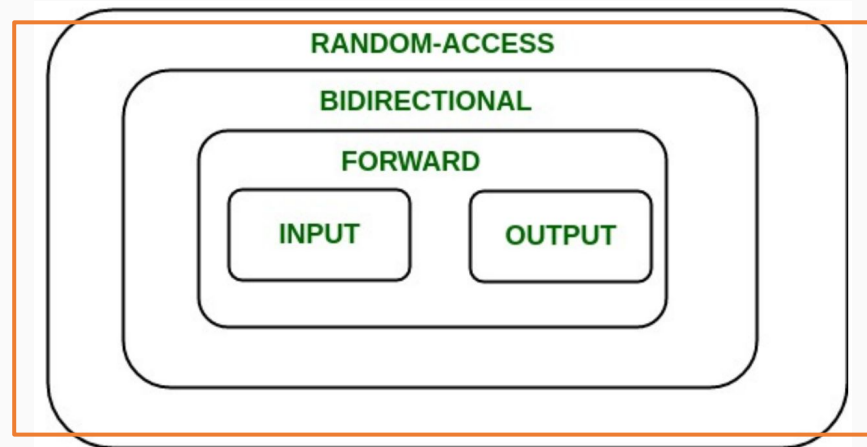
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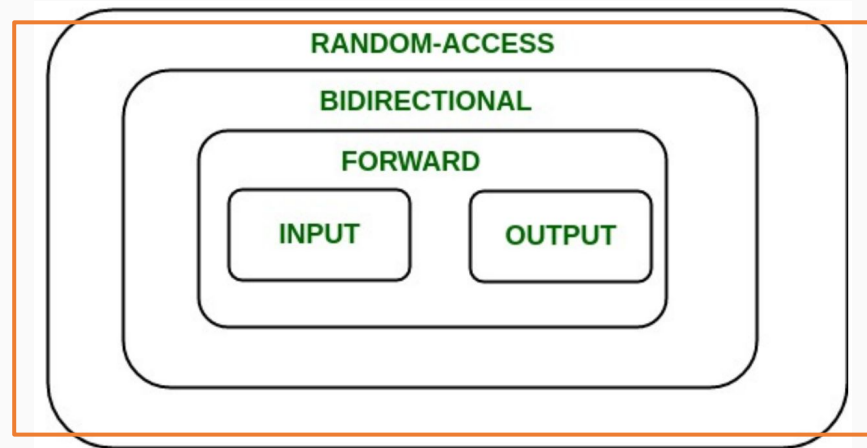


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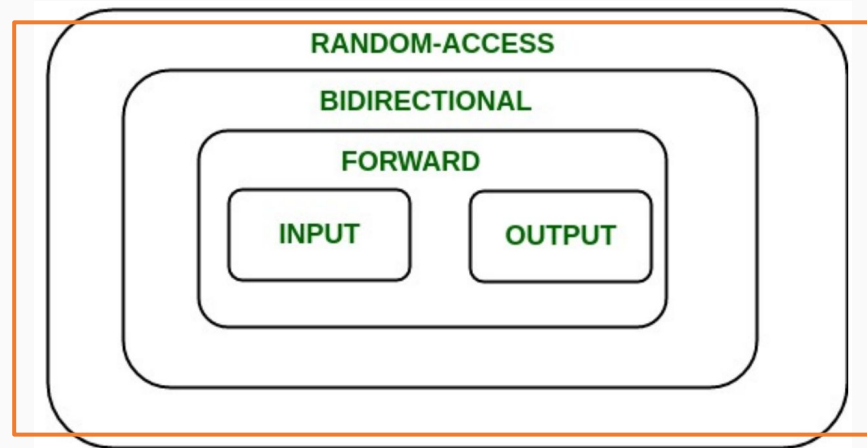


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iter += 3; ?

Categorizing STL iterators

Vectors and deques have the most powerful iterators!

Container	Type of Iterator
Vector	Random-Access
Deque	Random-Access
List	Bidirectional
Map	Bidirectional
Set	Bidirectional
Stack	No Iterator
Queue	No Iterator
Priority Queue	No Iterator

can't iterate

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- Creating your own containers means creating their iterators as well.

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- Iteration with iterators is **const**

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**This is now outdated!
`iter++` to your heart's content!**



Let's check out that for loop again!

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for (initialization; termination condition; increment) {
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for ( auto iter=set.begin() ; iter != set.end(); ++iter ) {
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const auto& elem = *iter;
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*const auto& elem = *iter;*



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std::map<int> map{{1, 6}, {1, 8}, {0, 3}, {3, 9}};  
for (auto iter = map.begin(); iter != map.end(); ++iter) {  
    const auto& [key, value] = *iter;           // structured binding!
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This is a C++ **for-each loop**!



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03. Pointers

Accessing objects by address

04. Iterators + Pointers demo





Introducing Pointers!

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Iterators are a particular type of pointer!

- Iterators “point” at particular elements in a **container**.
- Pointers can “point” at **any objects** in your code!

<http://web.stanford.edu/class/cs106l/>

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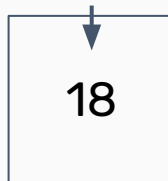
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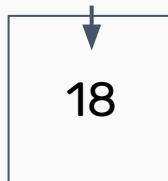
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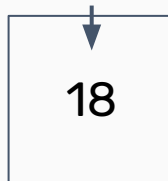
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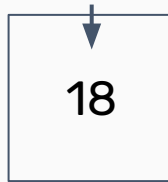
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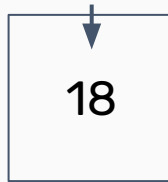
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What's the difference?

- Iterators are a type of pointer!
- Iterators have to point to elements in a container, but pointers can point to any object!
 - Why is this? All objects stored inside the big container known as **memory**!
- Can access memory addresses with **&** and the data at an address/pointer using *****



Agenda



01. Recap: Containers

02. Iterators

How to access container elements

03. Pointers

Accessing objects by address

04. Iterators vs. Pointers





What does that look like?

Live code demo
demonstrating pointers!



 <http://web.stanford.edu/class/cs106l/>



Thanks!

Next up: Classes!