



 <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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01. Recap: Containers

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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

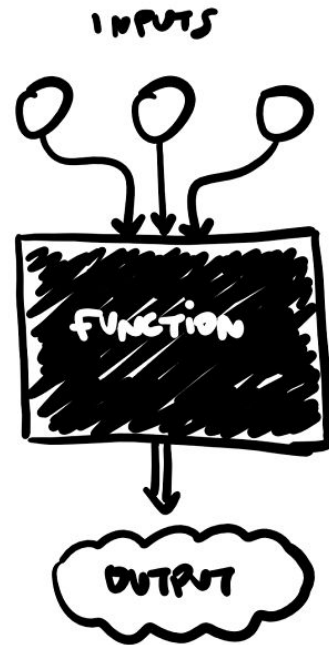
Lots of similarities between maps/sets! Broad tips:

- 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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All containers are collections of objects...

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?



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When do we
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something...++???

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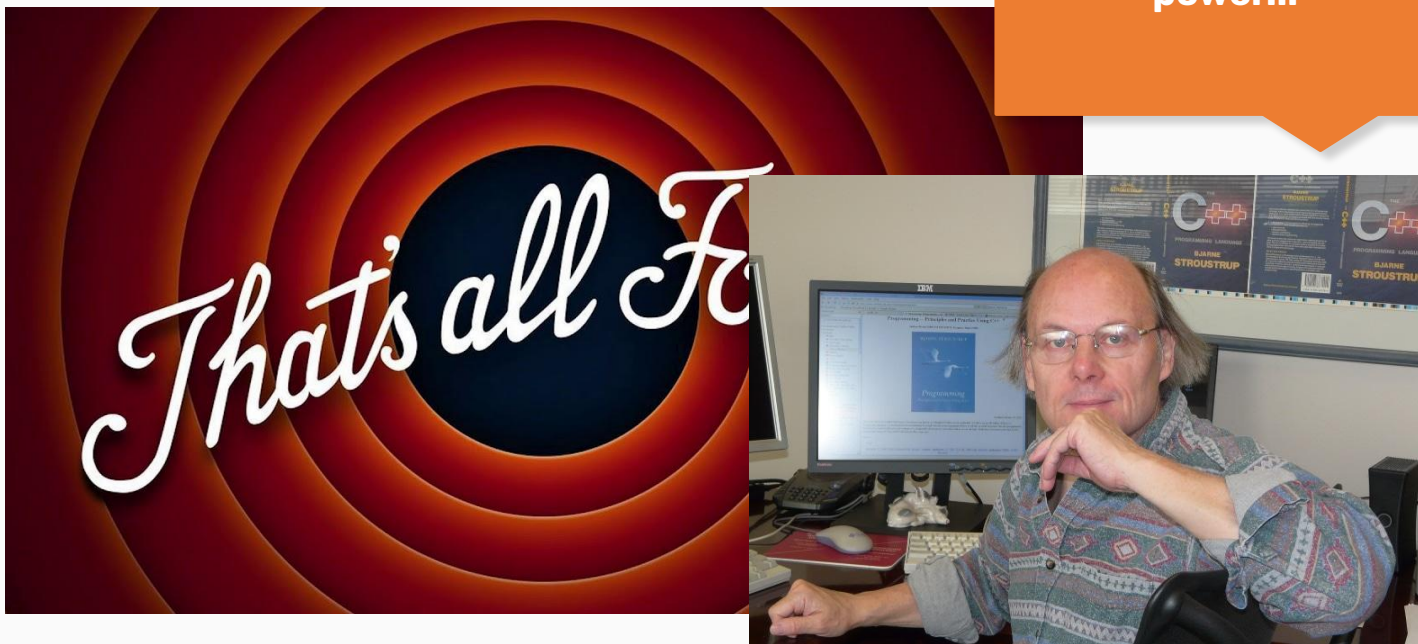


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You underestimate my
power...





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Containers all implement something called an iterator to do this!

- 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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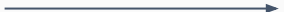

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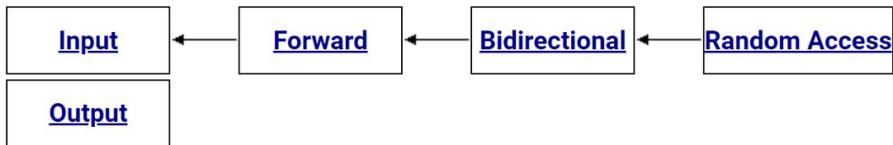
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What other
behaviors can
iterators have?

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.

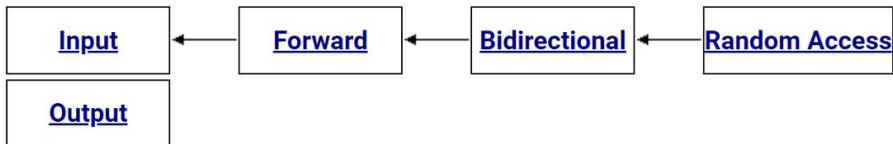
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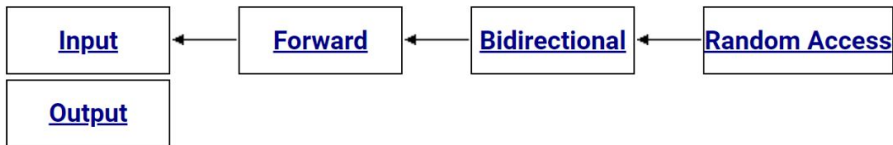
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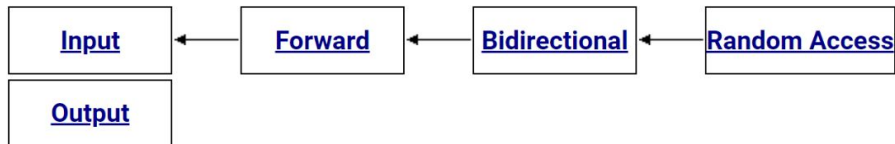
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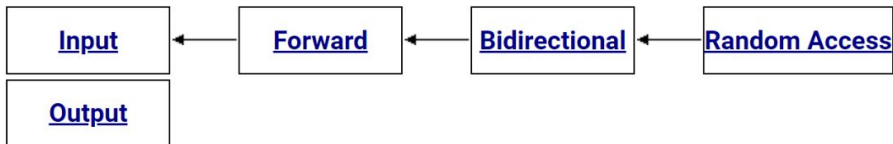
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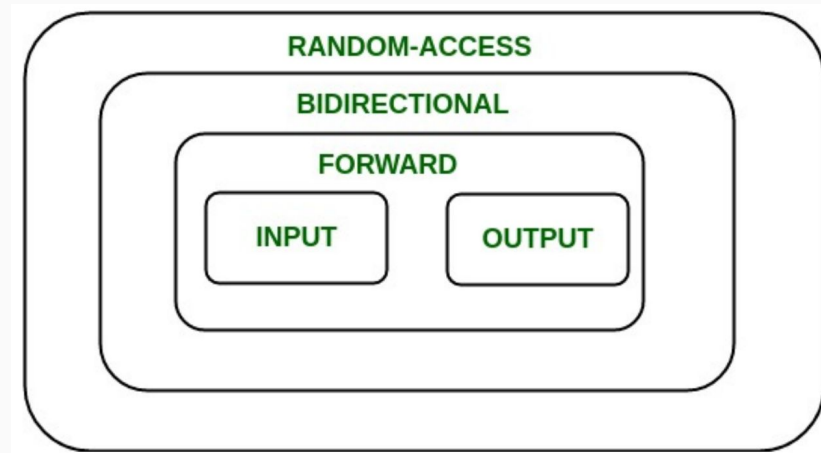
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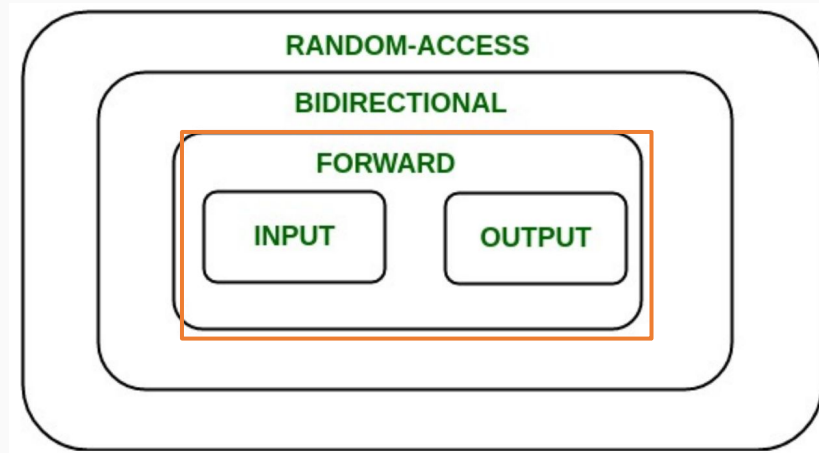
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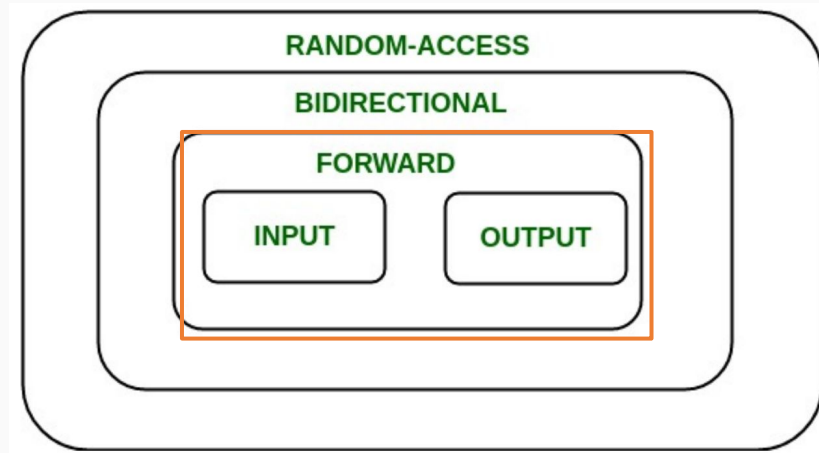
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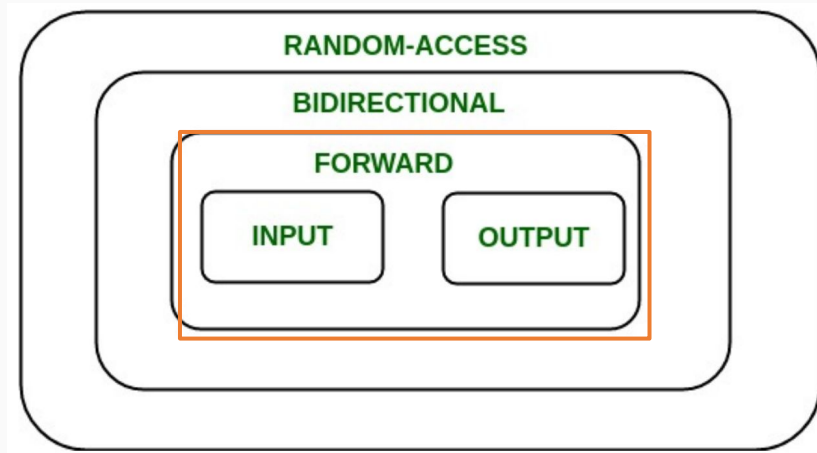


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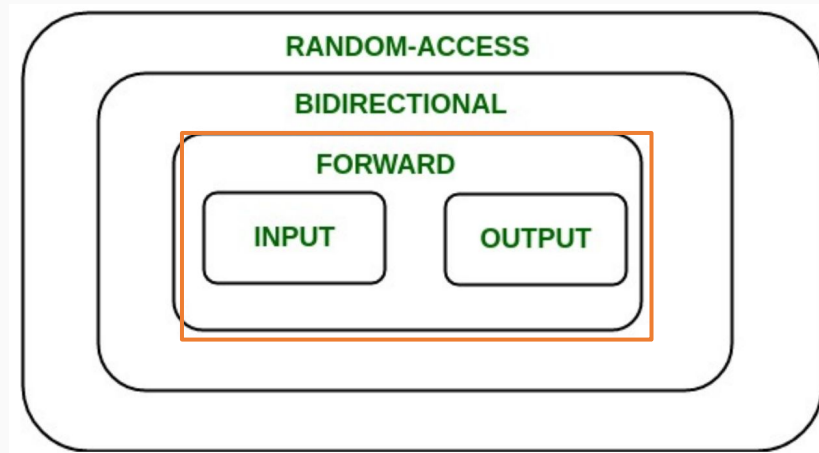
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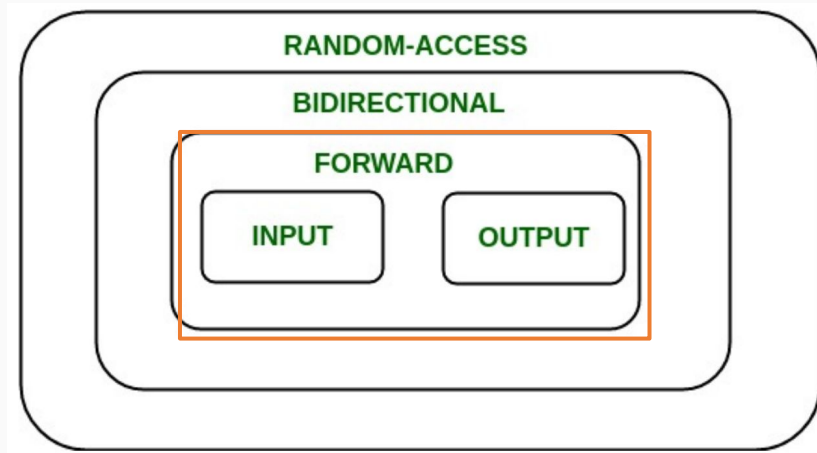
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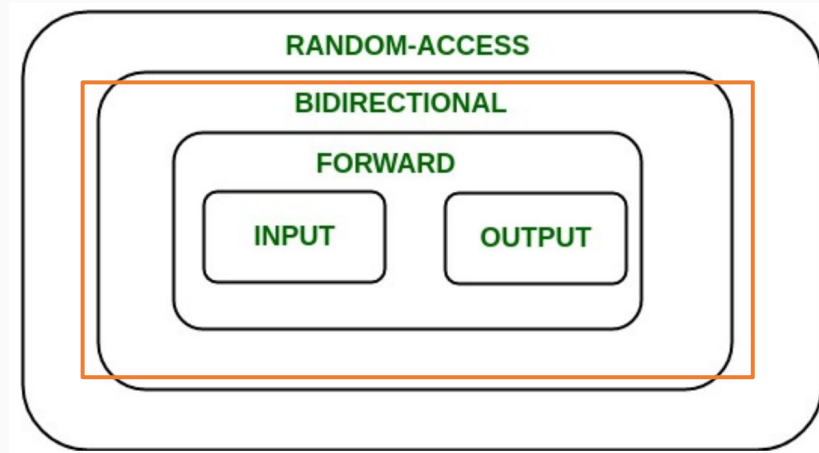
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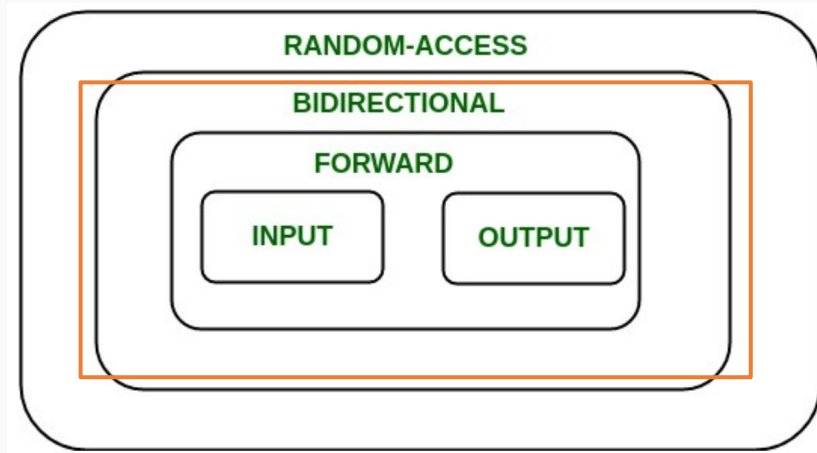
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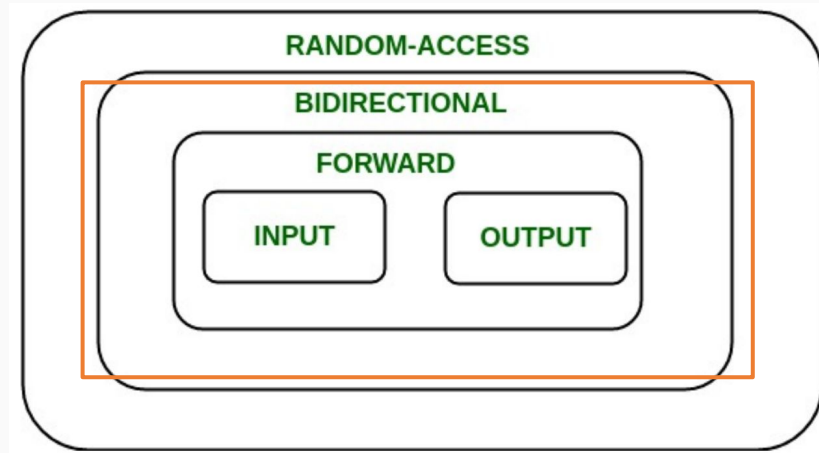
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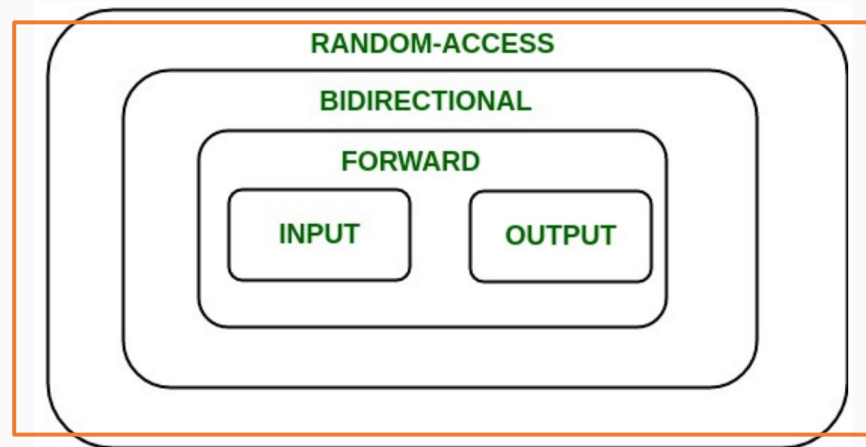
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- **--iter;**
- Still has the same functionality of forward iterators!



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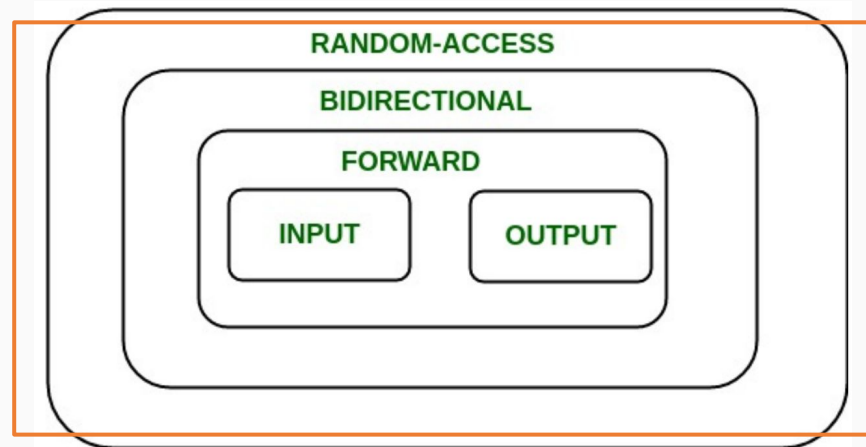
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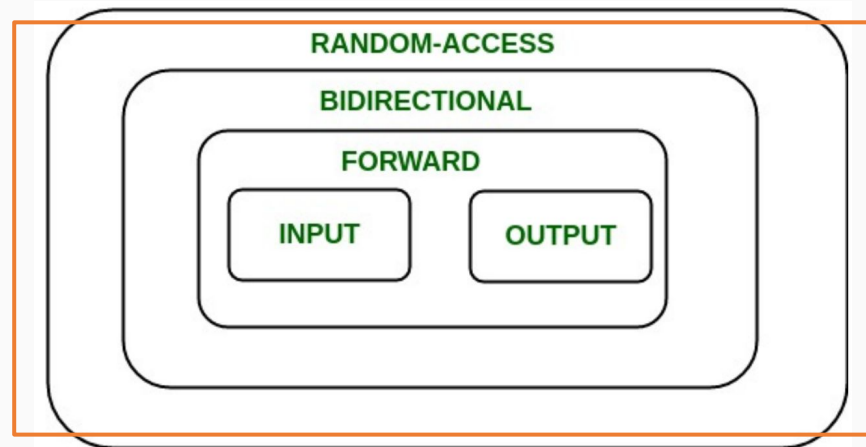
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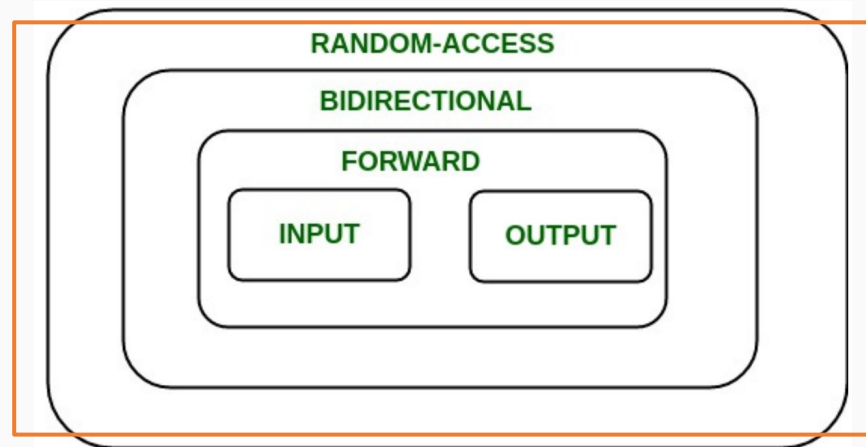
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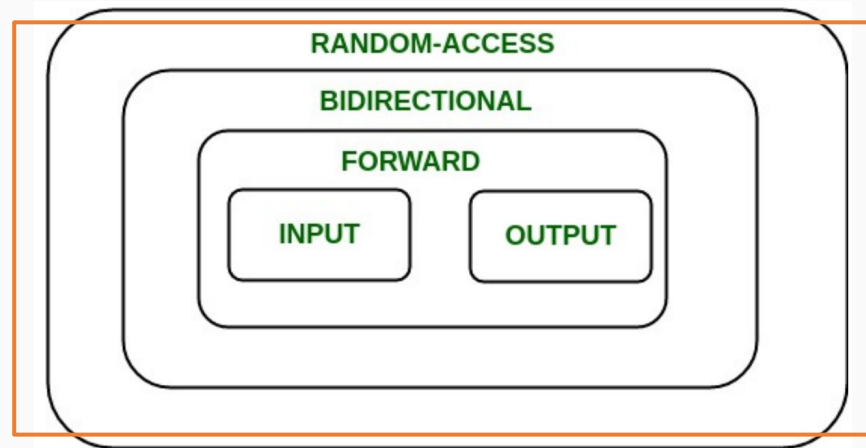


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---	---	---	---	---	---	---

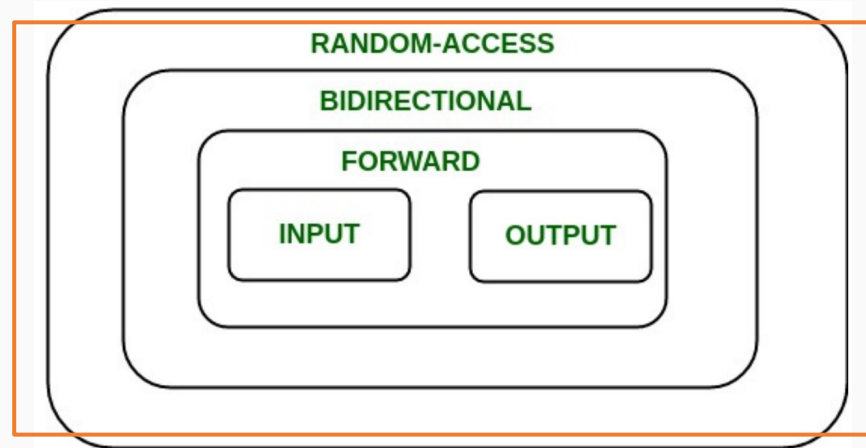


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iter += 3; ?

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

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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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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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Iterators are a particular type of pointer!

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



Memory and You

Variables created in your code take up space on your computer.



Memory and You

Variables created in your code take up space on your computer.

They live in memory at specific addresses.

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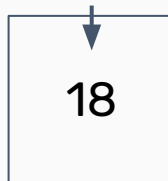
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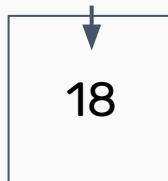
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#0106

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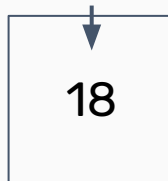
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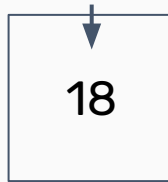
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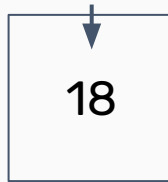
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- Iterators have to point to elements in a container, but pointers can point to any object!
 - Why is this? All objects stored inside the big container known as **memory**!
- Can access memory addresses with **&** and the data at an address/pointer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



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



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!



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Thanks!

Next up: Classes!