CSCI 136:
Data Structures
and
Advanced Programming

Lecture 20

Ordered Structures

Instructor: Dan Barowy

Williams

Topics

- Binary search
- Ordered structures

Your to-dos

1. Lab 6 (partner lab), **due Tuesday 11/1 by 10pm**.
2. Read **before Wed**: Bailey, Ch 12.6-12.9.

Announcements

- CS Colloquium this **Friday, Sept 23 @ 2:35pm in Wege Auditorium (TCL 123)**

Rachit Nigam (Cornell University)

Programming Support for Hardware Accelerators

Rachit Nigam is a visiting researcher in the PLSE group
at University of Washington and a PhD candidate
studying computer science at Cornell University.

He is a part of the CAPRA and PL@Cornell research
groups and is advised by Adrian Sampson. His research
(Dahlia, Calyx) is focused on building high-level
programming models for designing hardware accelerators.

Refresher: binary search

Binary search

100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Want to know **whether** the array contains the value **322**, and if so, what its **index** is.

Binary search is a **divide-and-conquer** algorithm that solves this problem.

Binary search is **fast**: in the **worst case**, it returns an answer in **O(log$_2$n)** steps.

Binary search

100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Important precondition: array must be **sorted**.

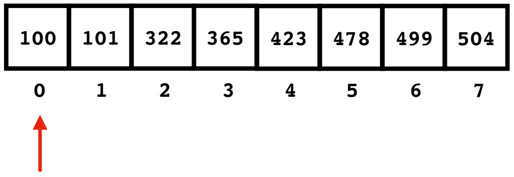
Binary search

Looking for the value **322**.

100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

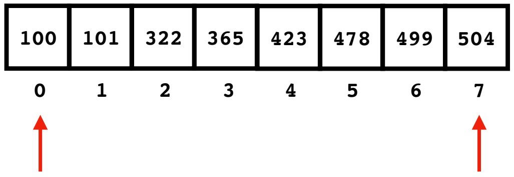
Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

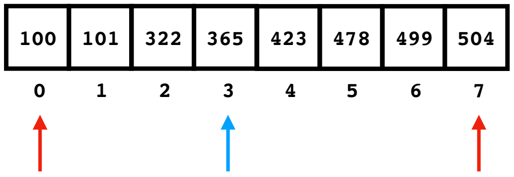
Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

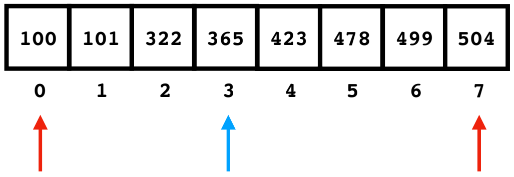
Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

Looking for the value **322**.



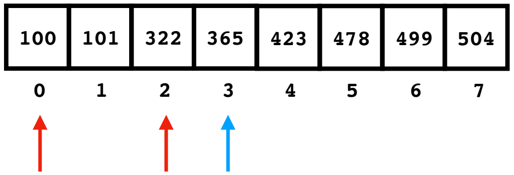
100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

322 = 365? **no**

322 < 365? **yes**

Binary search

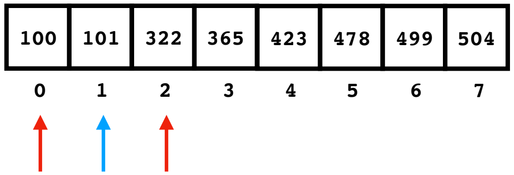
Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

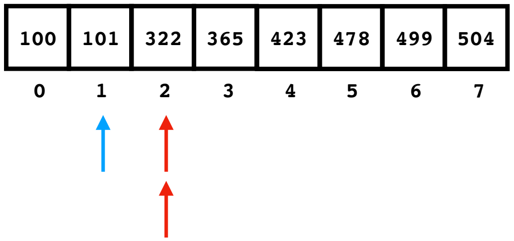
322 = 101? **no**

322 < 101? **no**

322 > 101? **yes**

Binary search

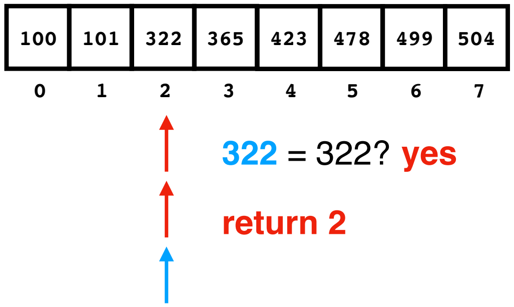
Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

Binary search

Looking for the value **322**.



100	101	322	365	423	478	499	504
0	1	2	3	4	5	6	7

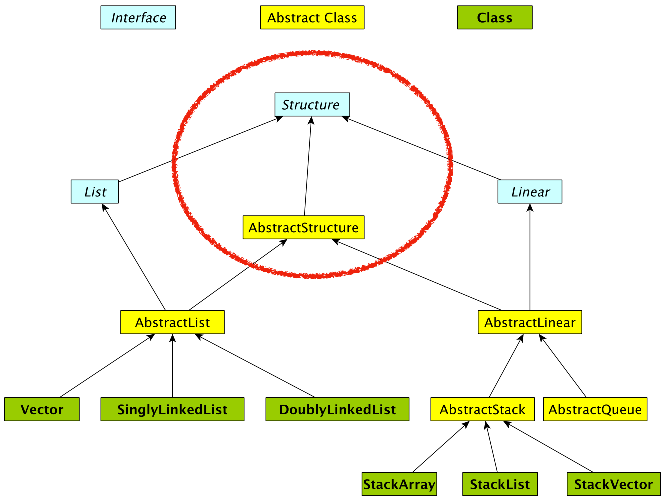
322 = 322? **yes**

return 2

Binary search implementation (code)

Ordered structures

structure5 Stack implementations



`structure` in `structure5`

A **structure** is an interface for any “traversable” collection of objects. In other words, it represents a class that **contains** some number of elements, and those elements can be **iterated**, **added**, and **removed**. **Membership** and **size** can also be checked.

Most of the data structures we discuss in this class implement `structure`.

structure in structure5

```
public interface Structure<E> extends Iterable<E>
{
    public int size();
    public boolean isEmpty();
    public void clear();
    public boolean contains(E value);
    public void add(E value);
    public E remove(E value);
    public java.util.Enumeration elements();
    public Iterator<E> iterator();
    public Collection<E> values();
}
```

Question for you

Why is a `structure` interface a **good idea**? What **benefit** do we get from having it?

One reason

Suppose we write a **method** that takes a `structure`. We could give it an instance of **any data structure** that implements the `structure` interface.

E.g., we could **iterate** over the elements and print them because **all structures** have the `iterator()` method.

What about **order**?

Does the `structure` interface require that elements be **ordered**?

structure in structure5

```
public interface Structure<E> extends Iterable<E>
{
    public int size();
    public boolean isEmpty();
    public void clear();
    public boolean contains(E value);
    public void add(E value);
    public E remove(E value);
    public java.util.Enumeration elements();
    public Iterator<E> iterator();
    public Collection<E> values();
}
```

What about **order**?

Does the `structure` interface require that elements be **ordered**?

No.

Is order a property that **could be enforced** using interfaces?

No. Order is a **data-dependent property**, so there's no way to check whether something is ordered until runtime.

OrderedStructure

Nonetheless, we can **signal our intent** with an interface.

How would we write an `OrderedStructure` interface?

Do its elements need to have **any special property**? (i.e., how would we **compare** them?)

Let's think about how we might implement this.

(code)

Recap & Next Class

Today:

Binary Search

Ordered structures

Next class:

OrderedVector

More iterators

Bitwise operations