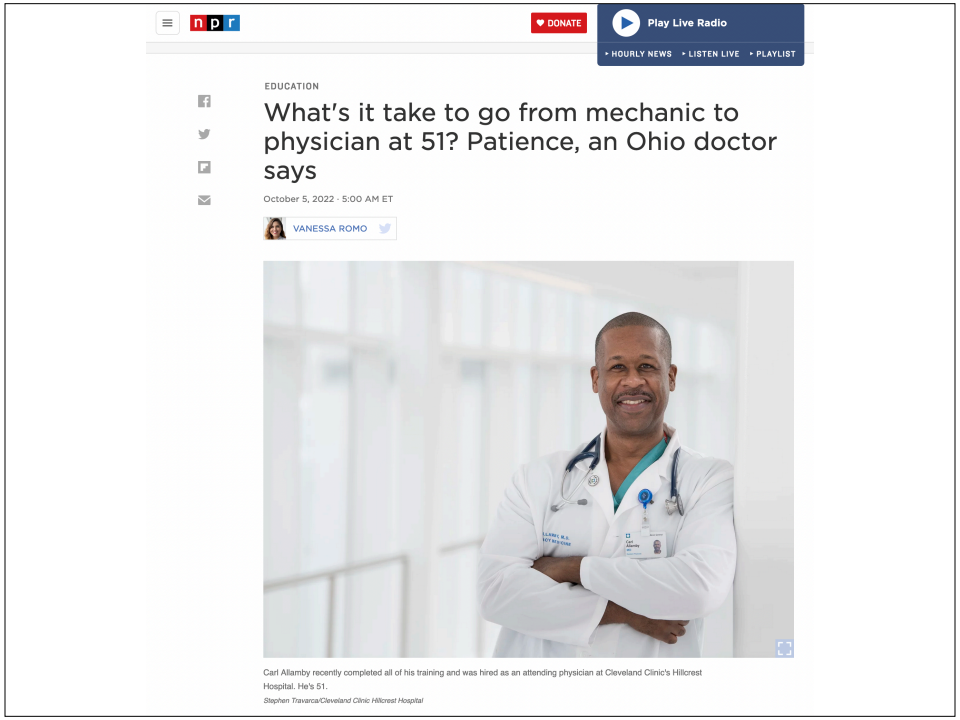
CSCI 136:
Data Structures
and
Advanced Programming

Lecture 12

Abstract data types

Instructor: Dan Barowy

Williams



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EDUCATION

What's it take to go from mechanic to physician at 51? Patience, an Ohio doctor says

October 5, 2022 · 5:00 AM ET

VANESSA ROMO

Carl Allamby recently completed all of his training and was hired as an attending physician at Cleveland Clinic's Hillcrest Hospital. He's 51.

Stephen Travarca/Cleveland Clinic Hillcrest Hospital

"If somebody were to watch most of my life over the past few years, it would be me sitting in a quiet room by myself studying and laboring over mounds of information," he told NPR.

"I think that sometimes people just look at the end product of somebody's hard work," he said, reflecting back on his own journey. "But you know, [by doing that] you kind of miss the part where people are doing all the work that it takes to become a success."

“[M]y philosophy has always been to be comfortable with being uncomfortable. And the more I can put myself into uncomfortable situations, the more I can grow."

In recent years, Allamby has been asked to speak publicly about his journey from fixing cars to saving lives. When he does, he avoids using language that makes him sound exceptional. In fact, he tries to do the opposite, stressing the methodical nature of his slow rise through the ranks of academia.

"There's going to be times when you feel like giving up, but those are the times to really push forward and to rely on the people who surround you," Allamby said. "People who give you positive feedback in order to kind of fill your bucket back up so that you can keep going."

Topics

- ADTs
- More linked lists

Your to-dos

1. Read **before Fri**: Bailey, Ch 9.4–9.5.
2. Quiz 4, **due Saturday by noon**.
3. Lab 4, **due Tuesday 10/11 by 10pm**.

Announcements

- Quizzes: earlier
- Colloquium: **What I Did Last Summer (Industry)**, 2:35pm in Wege Auditorium with **cookies**.

Linked List

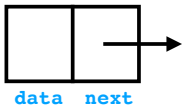
A **linked list** is a recursive data structure. A linked list is composed of simple pieces called **list nodes**. A list node contains **data** (of generic type **T**) and a **reference** (a "link") to either **another list node** or **null**.

Linked List

∅

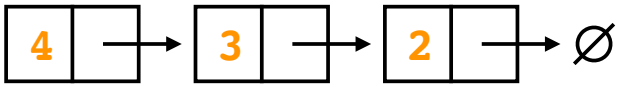
The empty list is defined as **null**.

Linked List



Every other list has at least one list node.

Singly Linked List



There's only **one link** in each node, to the **rest** of the list.

How would I represent the above idea **in Java**?

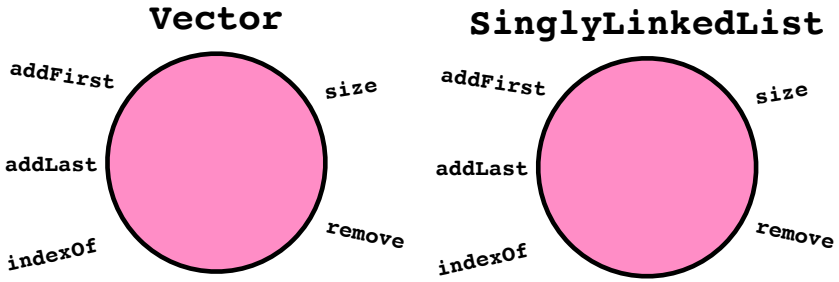
The purpose of a class:

To “abstract away” implementation details.

Abstraction

Abstraction is the process of **removing irrelevant information** so that a program is easier to understand.

Do you see any similarities?



The two classes share the same **interface**.

Interface

An **interface** defines boundary between two systems across which they share information. An interface is a **contract**: calling a method defined in an interface returns the data as promised.

Because an interface **contains no implementation**, programmers who use them **cannot rely on implementation details**.

E.g., the `List` interface states that there must be an `add` method but does not say how it should be implemented.

List

A **list** is an **ordered collection** of items of an element of type `E`. It supports **prepending** an element to the front, **appending** (**adding**) and element to the end, **finding** an element, and element **removal**.

A `Vector` is a **list**.

A `SinglyLinkedList` is a **list**.

A `DoublyLinkedList` is a **list**.

Observe that this similarity is "deeper" than just what an **interface** provides….

Abstract Data Type

An **abstract data type** is a mathematical formulation of a data type. ADTs abstract away **accidental** properties of data structures (e.g., implementation details, programming language). Instead, ADTs contain only **essential** properties and are **concisely defined by their logical behavior** over a **set of values** and a **set of operations**.

In an ADT, **precisely how data is represented** on a computer **does not matter**.

By contrast: data structure

A **data structure** is the physical form of a data type, i.e., it is an implementation of an ADT. Generally, data structures are designed to efficiently support the logical operations described by the ADT.

For data structures, precisely **how data is represented on a computer matters a lot**. Simple data structures are often composed of simple representations, like primitives, while more complex data structures are composed of other data structures.

`Vector`, `SinglyLinkList`, etc. are **data structures**.

A Vector is a List

structure5

Class Vector<E>

```
java.lang.Object
  └ structure5.AbstractStructure<E>
      └ structure5.AbstractList<E>
          └ structure5.Vector<E>
```

All Implemented Interfaces:
java.lang.Cloneable, java.lang.Iterable<E>, List<E>, Structure<E>

```
public class Vector<E>
extends AbstractList<E>
implements java.lang.Cloneable
```

A Linked List is a List

structure5

Class SinglyLinkedList<E>

```
java.lang.Object
  └ structure5.AbstractStructure<E>
      └ structure5.AbstractList<E>
          └ structure5.SinglyLinkedList<E>
```

All Implemented Interfaces:
java.lang.Iterable<E>, List<E>, Structure<E>

```
public class SinglyLinkedList<E>
extends AbstractList<E>
```

Vector Big-O

operation	worst	best
addFirst(E e)	O(n)	O(1)
get(int i)	O(1)	O(1)
indexOf(E e)	O(n)	O(1)
remove(E e)	O(n)	O(1)
size()	O(1)	O(1)

Singly-Linked List Big-O

operation	worst	best
addFirst(E e)	O(1)	O(1)
get(int i)	O(n)	O(1)
indexOf(E e)	O(n)	O(1)
remove(E e)	O(n)	O(1)
size()	O(n) [O(1) w/mod.]	O(n) [O(1) w/mod.]

Missing from Java: ADT behavior

Java provides no way of specifying behavior independently of implementation.

E.g., a **`List`** interface might require

```
public void prepend(T elem)
```

But there's no way to **require** that an implementation actually *place the element at the beginning of the list*.

The best we can do in Java: static types

Java uses **types** to stand in for ADTs.

However, Java provides some control over **abstractness**, and we can use this control to approximate what we want.

interface → **fully** abstract

abstract class → **partially** abstract

class → **not** abstract

Interface

An **interface** defines boundary between two systems across which they share information. An interface is a **contract**: calling a method defined in an interface returns the data as promised.

An interface **contains no implementation**!

You cannot specify **behavior** at all!

`Honkable`

Recap & Next Class

Today:

- ADTs
- Lists

Next class:

- Sorting