Hello ☺

CSE 373: Introduction, ADTs, Design Decisions, Generics

Michael Lee

Wednesday Jan 3, 2017

Overview

- Michael Lee (mlee42@cs.washington.edu)
  - Currently working on a master's degree in Computer Science
  - Supervised by Adam Blank
- Office hours (CSE 216)
  - Tuedays from 1:30 to 3:30
  - Fridays from 4:30 to 6:30
  - Or by appointment

Agenda

1. About this course
2. Data structures vs abstract data types (ADTs)
3. Generics
4. Administrivia

What are data structures and algorithms?

Data structure: a way of organizing and storing data

Algorithm: a series of precise instructions used to perform a task

What are data structures and algorithms?

Data structures store data

Algorithms do things

CSE 143

Basic techniques for storing and manipulating data

- "Expanding arrays"
- Nodes and pointers/references
- Trees and recursion

CSE 143

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- Trees and recursion

How to use pre-made data structures

- Using standard Java collections
- (Lists, Stacks, Queues, Sets, Maps...)

CSE 143

Basic techniques for storing and manipulating data

- “Expanding arrays”
- Nodes and pointers/references
- Trees and recursion

How to use pre-made data structures

- Using standard Java collections
- (Lists, Stacks, Queues, Sets, Maps...)

Techniques for organizing code

- Refactoring, coding style
- Client vs implementer

CSE 373

Content

- Learn new techniques
- Learn how exactly data structures work
- How to precisely analyze algorithms

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Core skills

- Design decisions, tradeoffs, and critical thinking
- Abstraction and implemention
- Communication: being able to justify your decisions

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Incidental skills

- Debugging and testing
- Exposure to tools used in industry

Course roadmap

- Week 1: Review of lists, stacks, and queues; misc Java tidbits
- Week 2: How to (precisely!) analyze code
- Week 3-5: Dictionaries (aka Maps) and Sets
- Week 6: Divide and conquer, sorting
- Week 7-9: Graphs and graph algorithms
- Week 10: Other interesting material

Definitions

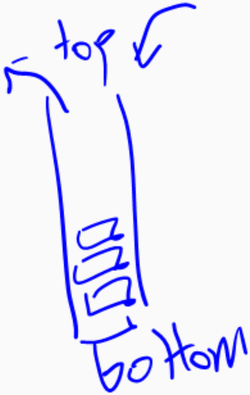
Definitions

Abstract Data Type (ADT)

A (mathematical) description of a ”thing” with a set of supported operations and how they ought to behave

What is a Stack?

A stack stores information in first-in, last-out order (like a deck of cards!)



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It should support the following *operations*:

- **push**:
- **peek**:
- **pop**:
- **size**:

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- **push**: add an item to the top of the stack
- **peek**: return (w/o removing) the top of the stack (if not empty)
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- **size**: return the number of elements in the stack

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This is the **Stack ADT**.

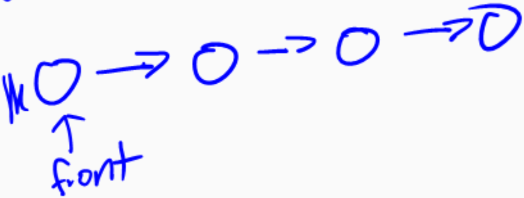
Definitions

Data structure

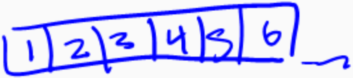
A specific way of organizing data and an associated family of algorithms that are used to implement an ADT

How do we implement a stack?

Idea 1



Idea 2



push 1, 2, 3, 4
5, 6, 7

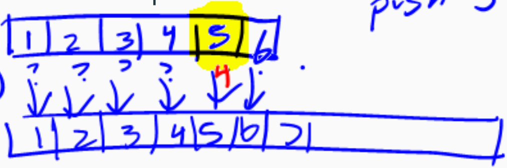
How do we implement a stack?

- Internal data a stack needs to keep track of:

push 5

array :

? index (int)



- Algorithms:
  - **push**:

push

  - **peek**:
  - **pop**:
  - **size**:

How do we implement a stack?

- Internal data a stack needs to keep track of:
  - `items`: An array containing our data
  - `numItems`: An int containing the number of items in the stack
- Algorithms:
  - **push**: If `numItems == items.length`, create a new array double the length, copy all elements over, and store the new array. Add the new item at the `numItems`-th index and increase `numItems` by one
  - **peek**: If `numItems == 0`, crash. Otherwise, return the item at the `numItems`-th index.
  - **pop**: Call *peek* and get the item to return. Decrease `numItems` by one.
  - **size**: Return `numItems`

How do we implement a stack?

- Internal data a stack needs to keep track of:
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  - **pop**: Call *peek* and get the item to return. Decrease numItems by one.
  - **size**: Return numItems

This is the **ArrayStack data structure**. An ArrayStack **implements the Stack ADT**.

Definitions

Implementation of a data structure

Is a *specific* implementation in a *specific* language

AKA a *concrete data structure* (CSE 373-specific term)

How do we implement a stack in Java?

How do we implement a stack in Java?

```
public class ArrayStack<T> {
    private T[] items;
    private int numItems;

    // Constructor omitted for space

    public void push(T item) {
        if (this.numItems == this.items.length) {
            T[] newItems = new T[this.items.length * 2];
            this.copyTo(this.items, newItems, this.items.length);
            this.items = newItems;
        }
        this.items[this.numItems] = item;
        this.numItems += 1;
    }

    private void copyTo(T[] src, T[] dst, int amount) {
        for (int i = 0; i < amount; i++) {
            dst[i] = src[i];
        }
    }
```

How do we implement a stack in Java?

```
    public T peek() {
        if (this.numItems == 0) {
            throw new IllegalStateException();
        }
        return this.items[this.numItems];
    }

    public T pop() {
        T out = this.peek();
        this.numItems -= 1;
        return out;
    }

    public int size() {
        return this.numItems;
    }
}
```

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    public T peek() {
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        this.numItems -= 1;
        return out;
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    public int size() {
        return this.numItems;
    }
}
```

This is a **concrete implementation of ArrayStack in Java**.

Java interlude 1: Generics

What is this thing?

```
public class ArrayStack<T> {
    private T[] items;
    private int numItems;

    public void push(T item) { ... }
    // ...
}
```

Java interlude 1: Generics

Previously, in CSE 143, if we wanted a stack of ints:

```
public class ArrayIntStack {
    private int[] items;
    private int numItems;

    public void push(int item) { ... }
    // ...
}
```

If we wanted a stack of Strings:

```
public class ArrayStringStack {
    private String[] items;
    private int numItems;

    public void push(String item) { ... }
    // ...
}
```

Rinse and repeat for each type.

Java interlude 1: Generics

Previously:

```
public class ArrayStringStack {
    private String[] items;
    private int numItems;

    public void push(String item) { ... }
    // ...
}
```

Java interlude 1: Generics

Previously:

```
public class ArrayStringStack {
    private String[] items;
    private int numItems;

    public void push(String item) { ... }
    // ...
}
```

Using generics:

```
public class ArrayStack<T> {
    private T[] items;
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    public void push(T item) { ... }
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}
```

Java interlude 1: Generics

Previously:

```
public class ArrayStringStack {
    private String[] items;
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    public void push(String item) { ... }
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Using generics:

```
public class ArrayStack<T> {
    private T[] items;
    private int numItems;

    public void push(T item) { ... }
    // ...
}
```

public class Map<K, V>

public class ArrayStack<lol> {

lol[] items

push(lol item)

In this class, we'll keep things simple/handle the messiness for you

Overloading

- Link to overload form available this **Friday**
- Other registration questions? Email cse373@cs.washington.edu
- Forwards emails to the CSE advisors
- Note: I have no control over course enrollment

Projects and Homework

Policies

- Mix of **partner projects** and solo **written homework**
- Three late days (lose 20% per day if no late days left)
- No submissions accepted after 2 days
- All assignments due at 11:30pm

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Grades

- 15%: Written assignments
- 45%: Partner projects
- 20%: Midterm
- 20%: Final

See syllabus for more details

Academic honesty

Policies regarding sharing work

1. Showing other students your code or written work is **not** ok.
2. Do not publicly publish your projects or homework (we want to reuse these assignments).

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Policies on discussion and collaboration

1. Discussing ideas on a high level **is ok**.
2. Rule-of-thumb: If you're taking notes/taking photos during group discussions, you're over-sharing.

Getting help

Course staff

- Piazza (Q&A forum)
- Office hours (see course website)

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Resources

- Lecture slides (posted after class)
- Panopto videos (posted after some delay)
- “Resources” section on course website
- Optional textbook: *Data Structures and Algorithms Analysis in Java*, 3rd edition, Weiss

Course survey

Course survey, due Friday, Jan 5 at 11:30pm

Link: https://goo.gl/KNuQL1

(Link ~~also~~ available on course website)

will be available.

Project 1

Full spec will be posted on class website later today

- Deliverables:
  - Implement a doubly-linked list and a dictionary (aka a map)
  - Implement a graphing calculator
  - Do a writeup
  - Extra credit: extend your calculator and implement a programming language

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- Timeline: two week project
  - Wed, Jan 10, 11:30pm: part 1 due
  - Wed, Jan 17, 11:30pm: part 2 due

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Summary: TODO list

Today:

- Skim through syllabus
- Make sure you're signed up on Piazza

By Friday, Jan 5:

- Course survey
- Look at project 1 spec and finish the setup instructions
- Find a partner and fill out form

By Wednesday, Jan 10:

- Project 1 part 1 due

By Wednesday, Jan 17:

- Project 1 part 2 due