CSE 373: Data Structures and Algorithms

Lecture 1: Introduction, ADTs, Stacks & Queues

Instructor: Lilian de Greef
Quarter: Summer 2017

Welcome!

Today's Structure:

- Introductions and course mechanics
- Start material
  - Abstract Data Types (ADTs)
  - Stacks
  - Queues

Self Introductions

(Your homework 0!)

Lilian de Greef

- CSE PhD Student
- Working with Shwetak Patel on health applications of CS
- Interests & Hobbies
  - Ultimate Frisbee
  - Piano
  - Hiking / backpacking
  - Some TV shows

ldegreef@cs.washington.edu

cse373-staff@cs.washington.edu

Kyle Thayer

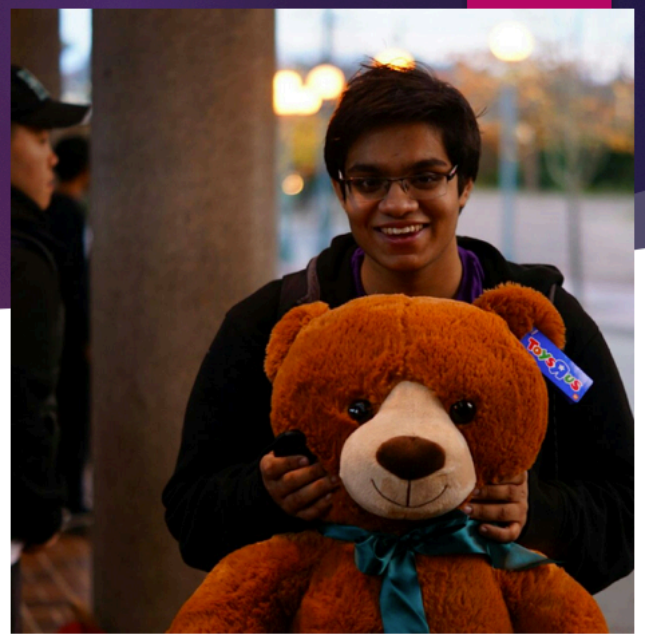
Ben Jones

Vlad Shamalov

Dorothy

- Senior (undergrad) in Computer Science and ACMS
- TAing this quarter because I loved this class both when I took it and when I've been a TA for 373 in the past
- Some of my hobbies are reading, exploring Seattle, and photography

Anupam Gupta



- Junior - Majoring in CSE and HCDE.
- Hobbies: Watching Movies, Sleeping.
- Interests: AI, Programming Languages, Data Mining.
- Why TA? Because it's a lot of fun and also because I get to meet a lot of new, fun, people and talk to them about CS (which is awesome!!)
- See you all around!

Course Logistics

Classroom environment

- Laptop policy
- Lectures starting promptly at 10:50
- Will have discussions in class
  - With neighbors
  - With entire class
  - Hence, pack yourselves to the front and sit together
- Somewhere we can feel comfortable making mistakes
  - One of the best ways to learn!

General Logistics

- Website: http://cs.washington.edu/373
- Mailing list: cse373a_17su@uw.edu
- Piazza discussion board
- Textbook: Weiss 3rd Edition in Java
- Computers for homework assignments
  - College of Arts & Sciences Instructional Computing Lab: http://depts.washington.edu/aslab/
  - Or your own machine
- Java
  - Used for programming assignments
  - Recommended environment: Eclipse

Sections & Office Hours

- TBA by Tuesday, in class on Wednesday
- Lilian's office hours (*for just today)*:
  - 1:00 – 2:00pm
  - CSE 220

Contact

- Use Piazza!
  - https://piazza.com/washington/summer2017/cse373
  - Don’t post code or solutions publicly
  - For questions with code, solutions, grades, etc., make private posts to instructors
  - Can post anonymously
- Email me
  - For "Lilian's eyes only" concerns
  - I'll reply within 24 hours
  - Put [CSE 373] at beginning of subject

Collaboration and Academic Integrity

DON’T CHEAT!

Seriously, read the policy online.

Using PollEverywhere

- How:
  - You anonymously vote on multiple choice questions in lecture
  - Via text messaging (SMS) or web browser (don't need to buy a clicker)*
- Why:
  - A way for me to check in
  - A way for *you* to check in
  - Research shows using Peer Instruction with polling improves learning!

* If access to SMS or a web browser in class is a challenge for you, please come talk to me

Using PollEverywhere: for Peer Instruction

- Format
  1. I'll pose a question
  2. Vote individually, invisible to class
  3. Discuss!
  4. Group vote
- Discussion is key!
  - "Just getting the right answer" is not enough - need to be able to explain/argue for it!
  - Testing yourself helpful ("right answer"), but learning happens during discussion

Take part in class-wide discussion!

- I know, can be intimidating
- Your questions and explanations are critical for fellow students' learning
- If you have a question, it’s likely that others have the same one. You're not alone!

Let’s get started with Data Structures!

Today: Abstract Data Types (ADTs), Stacks, Queues

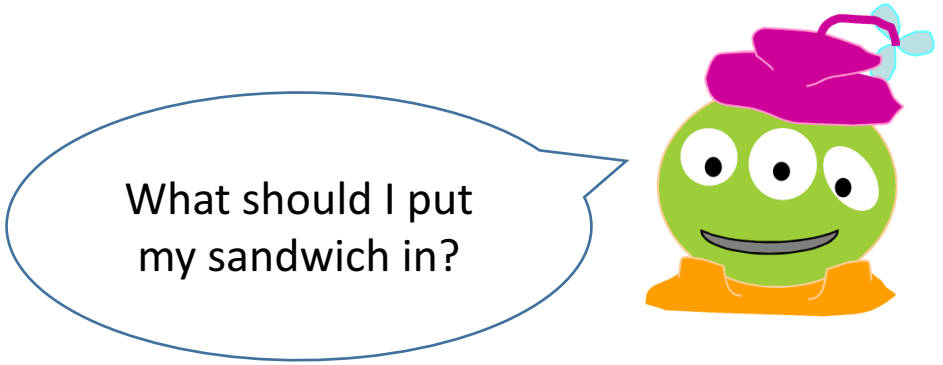
Expectations: Basic Understanding of

- Conditionals
- Loops
- Methods
- Fundamentals of defining classes and inheritance
- Basic algorithm analysis (e.g. O(n) vs O(n^2) etc.)
- Arrays
- Singly linked lists
- Simple binary trees
- Recursion
- A few sorting and searching algorithms

What is a Data Structure?

- On super high level: a container for data

What is a Data Structure?



- On super high level: a container for data
- Real-world examples of containers:








The crux of this course

- Understanding your data structures and algorithms to choose the right one for the job.
- Fundamental CS skill
- After this course, I want you to be able to
  - Make good design choices
  - Justify and communicate design decisions

Terminology

- **Abstract Data Type (ADT)**
  - Mathematical description of “thing”
    - Meaning
    - Operations
  - No implementation details

e.g. bag:
Meaning of bag:
flexible container with an opening at the top
Some of its operations:
open, close, insert, take out

- **Data structure**
  - Specific way to implement ADT (organization of data & family of algorithms)

e.g. bag:

- Different kinds of bags: with handles, without handles, with clasp, with drawstring, with zip-lock, etc.

- Is one kind of bag the best?

Terminology

- **Algorithm**
  - Language-independent description of step-by-step process

e.g. Algorithm for closing a zip-lock bag

1. Bring ends of opening together
2. Press one end
3. Run hand along top to seal

- **Implementation** of a data structure
  - Specific implementation in a specific language

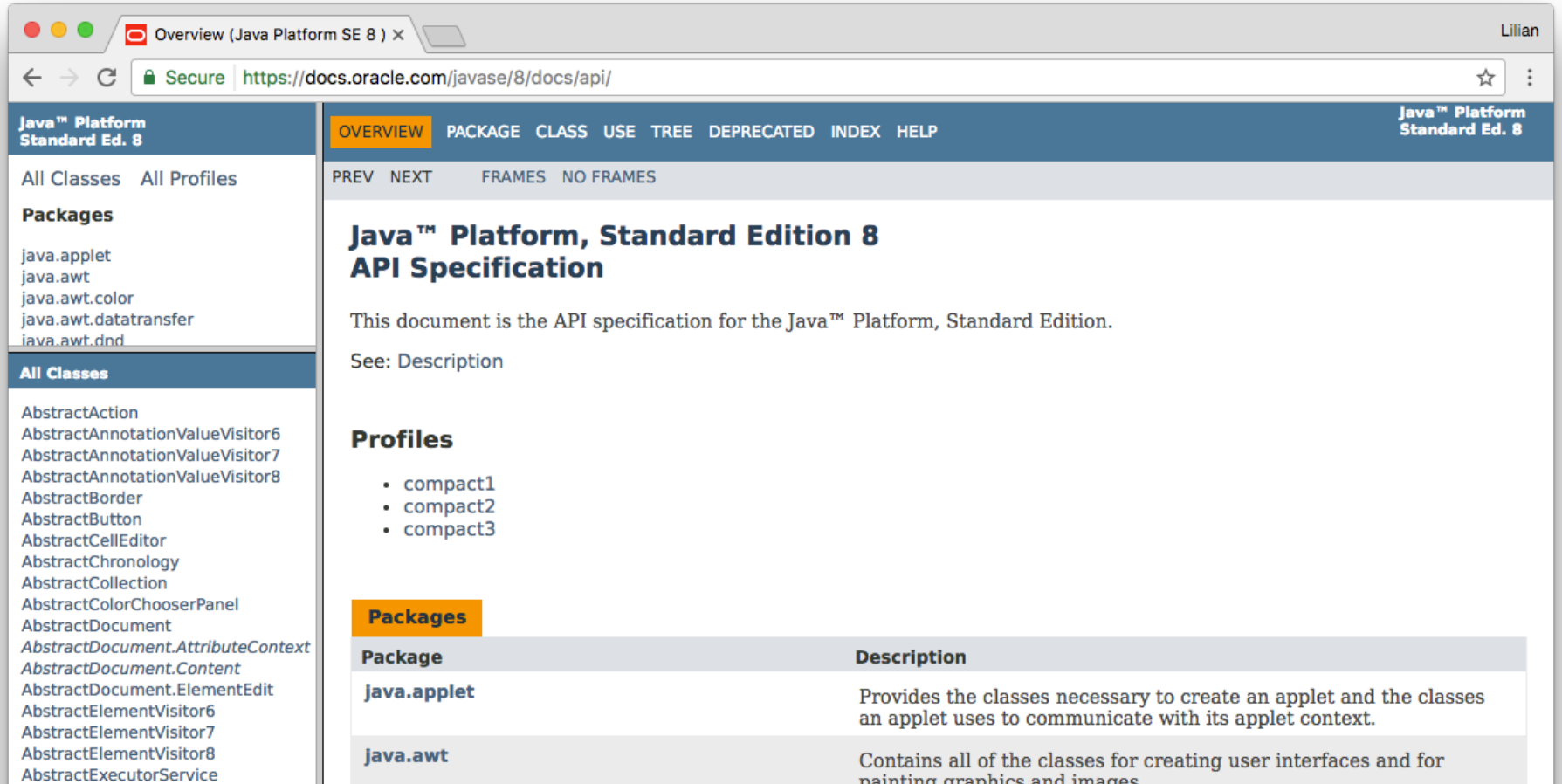
e.g. bag:

- Can implement in paper, plastic, canvas, leather, etc.

Terminology

Application Programmer Interface (API):

Implementation of an ADT in particular language



Computer Science example: Stacks!

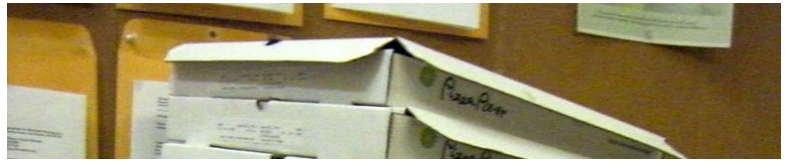
Stack ADT

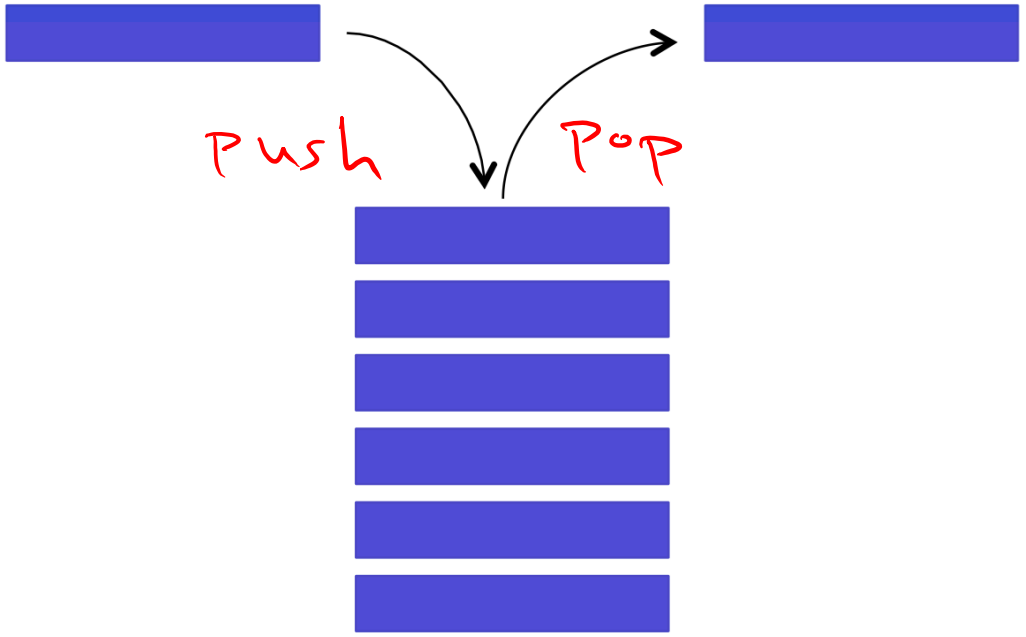
- Meaning

  LIFO (last-in-first-out)

- Operations

  - push()
  - pop()
  - peek
  - constructor
  - size
  - isEmpty





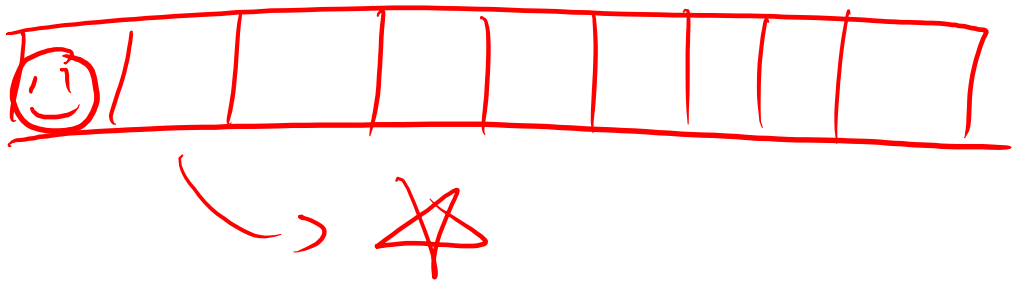
Stack data structures

- Specific kinds of stacks:
  - Stacks using Arrays
  - Stacks using Linked-lists
- Example implementation: library “java.util.Stack”

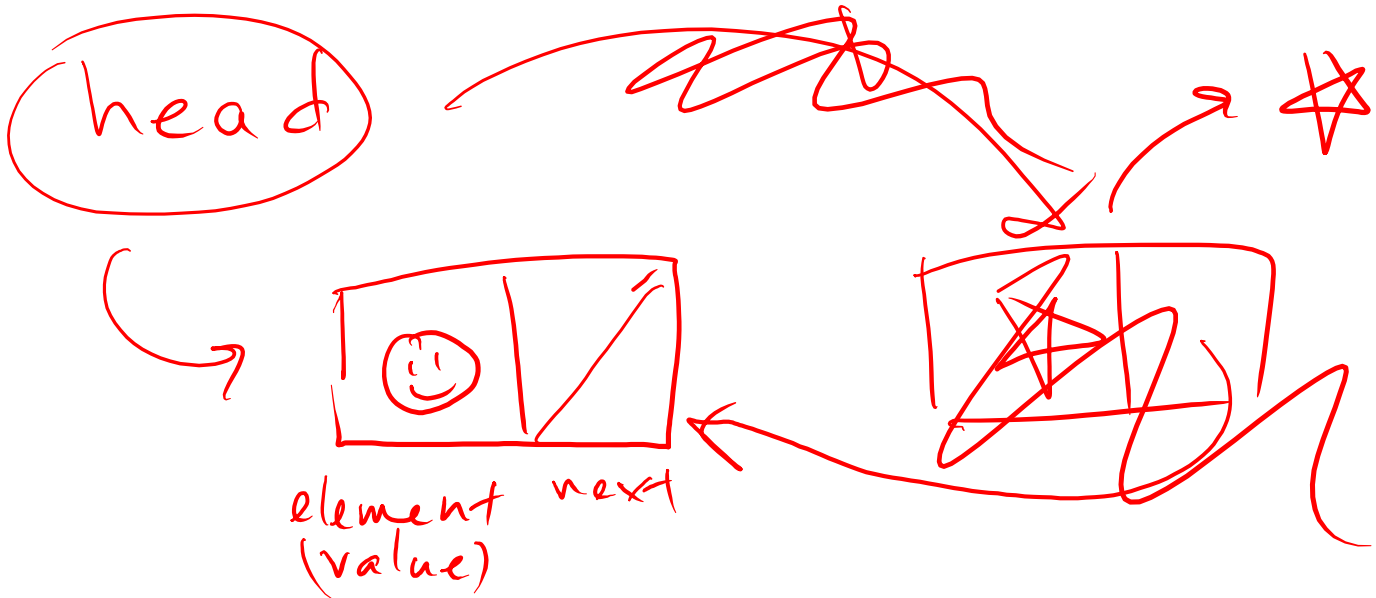
Stack Practice!

1. `new Stack`
2. `push(☺)`
3. `push(☆)`
4. `pop()`

- As an array

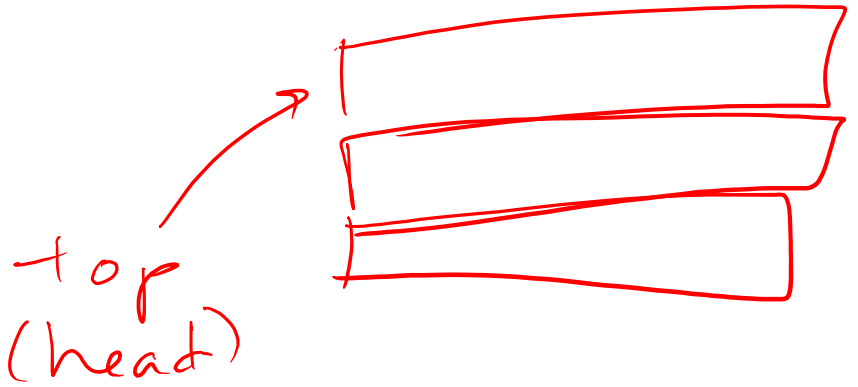


- As a linked list



Stacks are used a lot!

- Undo / redo
- Back / forward on browsers
- Recursion
- Matching braces



{ ((a + b) * c – (d / (e + f)) }

- … and much more!

Another example: Queues!

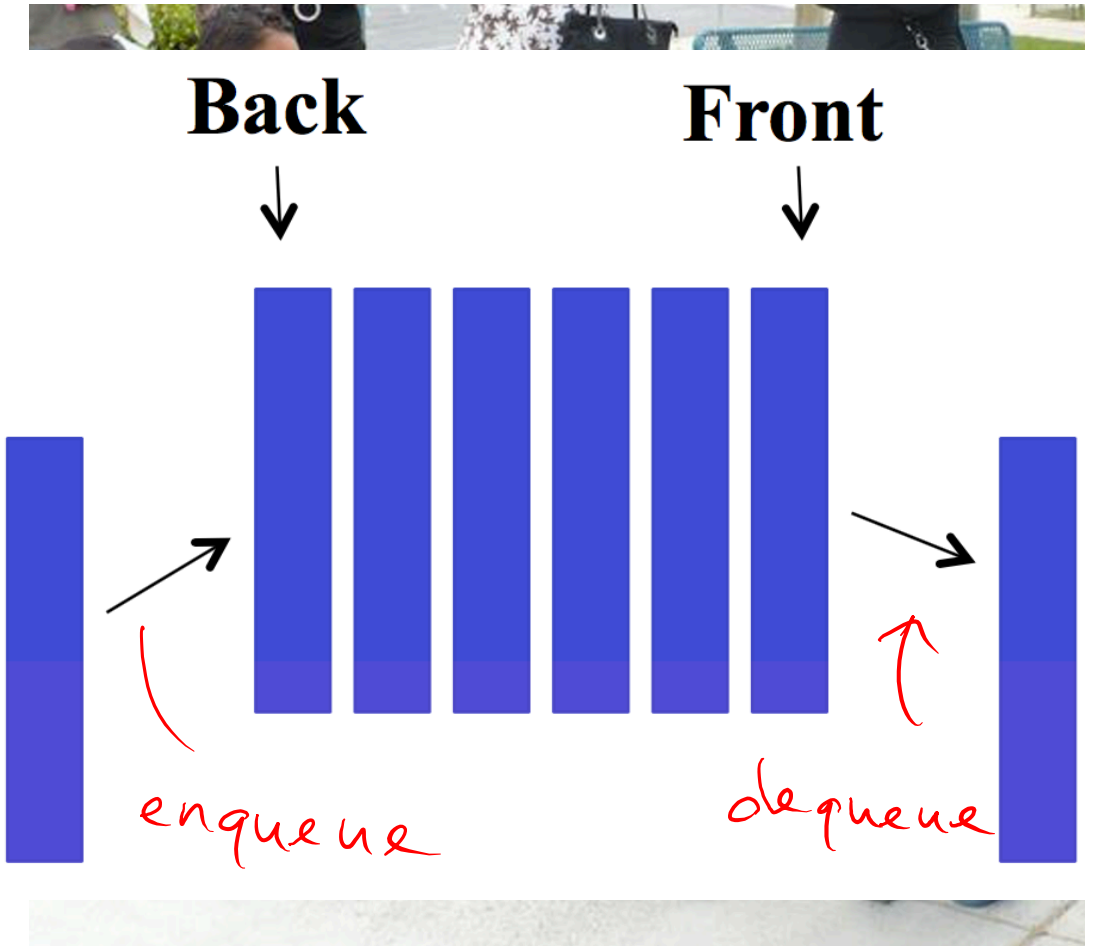
Queue ADT

- Meaning

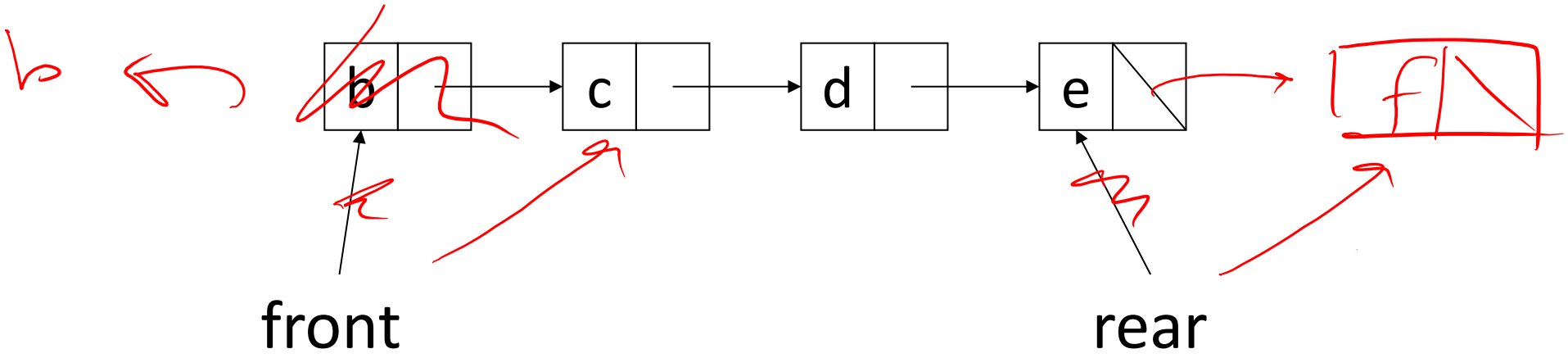
  FIFO (first-in-first-out)

- Operations

  - enqueue
  - dequeue
  - isEmpty
  - size



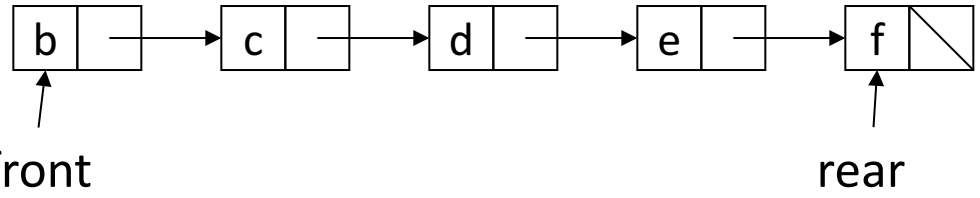
Queue Data Structure: Linked List

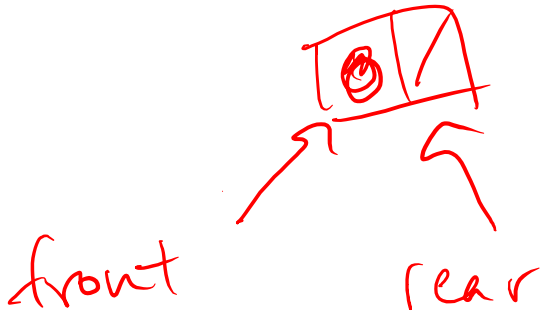


enqueue(f)

dequeue()

Queue Data Structure: Linked List



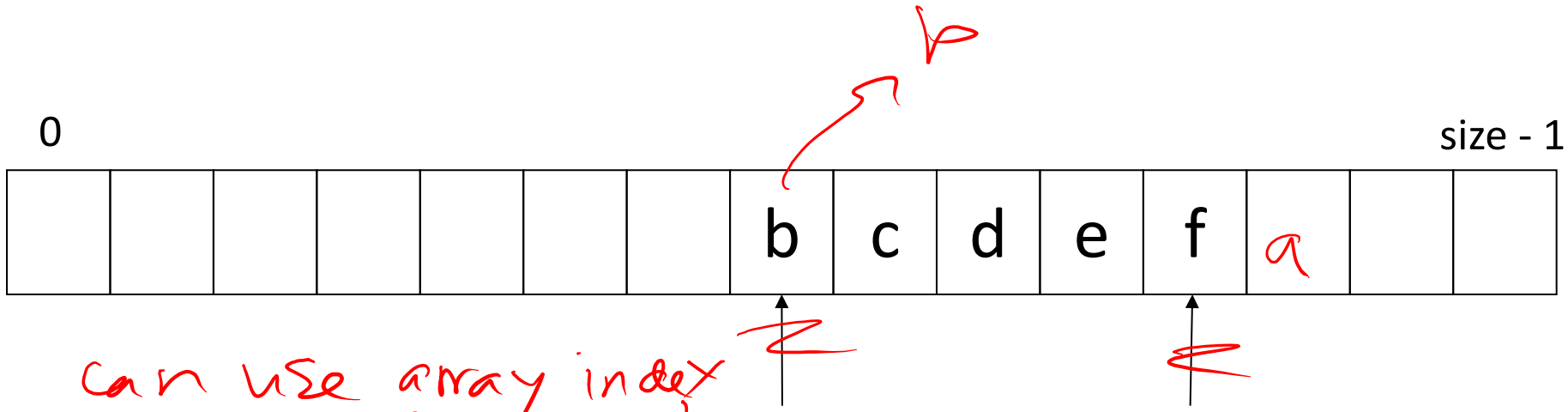


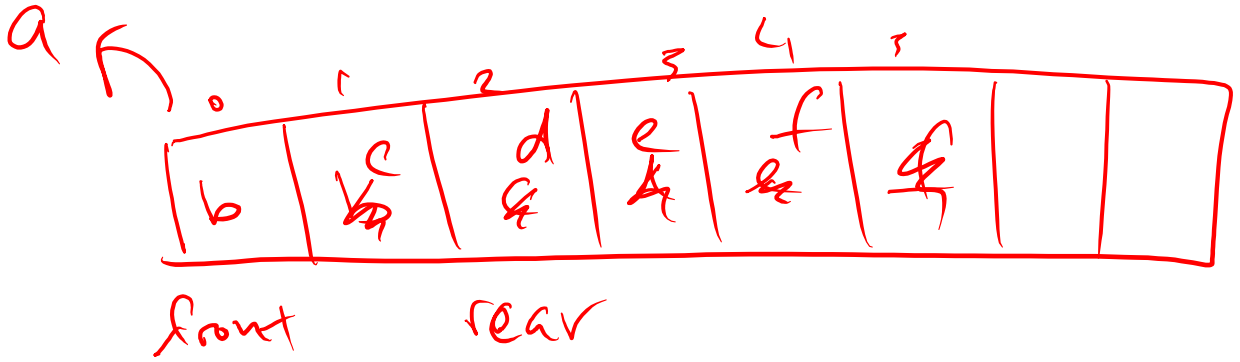

```
// Basic idea only!
enqueue(x) {
   rear.next = new Node(x);
   rear = rear.next;
}
```

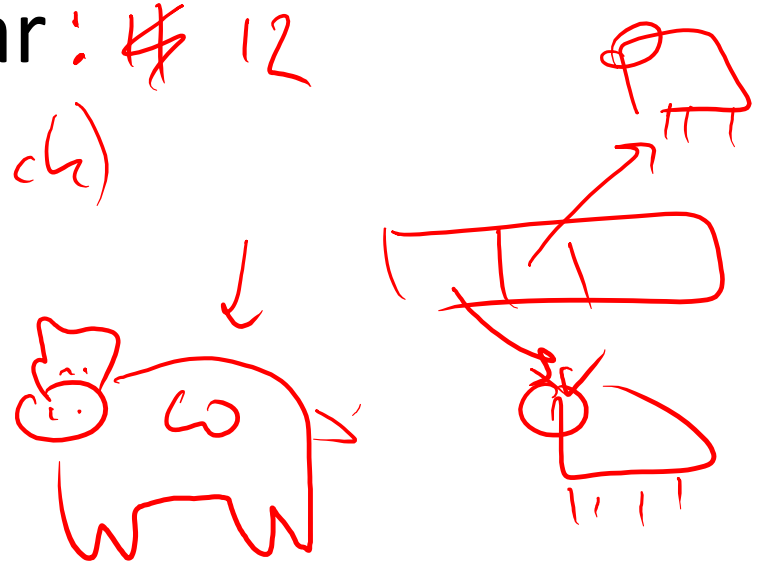
```
// Basic idea only!
dequeue() {
   x = front.item;
   front = front.next;
   return x;
}
```

- What if ***queue*** is empty?
  - Enqueue?
  - Dequeue?
- Can you find the k^{th} element in the queue?
- Can ***list*** be full?
- How to *test* for empty?
- What is the *complexity* of the operations?

Queue Data Structure: Array

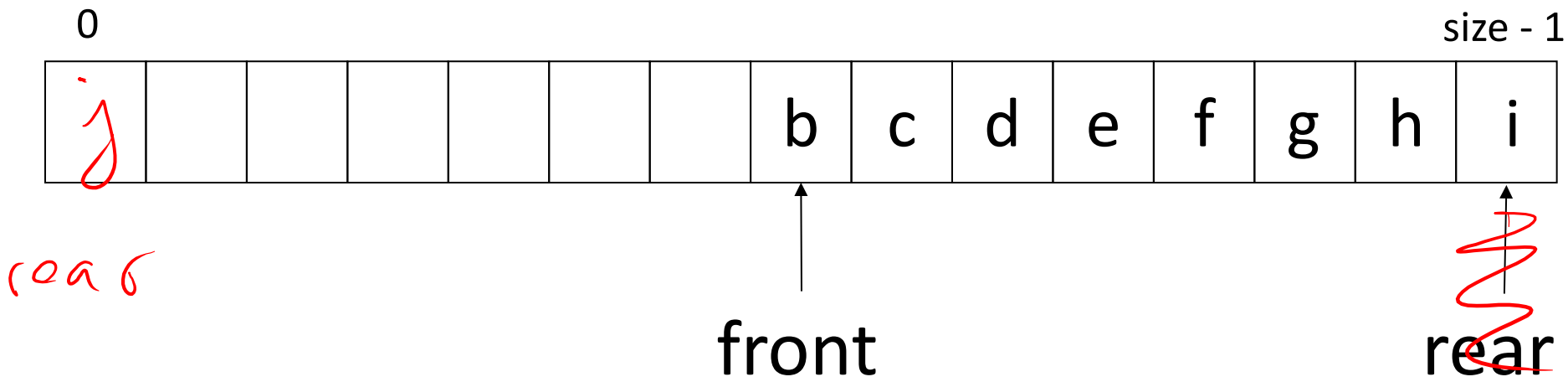






What happens when we dequeue several times, and *front* catches up to *rear*?

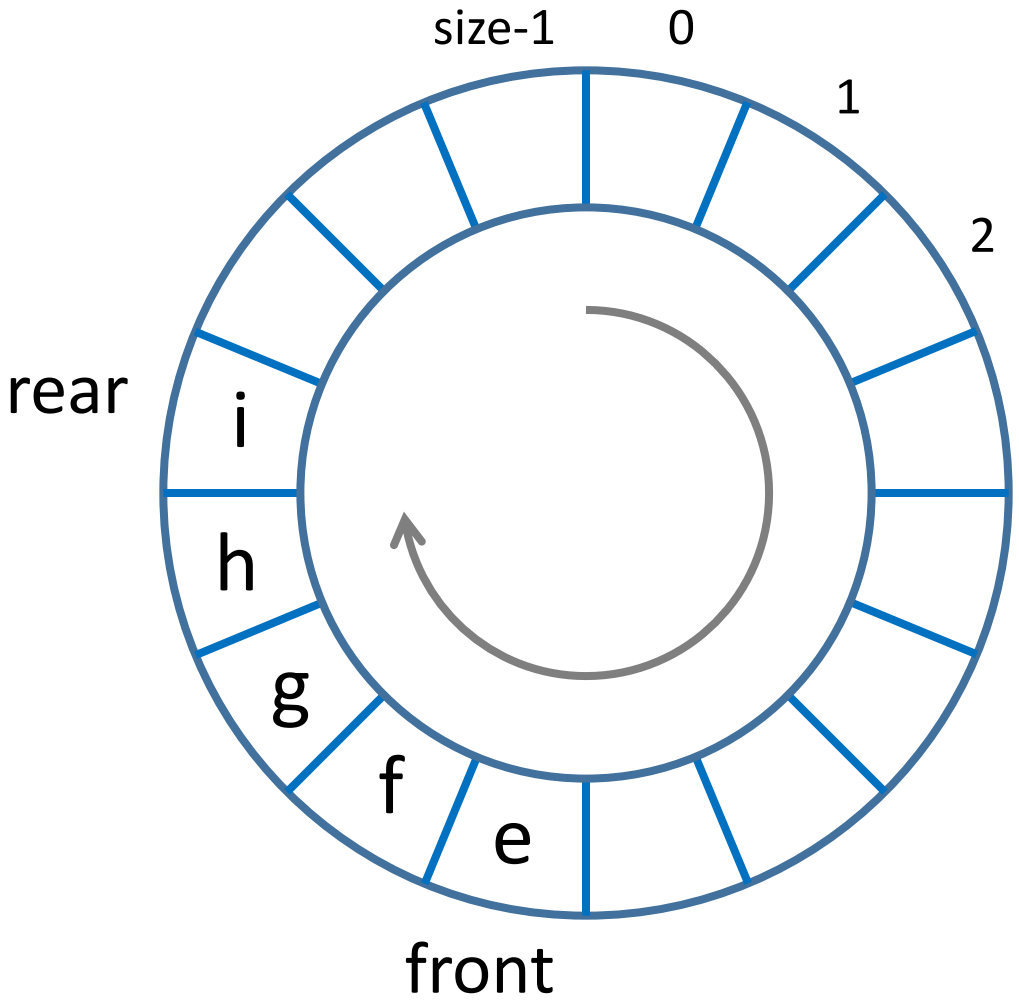
Queue Data Structure: Array



Hmmm…

How do we enqueue to the rear now?

Queue Data Structure: Circular Array!

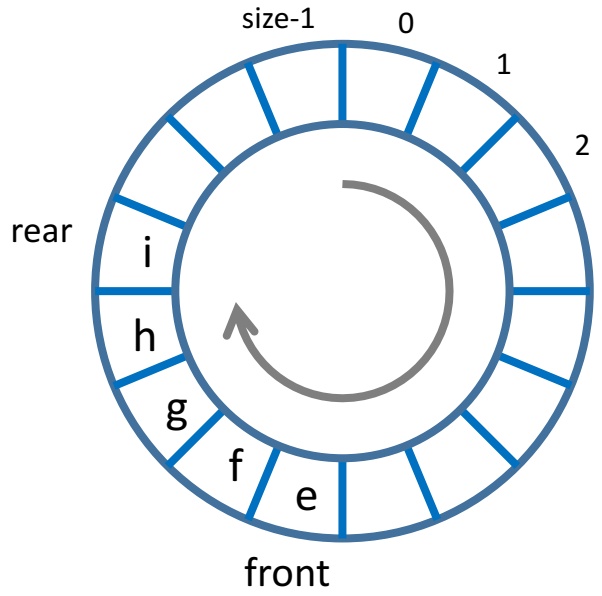


View the array as *circular* and allow both *front* and *rear* to advance through (around) the array

We wouldn't need to move elements for enqueues and dequeues!

If we can assume the queue is not empty, how can we implement dequeue()?

```
Public E dequeue() {
    size--;
    E e = array[front];
    <Your code here!>
    return e;
}
```



A)
```
front++;
if (front == array.length)
    front = 0;
```

B)
```
rear = rear-1;
if (rear < 0)
    rear = array.length-1;
```

C)
```
for (int i = 0; i < rear; i++) {
    array[i] = array[i+1]
}
front++;
if (front == array.length)
    front = 0;
```

D) None of these are correct