# Lecture 6: ArrayList Implementation

## CS 62

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# Programming Assignment

- Weak AI/Natural Language Processing:
- Generate text by building frequency lists based on pairs of words. `ArrayList` of `Association`s of `String` (words) and `Integer` (count of that word)
- Harder assignment, start early!

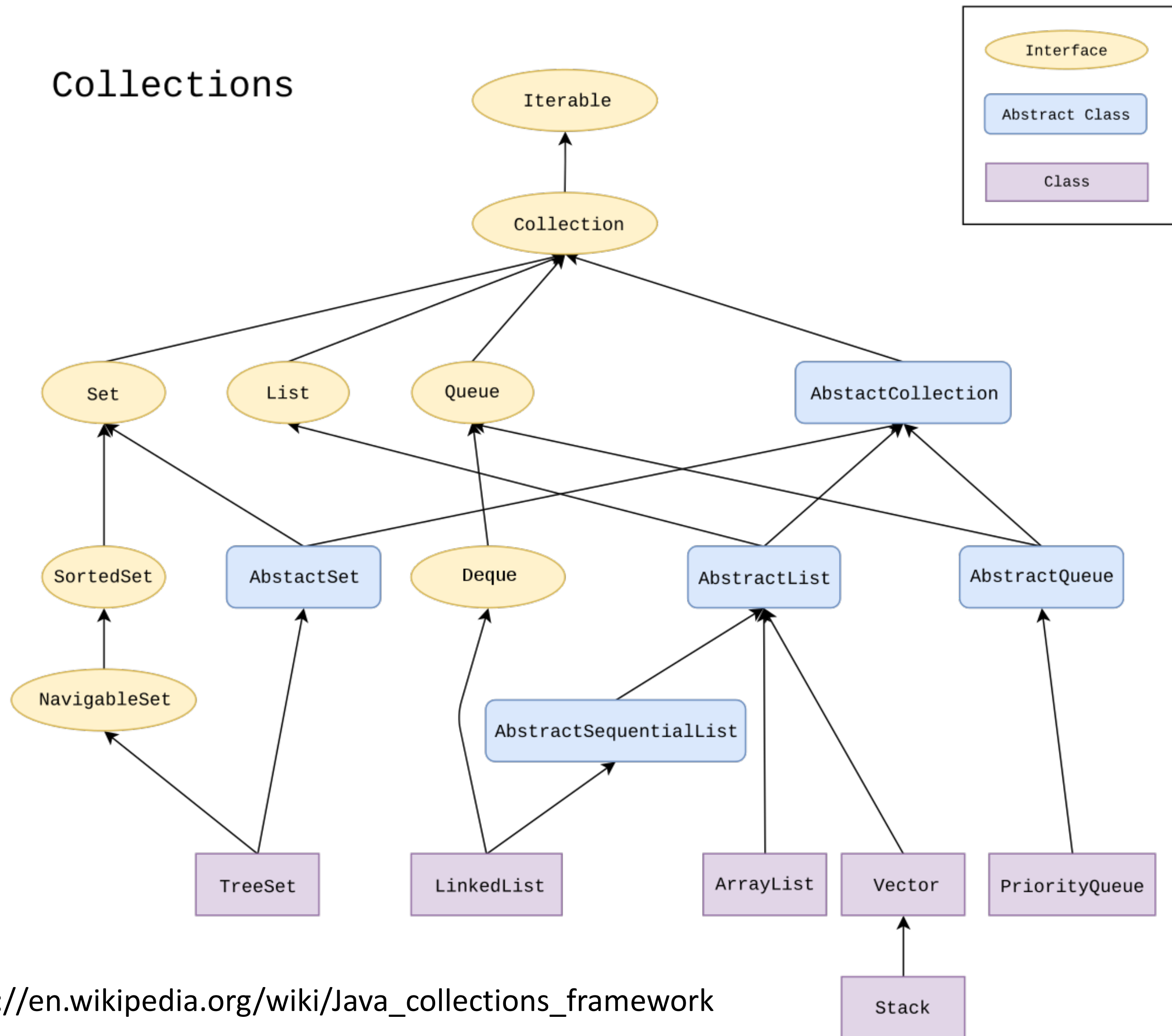
# The picture so far…

- When you wanted to store a collection of data you would use arrays
- The problem: fixed length (final instance variable length)
  - Once you have created them, they cannot grow or shrink
- Useful when we know in advance the number of elements to hold, but how often is this the case?
- Don’t play nicely with Generics

# Data Structures

- Collections of:
  - Data
  - Their relationships
  - The operations that can be applied to them
- In OOP a collection is an object of *elements*
- Some collections are ordered, some are not
- Some allow duplicate elements, some do not
- Typically collections provide operations that allow us to add, remove, search for an element, and ask for their size (# elements)

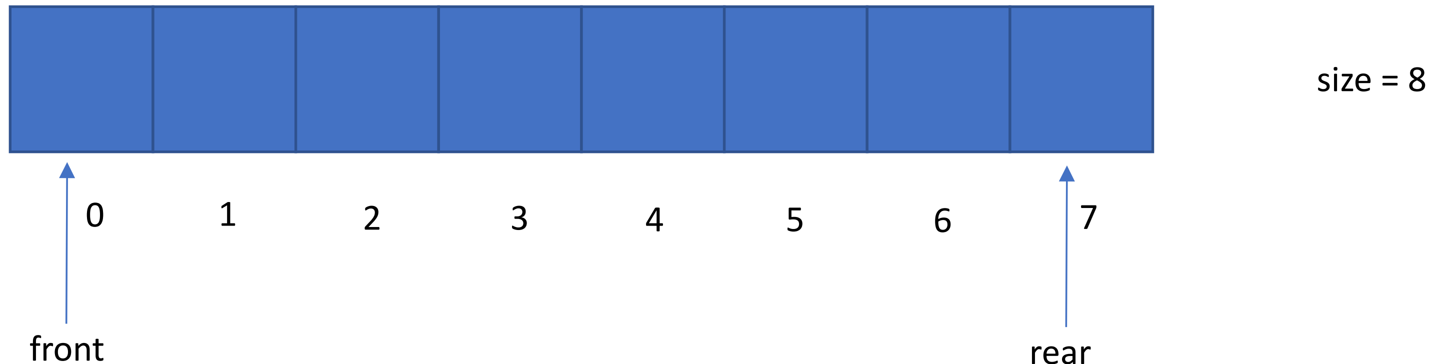
# Collections in Java




https://en.wikipedia.org/wiki/Java_collections_framework

# List ADT

- A collection storing elements in an ordered fashion
- Can access elements by a 0-based index
- It has a known size which is the number of elements it holds
- Elements can be added at the front, rear, or intermediately



# Array list

- Automatically resizable list
- By default, add a new element to end of list
- In Java, import `java.util.ArrayList;`
  - `public class ArrayList<E> extends AbstractList<E> implements List<E>`
- Remember wrapper classes

# ArrayList<E> major methods

- `ArrayList()`: constructs an empty list with initial capacity of 10.
- `ArrayList(int N)`: constructs an empty list with initial capacity of N.
- `boolean add(E e)`: appends element at end of list
- `boolean add(int index, E e)`: appends element at index
- `void clear()`: removes all elements from list
- `E get(int index)`: returns element at index
- `E remove(int index)`: removes & returns element at index
- `boolean remove(Object o)`: removes & returns first occurrence of element, if it exists
- `int size()`: returns number of elements

# `ArrayList<E>`

- Standard Java libraries have lots of extra methods not in our implementation
- Many involve working on other collections
  - irrelevant for us at this point:
  - `addAll`, `contains`, `containsAll`, `listIterator`, `removeAll`, `replaceAll`, `retainAll`, `sort`, `spliterator`, `sublist`, `toArray`

# `ArrayList<E>` and Generics

- When instantiating an array list, we need to specify the type of elements E that it will hold

- `ArrayList<Type> al = new ArrayList<Type>();`

# ArrayList<E> vs arrays

```
❖ String[] faculty = new String[2];
➢ ArrayList<String> faculty = new ArrayList<String>();
```

```
❖ faculty[0] = “Melanie Wu”;
➢ faculty.add(“Melanie Wu”);
```

```
❖ String name = faculty[0];
➢ String name = faculty.get(0);
```

```
❖ for(int i=0; i<faculty.length; i++)
      System.out.println(faculty[i]);
➢ for(int i=0; i<faculty.size(); i++)
      System.out.println(faculty.get(i));
➢ for(String name: faculty)
      System.out.println(name); //for-each loop
```

# Tamassia & Goodrich `ArrayIndexList<E>`

- Interface is `IndexList<E>`
- `ArrayIndexList<E>`
  - Similar to `ArrayList`
  - Instance variables:
    - `elts`: array instance variable
    - `eltsFilled`: number of slots filled.
- Creating new array list is weird
  - Can't construct array of variable type!
  - Create array of `Object`, but coerce to believe array of `E`

```java
public interface IndexList<E> {

    public int size();

    public boolean isEmpty();

    public void add(int i, E e) throws IndexOutOfBoundsException;

    public E get(int i) throws IndexOutOfBoundsException;

    public E remove(int i) throws IndexOutOfBoundsException;

    public E set(int i, E e) throws IndexOutOfBoundsException;
}
```

```
public class ArrayIndexList<E> implements IndexList<E> {

    private E[] elts; //array storing the elements
    private int capacity = 16; // initial length of array elts private int
    eltsFilled = 0; // number of elements stored

    @SuppressWarnings("unchecked")
    public ArrayIndexList() {
        elts = (E[]) new Object[capacity];
        // the compiler may warn, but this is ok
    }
    private void checkIndex(int r, int n) throws IndexOutOfBoundsException {
        if (r < 0 || r >= n) throw new
        IndexOutOfBoundsException("Illegal index: " + r);
    }

    //fill the rest

}
```

```java
/**
* @return the number of elements in the indexed list.
*/
public int size() {
        return eltsFilled;
}

/**
* @return whether the indexed list is empty.
*/
public boolean isEmpty() {
        return size() == 0;
}

/**
* @return the element stored at the given index.
*/
public E get(int r) throws IndexOutOfBoundsException {
        checkIndex(r, size());
        return elts[r];
}
```

```java
/**
* @param r the index to be updated
* @param newElt the element to go in slot r
* @return the element originally in slot r
* post: The element stored now at index r is now newElt
*/
public E set(int r, E newElt) {
        checkIndex(r, size());
        E temp = elts[r];
        elts[r] = newElt;
        return temp;
}
```

```java
/**
* post: If elts is full, then copy elements of elts to new array with twice the
* capacity. There is now at least one empty slot in the array representation
*/
@SuppressWarnings(“unchecked”)
private void ensureCapacity() {
        if(eltsFilled == capacity){
                capacity *= 2;
                E[] newElts = (E[]) new Object[capacity];
                for (int i=0; i<EltsFilled; i++){
                        newElts[i]=elts[i];
                }
                elts = newElts;
        }
}
```

```java
/**
* @param r the index to be updated
* @param newElt the element to go in slot r
* @return the element originally in slot r
* post: The element stored now at index r is now newElt
*/
public void add(int r, E newElt) {
        checkIndex(r, size()+1);
        ensureCapacity();
        for(int i= eltsFilled-1; i>=r; i--)
                elts[i+1] = elts[i] //shift elements to the right
        elts[r]=elt;
        eltsFilled++;
}
/**
* @param elt element to be added to the rear of indexed list.
* post: The element stored now at rear is newElt
*/
public void add(E elt) {
        add(size(),elt);
}
```

```java
/**
* @param r the index of the element to be removed
* @return the element at index r
* post: Removes the element at index r, shifts all elements on its right one to left
*/
public E remove(int r) {
        checkIndex(r, size());
        E temp = elts[r];
        for(int i= r; i< eltsFilled - 1; i++)
                elts[i] = elts[i+1] //shift elements to the right one to the left
        eltsFilled--;
        return temp;
}
```