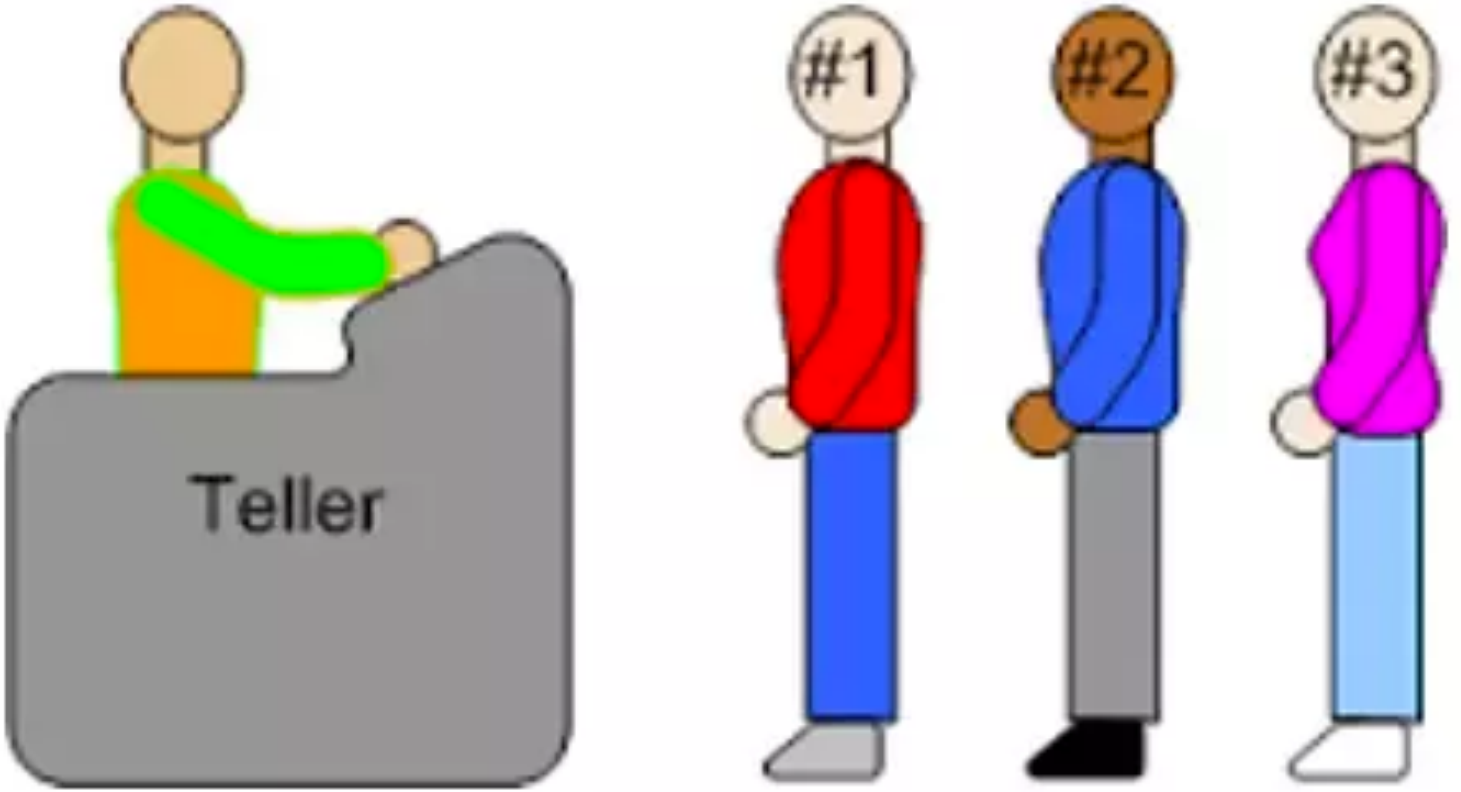
CS206

Queues

Queues

- Insertions and deletions are First In First Out – FIFO
  - Insert at the back
  - Delete from the front

Queues



Queueing Theory

Agner Krarup Erlang

`Queue` Interface

- `null` is returned from `peek()` and `poll()` when queue is empty
- return false from offer when cannot add to queue.

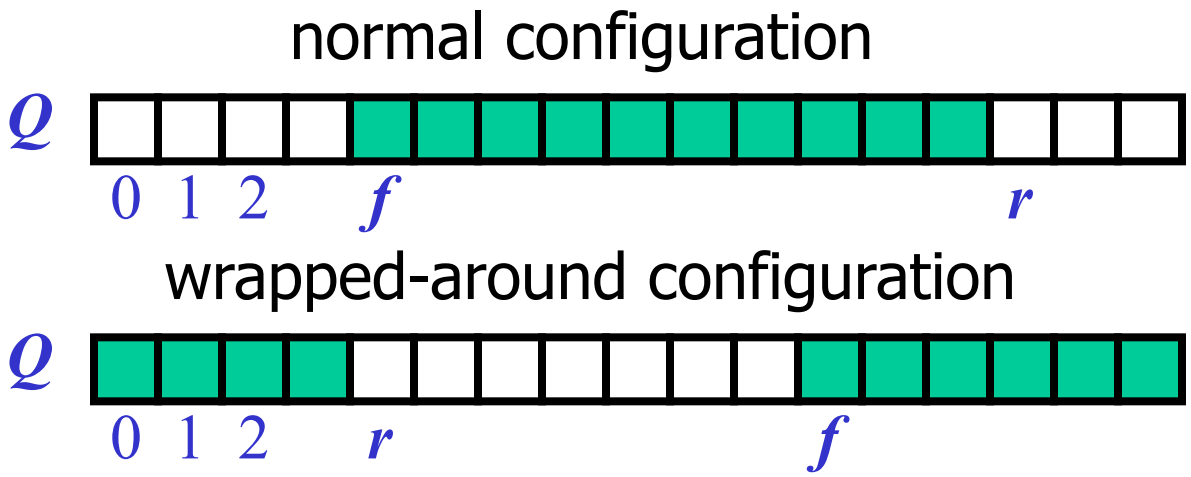
```
public interface QueueIntf<Q> {
    boolean isEmpty();
    int size();
    boolean add(Q q)
        throws IllegalStateException;
    Q remove()
        throws NoSuchElementException;
    Q element()
        throws NoSuchElementException;
    boolean offer(Q q);
    Q poll();
    Q peek();
}
```

Example

Operation	output	Queue Contents
offer(5)	TRUE	{5}
offer(3)	TRUE	{5, 3}
poll()	5	{3}
offer(7)	TRUE	{3, 7}
poll()	3	{7}
peek()	7	{7}
poll()	7	{}
poll()	null	{}

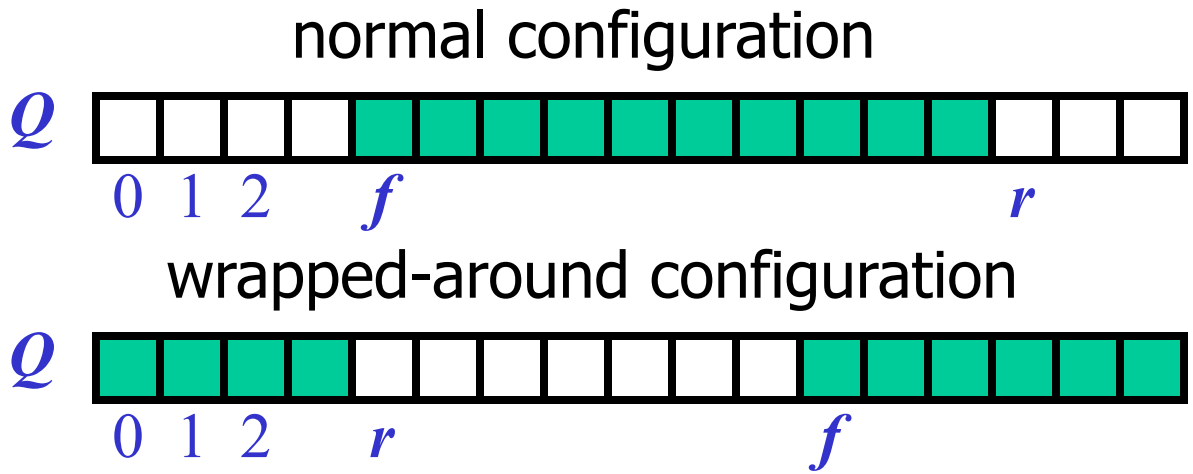
Array-based Queue

- An array of size `n` in a circular fashion
  - `frontLoc`: index of the front element
    - where objects are read
  - `count`: number of stored elements
  - `rearLoc`: index of rear element
    - where objects are added



Circular Array and Queue

- When the queue has fewer than `n` elements, location
  - `rearLoc =(frontLoc+count)%n`



Start of Queue Implementation

```
public class ArrayQueue<Q> implements QueueIntf<Q> {
    /** the default capacity for the backing array */
    private static final int CAPACITY = 40;
    /** The array in which the queue data is stored */
    private Q[] backingArray;
    /** the number of items in the queue*/
    private int count;
    private int frontLoc; /** The array location of the end of the queue */
    private int rearLoc; /** The array location of the head of the queue */
    /** Create an array backed queue with the default capacity. */
    public ArrayQueue() {
        this(CAPACITY);
    }
    /**
     * Create an array backed queue with the given capacity
     * @param qSize the capacity for the queue */
    public ArrayQueue(int qSize) {
        count = 0;
        frontLoc = 0;
        backingArray = (Q[]) new Object[qSize];
    }
```

write add, remove

Performance and Limitations for array-based Queue

- Performance
  - let n be the number of objects in the queue
  - The space used is $O(n)$
  - Each operation runs in time $O(1)$
- Limitations
  - Max size is limited and can not be changed
  - Adding to a full queue returns false (offer method)

The Comparable Interface

```
public interface Comparable<T>
  72: {
  73:   /**
  74:    * Compares this object with another, and returns a numerical result based
  75:    * on the comparison.  If the result is negative, this object sorts less
  76:    * than the other; if 0, the two are equal, and if positive, this object
  77:    * sorts greater than the other.  To translate this into boolean, simply
  78:    * perform <code>o1.compareTo(o2) <em>&lt;op&gt;</em> 0</code>, where op
  79:    * is one of &lt;, &lt;=, =, !=, &gt;, or &gt;=.
  80:    *
  81:    * (deleted more)    *
  92:    * @param o the object to be compared
  93:    * @return an integer describing the comparison
  94:    * @throws NullPointerException if o is null
  95:    * @throws ClassCastException if o cannot be compared
  96:    */
  97:   int compareTo(T o);
  98: }
```

Short story: return 0 if equal, negative if less, positive if greater

Comparable example
Integer and String

```
public class ComparableEx {
    public static void main(String[] args) {
        Integer i5 = new Integer(50);
        Integer i3 = new Integer(30);
        Integer j5 = new Integer(50);
        System.out.println("i5:" + i5 + "  i3:" + i3 + "  j5:" + j5);
        System.out.println("i3.compareTo(i5) " + i3.compareTo(i5));
        System.out.println("i5.compareTo(i3) " + i5.compareTo(i3));
        System.out.println("i5.compareTo(j5) " + i5.compareTo(j5));
        System.out.println("i5.equals(j5) " + i5.equals(j5));
        System.out.println("(i5 == j5) " + (i5 == j5));

        String abc = "abc";
        String def = "def";
        String abc1 = new String("abc");
        System.out.println("abc:" + abc + "  def:" + def + "  abd0:" + abc1);
        System.out.println("abc.compareTo(def) " + abc.compareTo(def));
        System.out.println("def.compareTo(abc) " + def.compareTo(abc));
        System.out.println("abc.compareTo(abc0) " + abc.compareTo(abc1));
        System.out.println("abc.equals(abc0) " + abc.equals(abc1));
        System.out.println("abc == abc0 " + (abc == abc1));
    }
}
```

Comparable Rabbit

```
public class Rabbit implements Comparable<Rabbit> {
    enum BreedEnum {  DwarfDutch, Angora, FrenchLop }
    private final BreedEnum breed;
    private final int iD;
    private final String nickname;
    public Rabbit(BreedEnum breed, int id, String nn) {
        this.breed = breed;
        this.iD = id;
        this.nickname = nn==null ? makeName() : nn;
    }
…

    public int compareTo(Rabbit o) {
        return iD - o.getId();
    }
```

Comparable in SortedArray

- SortedArray implicitly used comparable as String implements it.
- So, make it explicit

```
public class SAL<E extends Comparable<E>> {
    enum Ordering { ASCENDING, DESCENDING }
    ArrayList<Comparable<E>> sortedAL;
    public void add(Comparable<E> stringToAdd)
    {   int loc = findPlace(stringToAdd);
        insertAtLoc(stringToAdd, loc);
    }
    private int findPlace(Comparable<E> toAdd)
   {    int place=0;
        while (place<sortedAL.size()) {
            if
(toAdd.compareTo((E)sortedAL.get(place))<0) {
                break;
            }
            place++;
        } return place; }
```

A little more in SAL

```
private int findPlace(Comparable<E> toAdd) {
        int place=0;
        while (place<sortedAL.size()) {
            switch (theOrder) {
                case ASCENDING:
                    if (toAdd.compareTo(sortedAL.get(place))<0) {
                        break; }
                    break;
                case DESCENDING:
                default:
                    if (toAdd.compareTo(sortedAL.get(place))>0) {
                        break; }
                    break;
            } place++;
        } return place; }
```

Putting this together

```
public class CompRabbits {
    public static void main(String[] args) {
        SAL<Rabbit> rsal = new SAL<>();
        rsal.add(new Rabbit(Rabbit.BreedEnum.Angora, 45, "Flopsy"));
        rsal.add(new Rabbit(Rabbit.BreedEnum.DwarfDutch, 46, "Mopsy"));
        rsal.add(new Rabbit(Rabbit.BreedEnum.FrenchLop, 47, "Cottontail"))
        rsal.add(new Rabbit(Rabbit.BreedEnum.Angora, 44, "Peter"));
        rsal.add(new Rabbit(Rabbit.BreedEnum.DwarfDutch, 10, "Josephine"))
        rsal.add(new Rabbit(Rabbit.BreedEnum.FrenchLop, 17, "Benjamin"));
        System.out.println(rsal);
    }
}
```

Queue Offer Method