CS200: Queues

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Queues

- First In First Out (FIFO) structure
- Imagine a checkout line
- So removing and adding are done from opposite ends of structure.

  - add to tail (back), remove from head (front)
- Used in operating systems (e.g. print queue).

Operations

- **Create** an empty queue
- Determine whether a queue is **empty**
- **Add** a new item to the queue
- **Remove** item from the queue (that was added the *earliest*)
- **Remove all** items from the queue
- **Retrieve** item from queue that was added earliest

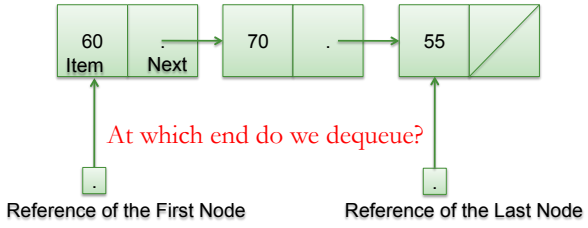
Queue Operations

- **`enqueue`**`(in newItem: QueueItemType)`
  - Add new item at the back of a queue
- **`dequeue`**`();QueueItemType`
  - Retrieves and removes the item at the *front* of a queue
- **`peek`**`(): queueItemType {query}`
  - Retrieve item from the *front* of the queue. Retrieve the item that was added earliest.
- **`isEmpty`**`():boolean{query}`
- **`createQueue`**`()`
- **`dequeueAll`**`()`

Reference-Based Implementation 1

A linked list with two external references

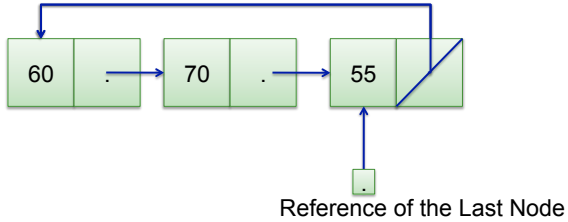
- A reference to the front
- A reference to the back



Reference-Based Implementation 2

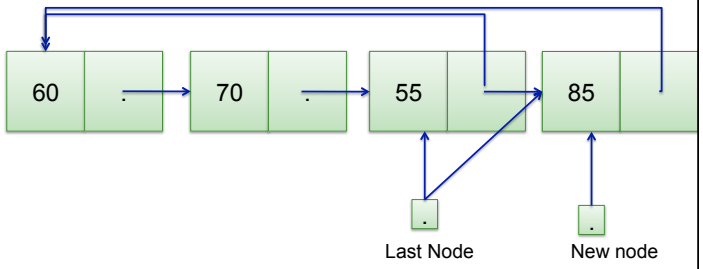
A circular linked list with one external reference

- lastNode references the back of the queue
- lastNode.getNext() references the front



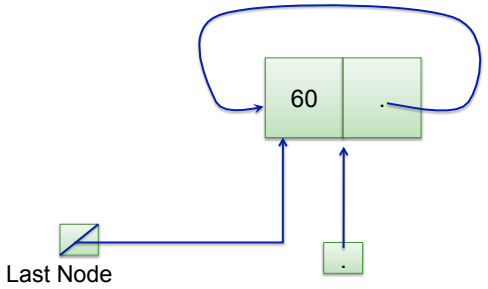
Inserting an item into a nonempty queue

1. newNode.next = lastNode.next;
2. lastNode.next = newNode;
3. lastNode = newNode;



Inserting a New Item

- Insert a ***new item*** into the **empty queue**



Insert new item into the queue

```
public void enqueue (Object newItem){
    Node newNode = new Node(newItem);

    if (isEmpty()){
      newNode.next = newNode;
    } else {
      newNode.next = lastNode.next;
      lastNode.next = newNode;
    }

    lastNode = newNode;
}
```

A. Empty queue

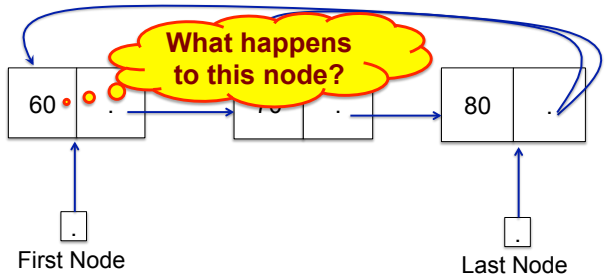
B. More than 1 item

Removing an item from queue

```
public Object dequeue() throws QueueException{
    if (!isEmpty()){
        Node firstNode = lastNode.next;
        if (firstNode == lastNode) {
            lastNode = null;
        }
        else{
            lastNode.next = firstNode.next;
        }
        return firstNode.item;
    }
    else { exception handling..
    }
}
```

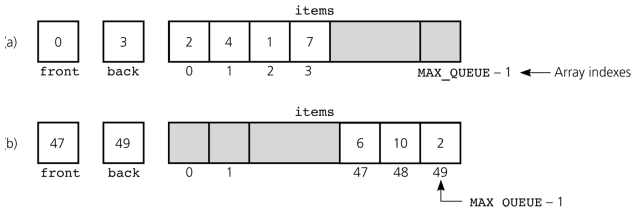
Why?

Removing an Item




```
Node firstNode = lastNode.next;
if (firstNode == lastnode) {
          lastNode = null;}
   else{lastNode.next = firstNode.next;}
return firstNode.item;
```

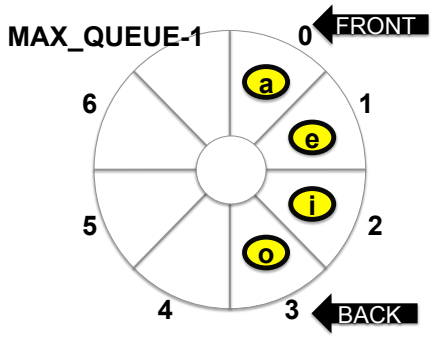

Naïve Array-Based Implementation



Drift can cause the queue to appear full

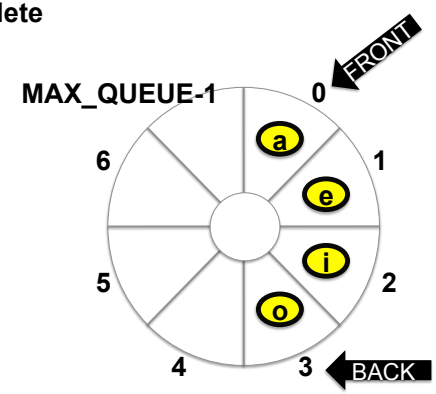
How do we initialize front and back?
(Hint: what does a queue with a single element look like?)

Solving Drift:
Circular implementation of a queue



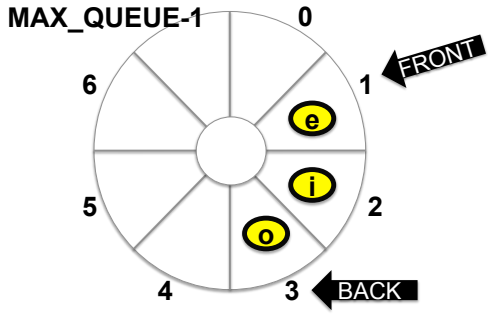
Solving Drift:

- **Delete**



Solving Drift:

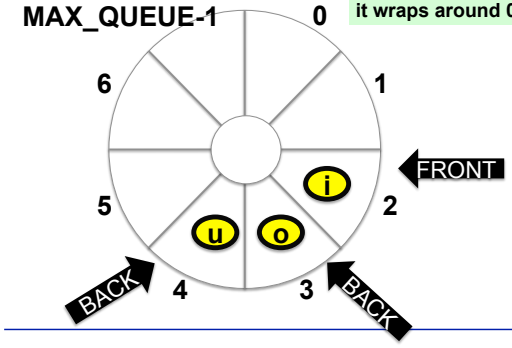
- **Delete**



Solving Drift

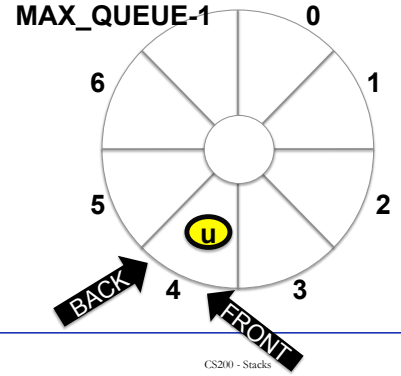
- **Insert u**

When either front or back advances past MAX_QUEUE-1, it wraps around 0



Queue with Single Item

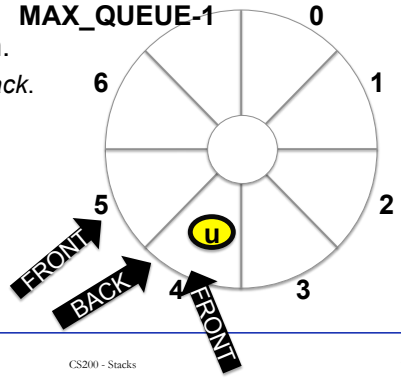
- *back* and *front* are pointing at the same slot.



Queue with Single Item

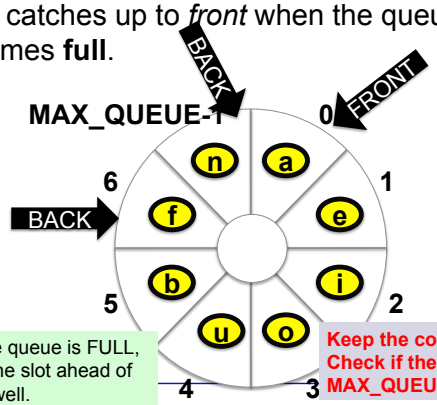
Remove last item.

- *front* passed *back*.



Insert the last item

back catches up to *front* when the queue becomes **full**.



When the queue is FULL, *front* is one slot ahead of *back* as well.

Keep the count of items and Check if the count is equal to MAX_QUEUE

Wrapping the values for front and back

- Initializing

```
front = 0
back = MAX_QUEUE-1
count = 0
```

- Adding

```
back = (back+1) % MAX_QUEUE;
items[back] = newItem;
++count;
```

- Deleting

```
deleteItem = items[front];
front = (front +1) % MAX_QUEUE;
--count;
```

enqueue with Array

```
public void enqueue(Object newItem) throws
  QueueException{

   if (!isFull()){
      back = (back+1) % (MAX_QUEUE);
      items[back] = newItem;
      ++count;

   }else {
      throw QueueException(your_message);
   }
}
```

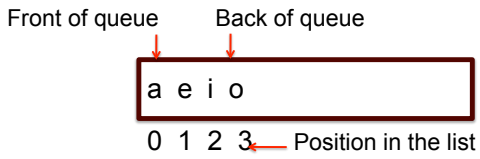

dequeue()

```
public Object dequeue() throws QueueException{

   if (!isEmpty()){
      Object queueFront = items[front];
      front = (front+1) % (MAX_QUEUE);
      --count;
      return queueFront;
   }else{
     throw new QueueException (your_message);
   }
}
```


Implementation with List

- You can implement operation **`dequeue()`** as the list operation **`remove(0)`**.
- **`peek()`** as **`get(0)`**
- **`enqueue()`** as **`add (size()-1, newItem)`**



Queue implementations

- What are the advantages/disadvantages of the circular array / linked list implementations?