CS311 Data Structures
Lecture 03 — Stack, Queue

Jyh-Ming Lien

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Stack
- Introduction
- Implementation
- Applications

Queue
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- Implementation
- Applications

Stack

Queue

Iterators (Review)

Logistics

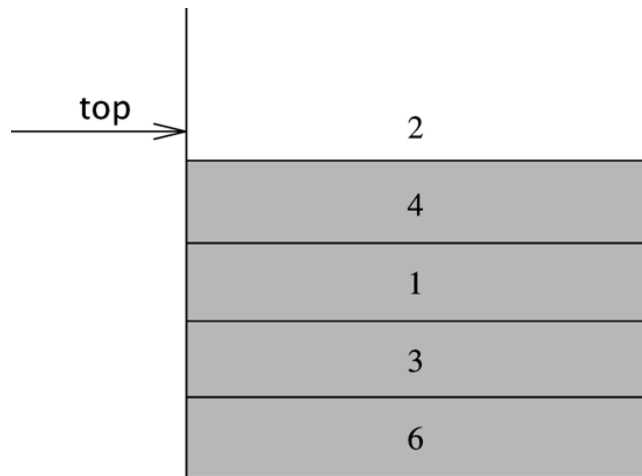
At Home

- Weiss Ch 15 on ArrayLists
- Weiss Ch 16 Stacks/Queues
- Weiss Ch 17 Linked Lists
- Your PA01 due June 18.

Goals Today

- Implementation of Stacks and Queues
- Work on some example code
- Review iterator

What is a stack?



- Last In, First Out (LIFO)
- In $java$, it extends class Vector
- Operations
  - pop
  - push
  - peek
  - empty

Implementation

- Using Array List
  - pop
  - push
  - peek
  - empty
- Using Linked list
  - pop
  - push
  - peek
  - empty

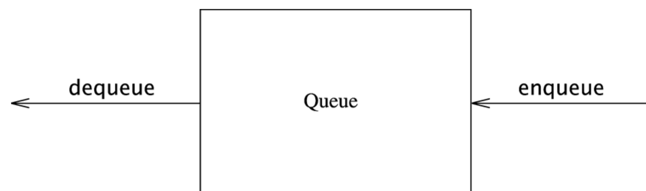
Applications

- Check balancing
  - $\{\ (\ <\ >\ [\ \{\ <\ >\ \}\ ]\ )\ \{\ \}\ \}$ vs. $\{\ (\ <\ [\ \{\ <\ >\ >\ \}\ ]\ )\ \{\ \}\ \}$
- Postfix calculation
  - $6523 + 8 * +3 + * = 288$
- Infix to Postfix Conversion
  - $a + b * c + (d * e + f) * g \rightarrow abc * +de * f + g * +$

- Call stack
  - fib(4)=

- Tree traversal — preorder traversal
- Graph search — depth first search
- ...

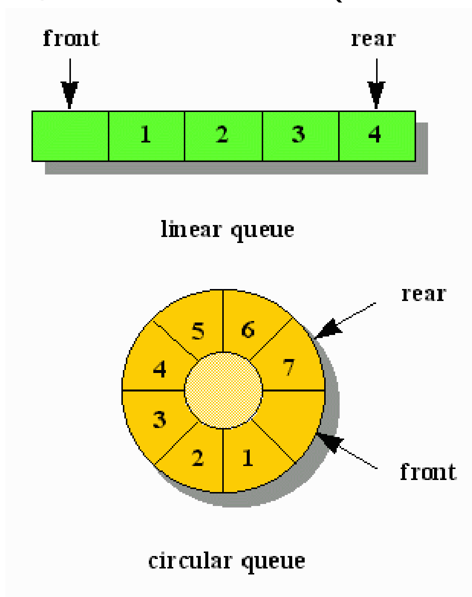
What is a queue?



- First In, First Out (FIFO)
- In *java*, it is an interface. LinkedList implements this interface.
- Operations
  - enqueue
  - dequeue
  - peek
  - empty

Implementation

- Queue can be implemented easily by linked list
- Using Array List (circular array)

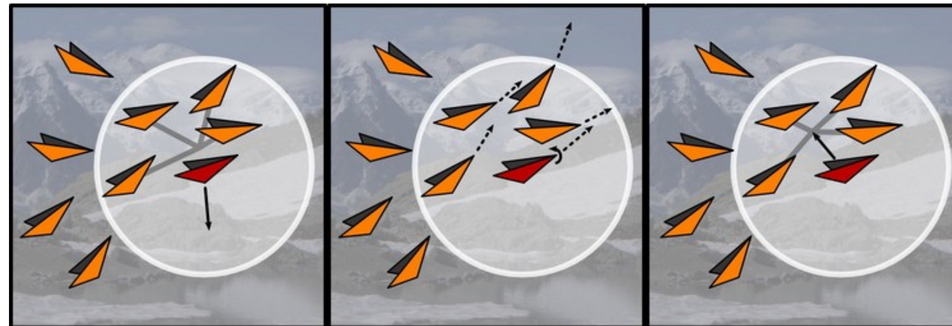


(image from http://www.javaworld.com/)

- enqueue
- dequeue
- peek
- empty

Flocking system

- a coordinated group (e.g., school of fish, flock of bird, crowd)
- simulation is based on very simple *local* rules
  - separation
  - coherence
  - alignment



(http://cmol.nbi.dk/models/boids)

- Question: how do you get a list of neighboring agents efficiently?
  - a brute force method will take $O(n)$ time for each of the n agents
- Answer: Using a regular grid and a queue.

Stack: Array Based Implementation

```
class AStack<T>{
  private T [ ] stuff;
  int initial_array_size=5;
  int top=0;

  public AStack(){}
  public void push(T x){}
  public void pop(){}
  public T getTop(){}
  public boolean isEmpty(){}
}
```

Work It

- Stacks: more or less functionality than `ArrayList`?
- Worst and Amortized Complexity of stack operations?
- Can you make the stack "iterable", i.e., derive from `Iterable<T>`?

Queue: Create a LinkedQueue with Nodes

```
class LinkedQueue<T>{
  Node<T> front, back;
  public LinkedQueue();
  // x enters a back
  public void enqueue(T x);
  // front leaves
  public void dequeue();
  // return who's in front
  public T getFront();
  // true when empty
  public boolean isEmpty();
}
```

```
class Node<X>{
  public X data;
  public Node<X> next;
  public Node(X data, Node<X> next)
  {
    this.data=data;
    this.next=next;
  }
}
```

Consider

- Worst case $O(1)$ for all ops
- Can you make the queue "iterable", i.e., derive from `Iterable<T>`?

Queue: Create a ArrayQueue

```
class ArrayQueue<T>{
  T [ ] stuff;
  int front=0, back=0;
  int initial_array_size=5;
  public ArrayQueue();
  // x enters a back
  public void enqueue(T x);
  // front leaves
  public void dequeue();
  // return who's in front
  public T getFront();
  // true when empty
  public boolean isEmpty();
}
```

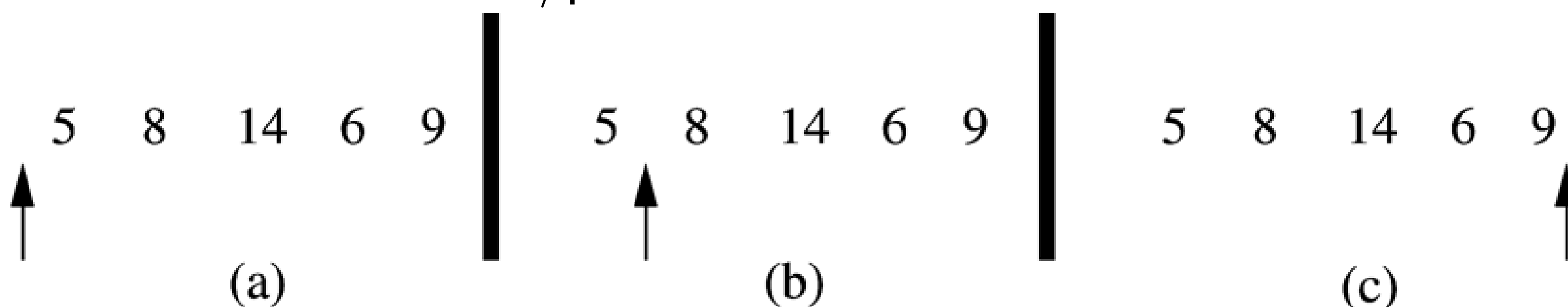
```
class Node<X>{
  public X data;
  public Node<X> next;
  public Node(X data, Node<X> next)
  {
    this.data=data;
    this.next=next;
  }
}
```

Consider

- Worst case time complexity for all ops?
- Can you make the queue "iterable", i.e., derive from `Iterable<T>`?

Iterators (Review)

- Iterators are pointers to the object in the list
- Java Collection creates/provides an iterator



- operators
  - Use `next()/previous()` to move
  - `next()/previous()` returns element "moved over"
  - `remove()` removes element that was returned from last `next()/previous()`
  - Illegal to remove w/o first calling `next()/previous()`
  - `add(x)` before whatever `next()` would return
  - set(E o)

What would you do?

```
// l = [A, B, C, D];
it1 = l.iterator().next().next();
it2 = l.iterator().next();
// l = [ A B C D ]
//          1
//        2
it1.remove();
it2.next(); // ??
```

Where should `it2` be now?

- Determine viable possibilities
- Explore what Java actually does

ConcurrentModificationException

Java's premise: Danger!

```
it1 = l.iterator();
it2 = l.iterator();
it1.remove();
it2.next(); // Error
```

Doesn't try to coordinate multiple iterators changing a collection

- Multiple iterators easy for reading/viewing
- Very difficult to coordinate modifications
- A generally recurring pattern in CS: *multiple simultaneous actors are a pain in the @$$*
- Detect multiple concurrent modifications using `modCount` field, see Weiss