CS 225

Data Structures

February 11 – Iterators

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CS 225 So Far…

List ADT

- Linked Memory Implementation (“Linked List”)
  - O(1) insert/remove at front/back
  - O(1) insert/remove after a given element
  - O(n) lookup by index
- Array Implementation (“Array List”)
  - O(1) insert/remove at front/back
  - O(n) insert/remove at any other location
  - O(1) lookup by index

CS 225 So Far…

Queue ADT

- [Order]:

- [Implementation]:

- [Runtime]:

CS 225 So Far…

Stack ADT

- [Order]:

- [Implementation]:

- [Runtime]:

Queue.h

```
 1  #pragma once
 2
 3  template <typename T>
 4  class Queue {
 5    public:
 6      void enqueue(T e);
 7      T dequeue();
 8      bool isEmpty();
 9
10    private:
11      T *items_;
12      unsigned capacity_;
13      unsigned count_;
14  };
15
16
17
18
19
20
21
22
```

What type of implementation is this Queue?

How is the data stored on this Queue?

Queue.h

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16
17
18
19
20
21
22
```

What type of implementation is this Queue?

How is the data stored on this Queue?

```
Queue<int> q;
q.enqueue(3);
q.enqueue(8);
q.enqueue(4);
q.dequeue();
q.enqueue(7);
q.dequeue();
q.dequeue();
q.enqueue(2);
q.enqueue(1);
q.enqueue(3);
q.enqueue(5);
q.dequeue();
q.enqueue(9);
```

Queue.h

```
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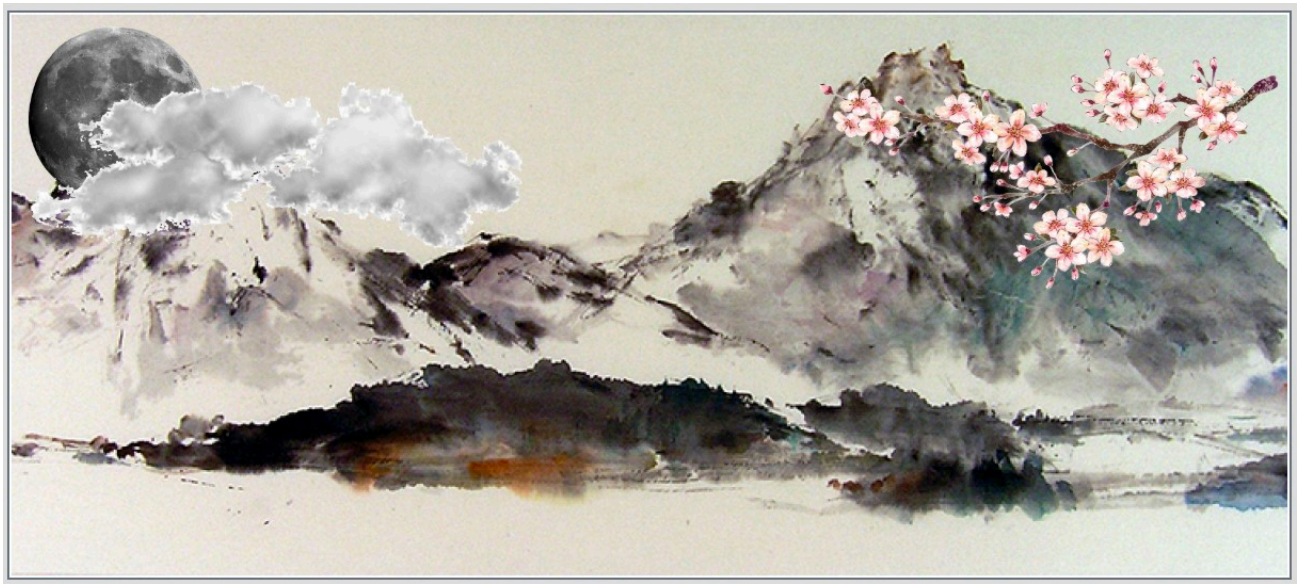
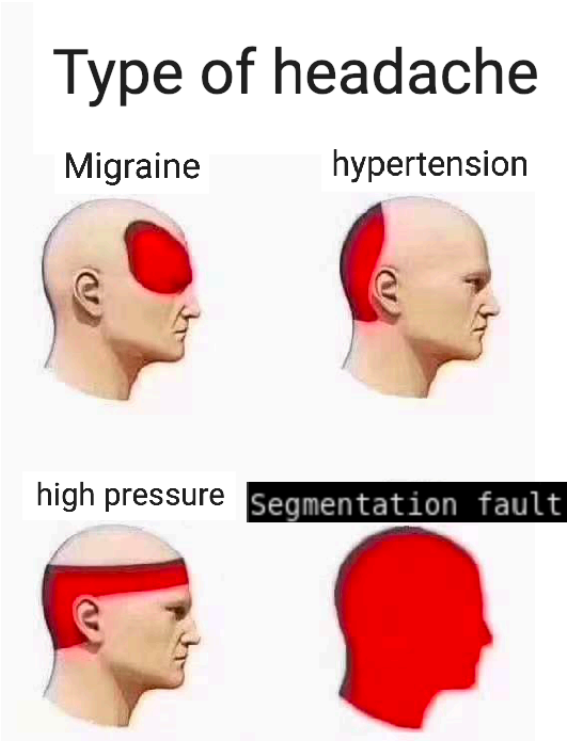
3  template <typename T>
4  class Queue {
5    public:
6      void enqueue(T e);
7      T dequeue();
8      bool isEmpty();
9
10   private:
11     T *items_;
12     unsigned capacity_;
13     unsigned count_;
14 };
15
16
17
18
19
20
21
22
```

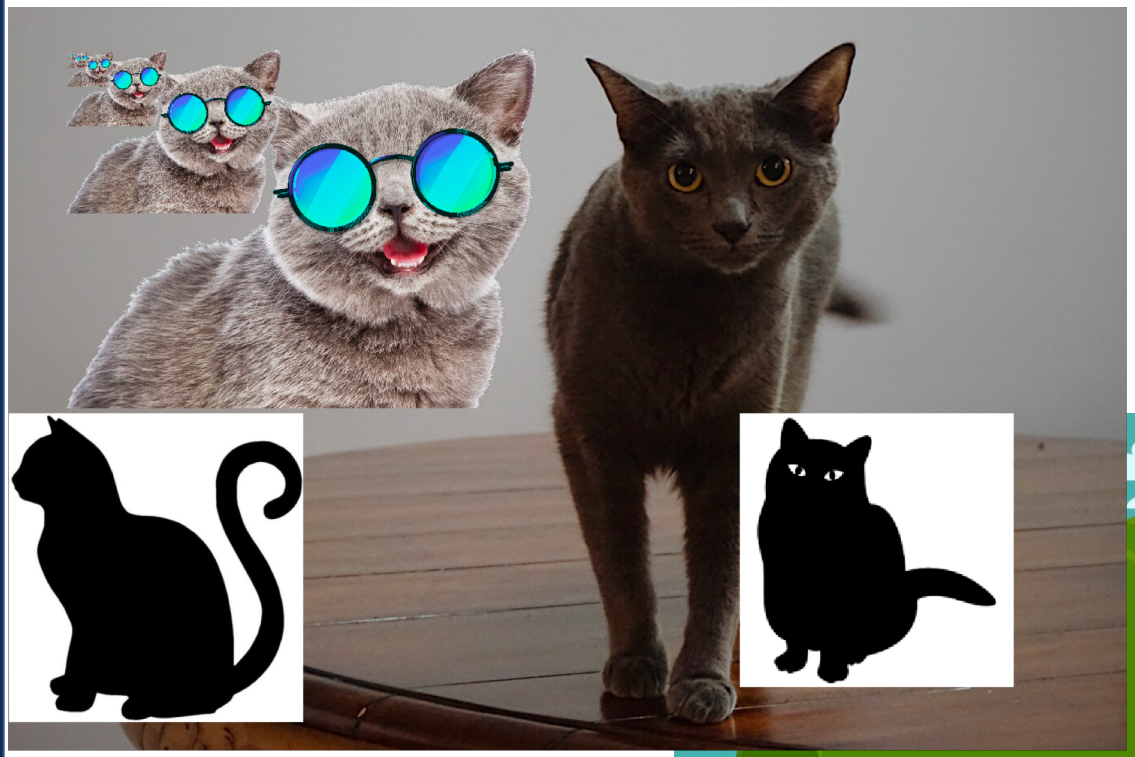

```
Queue<char> q;
q.enqueue(m);
q.enqueue(o);
q.enqueue(n);
…
q.enqueue(d);
q.enqueue(a);
q.enqueue(y);
q.enqueue(i);
q.enqueue(s);
q.dequeue();
q.enqueue(h);
q.enqueue(a);
```

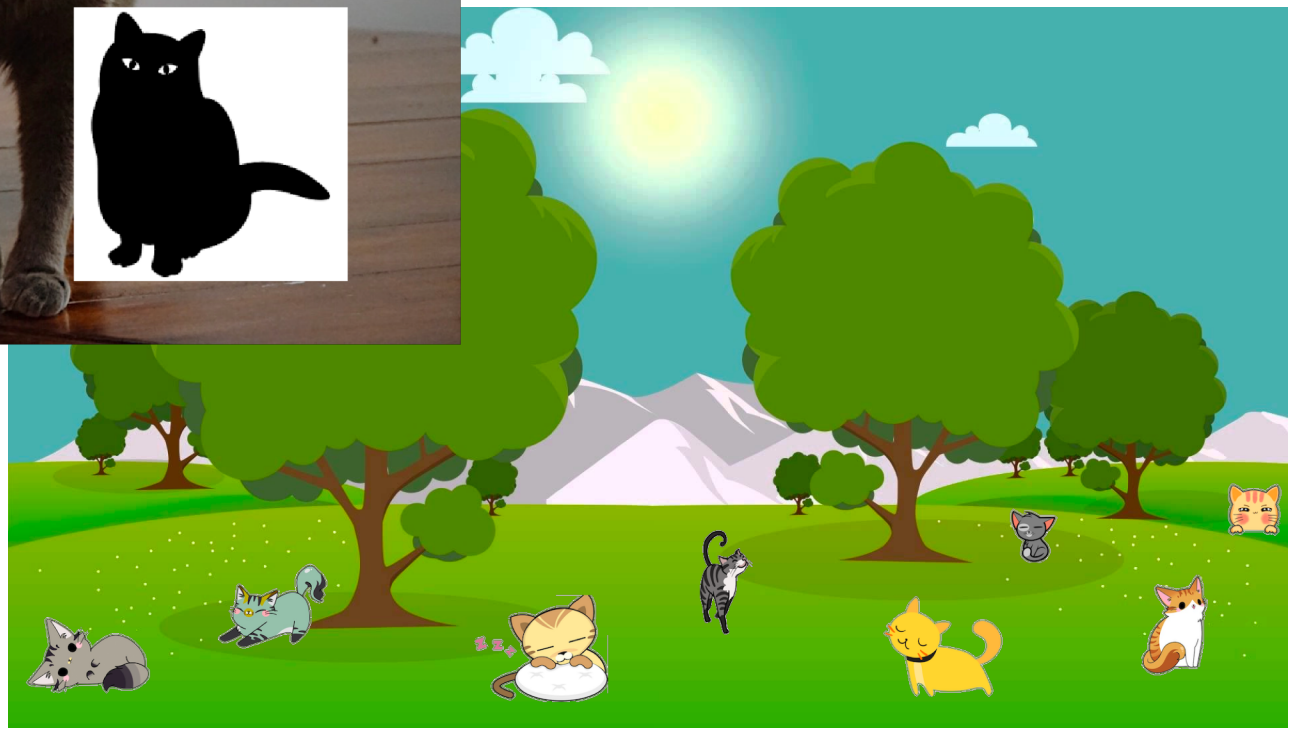


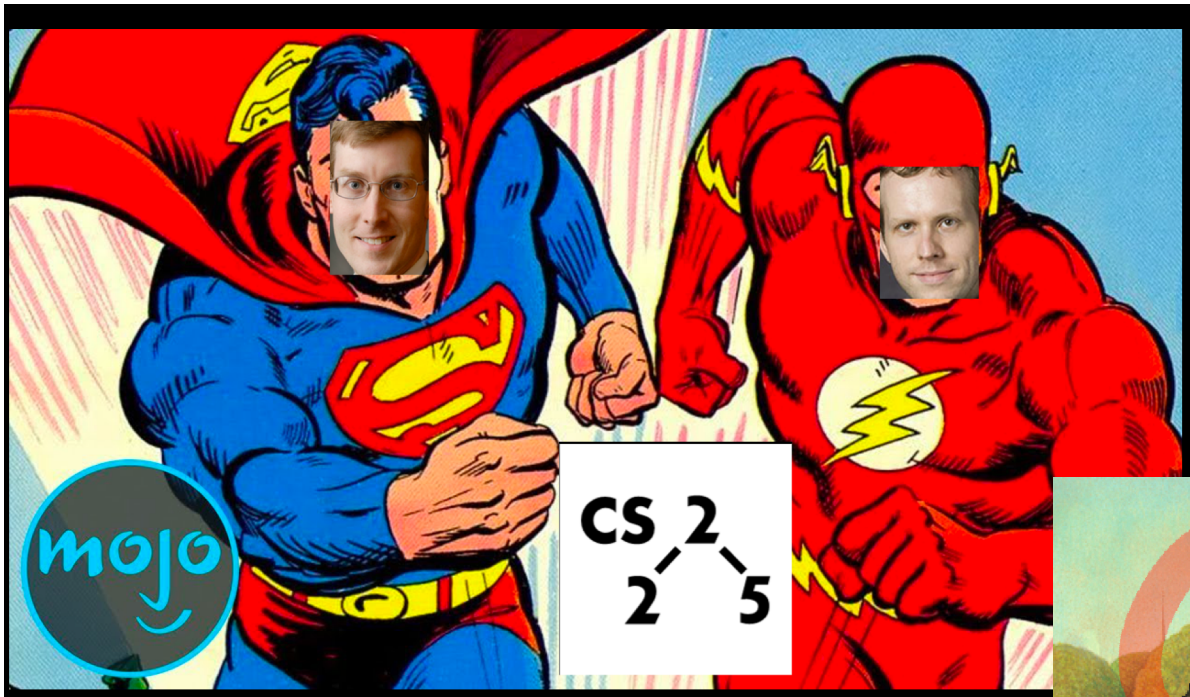

BOSTON
CELTICS
BOSTON
RED SOX


Segmentation fault
Segmentation fault
Segmentation fault
Segmentation fault
CS 225
All tests passed


Type of headache
Migraine
hypertension
high pressure
Segmentation fault






mojo
CS 225


CS 225

Implications of Design

1.

```
class ListNode {
  public:
    T & data;
    ListNode * next;
    …
```

2.

```
class ListNode {
  public:
    T * data;    …
```

3.

```
class ListNode {
  public:
    T data;    …
```

Implications of Design

	Storage by Reference	Storage by Pointer	Storage by Value
Who manages the lifecycle of the data?			
Is it possible for the data structure to store NULL?			
If the data is manipulated by user code while in our data structure, is the change reflected in our data structure?			
Speed			

Data Lifecycle

Storage by reference:

```
1  Cube c;
2  myStack.push(c);
```

Storage by pointer:

```
1  Cube c;
2  myStack.push(&c);
```

Storage by value:

```
1  Cube c;
2  myStack.push(c);
```

Possible to store NULL?

Storage by reference:

```
class ListNode {
  public:
    T & data;
    ListNode * next;
    ListNode(T & data) : data(data), next(NULL) { }
};
```

Storage by pointer:

```
T ** arr;
```

Storage by value:

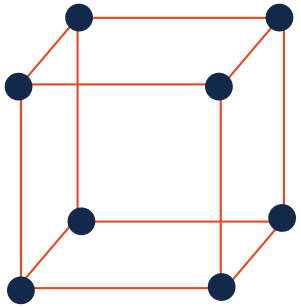
```
T * arr;
```

Data Modifications

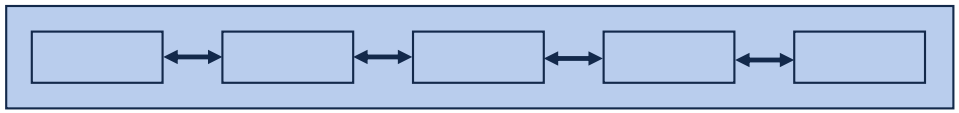
```
1  Cube c(1);
2  myStack.push(c);
3
4  c.setLength(42);
5
6  Cube r = myStack.pop();
7  // What is r's length?
```

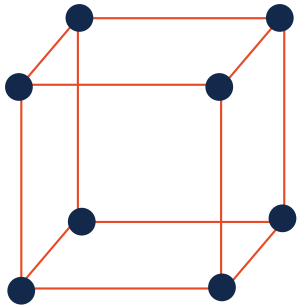
Iterators

Suppose we want to look through every element in our data structure:



Iterators encapsulated access to our data:





Cur. Location	Cur. Data	Next

Iterators

Every class that implements an iterator has two pieces:

1. [Implementing Class]:

Iterators

Every class that implements an iterator has two pieces:

2. [Implementing Class' Iterator]:

- Must have the base class **std::iterator**
- Must implement

  operator*

  operator++

  operator!=

stlList.cpp

```
 1 #include <list>
 2 #include <string>
 3 #include <iostream>
 4
 5 struct Animal {
 6   std::string name, food;
 7   bool big;
 8   Animal(std::string name = "blob", std::string food = "you", bool big = true) :
 9     name(name), food(food), big(big) { /* nothing */ }
10 };
11
12 int main() {
13   Animal g("giraffe", "leaves", true), p("penguin", "fish", false), b("bear");
14   std::vector<Animal> zoo;
15
16   zoo.push_back(g);
17   zoo.push_back(p);   // std::vector's insertAtEnd
18   zoo.push_back(b);
19
20   for ( std::vector<Animal>::iterator it = zoo.begin(); it != zoo.end(); it++ ) {
21     std::cout << (*it).name << " " << (*it).food << std::endl;
22   }
23
24   return 0;
25 }
```

stlList.cpp

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 4
 5 struct Animal {
 6   std::string name, food;
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 8   Animal(std::string name = "blob", std::string food = "you", bool big = true) :
 9     name(name), food(food), big(big) { /* none */ }
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14   std::vector<Animal> zoo;
15
16   zoo.push_back(g);
17   zoo.push_back(p);   // std::vector's insertAtEnd
18   zoo.push_back(b);
19
20   for ( const Animal & animal : zoo ) {
21     std::cout << animal.name << " " << animal.food << std::endl;
22   }
23
24   return 0;
25 }
```