SpamSeeker; Improving on `StringStack`

February 23–24, 2012

CS 60: Principles of Computer Science

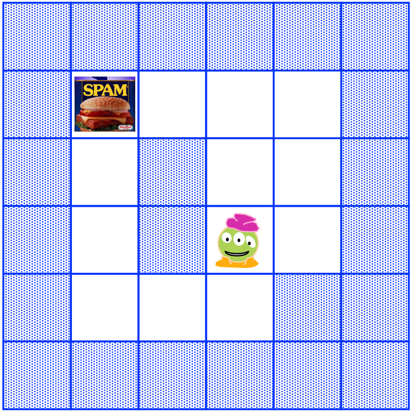
Assignment 5 due Monday February 20: Spamseeker

Review: Stacks and Queues

Which terms go together?

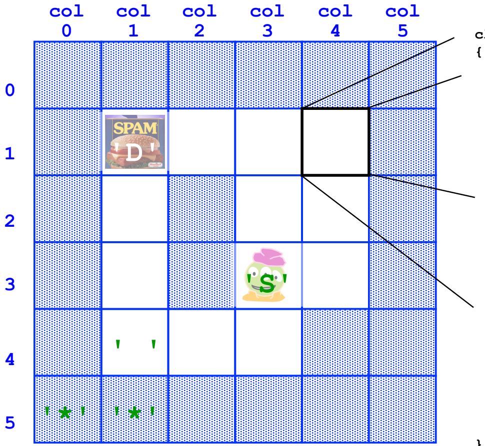
dequeue	Stack	FIFO
enqueue		FILO
pop	Queue	LIFO
push		LILO

SpamSeeker!




```
class Maze
{
  private MazeCell[][] maze;
```

MazeCells




```java
class MazeCell
{
    private int row;
    private int col;
    private char contents;
    private boolean visited;
    private MazeCell parent;

    MazeCell(int row, int col, char c)
    {
        this.row = row;
        this.col = col;
        this.contents = c;
        this.visited = false;
        this.parent = null;
    }

    public String toString()
    {
        return "[" + row + "," +
                     col + "," +
                     contents  + "]";
    }
}
```

Here are the available characters:

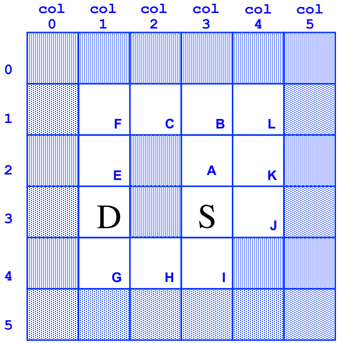
'S' = Start Spam Seeking

'D' = Delectible Dinner Destination

'*' = Wall!

' ' = Open *Space*

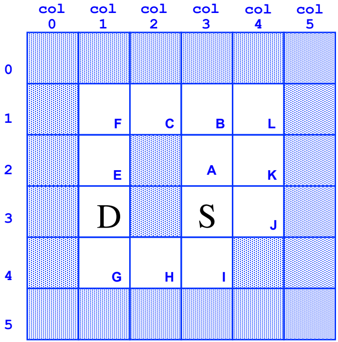
Pseudocode for DFS in a Maze



'S' = Start Spam Seeking
'D' = Delectible Dinner Destination

```
Create an empty Stack
Mark starting MazeCell as visited
push starting MazeCell onto our Stack

while (the stack's not empty)
{
  current = pop the stack
  for each of current's neighbors
  {
    if (it's not visited or a wall)
    {
     mark it (neighbor) as visited
     set its parent to current MazeCell
     push it onto the stack
    }
  }
}
```

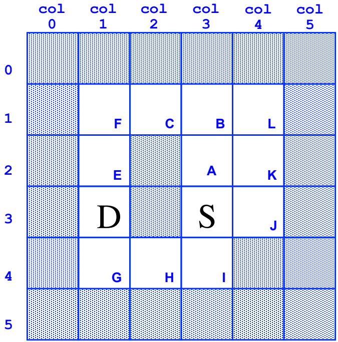
Pseudocode for BFS in a Maze?



'S' = Start Spam Seeking
'D' = Delectible Dinner Destination

```
Create an empty Queue
Mark starting MazeCell as visited
enqueue starting MazeCell in our Queue

while (the queue's not empty)
{
  current = dequeue the queue
  for each of current's neighbors
  {
    if (it's not visited or a wall)
    {
//        mark it (neighbor) as visited
      set its parent to current MazeCell
      enqueue it in the queue
    }
  }
}
```

Pseudocode for DFS in a Maze, Revisited



'S' = Start Spam Seeking
'D' = Delectible Dinner Destination

```
DFS(MazeCell start)
{
  if (start isn't visited or a wall)
  {
     mark it as visited

     DFS(southNeighbor)
     DFS(eastNeighbor)
     DFS(westNeighbor)
     DFS(northNeighbor)
  }
}
```

Where'd the stack go?

Review: StringStack

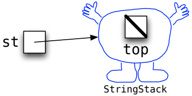
```
public class StringStack extends Object
{
   private class StackCell {
      private String data;
      private StackCell next; ...
   }

   private StackCell top;

   public StringStack() { ... }
   public void    push(String data) { ... }
   public String  pop()     { if (this.isEmpty()) return null;
                              String topItem = this.top.data;
                              this.top = this.top.next;
                              return topItem; }
   public String  peek()    { ... }
   public boolean isEmpty() { ... }
}
```

Stacks as Linked Lists

Here is memory changing over time. What code is executing?

1.

2.



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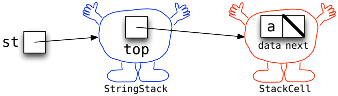

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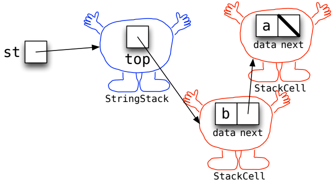

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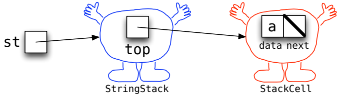

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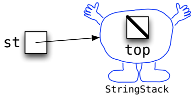
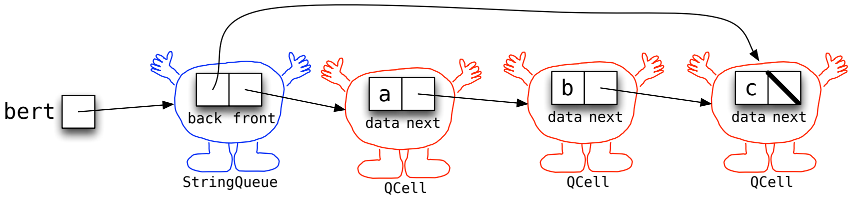
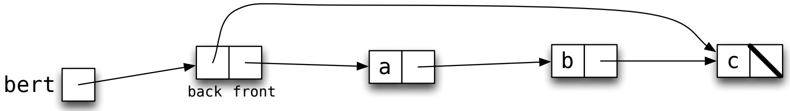


Queues via Linked Lists



(Simplified Diagram)



Name:

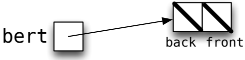
"Quiz"

Draw memory after each line. How many references change at each step?

```
1  StringQueue bert;
2  bert = new StringQueue();
3  bert.enqueue("U");
4  bert.enqueue("C");
5  bert.dequeue();
6  bert.dequeue();
```

1.

2.



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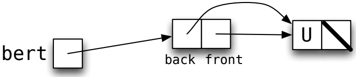

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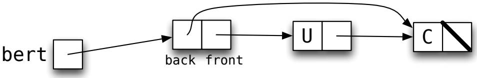

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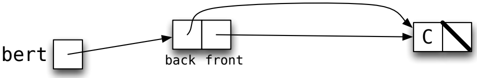

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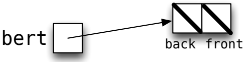

"Industrial Strength" Stacks and Queues

February 23–24, 2012

CS 60: Principles of Computer Science

Problems with StringStack

The `StringStack` class you've seen works. But it's not perfect:

1. What if we want a stack of `Point`s, or a stack of `MazeCell`s?
2. It blurs interface and implementation.
3. The `toString()` method is really slow.

How Many Changes are Required to Make a PointStack?

```
public class PointStack extends Object                          // 1
{
   private class StackCell {
      private Point data;                                       // 2
      private StackCell next; ... }

   private StackCell top;

   public PointStack() { ... }                                  // 3
   public void    push(Point data) { ... }                      // 4
   public Point   pop()     { if (this.isEmpty()) return null; // 5
                              Point topItem = this.top.data;   // 6
                              this.top = this.top.next;
                              return topItem; }
   public boolean isEmpty() { ... }
   public String  toString() { ... }                            // careful!
   ...
}
```

Alternative 1: ObjectStack

```
public class ObjectStack extends Object
{
   private class StackCell {
      private Object data;
      private StackCell next; ... }

   private StackCell top;

   public ObjectStack() { ... }

   public void    push(Object data) { ... }
   public Object  pop()     { if (this.isEmpty()) return null;
                              Object topItem = this.top.data;
                              this.top = this.top.next;
                              return topItem; }
   public Object  peek()    { ... }
   public boolean isEmpty() { ... }
}
```

Advantages!

We can use `ObjectStack` with any sort of objects!

```
ObjectStack st1 =
   new ObjectStack();

st1.push("1");
st1.push("2");
st1.push("3");
st1.push("4");
```

```
ObjectStack st2 =
   new ObjectStack();

st2.push(new Point(1,2));
st2.push(new Point(2,4));
st2.push(new Point());
st2.push(new Point(4,8));
```

Disadvantages

We can use `ObjectStack` *with any sort of objects!*

```
ObjectStack st1 = new ObjectStack();

st1.push("1");
st1.push("2");
st1.push("3");
st1.push("4");

String four = st1.pop(); // Doesn't compile!  Why not?
// String four = st1.pop(); <--- Doesn't compile!  Why not?
Object four = st1.pop();
String three = (String) st1.pop();

st1.push(new Point());
```

Alternative 2: Write a *Generic* Stack Class

```
Stack<String> st1 =
   new Stack<String>();

st1.push("1");
st1.push("2");
st1.push("3");
st1.push("4");

String four = st1.pop();
```

```
Stack<Point> st2 =
   new Stack<Point>();

st2.push(new Point(1,2));
st2.push(new Point(2,4));
st2.push(new Point());
st2.push(new Point(4,8));

Point p = st2.pop();
```

A Generic Stack

```
public class Stack<T extends Object> extends Object
{
   private class StackCell {
      private T data;
      private StackCell next; ... }

   private StackCell top;

   public Stack() { ... }        // Constructor just called "Stack"
   public void    push(T data)  { ... }
   public T       pop()      { if (this.isEmpty()) return null;
                               T topItem = this.top.data;
                               this.top = this.top.next;
                               return topItem; }
   public T       peek()     { ... }
   public boolean isEmpty() { ... }
}
```

Warning

Generics were added to the language in Java 5.

The Java Virtual Machine that runs *code still* doesn't know about generics!

- ✓ Compiler checks that you're using your generic stack correctly.
- ✓ But, the generated code only has stacks of `Object`, with the required typecasts inserted automatically.

As a consequence, there are a few things you might expect to be able to do with generics, but can't. We shouldn't run into these issues in CS 60.

Interfaces in Java

Suppose we have program that uses StringStack

```
public class StringStack extends Object
{
   private class StackCell { ... }

   private StackCell top;

   // ...constructor and methods...
}
```

```
public static boolean test(StringStack st)
{
  st.push("a");
  st.push("b");
  boolean test1 = (st.pop() == "b");
  boolean test2 = (st.pop() == "a");
  boolean test3 = st.isEmpty();
  return ( test1 && test2 && test3 );
}
```

What if We Also Have a Different Implementation...

Can we use both kinds of stack with `test`? Would generics help? Inheritance?

```
public class StringStack  extends Object { ... }

public class StringStack2 extends Object
{
  private ArrayList<String> items;    // growable array of strings

  public void push(String s) { items.add(s); }
  public String pop()        { return (items.remove(items.size() - 1)); }
  public boolean isEmpty()   { return ( items.size () == 0); }
  // ...other methods...
}

public static boolean test(StringStack st)
{
  st.push("a");
  st.push("b");
  boolean test1 = (st.pop() == "b");
  boolean test2 = (st.pop() == "a");
  boolean test3 = st.isEmpty();
  return ( test1 && test2 && test3 );
}
```

Solution: interfaces

```
interface StringStackInterface
{
  public boolean isEmpty();
  public String peek();
  public String pop();
  public void push(String data);
  public String toString();
}
```

```
class StringStack
   extends Object
   implements StringStackInterface
{ ... }
```

```
class StringStack2
   extends Object
   implements StringStackInterface
{ ... }
```

```
public static boolean test(StringStackInterface st)
{
  st.push("a");
  ...
}
```

Interfaces can be Generic Too

```
interface StackInterface<T extends Object>
{
  public boolean isEmpty();
  public T peek();
  public T pop();
  public void push(T data);
  public String toString();
}
```

```
class Stack<T extends Object>
   extends Object
   implements StackInterface<T>
{ ... }
```

```
class Stack2<T extends Object>
   extends Object
   implements StackInterface<T>
{ ... }
```

```
public static boolean test(StackInterface<String> st)
{
  st.push("a");
  ...
}
```

Speeding up `toString`

Strings and String Concatenation

Strings (string objects) in Java:

- ✓ contain a sequence of (unicode) characters
- ✓ are *immutable* once created.

What is the asymptotic running time of string concatenation?

```
s1 + s2
```

$O(n + m)$, where n is the length of `s1` and m is the length of `s2`

Consequences

What is the asymptotic running time of this **toString()** method?

```
public String toString()
{
  StackCell current = this.top;

  String accum = "<TOP> ";

  while (current != null)
  {
     accum += " " + current.data.toString() + " ";
     current = current.next;
  }

  accum  += "<BOT>";

  return accum;
}
```

(You may assume we're adding $O(1)$ characters to **accum** in every iteration of the loop.)

Better Java Style: Use StringBuffer to Grow a String

StringBuffer *objects are mutable/growable strings.*
Most importantly, adding one character at the end is $O(1)$!

```
public String toString()
{
  StackCell current = this.top;

  StringBuffer accum = new StringBuffer("<TOP> ");

  while (current != null)
  {
     accum.append(current.data.toString() + " ");
     current = current.next;
  }

  accum  += "<BOT>";

  return accum.toString();
}
```