Section 5: HW6 and Interfaces

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Slides adapted from Alex MariaKakis, with material from Krysta Yousoufian, Mike Ernst, Kellen Donohue
How is Homework 5 going?
Agenda

BFS

Interfaces
Reminders:

Expensive CheckReps == BAD
(at least when assignments are turned in, but can be useful for finding hard-to-discover problems – so need to be able to control expensive checks)

Debug flags == GOOD
Can I reach B from A?
Breadth-First Search (BFS)

Often used for discovering connectivity

Calculates the shortest path *if and only if* all edges have same positive or no weight

Depth-first search (DFS) is commonly mentioned with BFS
- BFS looks “wide”, DFS looks “deep”
- Can also be used for discovery, but not the shortest path
BFS Pseudocode

```java
public boolean find(Node start, Node goal) {
    put start node in a queue
    while (queue is not empty) {
        deque node N off queue
        if (N is goal)
            return true;
        else {
            for each node O that is child of N
                enqueue O onto queue
        }
    }
    return false;
}
```
Breadth-First Search

START:
Q: <A>
Deque: A, Q: <>
Q: <B, C>
Deque: B, Q: <C>
Q: <C>
Deque: C, Q: <>
Q: <>
DONE

Starting at A
Goal: Fully explore
Breadth-First Search with Cycle

START:
Q: <A>
Dequeue : A, Q: <>
Q: <B>
Dequeue : B, Q: <>
Q: <C>
Dequeue : C, Q: <>
Q: <A>
NEVER DONE

Starting at A
Goal: Fully Explore
BFS Pseudocode

public boolean find(Node start, Node end) {
  put start node in a queue
  while (queue is not empty) {
    pop node N off queue
    mark node N as visited

    if (N is goal)
      return true;
    else {
      for each node O that is child of N
        if O is not marked visited
          push O onto queue
      }
    }
  }
  return false;
}

Mark the node as visited!
Breadth-First Search

Q: <>
Breadth-First Search

Q: <>
Q: <A>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Q: <C,D>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Q: <C,D>
Q: <D>

Diagram:
- A
- B
- C
- D
- E

Connections:
- A to B
- A to C
- C to A
- C to B
- C to D
- D to C
- D to E
- E to C
- E to D
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Q: <C,D>
Q: <D>
Q: <D,E>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Q: <C,D>
Q: <D>
Q: <D,E>
Q: <E>
Breadth-First Search

Q: <>
Q: <A>
Q: <>
Q: <C>
Q: <C,D>
Q: <D>
Q: <D,E>
Q: <E>
DONE
Shortest Paths with BFS

From Node B

<table>
<thead>
<tr>
<th>Destination</th>
<th>Path</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;B,A&gt;</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>&lt;B&gt;</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>&lt;B,A,C&gt;</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shortest path to D? to E? What are the costs?
Shortest Paths with BFS

From Node B

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<td>C</td>
<td>&lt;B,A,C&gt;</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>&lt;B,D&gt;</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>&lt;B,D,E&gt;</td>
<td>2</td>
</tr>
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Shortest Paths with Weights

Weights are not the same!
Are the paths?
Shortest Paths with Weights

From Node B

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<th>Cost</th>
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<tbody>
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<td>2</td>
</tr>
<tr>
<td>B</td>
<td>&lt;B&gt;</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>&lt;B,A,C&gt;</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>&lt;B,A,C,D&gt;</td>
<td>7</td>
</tr>
<tr>
<td>E</td>
<td>&lt;B,A,C,E&gt;</td>
<td>7</td>
</tr>
</tbody>
</table>
Dijkstra’s Algorithm
Finds the shortest path
It’s in your Homework 7
The Wikipedia page is also a good resource
Interfaces
Classes, Interfaces, and Types

The fundamental unit of programming in Java is a class.

Classes can extend other classes and implement interfaces.

Interfaces can extend other interfaces.
Classes, Objects, and Java

Everything is an instance of a class
- Defines data and methods

Every class extends exactly one other class
- Object if no explicit superclass
- Inherits superclass fields
- (You can make a ladder of “extends”)

Every class also defines a type
- Foo defines type Foo
- Foo inherits all inherited types

Java classes contain both specification and implementation!
Interfaces

Pure type declaration

```java
public interface Comparable {
    int compareTo(Object other);
}
```

Can contain:
- Method specifications (implicitly `public abstract`)
- Named constants (implicitly `public final static`)

Does not contain implementation!*

Cannot create instances of interfaces

*Java 8 does allow a form of “default” implementations in interfaces, but we will not use that, at least for now. So for us, for now, interfaces are pure specifications.
Implementing Interfaces

A class can implement one or more interfaces

```java
class Kitten implements Pettable, Huggable
```

The implementing class and its instances have the interface type(s) as well as the class type(s)

The class must provide or inherit an implementation of all methods defined by the interface(s)

- Not true for abstract classes
Using Interface Types

An interface defines a type, so we can declare variables and parameters of that type

A variable with an interface type can refer to an object of any class implementing that type

\[
\text{List<String> } x = \text{ new ArrayList<String>();
void sort(List aList) \{...
\]
Guidelines for Interfaces

Provide interfaces for significant types and abstractions

Write code using interface types like Map instead of HashMap and TreeMap wherever possible
  ◦ Allows code to work with different implementations later on

Both interfaces and classes are appropriate in various circumstances