Graphs!
We’ve seen...

Linked Lists  
Binary (Search) Trees  
Heaps  
Tries
Graphs

A set of nodes and a set of edges.

Edges can be directed or undirected.

Nodes and edges can have labels, or values, or whatever.
Nodes are cities (or addresses, maybe).
Edges are roads. Edges have weights.
Examples

Nodes are cities. Edges are routes. Edges have weights.
Examples

Suppose you’re building a power grid.

How much power can my stove draw?

See the Ford-Fulkerson algorithm for details.
Examples

An example from Facebook. From http://asawicki.info
First question: connectivity

Driving directions to Anchorage, AK
This route has tolls.
This route crosses through Canada.

Chapel Dr
Durham, NC
1. Head southeast on Chapel Dr
   0.2 mi
2. At the traffic circle, take the 4th exit onto Flowers Dr
   0.5 mi
3. Turn left onto Trent Dr
   0.3 mi
4. Turn left onto Erwin Rd
   0.2 mi
5. Turn right onto Fulton St
   0.4 mi
6. Turn left onto the N Carolina 147 N/Durham Fwy N ramp
   0.3 mi
7. Merge onto N Carolina 147 N/Durham Fwy
   1.7 mi
8. Take the Interstate 85/U.S. 70 exit
   0.7 mi

We could not calculate directions between Chapel Dr, Durham, NC and Westminster, London SW1A 0AA, United Kingdom.

Map data ©2012 Google

I am a banana!

Your circles
Public
Extended circles
Friends (13)
Family (2)
Share
Second question: representation

So, if you were going to write a Graph class, what data would you store?

Operations you’ll need to support:
1. Iterating through the nodes.
2. Assigning each node a label.
3. Getting the neighbors of a node.
4. Assigning each edge a label.

Tell us!

http://goo.gl/p1PKN
Back to the first question

Complete connectedTo.

/* A node in a generic, directed, graph. */
public class GraphNode {
    private String myLabel;
    private ArrayList<GraphNode> myNeighbors;

    public GraphNode(String l) {
        myLabel = l;
    }

    boolean connectedTo(GraphNode gn) {
        // Can you get to gn from this node?
    }
}

This particular implementation is called an adjacency list.
Breadth-first & Depth-first Search

In what order would your code visit these nodes?
Breadth-first & Depth-first Search

Keep track of the frontier.
(And where you’ve been)
Breadth-first & Depth-first Search

Keep track of the **frontier**.
(And where you’ve been)

- Add start to your frontier.
- While the frontier isn’t empty
  - Pop the first element off the frontier.
  - Process that element.
- Add that element’s neighbors to the frontier.
  (skipping those you’ve seen before)

This may remind you of a test question. Funny how that works...
Breadth-first & Depth-first Search

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Trees are *directed acyclic graphs*.  

Demo time!

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Wednesday, November 28, 12
Breadth-first & Depth-first Search

Keep track of the frontier.
(And where you’ve been)

Code!

This may remind you of a test question. Funny how that works...

Wednesday, November 28, 12
Nodes are cities (or addresses, maybe).
Edges are roads. Edges have weights.
Connectivity isn’t enough.

Shortest path problem.

DFS? BFS?
An aside

Inventor of or advocate for:
- Semaphores (used in parallel computation)
- The switchyard algorithm (used in parsing)
- Loops.
- Not using goto. See “Goto considered harmful.”
- And a great many funny ways of telling people off:

   It is practically impossible to teach good programming to students that have had a prior exposure to BASIC: as potential programmers they are mentally mutilated beyond hope of regeneration.

Edsger W. Dijkstra

On a more philosophical note:

The job [of operating or using a computer] was actually beyond the electronic technology of the day, and, as a result, the question of how to get and keep the physical equipment more or less in working condition became in the early days the all-overriding concern. As a result, the topic became —primarily in the USA— prematurely known as "computer science" —which, actually is like referring to surgery as "knife science"— and it was firmly implanted in people's minds that computing science is about machines and their peripheral equipment.
Dijkstra’s Algorithm

Expanding frontier.
+ Distance from start
+ Previous node in shortest path

You’ll need to assume that your edge weights are non-negative.
Dijkstra’s Algorithm

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Expanding frontier.
+ Distance from start
+ Previous node in shortest path

Big idea: everything behind the frontier is correct.
So how do we grow the frontier?

Demo time!

You’ll need to assume that your edge weights are non-negative.