Announcements

Test #2 is Wednesday
• Topics: BSTs (incl. balanced), PQs, heaps, Markov model (applied to text generation), comparators, Iterators

From the labs, you should know:
• AVL rotations
• ADT operations
• RT of various implementations (our "ideas" from slides)
• Any assumptions about the data, (e.g., comparable?)
• The supported operations

For each data structure, you should know:
• topics: BST, PQ, balanced BST
• avl, heap, comparator

Prelab 9 is due Monday after break (you can do it now)

Graphs
Nodes and Edges

A graph is a way of specifying relationships among a collection of items. It consists of a set of nodes, called nodes, with certain pairs of these nodes connected by edges. Two nodes are neighbors or adjacent if they are connected by an edge.

If a graph is not directed, we call it an undirected graph. With a set of directed edges (where the direction on the edge matters), we define a directed graph.

Graphs: nodes and edges
Examples of Graphs

Example 1: The network structure of the Internet --- then called the Arpanet --- in December 1970.

Example 2: A social network of friendships within a 34-person karate club.

Example 3: Links between political blogs prior to the 2004 U.S. Presidential Election.

Example 4: The network structure of the Internet --- then called the Arpanet --- then called the Internet.
Graphs appear in many domains, whenever it is useful to represent how things are either physically or logically linked to one another in a network structure.

Diverse Applications

- Game networks
  - Nodes are states in a game, such as placements of O/X in tic-tac-toe
  - Edges represent legal transitions such as player's moves

- Communication networks
  - Nodes are computers or other devices that can relay messages
  - Edges represent links through which messages can be transmitted

- Social networks
  - Nodes are people or groups of people
  - Edges represent relations such as friendships

- Information networks
  - Nodes are information resources such as web pages or documents
  - Edges represent logical connections such as hyperlinks, citations, or refs

- Epidemic networks
  - Nodes are outbreaks of an epidemic disease
  - Edges represent links between infected nodes

- Game networks
  - Nodes are states in a game, such as placements of O/X in tic-tac-toe
  - Edges represent legal transitions such as player's moves

Examples of Graphs

Example 1: airline routes

Example 2: the spread of an epidemic disease (such as the Influenza)

Example 3: links between tic-tac-toe game states

Example 4: links between tic-tac-toe game states

Example 5: the spread of an epidemic disease (such as the Influenza)

Example 6: airline routes
Examples of Graphs

Paths

A path is a sequence of nodes with the property that each consecutive pair in the sequence is connected by an edge.

For example: MIT, BBN, RAND, UCLA is a path in the Internet graph. According to this definition, a path can repeat nodes. For example, SRI, STAN, UCLA, SRI, UTAH, MIT is a path.

A simple path is a path that does not repeat nodes.

A length of a path is the number of edges in that path.

Example 7: Metro map

Example 8: Prerequisite chart among CS courses at Oberlin College

Example 9: The structure of a bridge

Example 10: The structure of a bridge in Disneyland
A cycle is a path with at least three edges, in which the first and last nodes are the same, but otherwise all nodes are distinct. For example, SRI, STAN, UCLA, SRI is a cycle in the Internet graph. In fact, every edge in the 1970 Arpanet belongs to a cycle, and this was by design: if any edge were to fail, there would still be a way to get from any node to any other node.

Cycles in communication and transportation networks are often present to allow for redundancy, and provide alternate routings that go the other way around the cycle. Also have cycles in social networks...

A graph is connected if there is a path between every pair of nodes. Given a graph, it is natural to ask whether every node can reach every other node. A graph is strongly connected if there is a directed path between every pair of nodes.

A graph is connected if it has a single component. A graph is strongly connected if it has a single strongly connected component. A connected component of a graph is a subset of the nodes such that:

• every node in the subset has a path to every other, and
• every node in the subset has a path to every other of the nodes such that:
  • the subset is not a part of some larger set with the connected property.

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A strongly connected component of a graph is a subset of the nodes such that:

• the subset is not part of some larger set with the strongly connected property.

For example, look at largest example in collaboration network. Whiten a component, these may be other internal structure. Dividing a graph into its components is just one of describing its structure. Given a graph, it is natural to ask whether every node can reach every other node. A connected component of a graph is a subset of the nodes such that:

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Giant Components

1. Consider the social network of the entire world. The largest component is likely to include a significant fraction of the world's population.

2. Is this global friendship network connected?

3. How big is the component that you are in?

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