1 Introduction and Objective

This tutorial marks the end of the first $\frac{1}{3}$ of CS2010: Various Data Structures (DSes). In the past three weeks, we have learned about tree-related Data Structures: Binary Heap, Binary Search Tree, and AVL Tree as a form of Balanced Binary Search Tree. In this tutorial, we discuss more DSes that were discussed in Lecture 05: Union-Find Disjoint Sets (UFDS), Bitmask, and three basic Graph DSes: Adjacency Matrix, Adjacency List, and Edge List.


As we will have the supposedly easier 4% Online Quiz 1 on Thursday of Week 06 and the supposedly more challenging 10% Written Quiz 1 on Saturday of Week 06, we have made the questions in this tutorial slightly shorter so that students can discuss Online/Written Quiz 1 related materials with the tutor if needed.
2 Tutorial 04 Questions

Basic Stuffs About UFDS, Bitmask, and Graph DSes

Q1. First, tutor will choose one of the random UFDS [http://visualgo.net/ufds.html](http://visualgo.net/ufds.html) menu Samples) or initialize an UFDS with $N$ disjoint sets ($N$ is chosen at random). Then, tutor will ask students to perform $\text{FindSet}(i)$ and $\text{UnionSet}(i, j)$ operations on that UFDS. We assume that both ‘path-compression’ and ‘union-by-rank’ heuristics are used.

Q2. Second, tutor will select a random (and small) positive integer $S$ (in base 10) [http://visualgo.net/bitmask.html](http://visualgo.net/bitmask.html) menu Set $S$) and describe the binary (base 2) representation of that integer. Then, tutor will ask students to perform several basic bit manipulation operations on that random integer: Setting on a certain bit, Checking if a certain bit is on, Toggle the state of a certain bit (a NEW operation, check VisuAlgo), Clear a certain bit (a NEW operation, check VisuAlgo), identify the Least Significant Bit of that random integer, that is, the last bit that is on of that random integer (also a NEW operation, check VisuAlgo).

Q3. Third, tutor will draw random small graph on whiteboard and ask students to store that graph in either Adjacency Matrix, Adjacency List, or Edge List data structure. Then, the tutorial group can compare that answer by drawing the same small graph on [http://visualgo.net/graphds.html](http://visualgo.net/graphds.html).

Not-So-Basic Stuffs

Q4. Given $n$ disjoint sets initially in a UFDS, is it possible to call $\text{unionSet}(i, j)$ and/or $\text{findSet}(i)$ operations to get a single tree with actual height $h$ that represents a certain set? Both ‘path-compression’ and ‘union-by-rank’ heuristics are used.
This question has been integrated in VisuAlgo Online Quiz :).

Q5. Describe a simple $O(n)$ algorithm to count how many bit(s) in an integer $S$ that is/are on where $n$ is the number of bits present in $S$.
Can you do that in $O(k)$ where $k$ is the answer that we are looking for (the number of bit(s) that is/are actually on in $S$)?
This question appeared in last year final exam :).

Q6. Draw a Directed Acyclic Graph with $V$ vertices and $V \times (V - 1)/2$ edges.
This question has been integrated in VisuAlgo Online Quiz :).

That is the end of Tutorial 04 for now. Students can stay back and ask tutor about questions in Online Quiz 1 or in past Written Quiz 1 papers (no ongoing PS this week).