CS2040S Semester 1 2023/2024

Data Structures and Algorithms

# Tutorial+Lab 08
# Graph DS and Traversal; UFDS Revisited

For Week 10

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## 1 Introduction and Objective

In this tutorial, we will transition to the last $\frac{1}{3}$ of CS2040/C/S: Graph. We will discuss various graph data structures and on how to explore them with basic graph traversal algorithms.

We will also revisit the UFDS data structure as it has one related graph application (to be contrasted with Graph Traversal solution).

The VisuAlgo pages that are used in this tutorial are `https://visualgo.net/en/graphds`, `https://visualgo.net/en/dfsbfs`, and `https://visualgo.net/en/ufds`.

## 2 Tutorial 08 Questions

### Basic Stuffs About Graph DSes

Q1). The tutor will draw a *two-dimensional depiction* of **a random small** graph on the **whiteboard** first and ask students to store that graph in **either** Adjacency Matrix (AM)/Adjacency List (AL)/Edge List (EL) data structure on the **whiteboard**. Then, the tutorial group can compare the answers by re-drawing the same small graph on `https://visualgo.net/en/graphds`, possibly in different 2D depictions of the same graph to reinforce the concept that graph is a set of vertices and edges and can have many possible 2D depictions/embeddings.

### Not-So-Basic Stuffs About Graph DSes

Q2). (Choose 2 out of 3) Many of these are in VisuAlgo online quiz, get ready:
a). Draw a Directed Acyclic Graph (DAG) with $V$ vertices and $V \times (V-1)/2$ directed edges.
b). Draw a Bipartite Graph with $V$ vertices (assume that $V$ is even) and $V^2/4$ undirected edges.

c). Draw a Tree with $V$ vertices (and $E = V - 1$ edges) that is not a Bipartite graph.
All these drawing questions have been integrated in VisuAlgo Online Quiz :).

Q3). (Choose 2 out of 6) Show what is the best (fastest) way to convert a graph currently stored in graph data structure $A$ into graph data structure $B$.
a). From Adjacency Matrix (AM) to Adjacency List (AL)
b). From AM to Edge List (EL)
c). From AL to AM
d). From AL to EL
e). From EL to AM
f). From EL to AL
For the interest of time, tutor will only pick subset of two of these for live discussion (the rest are documented in modal answers)

### DFS/BFS Initial Review

Q4). The tutor will then review (the basic form of) DFS ~~and BFS; ran out of time on Lecture 9b - 19 Oct 2023~~ graph traversal algorithms using `https://visualgo.net/en/dfsbfs` starting from the same randomly drawn graph from Q1). discussion. The tutor will ask some students to join the live demonstration. We will discuss harder applications of these two graph traversal algorithms in Tut09.

### UFDS, Revisited

Q5). Previously, we have discussed a one-off data structure with specific application: Union-Find Disjoint Sets (UFDS). Now we want to connect this data structure with one specific graph application: To find Connected Components (CCs) of an undirected unweighted graph. Contrast this UFDS data structure with DFS/BFS approach for the same application (finding CCs).

### Hands-on 8

TA will run the second half of this session with a few to do list:

- Very quick review of Prof Halim's `https://github.com/stevenhalim/cpbook-code/blob/master/ch2/ourown/graph_ds.cpp`,
- Very quick review of Prof Halim's `https://github.com/stevenhalim/cpbook-code/blob/master/ch4/traversal/dfs_cc.cpp` (BFS will be covered next week),
- Do a sample speed run of VisuAlgo online quiz that are applicable so far (just skip BFS-related questions first), e.g., `https://visualgo.net/training?diff=Medium&n=5&tl=5&module=graphds,dfsbfs`.
- Then, live solve another chosen Kattis problem involving graph data structure.

## Problem Set 5 (Again)

We will end the tutorial with **high-level** discussion of PS5.
Restrictions are now lifted.
TAs can discuss the **high-level** ideas to get full marks for PS5 A+B, hence it is just an 'implementation issue' from here onwards.

**WARNING: Anyone who still relying too much on TA/peer hints to get unstuck in the much longer ($\approx 2$ weeks) PS need to prepare to say goodbye to lots of marks for the 2 hours PE on Week 11.**