

CS2040S Semester 1 2023/2024
Data Structures and Algorithms

Tutorial+Lab 09
Graph Traversal
For Week 11

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1 Introduction and Objective

Now that we have stored our graphs in one (or more – by now you should realize that you can do this) graph data structure(s) — or even not explicitly storing our graph (implicit graph), we want to run various (graph) algorithms on it.

In this tutorial, we will focus on two graph traversal algorithms: Depth-First Search (DFS) and Breadth-First Search (BFS) and concentrate on what they can do on top of just traversing the underlying graph.

We will heavily use <https://visualgo.net/en/dfsbfbs> in this tutorial.

The tutorial part will be shorter to give more time for PE preparation this week.

2 Tutorial 09 Questions

Prelude: BFS Review

Q0). As Prof Halim ran out of time to show BFS on Thursday, 19 Oct 2023 (9b), we skipped BFS review during Tut08. It is now time to properly review this important algorithm (will be revisited again for unweighted SSSP problem soon). Tutor can use <https://visualgo.net/en/dfsbfbs>, load any graph, and BFS from any randomly selected source vertex.

Review the Harder Topics

Q1). Tutor will spend some time (depending on the requests) to review any remaining harder topics about graph traversal that may not be clear even after Week 09+10 classes. In recent years, these are the usually harder topics for students, in decreasing order of difficulty:

1. <https://visualgo.net/en/dfsbfbs?slide=7-1> to 7-3 (about back edge/detecting cycle in the graph; we will review this if majority still have difficulty)
2. <https://visualgo.net/en/dfsbfbs?slide=7-10> to 7-11 (toposort, revisited below)
3. <https://visualgo.net/en/dfsbfbs?slide=7-6> to 7-9 (finding connected components; check your understanding about the $O(V \times (V + E))$ versus just $O(V + E)$ analysis again)
4. <https://visualgo.net/en/dfsbfbs?slide=8> (all other more advanced graph traversal topics that are not the main focus of CS2040/C/S are optional and such questions will be answered **offline**, after/outside class and will not be part of this semester's CS2040/C/S final assessment)

Deeper Stuff about Topological Sort

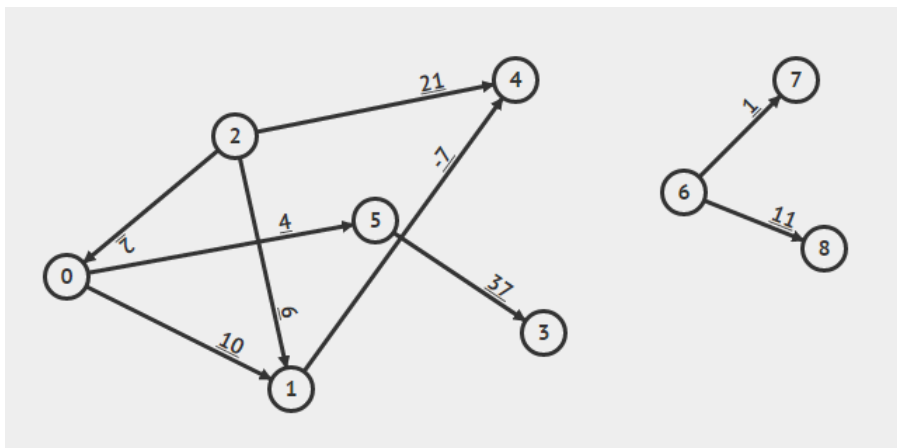


Figure 1: A Sample DAG (ignore edge weights for this question)

Q2). The modified DFS or modified BFS (Kahn's) topological sort algorithm given in class (please review <https://visualgo.net/en/dfsbfbs>, 'topological sort', either the DFS or BFS version) only gives *one* valid topological ordering. How can we find **all** possible valid topological orderings for a given DAG? For example, there are **1008** possible valid topological orderings of the DAG in Figure 1. Starting point: What kind of DAG has the smallest/largest number of possible valid topological ordering, respectively?

Q3). The modified BFS (Kahn's) topological sort algorithm is actually quite interesting (read the details at https://en.wikipedia.org/wiki/Topological_sorting#Kahn's_algorithm). Can we change the underlying data structure (from a queue that is used in the modified BFS @ VisuAlgo) into another data structure? What if we replace the queue with a stack? What if we replace the queue with a hash table)?

Graph Modeling Exercise

Q4). If time permitting (if the clock is still around 30m into the tutorial because there is not much issues with in Q0 and/or Q1), then the tutor will open Q4). and do 'live algorithm-level solve' for that (CS2040/C/S-level) problem.

Hands-on 9

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

- PS5 Debrief (A Quick One),
- Very quick review of Prof Halim's <https://github.com/stevenhalim/cpbook-code/blob/master/ch4/sssp/bfs.java>,
- Speedrun two more components of VisuAlgo Online Quiz (for next week):
<https://visualgo.net/training?diff=Medium&n=5&t1=5&module=dfs bfs,sssp>
- Past PE Reviews

Problem Set 6 – Omitted

The focus this week is not PS6, but PE, so this component is omitted.