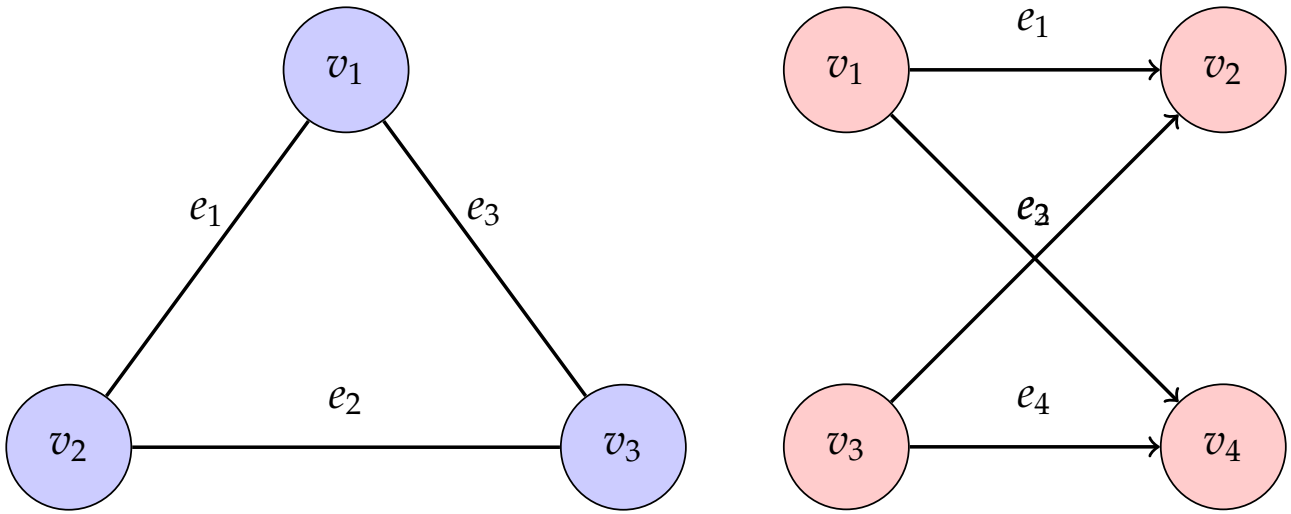
CSCI 2270: Data Structures

Lecture 28–30: Graph Traversal

Ashutosh Trivedi



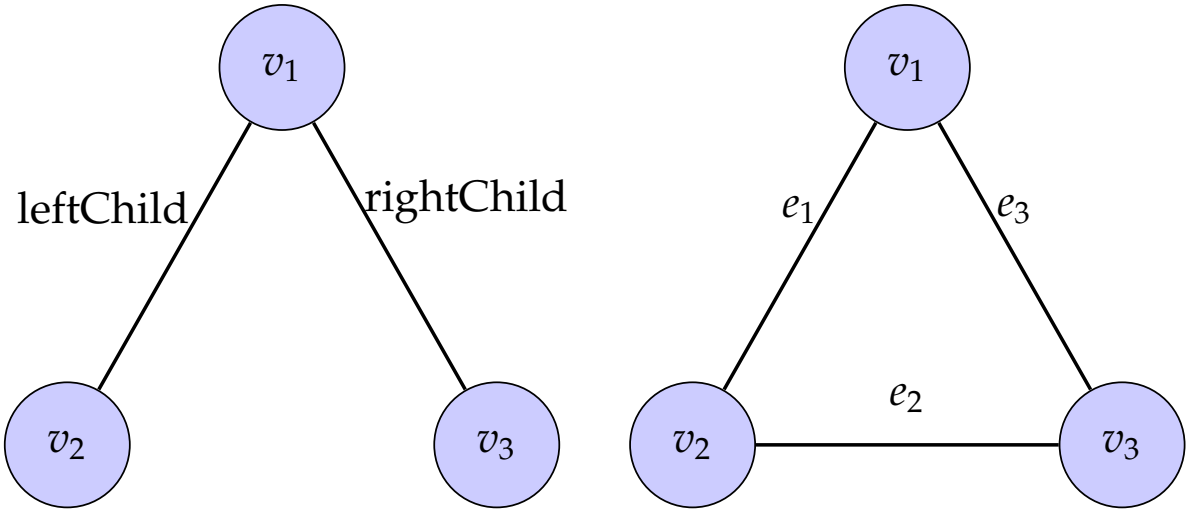
Department of Computer Science
UNIVERSITY OF COLORADO BOULDER

Graphs

Graph Traversal

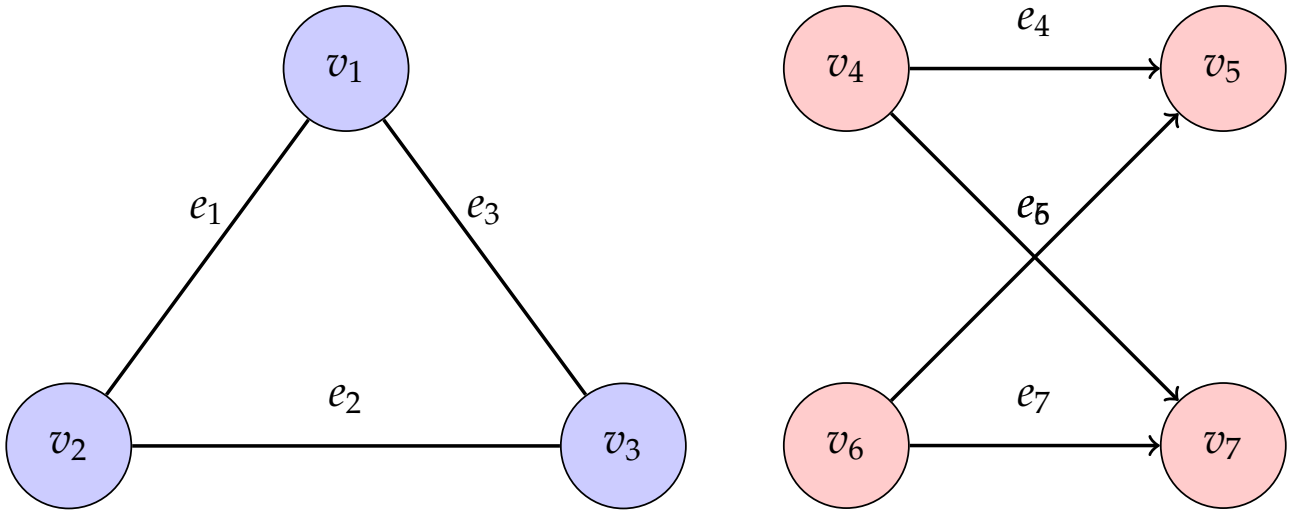
C++ Standard Template Library: Containers

Trees Vs Graph



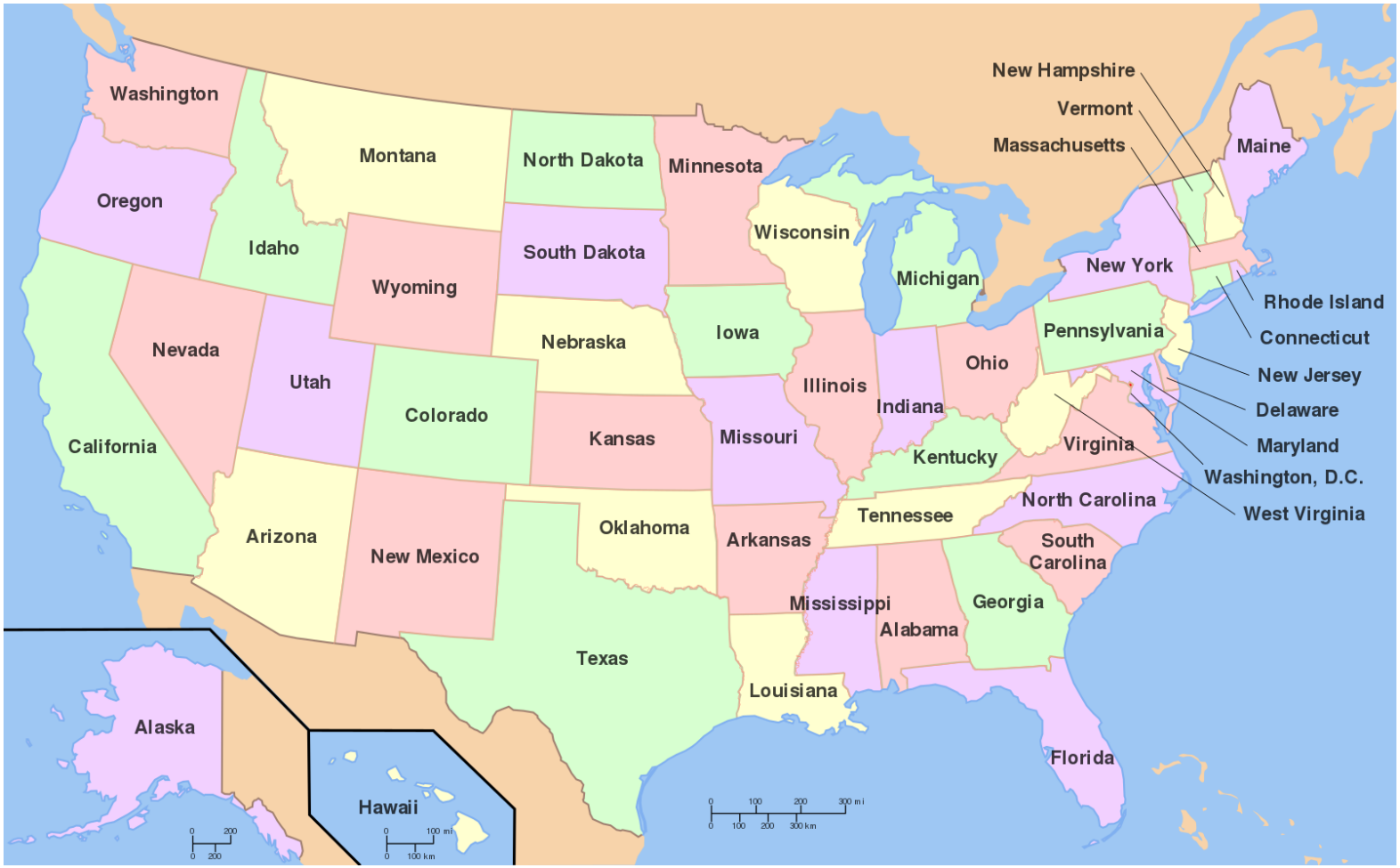
- Trees: *parent, child, sibling, ancestors, successors*
- Graphs: *adjacent node, nodes distance k apart, path, shortest path*

Undirected vs directed graphs



- $G = (V, E)$ where V is the set of *vertices* and E is the set of edges.
- Example: $G_1 = (V_1, E_1)$ where $V_1 = \{v_1, v_2, v_3\}$ and $E_1 = \{e_1, e_2, e_3\}$.
- Undirected Graph: edges are bi-directional.
- Directed Graphs: edges are one-directional.

Graphs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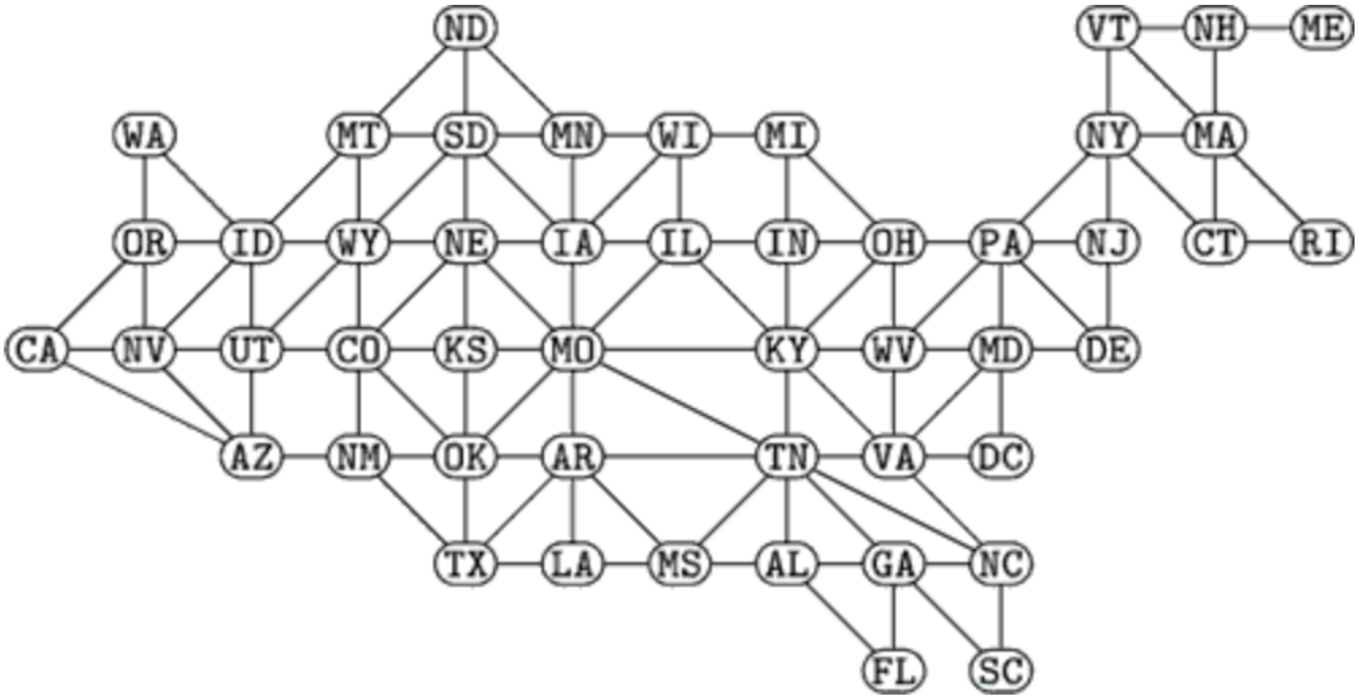
Graphs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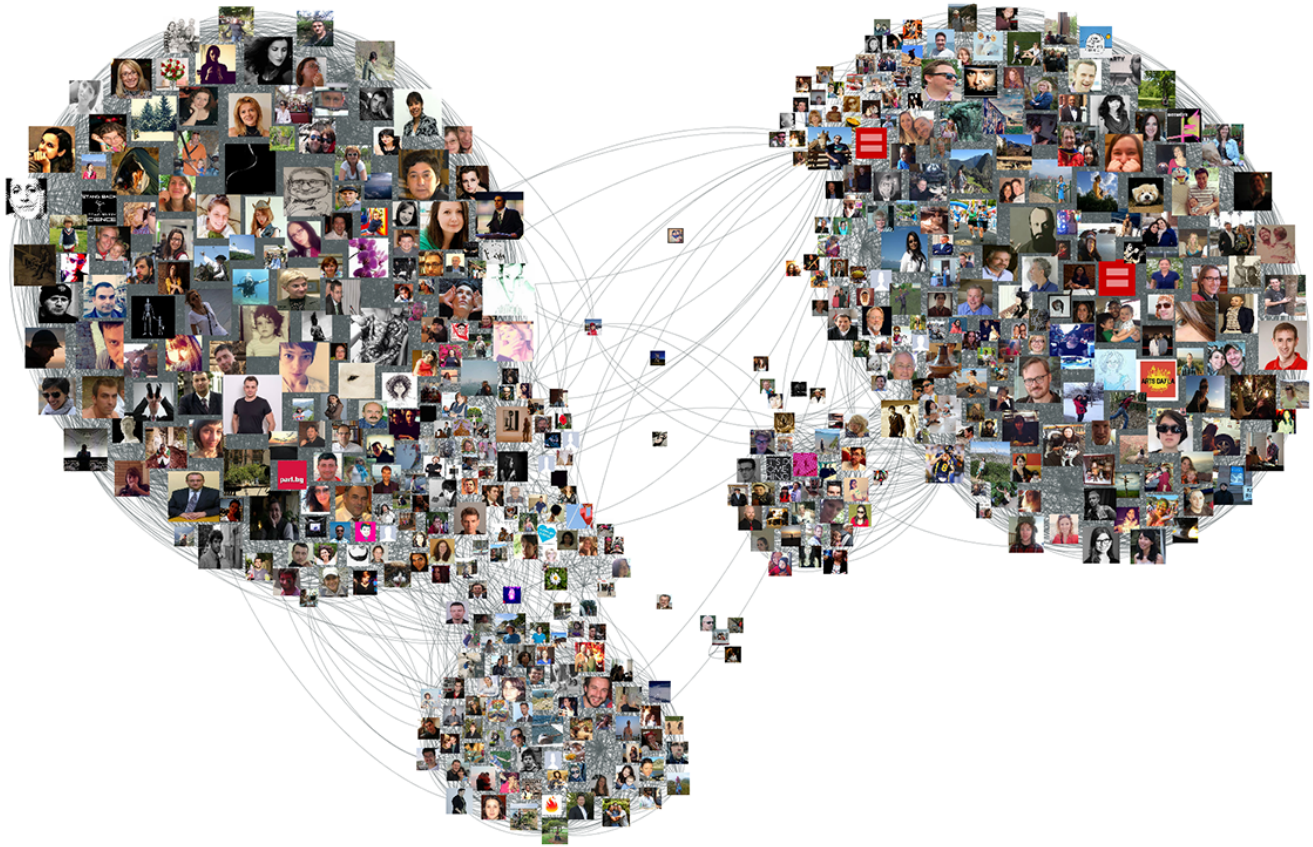
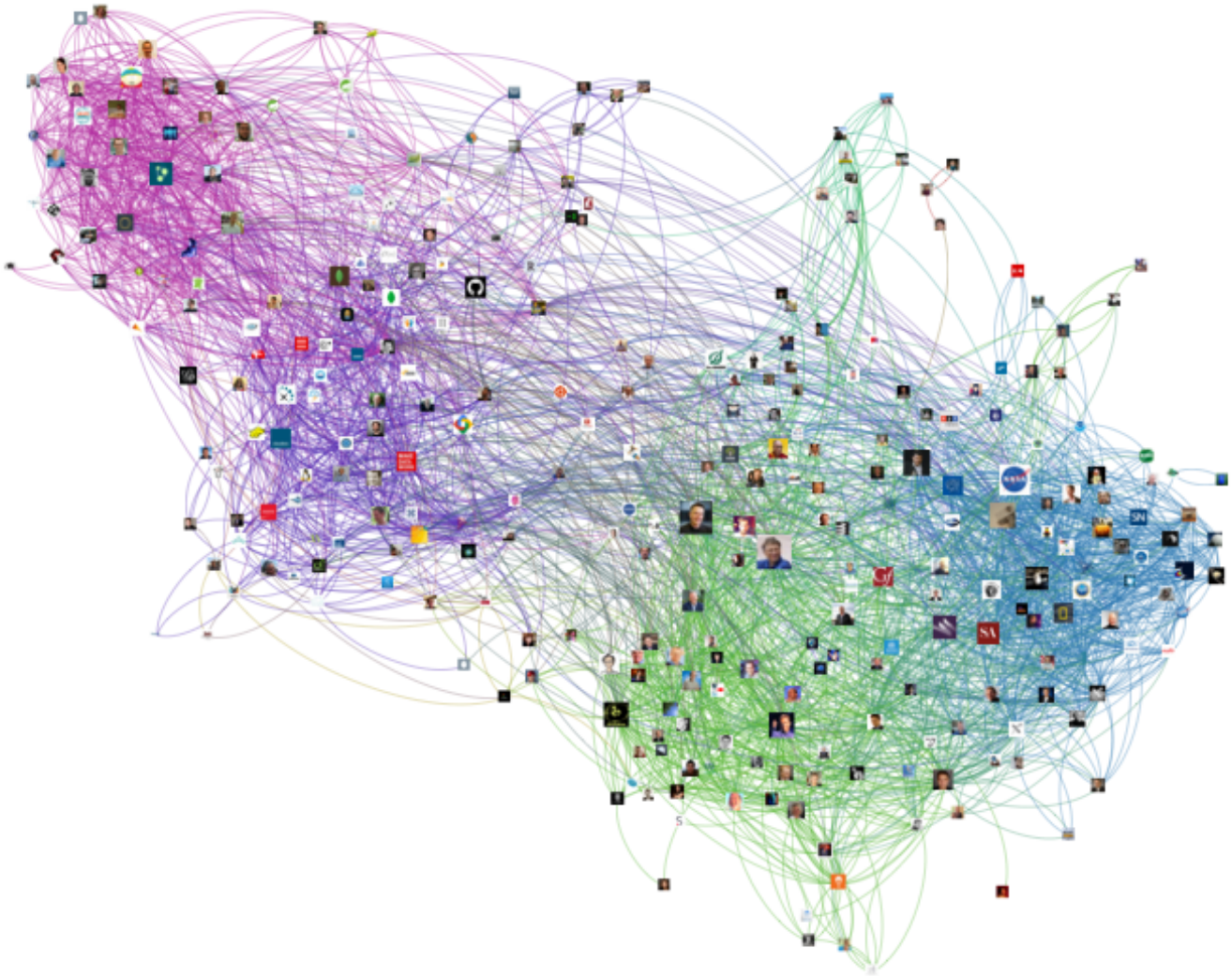
Graphs-Facebook Friends Graph



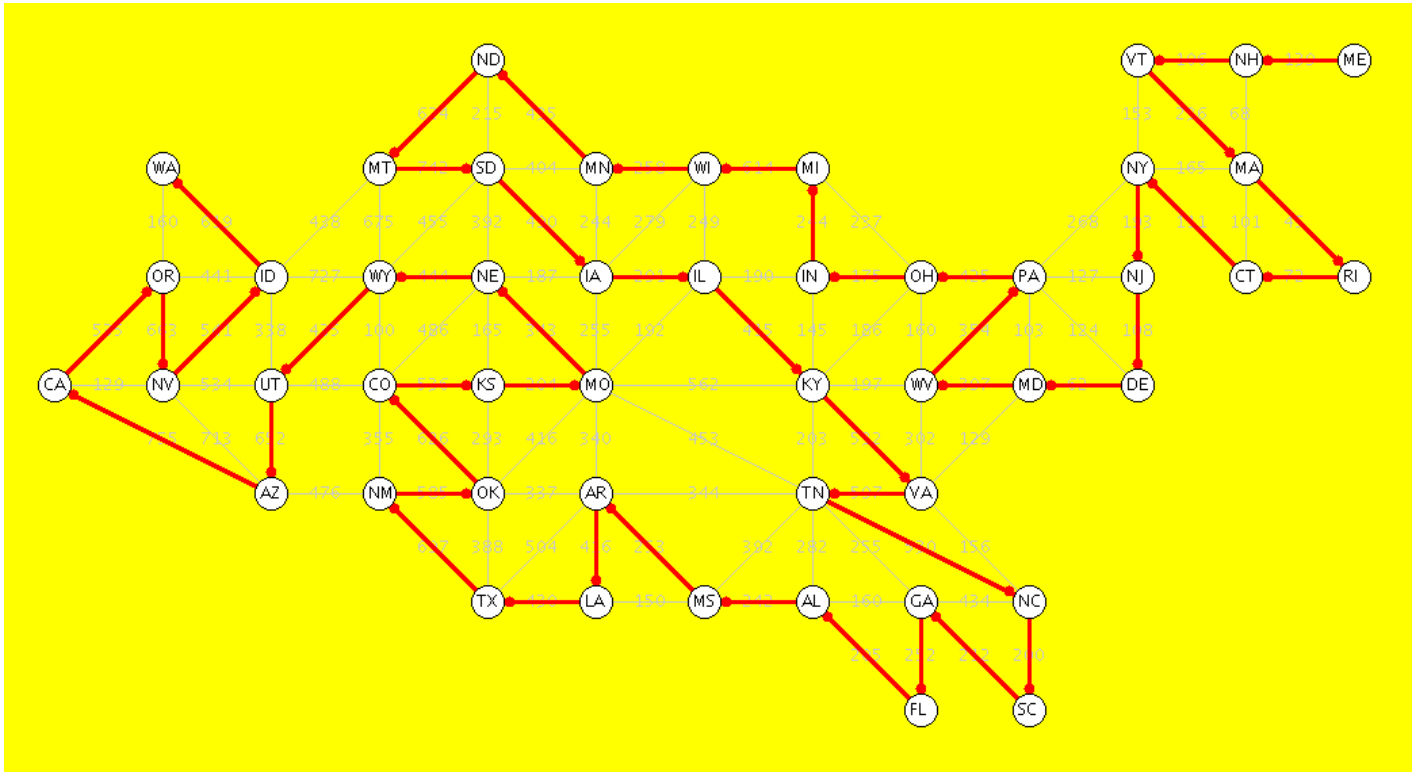
https://gephi.org

Graphs—Twitter Follower Graph

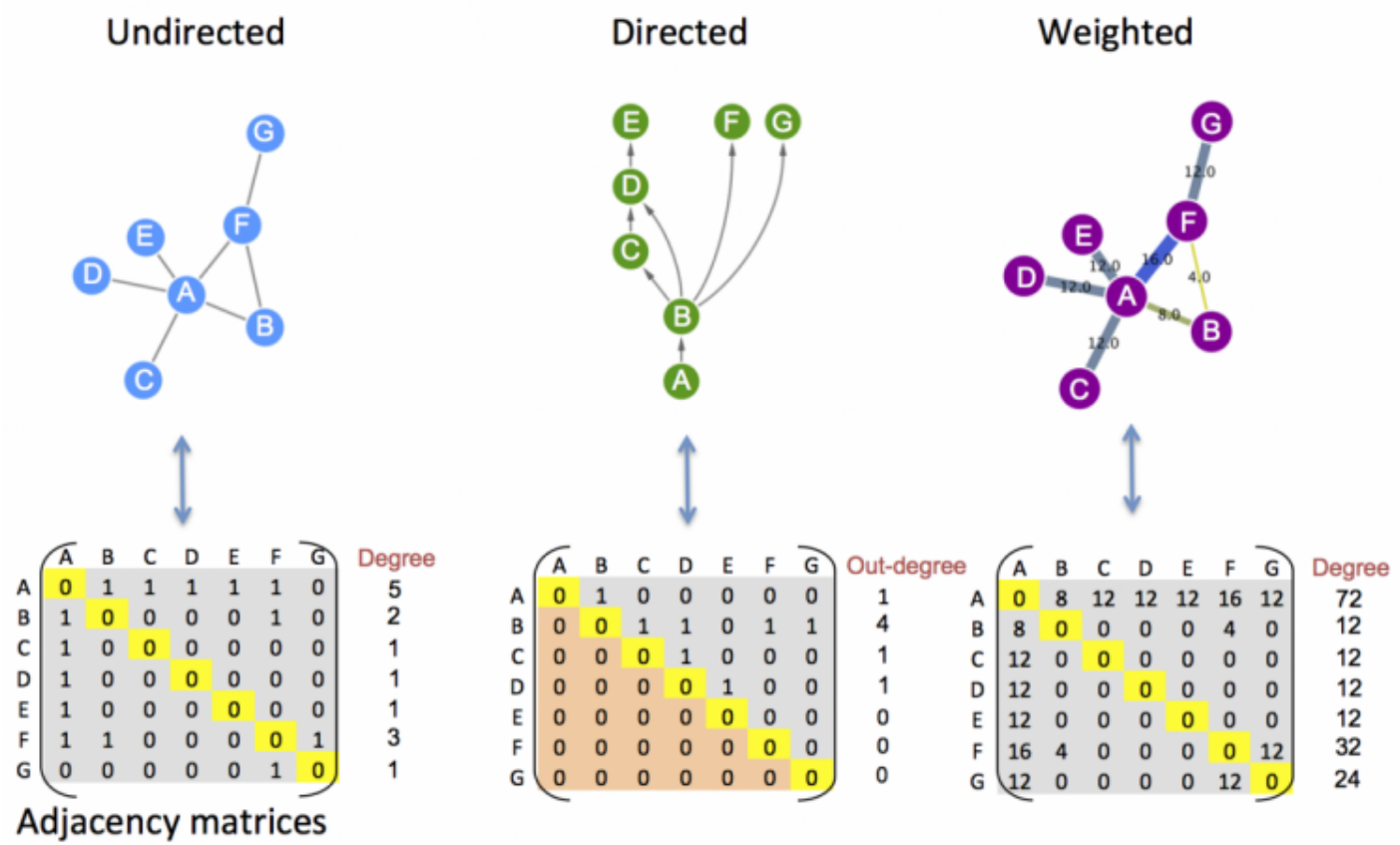


http://allthingsgraphed.com/2014/11/02/twitter-friends-network/

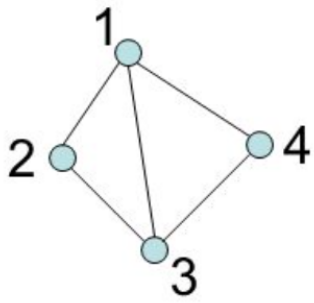
Weighted Graphs—Distance Graph



Graph: Adjacency Matrix

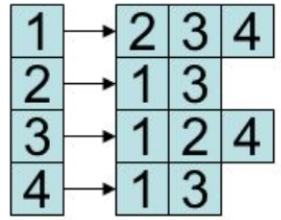


Graph: Adjacency List



	1	2	3	4
1	0	1	1	1
2	1	0	1	0
3	1	1	0	1
4	1	0	1	0

Adjacency matrix



Adjacency list

- Adjacency matrix can be represented as a $2D$ array.
- Adjacency list can be represented as an array of lists.

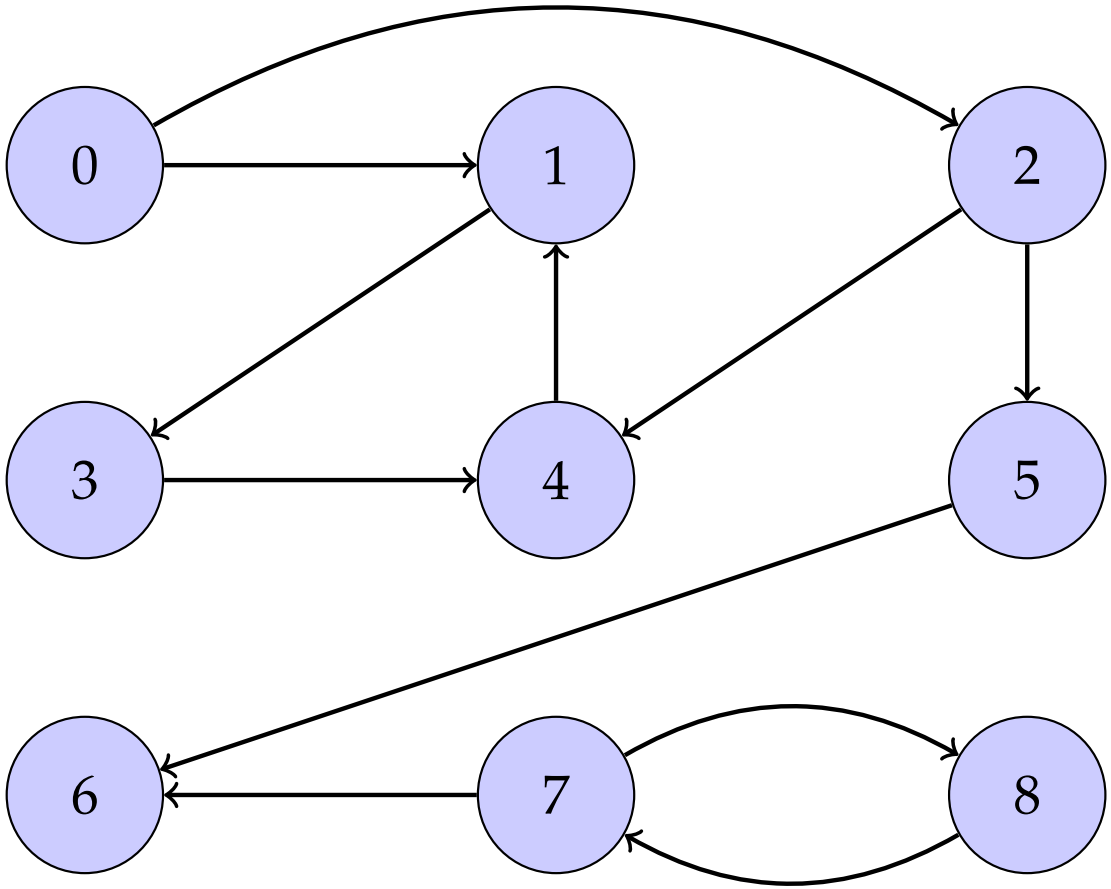
Graphs

Graph Traversal

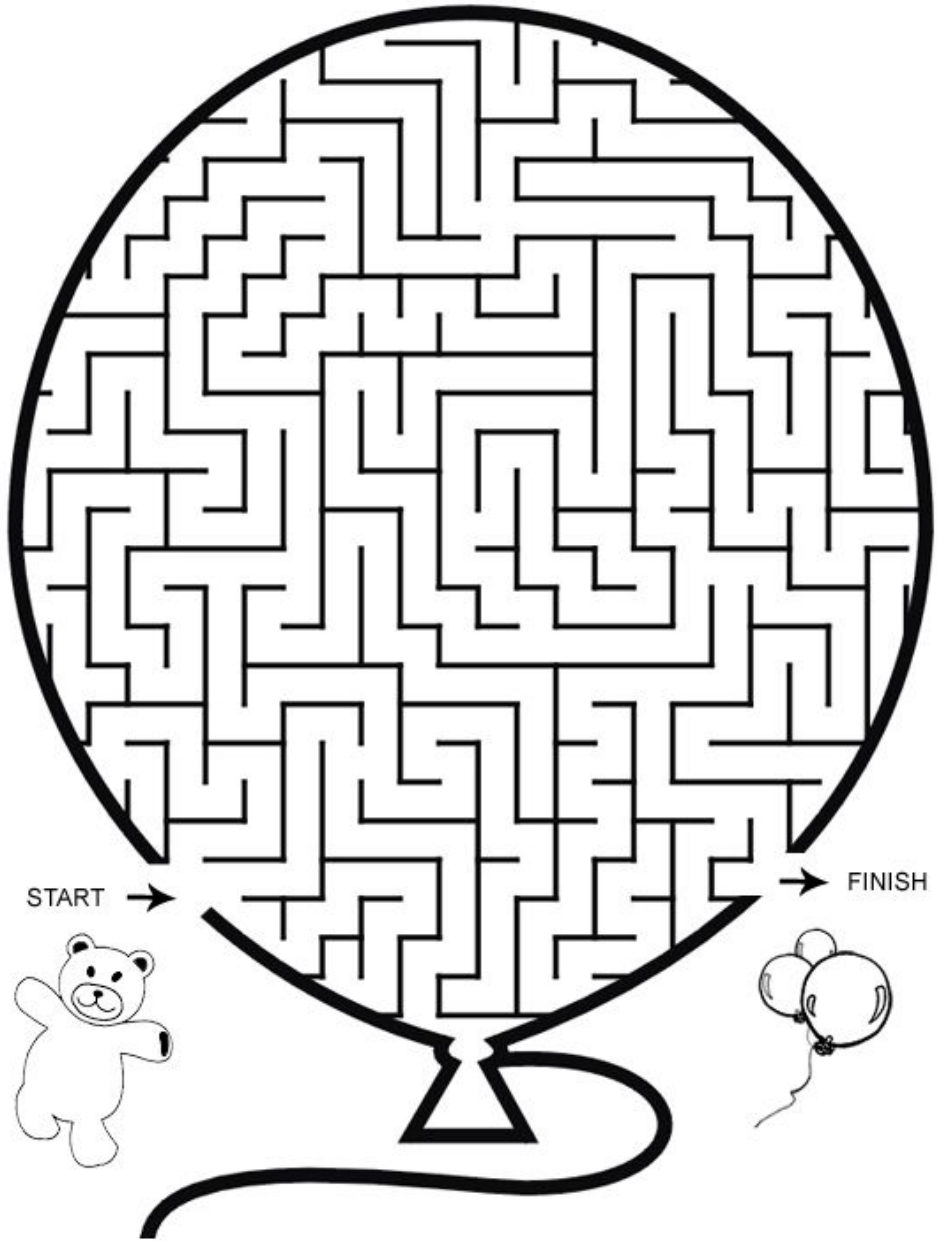
C++ Standard Template Library: Containers

Graph Traversal

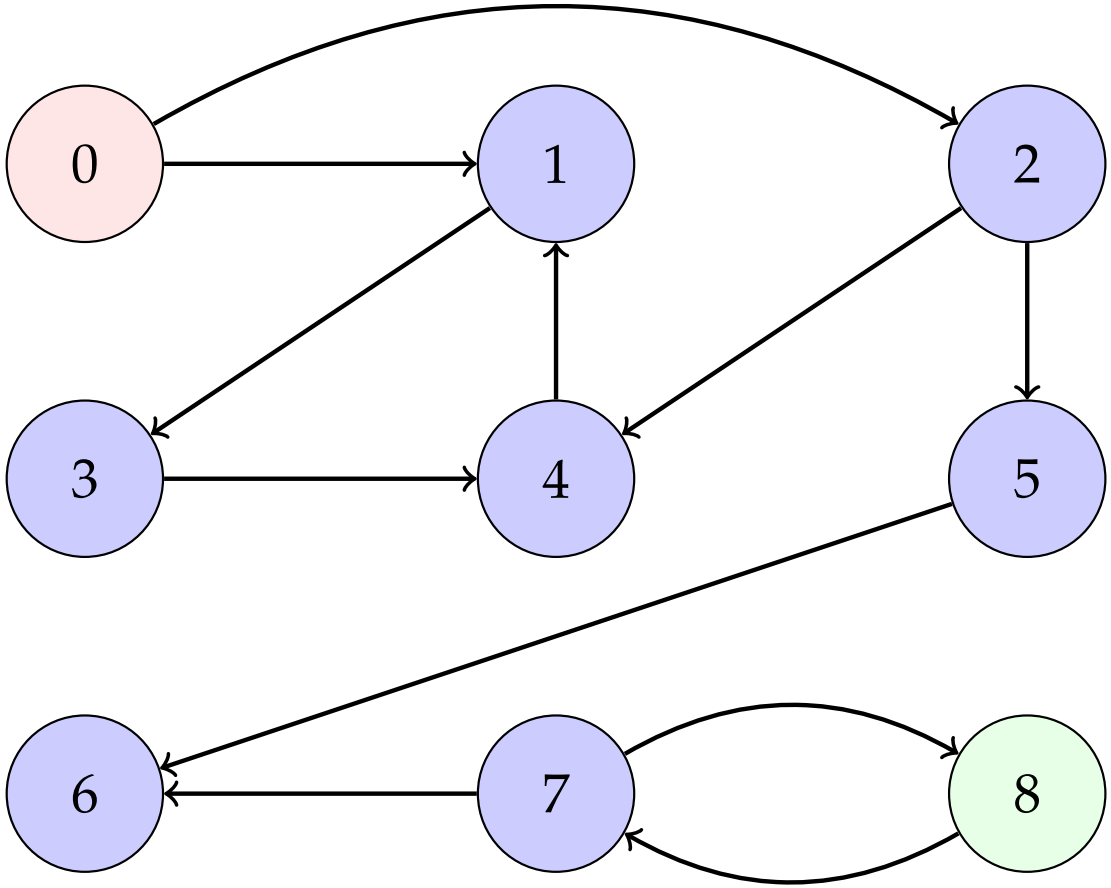
1. *Is there a sequence of edges (path) following which we can reach from s to t?*
2. *What is a shortest such path?*



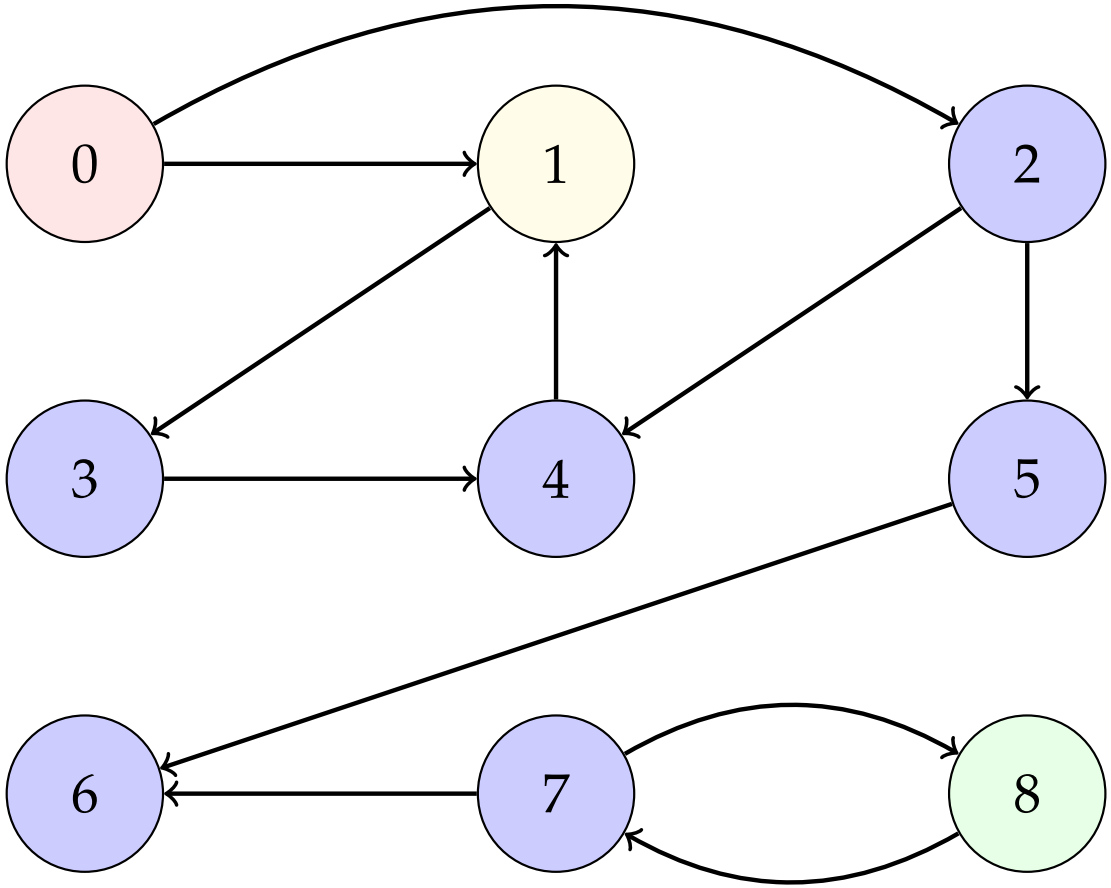
Show Benny the bear the way to his balloon



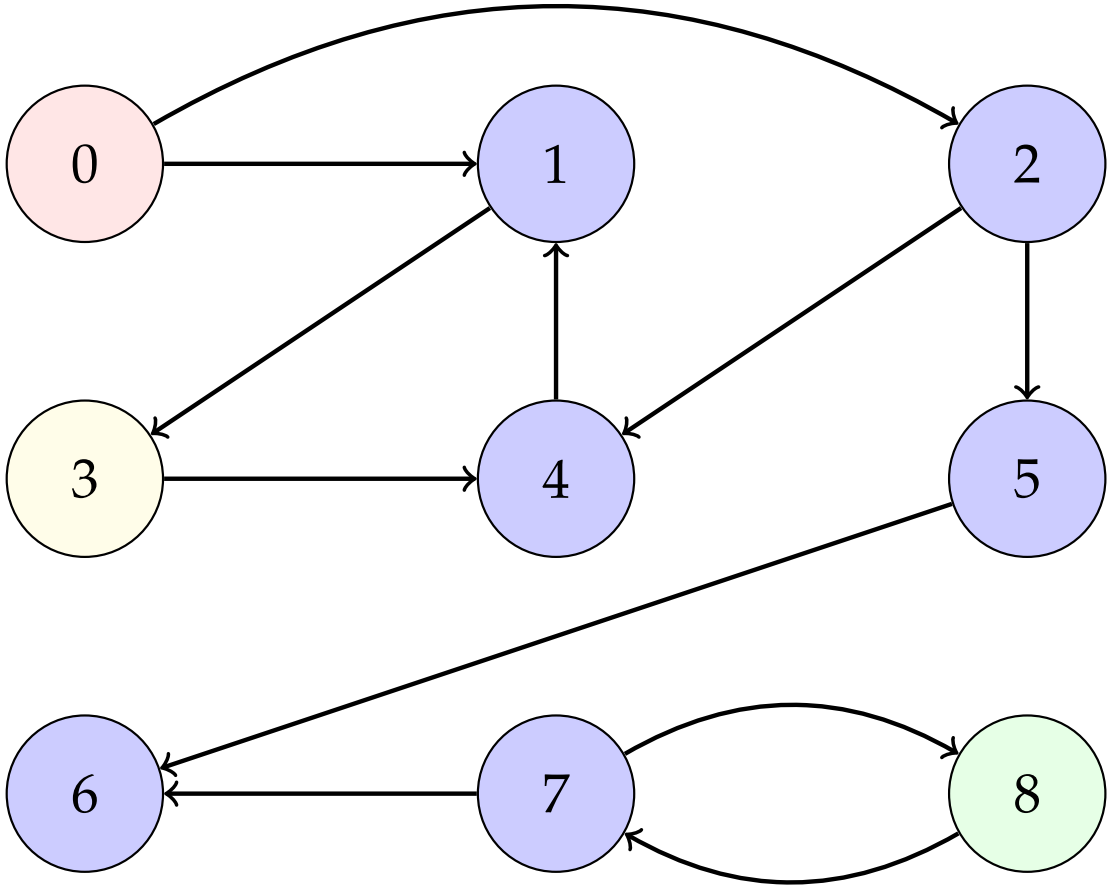
Graph Traversal: Naïve



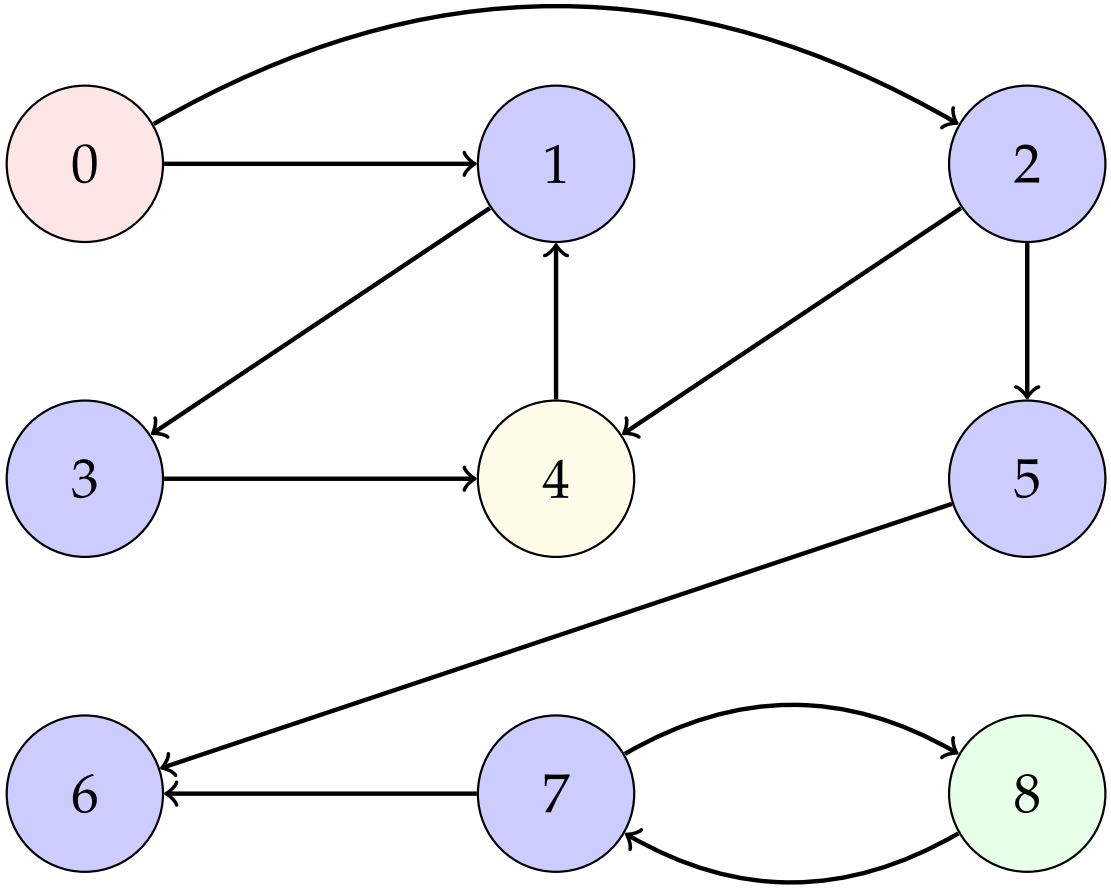
Graph Traversal: Naïve



Graph Traversal: Naïve



Graph Traversal: Naïve



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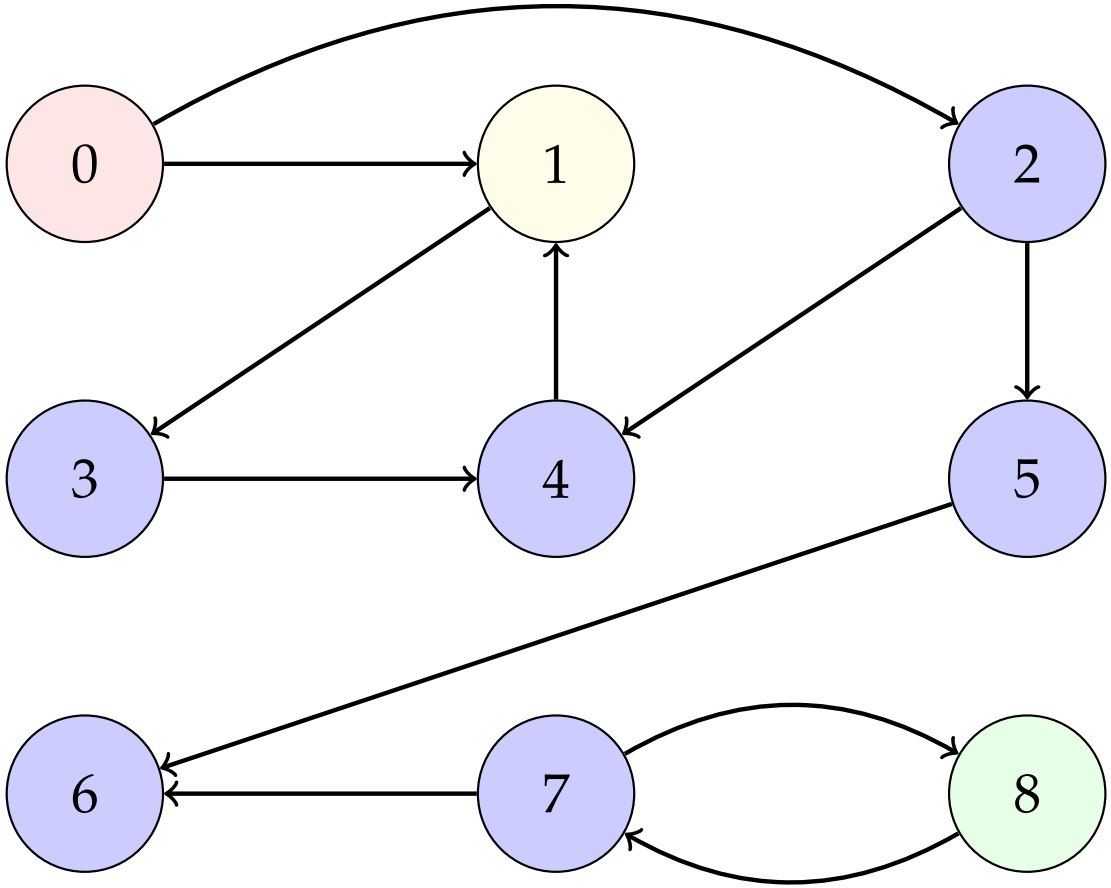

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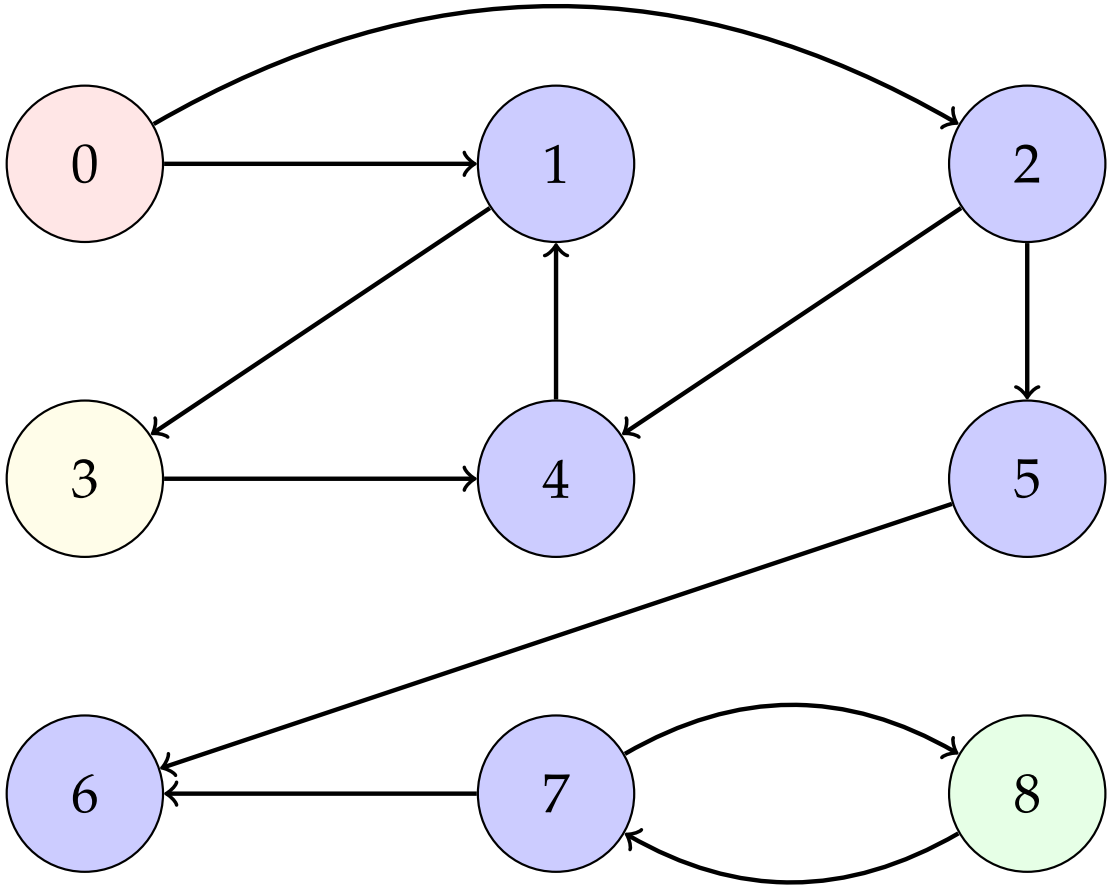

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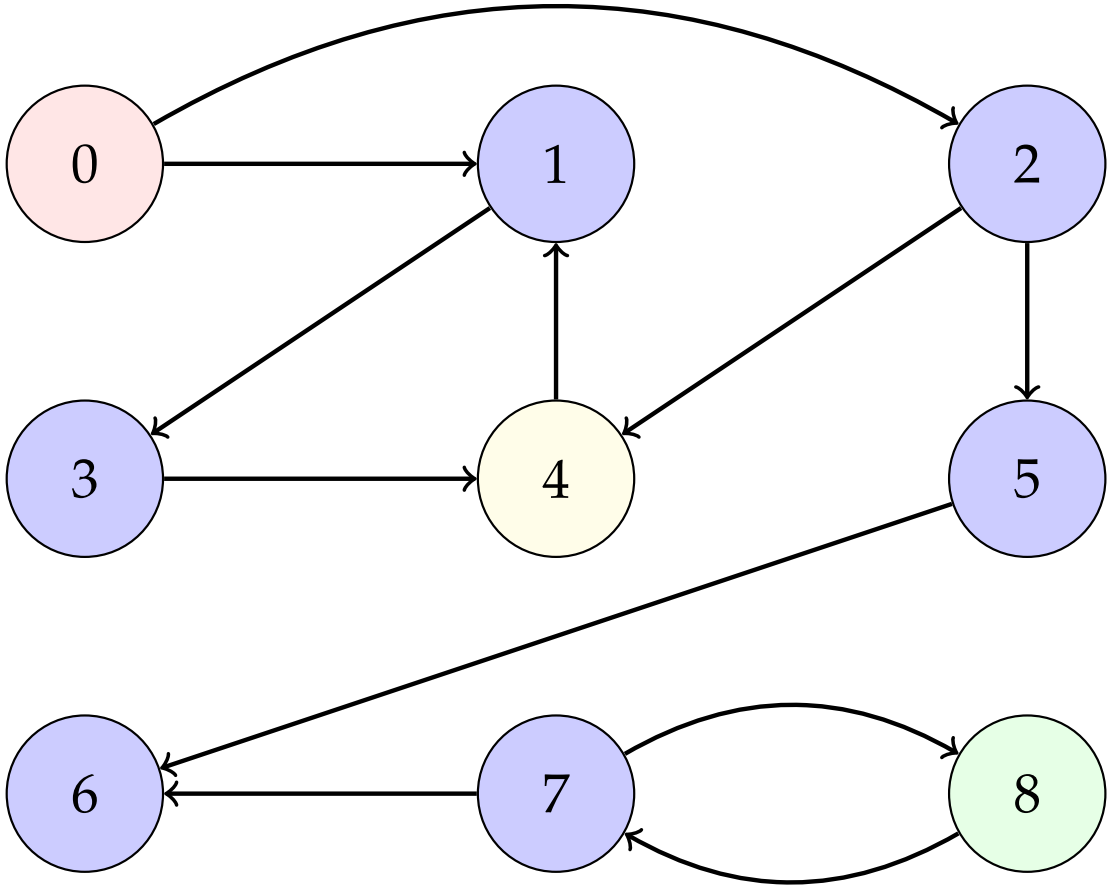

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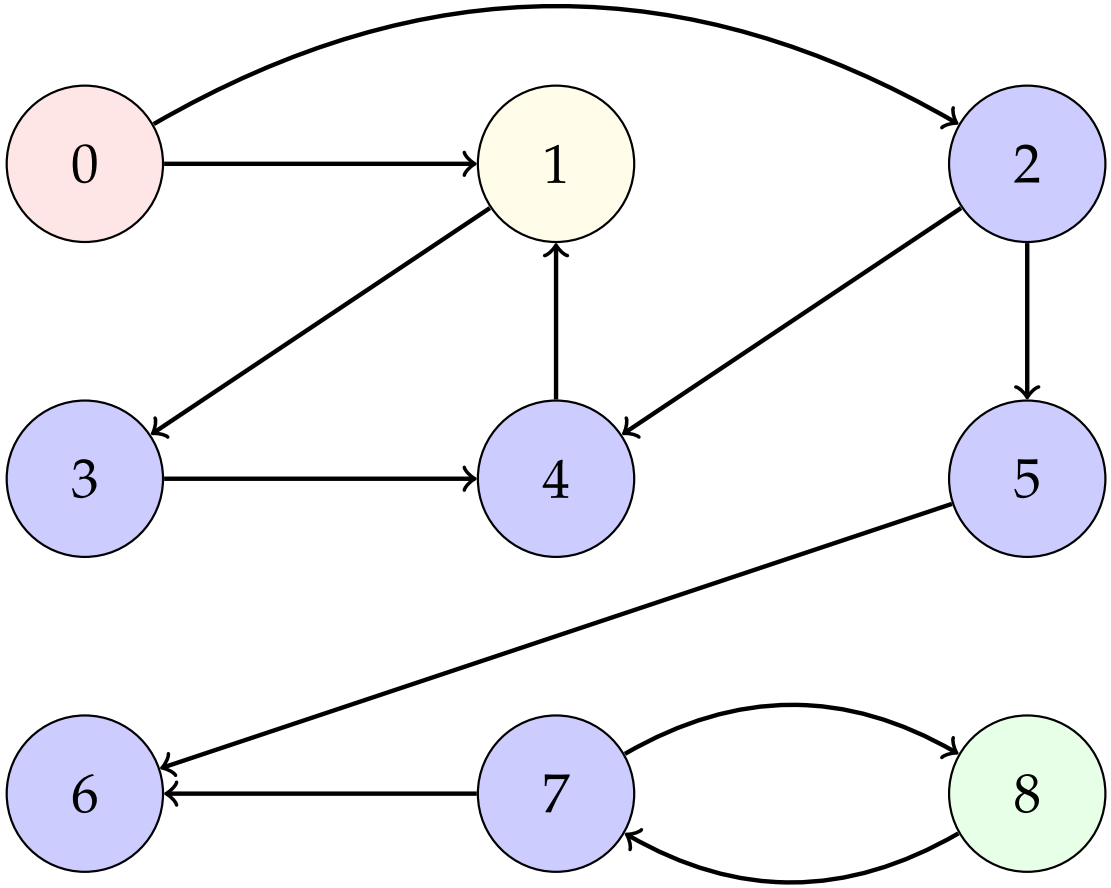
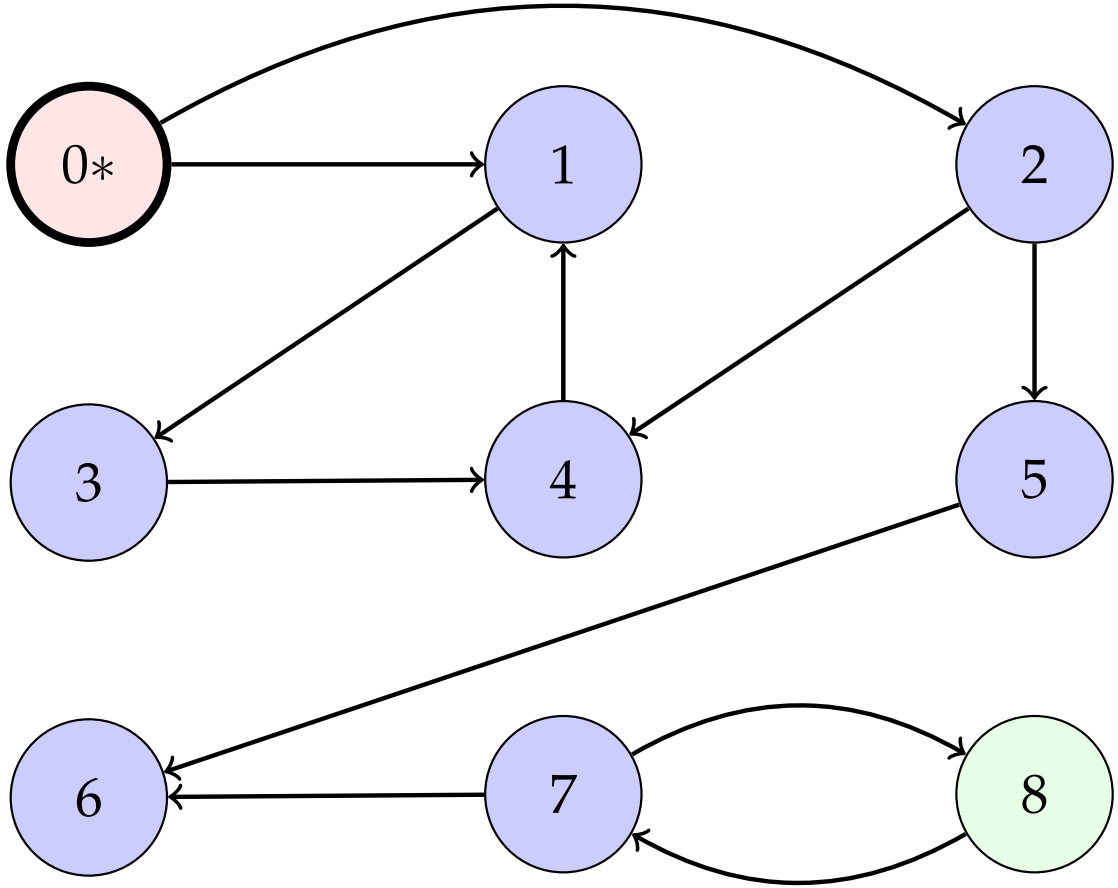


Graph Traversal: Depth-first search (DFS)

Depth-first Traversal: *Explore as far as possible along a branch before backtracking and trying another.*

Graph Traversal: Depth-first search (DFS)



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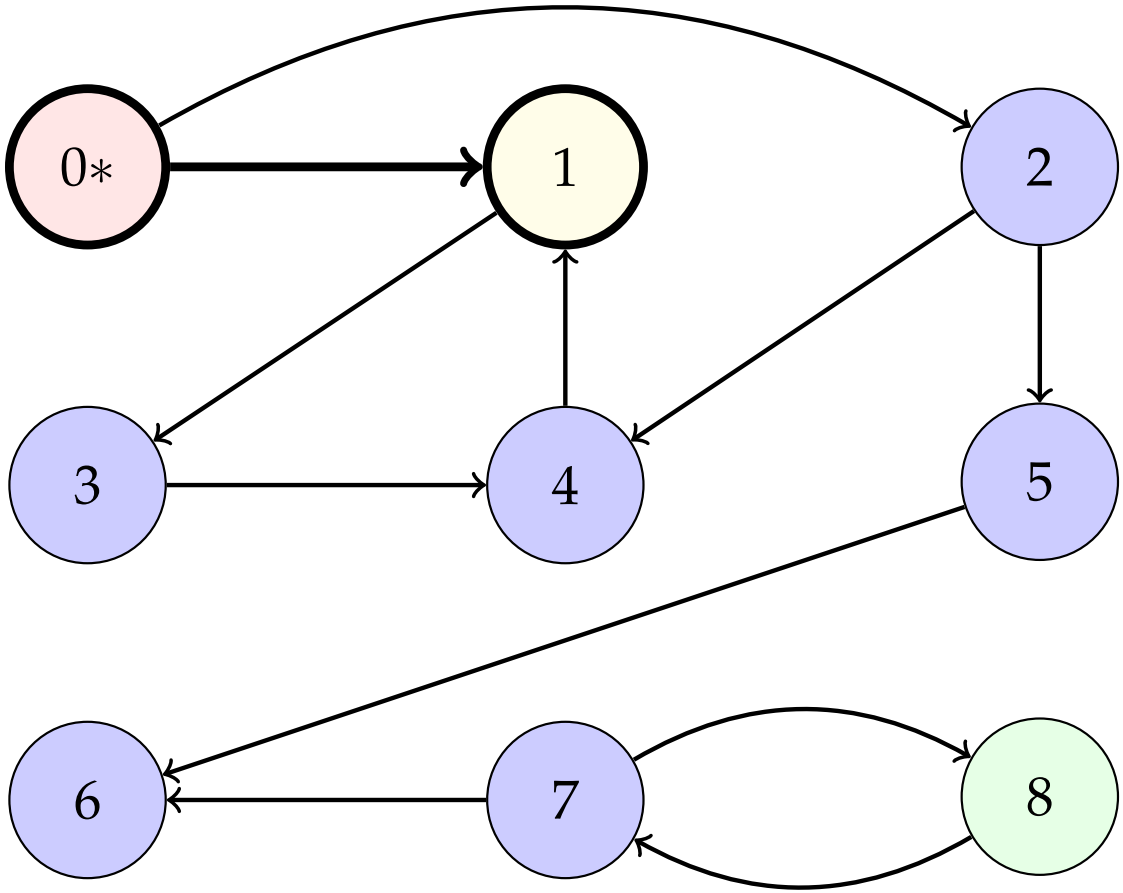

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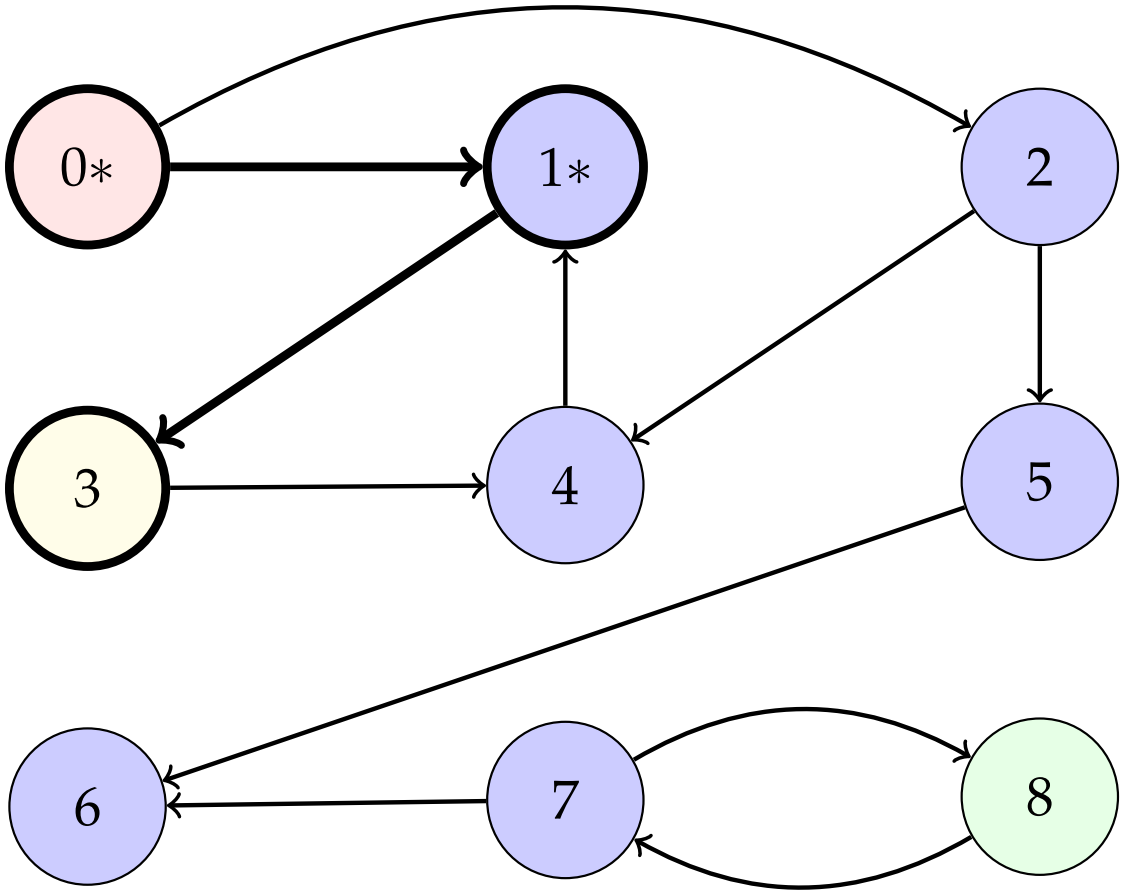

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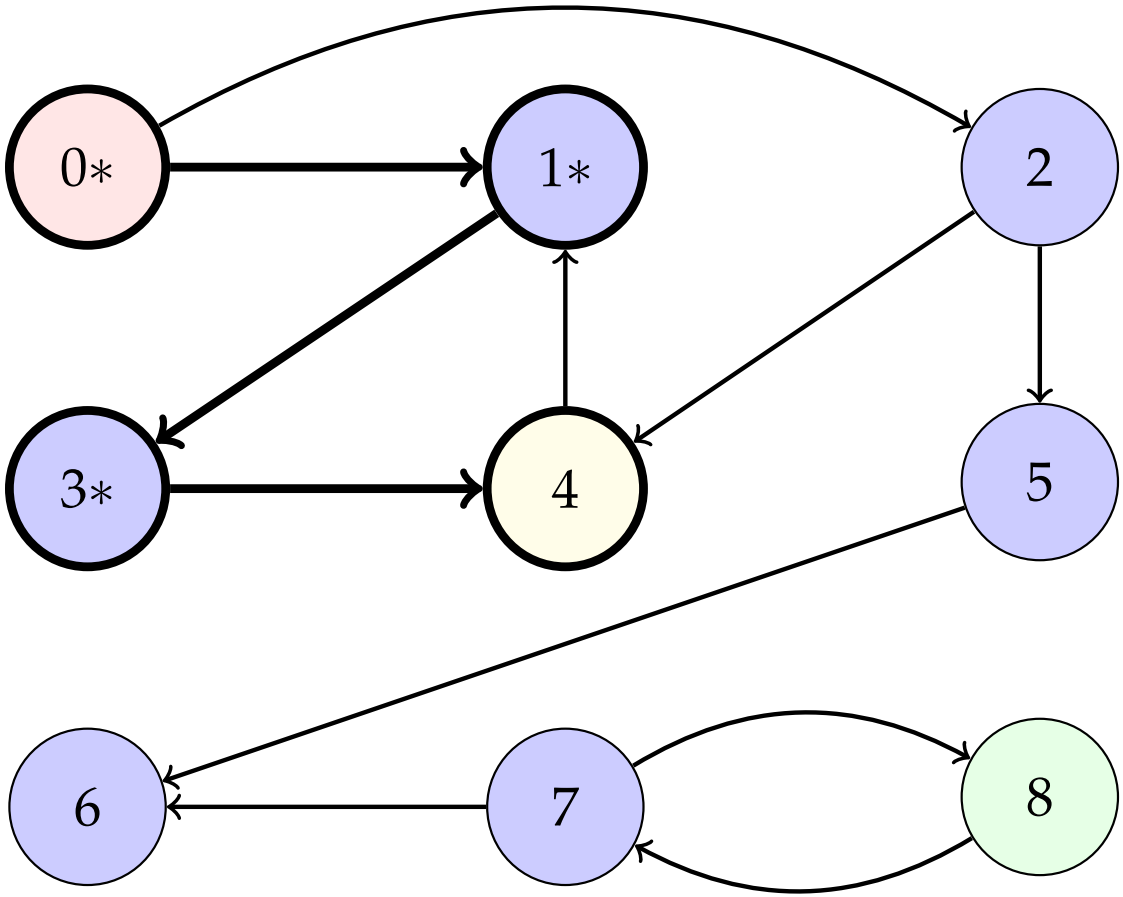

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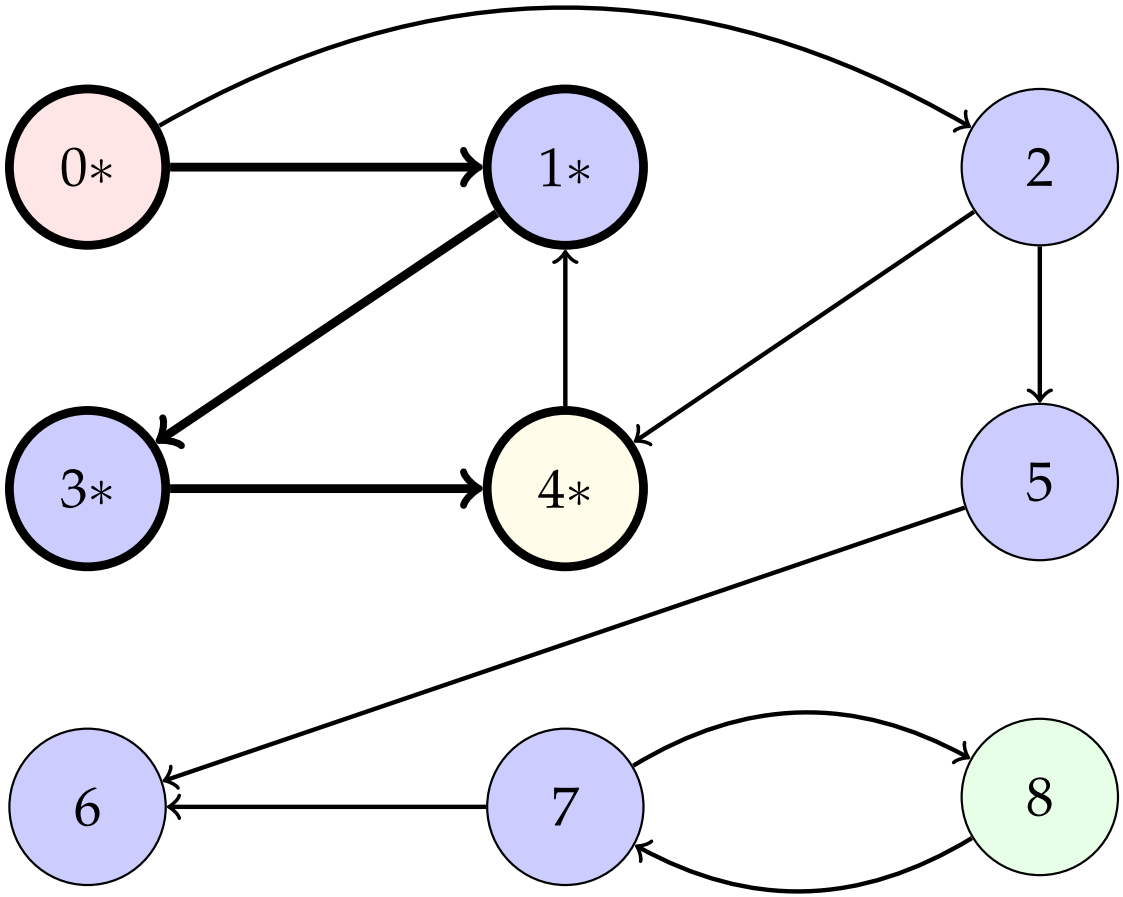

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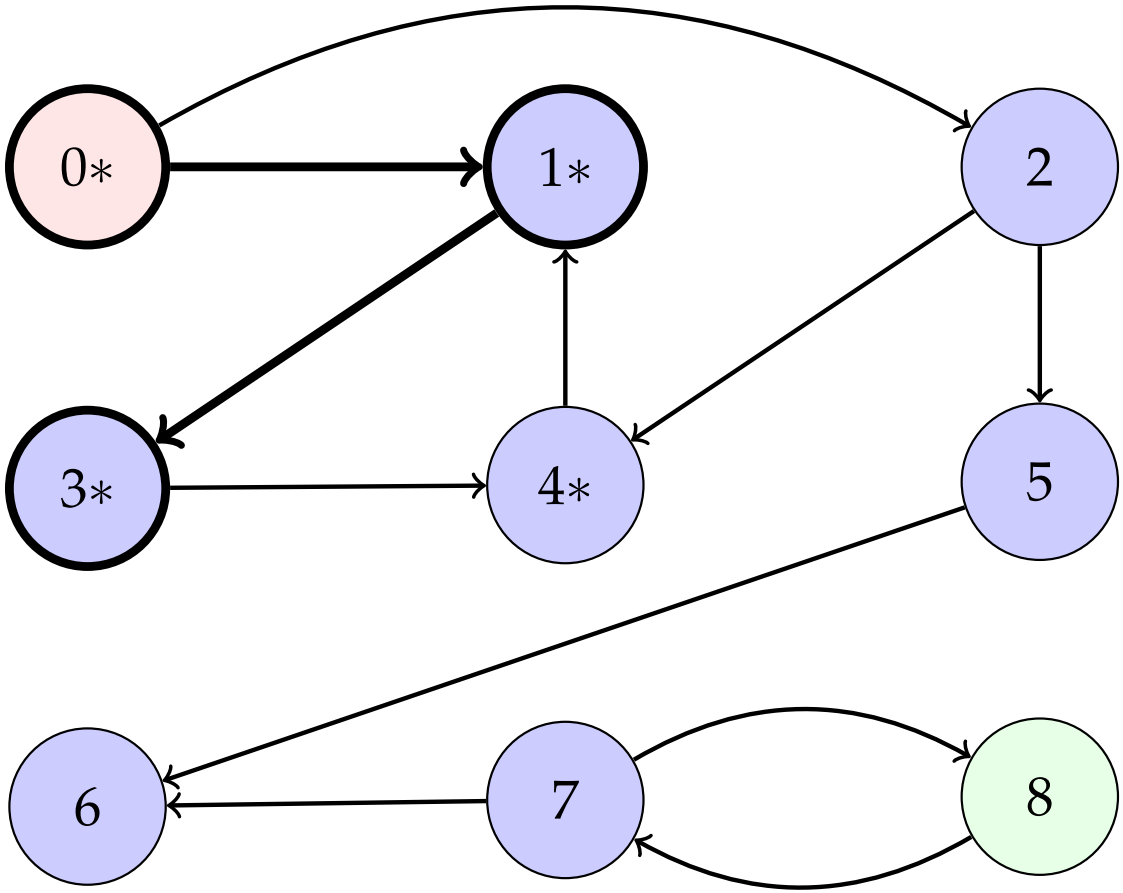

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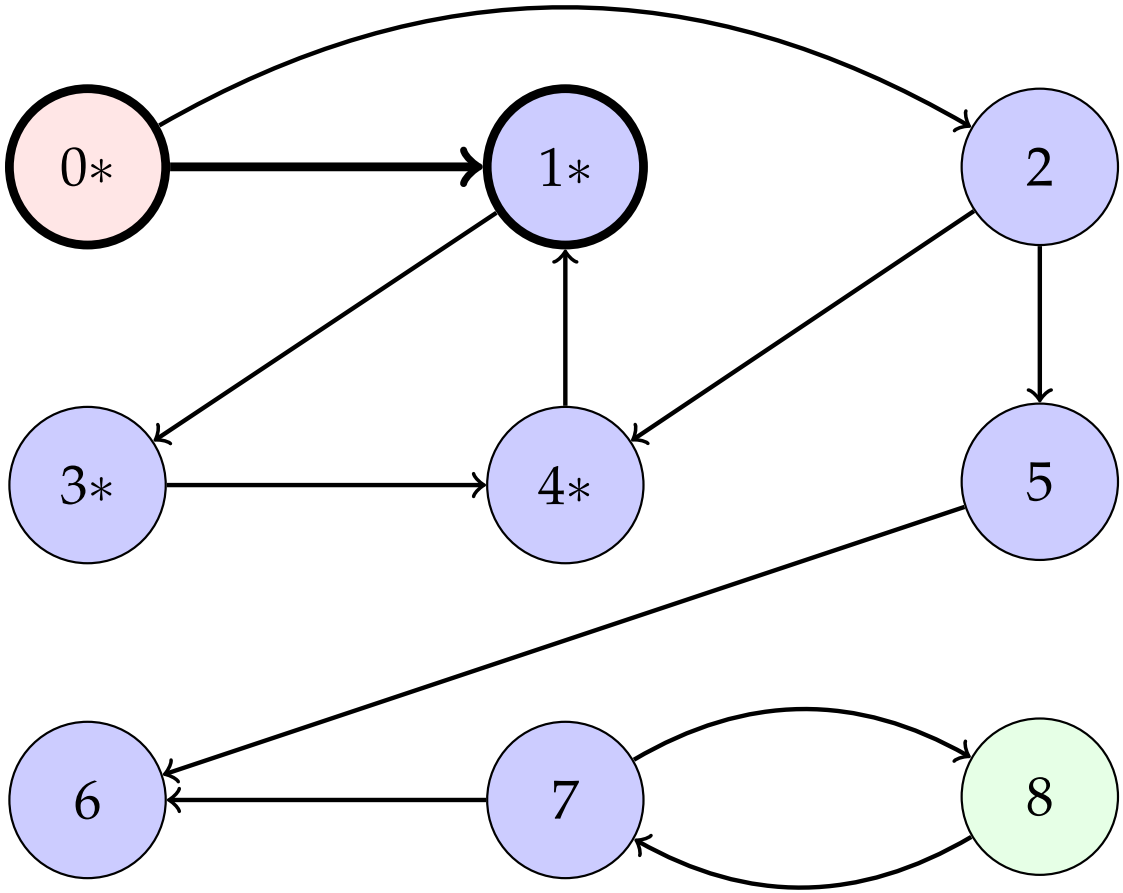

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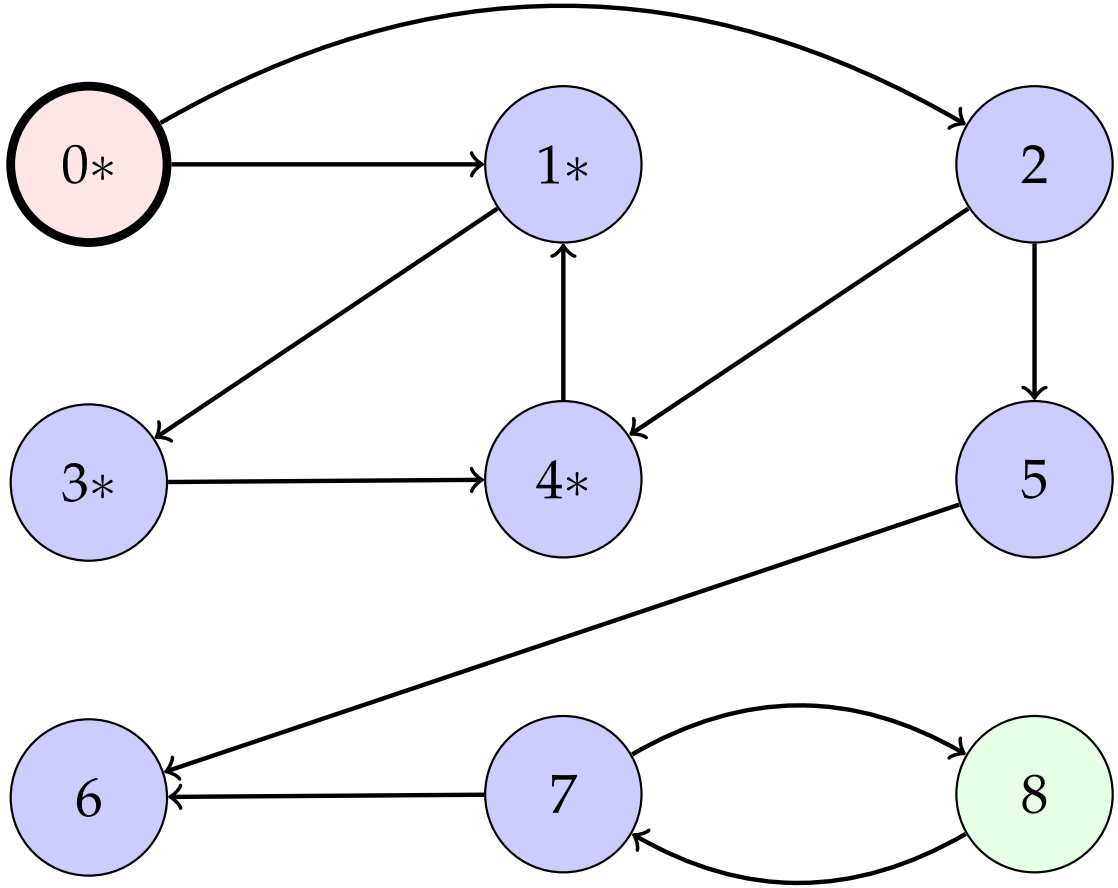

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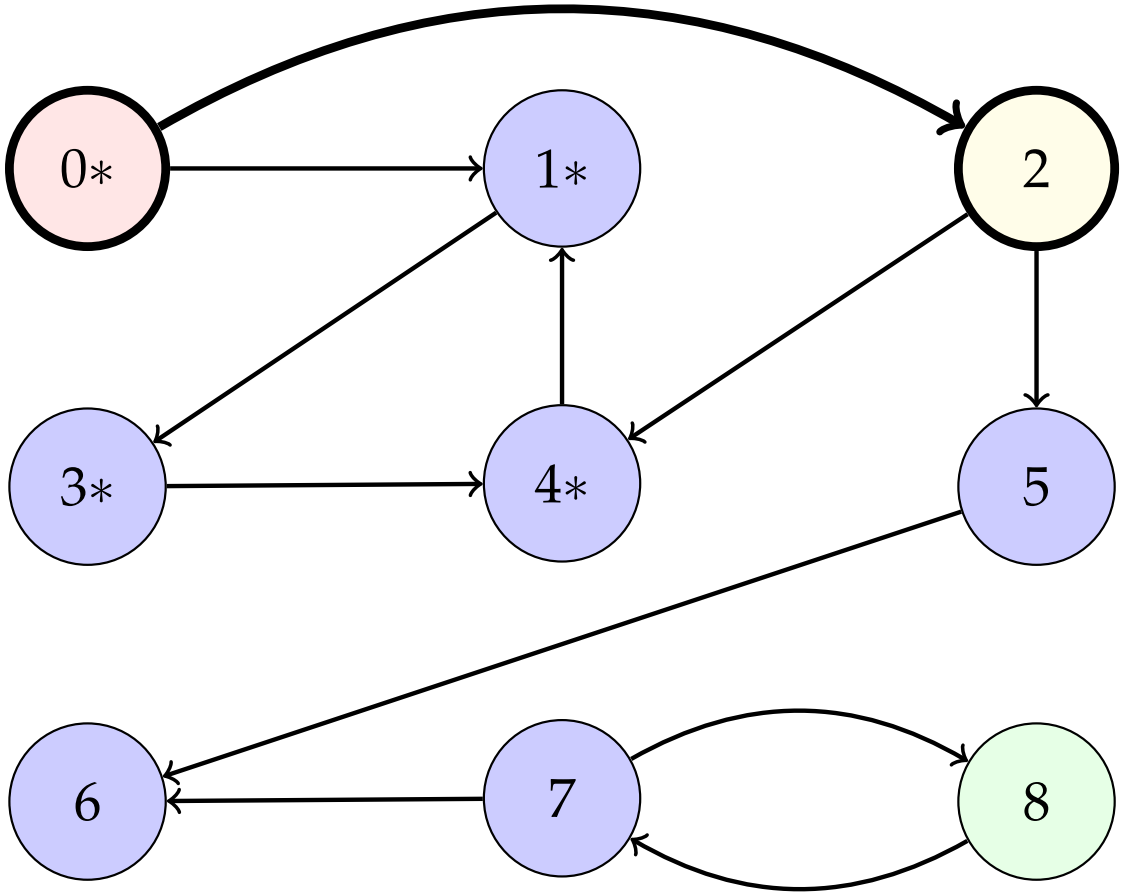
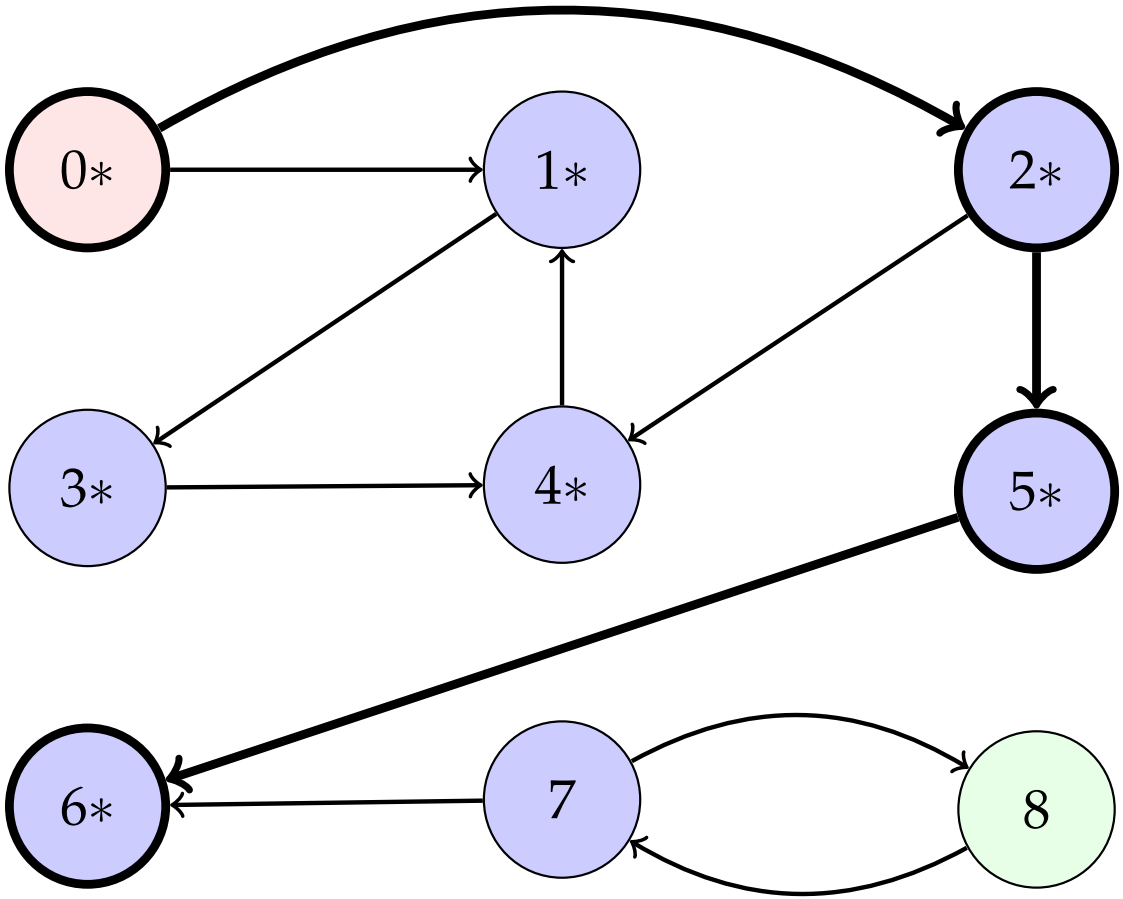
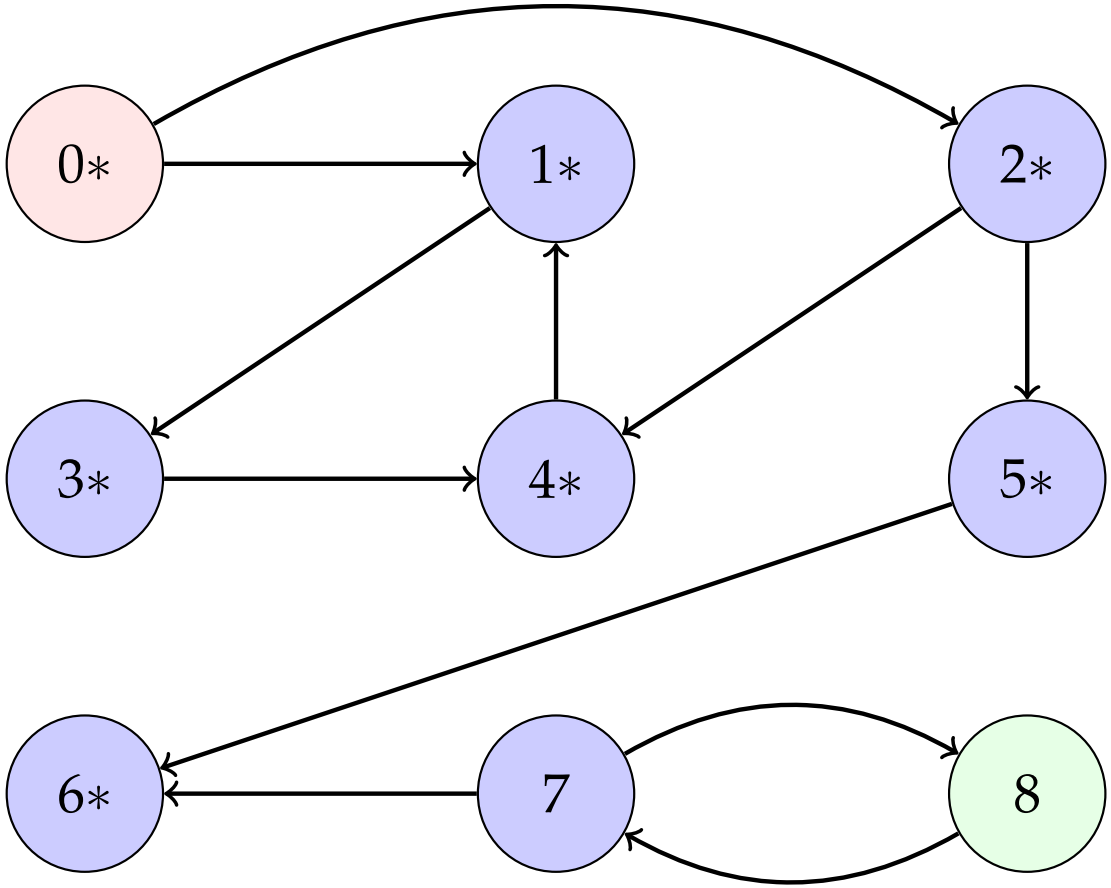


Graph Traversal: Depth-first search (DFS)



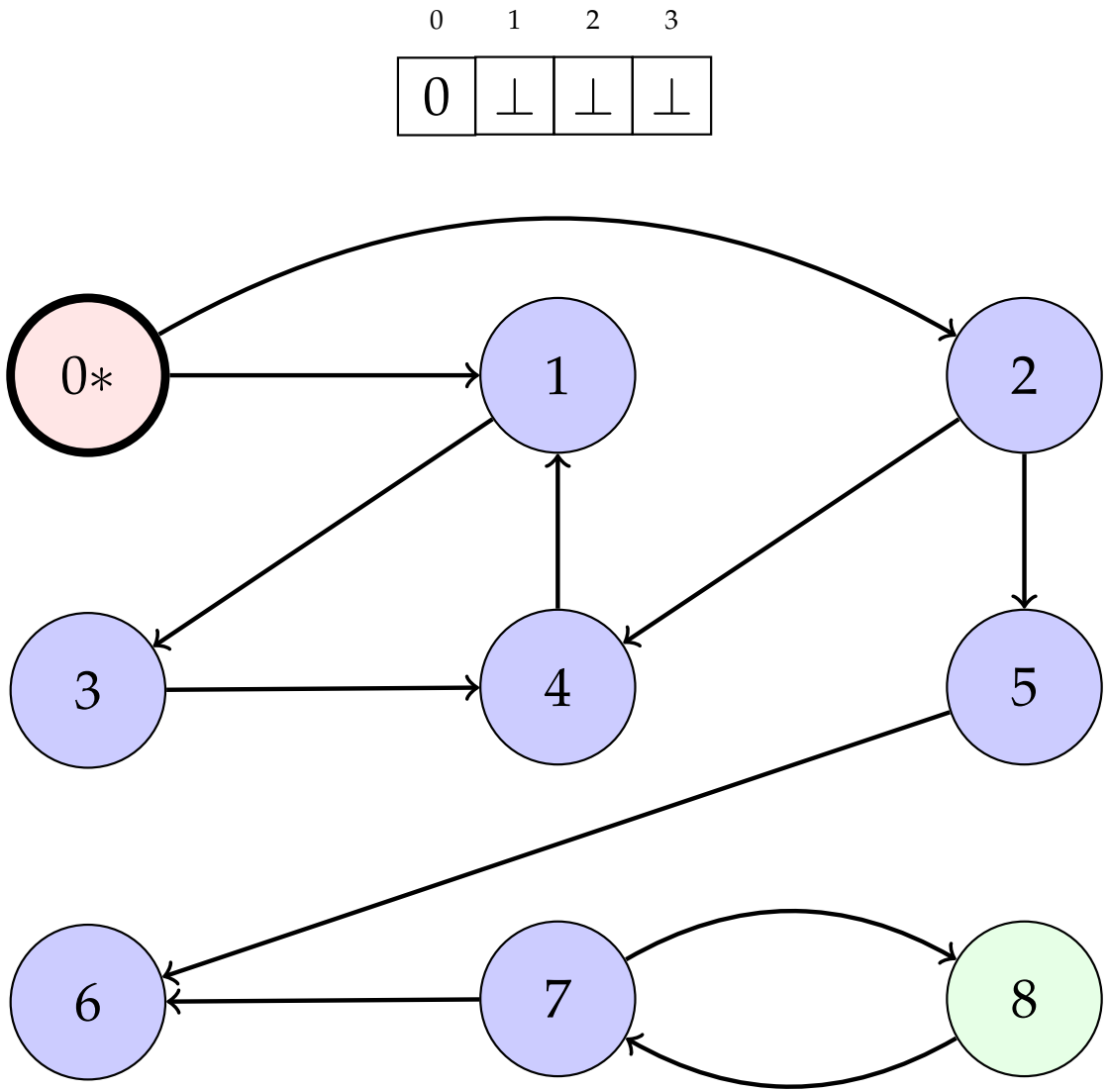
Graph Traversal: Depth-first search (DFS)



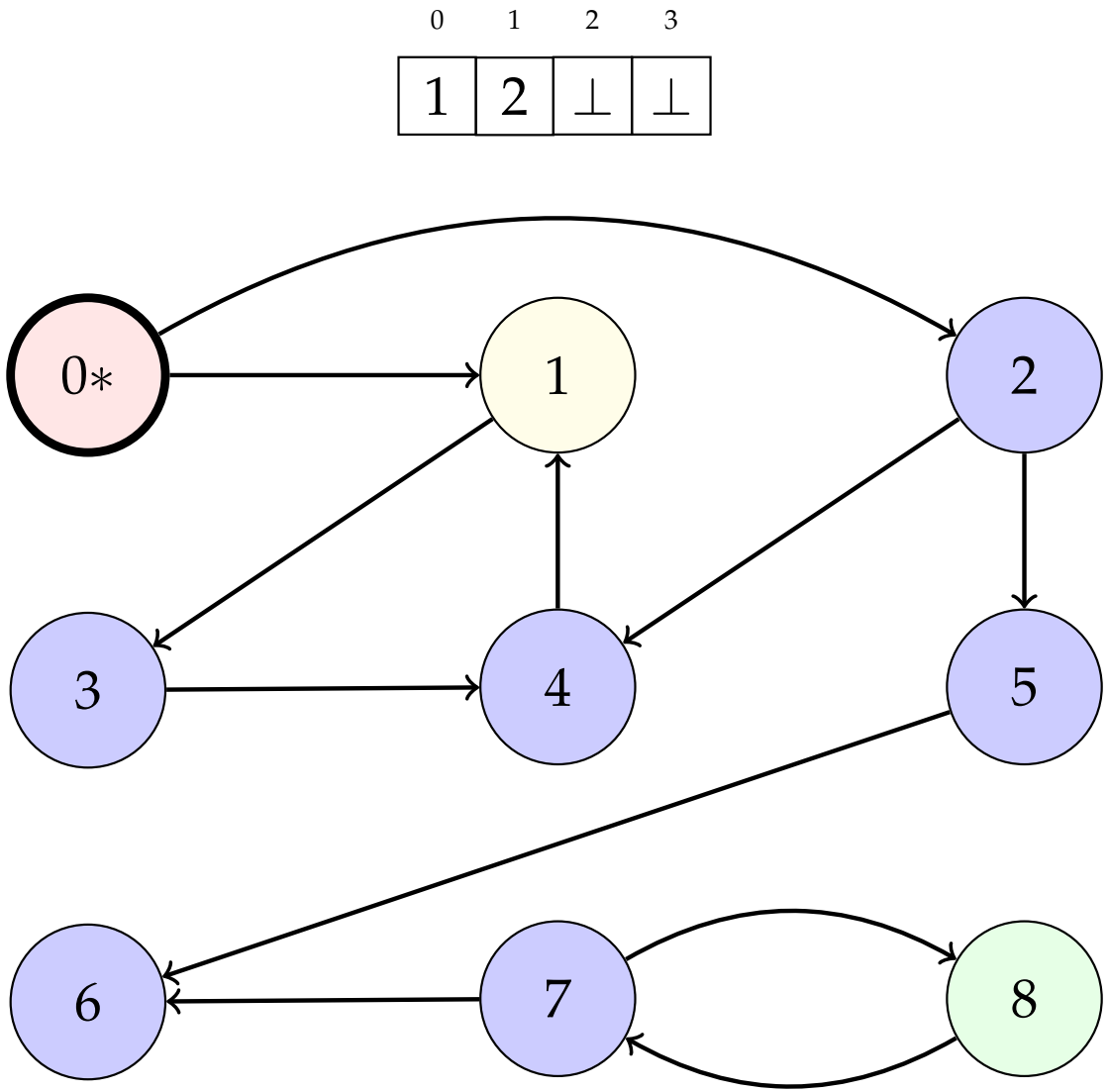
Graph Traversal: Breadth-first search (BFS)

Breadth-first Traversal: *Explore all nodes at a level (distance form the root) before visiting nodes at a greater level.*

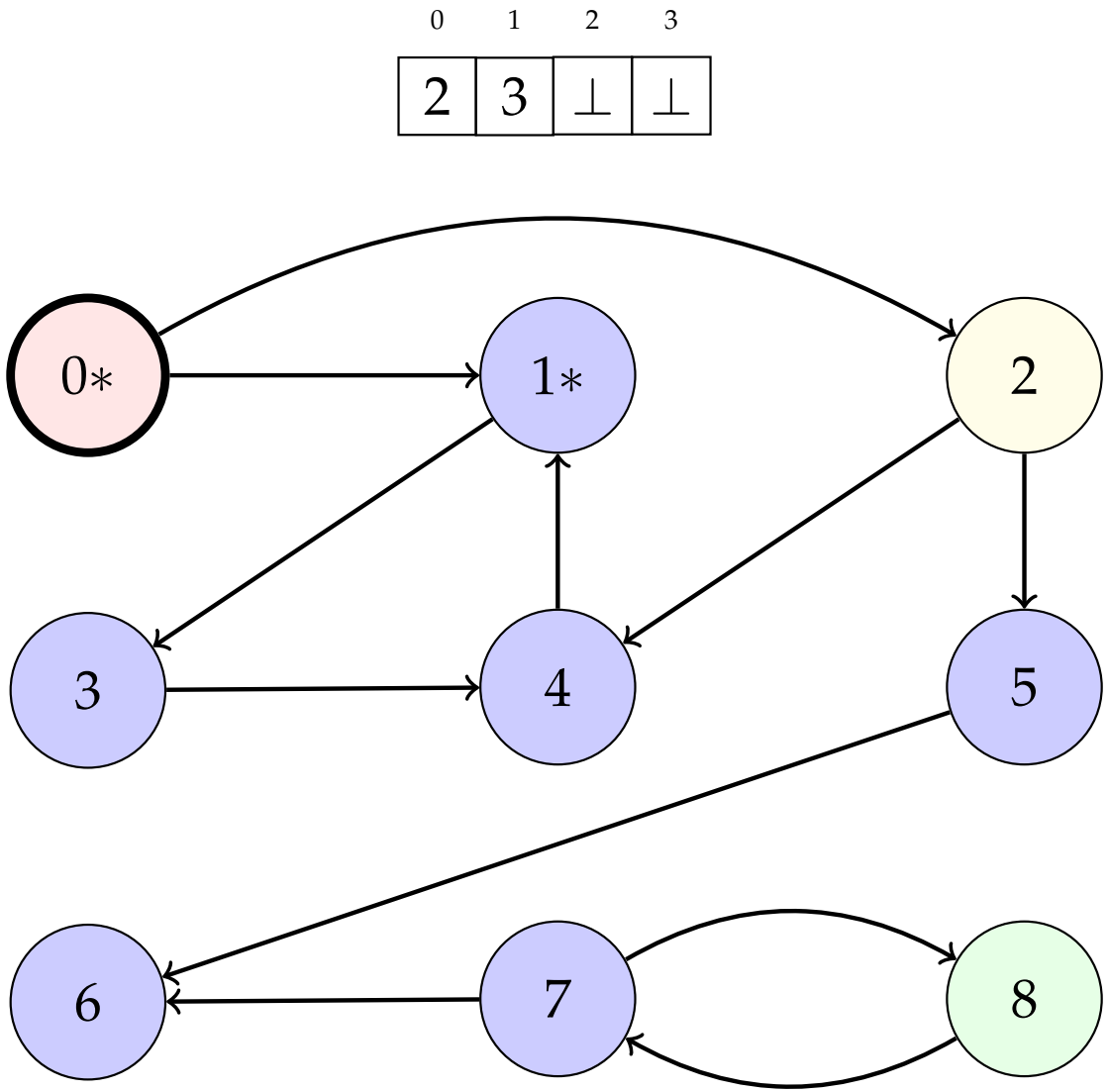
Graph Traversal: Breadth-first search (DFS)



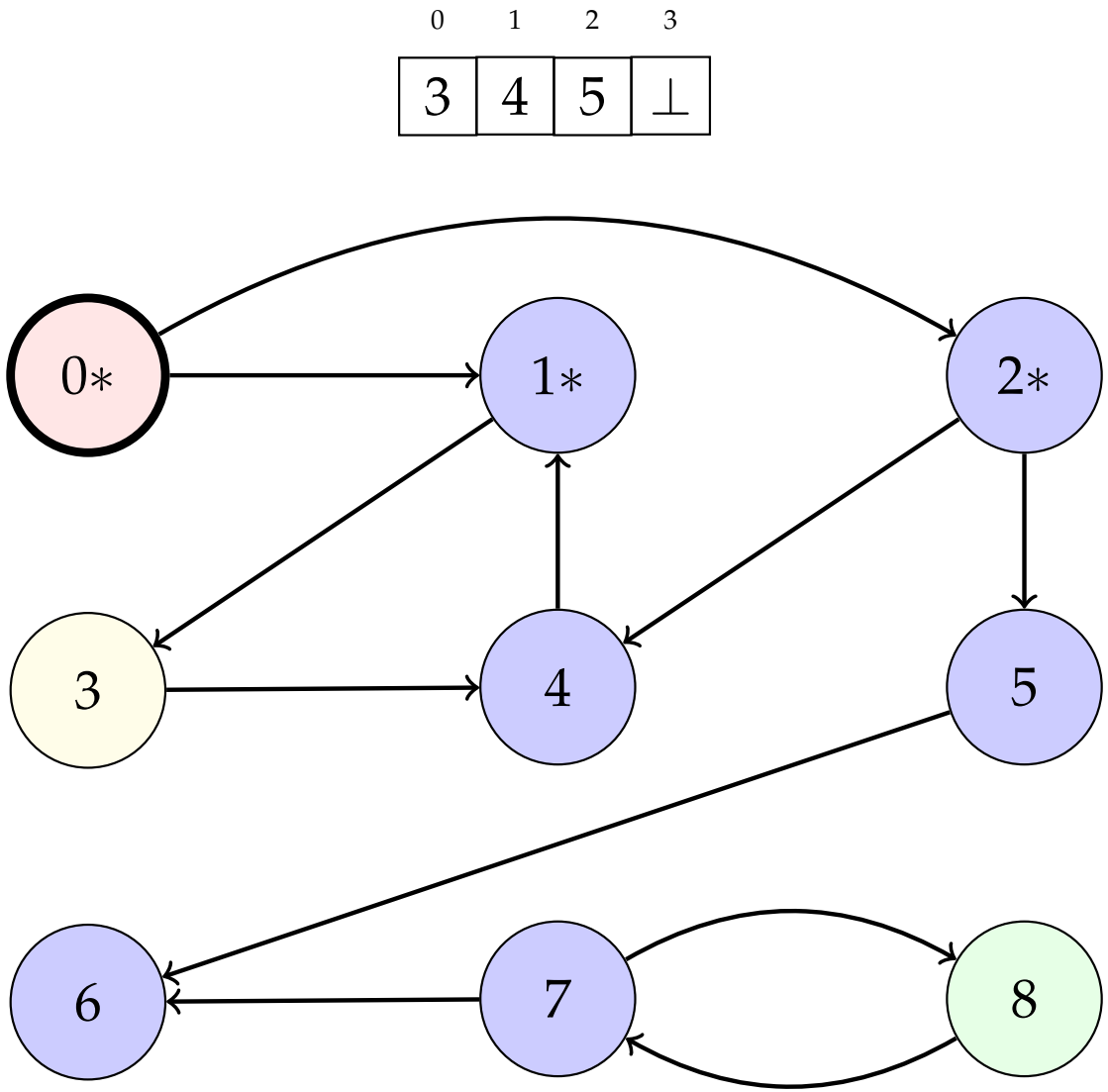
Graph Traversal: Breadth-first search (DFS)



Graph Traversal: Breadth-first search (DFS)



Graph Traversal: Breadth-first search (DFS)



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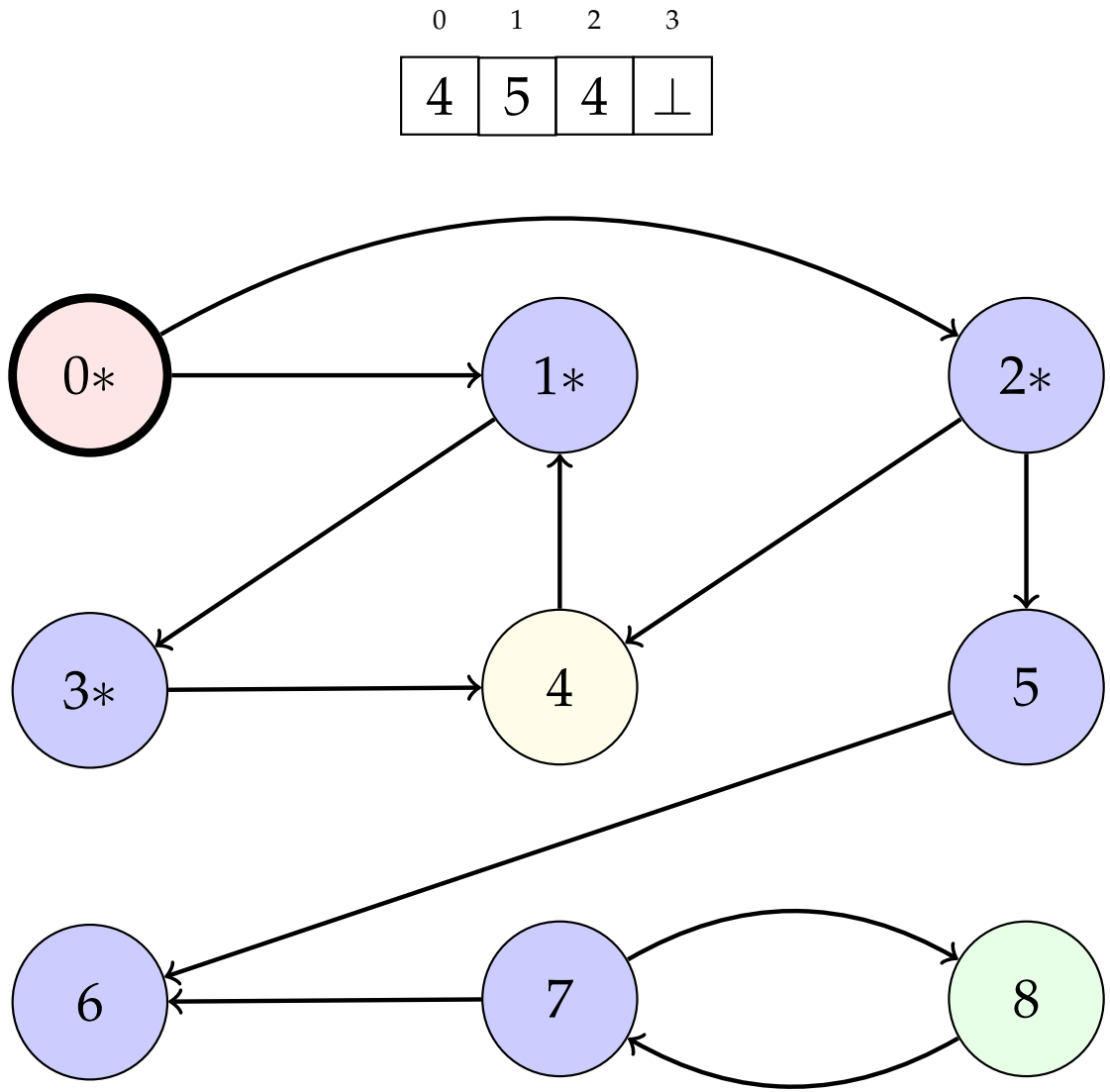

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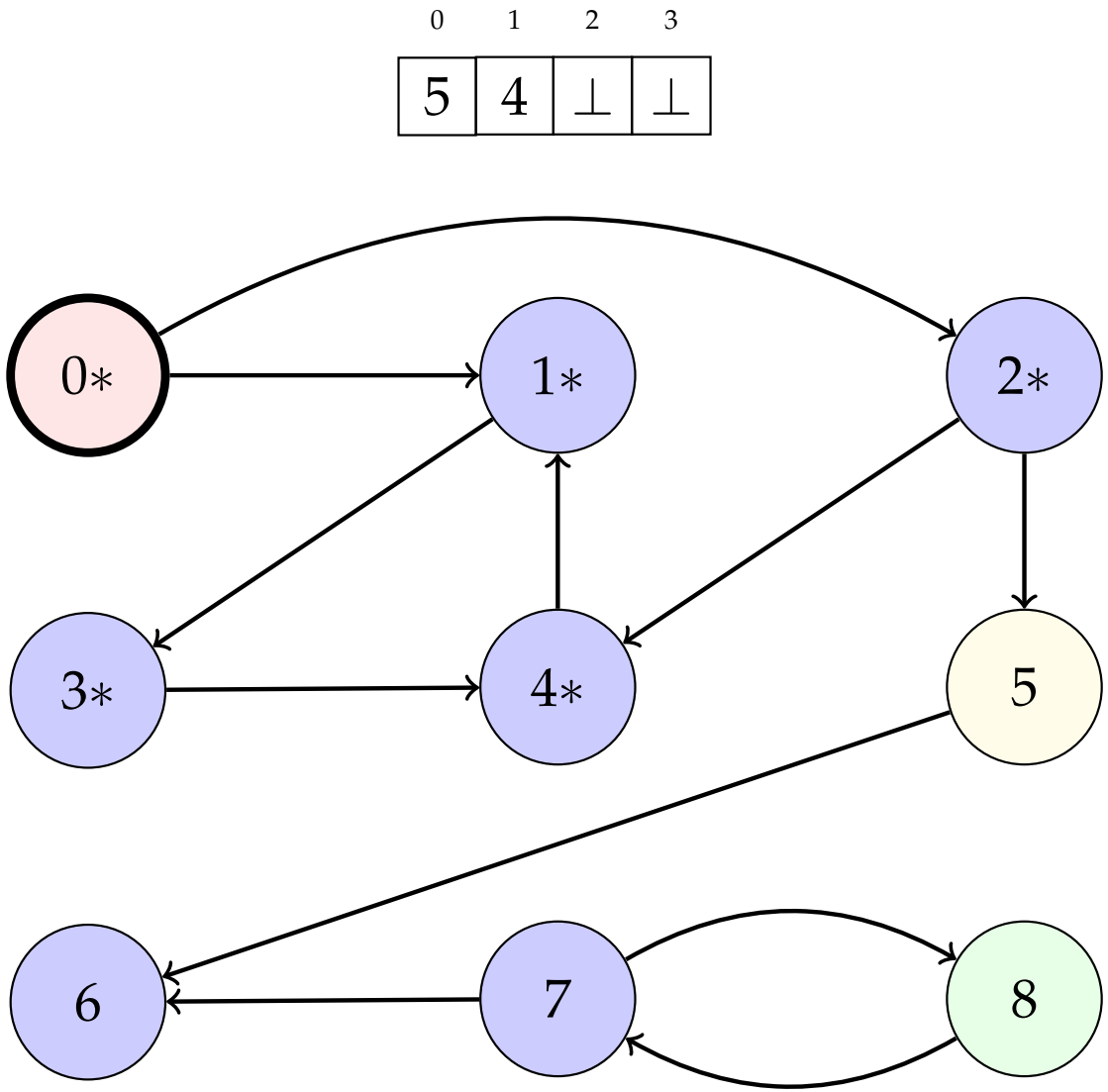

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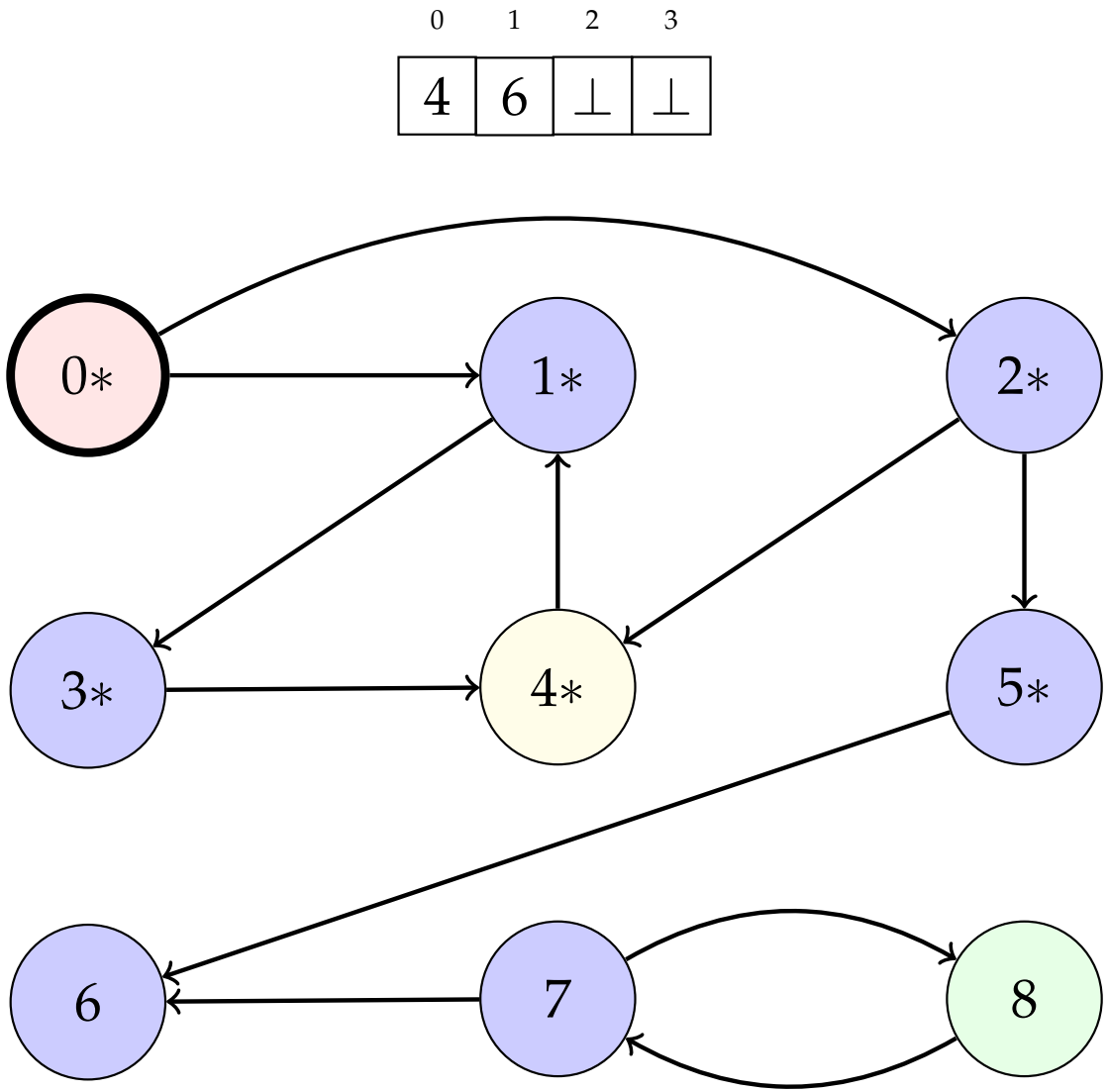

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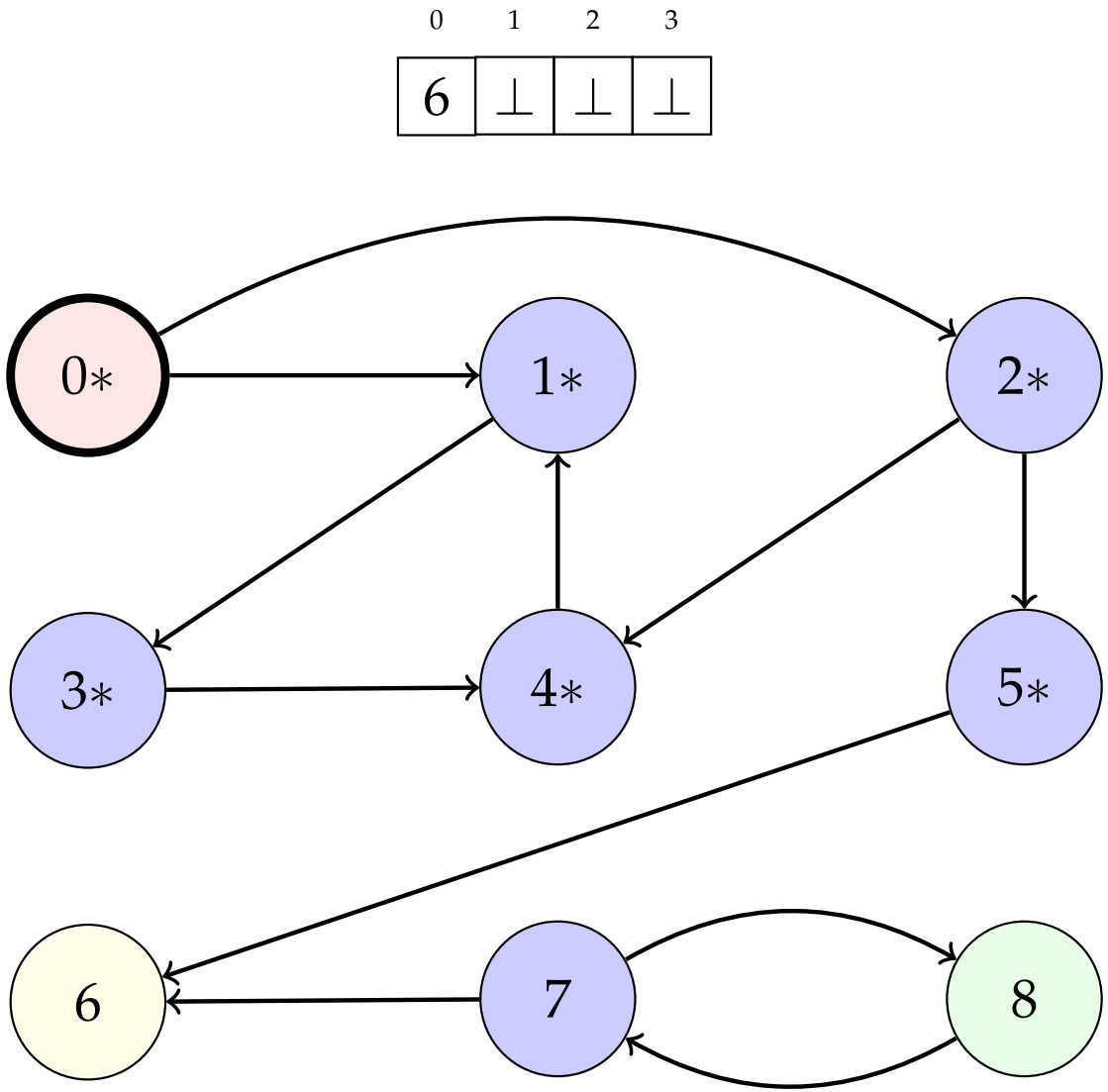
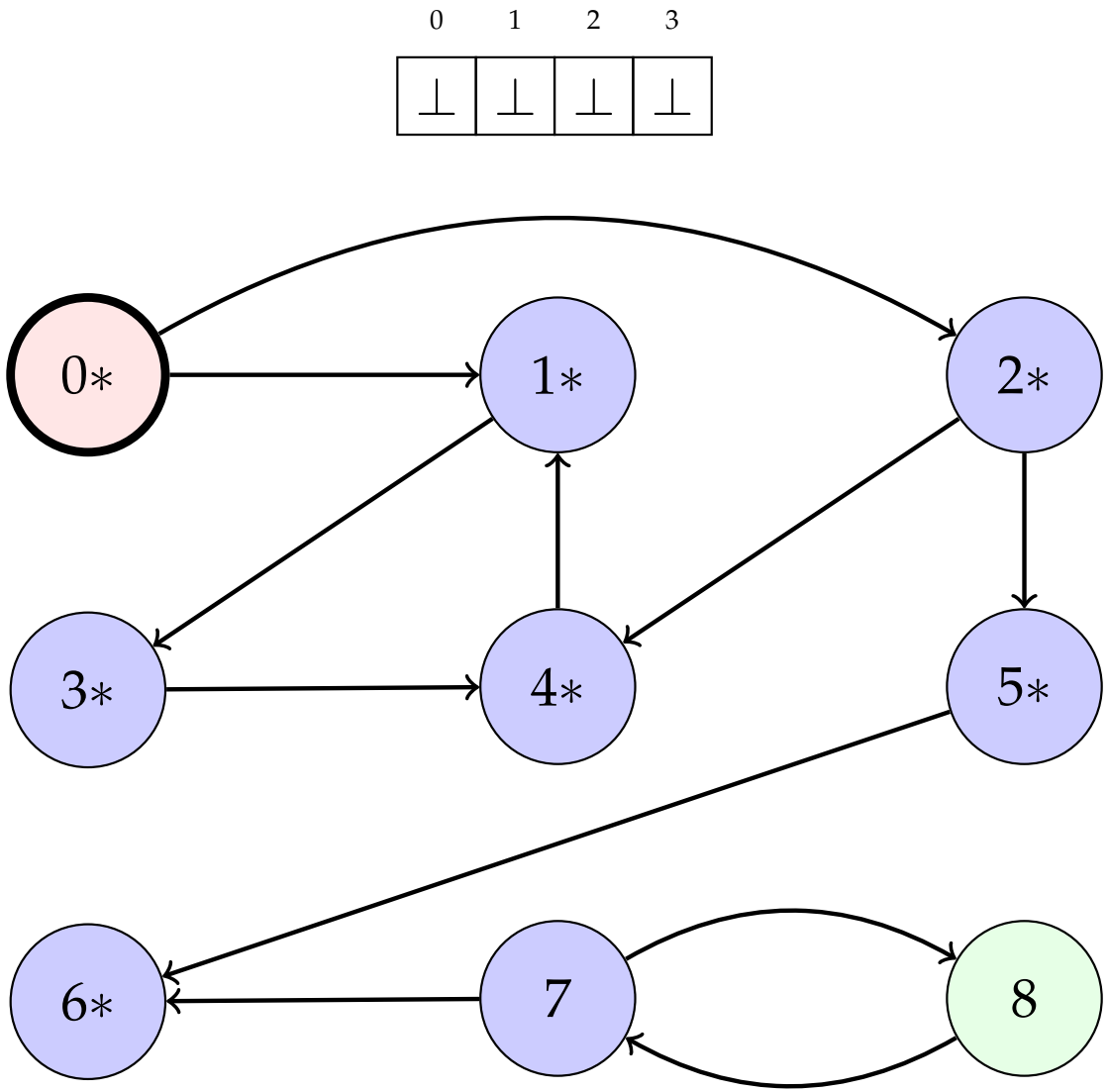


Graph Traversal: Breadth-first search (DFS)



Graph Traversal: BFS Vs DFS

DFS is BFS with a stack instead of a queue!

Graphs

Graph Traversal

C++ Standard Template Library: Containers

C++ Containers

- The containers library is a collection of templates and algorithms that implement the common data structures that we work with as programmers
- A container is an object that stores a collection of elements.
- Containers implement commonly used data-structures:
  - static arrays: *array*
  - dynamic arrays : *vector*
  - singly-linked list: *forward_list*
  - linked lists: *list*
  - queues : *queue*
  - double-ended queue: *dequeue*
  - stacks : *stack*
  - heaps : *priority_queue*
  - binary search trees : *set*
  - dictionary or associative arrays: *map*

Reasons to Use Standard Containers

- STL containers are implemented correctly.
- STL containers are fast and efficient.
- STL containers share common interfaces.
- STL containers are well-documented and easily understood by other developer.

Vectors

- C++ STL implementation of dynamic arrays (with doubling)
- Vector elements are placed in contiguous storage, so that they can be accessed and traversed using iterators.
- Key functions:
  - push_back — to push an element to the last free index of the array.
  - size() — returns the number of elements in the vector.
  - capacity() — returns the size of the storage space currently allocated to the vector expressed as number of elements.
  - reserve() — requests that the vector capacity be at least enough to contain n elements.
  - pop_back() — It is used to pop or remove elements from a vector from the back.

Queues

- C++ STL implementation of queues (FIFO)
- Key functions:
  - empty() — Returns whether the queue is empty.
  - size() — Returns the size of the queue.
  - queue::front() and queue::back() — front() function returns a reference to the first element of the queue and back() function returns a reference to the last element of the queue.
  - push(g) and pop() — push() function adds the element 'g' at the end of the queue. pop() function deletes the first element of the queue.
  -
- Further reading: *http://www.cplusplus.com/reference/stl/*