COMP - 285

Analysis of Algorithms

Welcome to COMP 285

Lecture 14: CS Job Hunting (Interview Training)

Lecturer: Chris Lucas (cflucas@ncat.edu)

Midterm by EoW!

HW4 due tonight!

10/13 @ 11:59PM ET

HW5 released by EoD!

Zoom Office Hours!

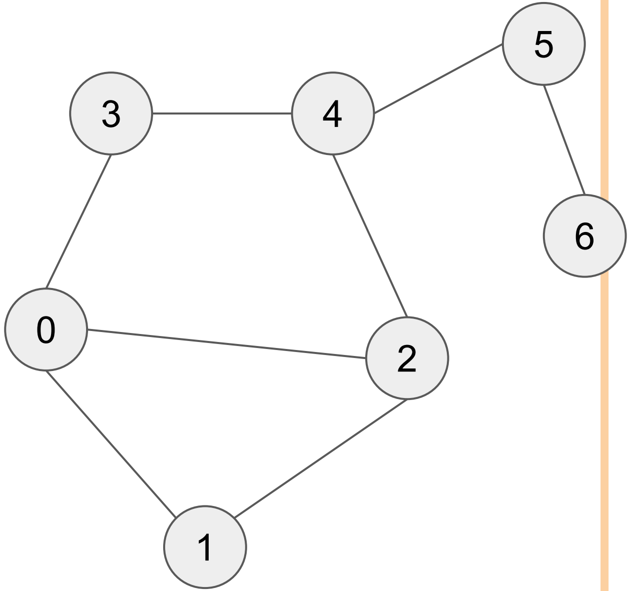
Google STEP program! (link)

Recall where we ended last lecture…

Graphs

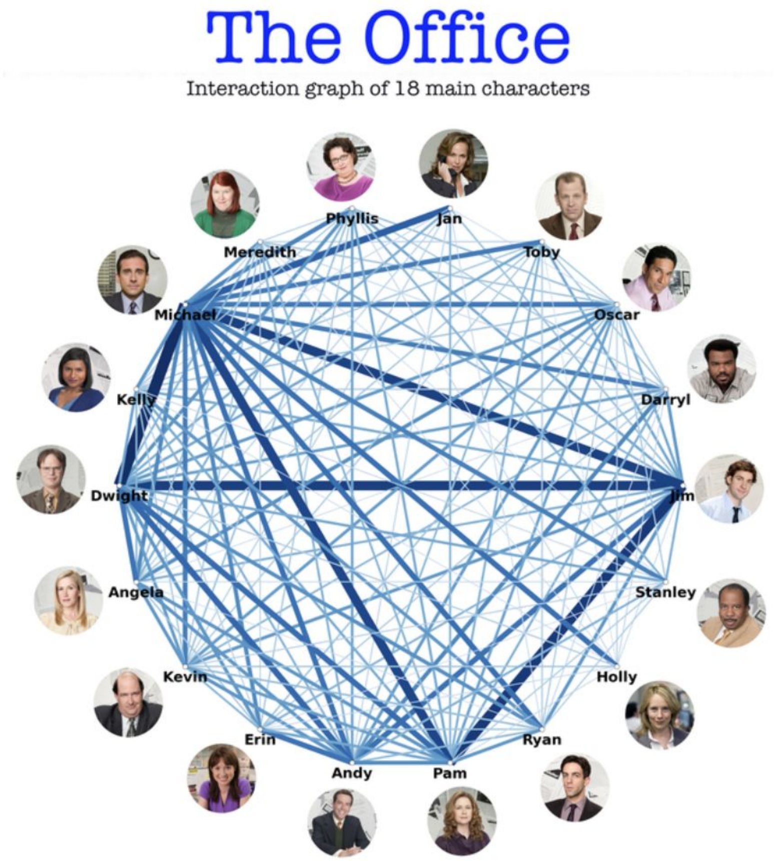
G = (V, E) is an undirected graph where
V = {0, 1, 2, 3, 4, 5, 6}
E = {(0,1),(0,2),(0,3),(1,2),(2,4),(3,4),(4,5),(5,6)}

- Graphs are composed of **vertices** (AKA nodes) and **edges**.
- Each vertex is connected to other vertices with edges. Each vertex has a **degree**.
- The edges can be **directed** or **undirected**.
- Graphs may contain cycles or otherwise be acyclic.
- When two vertices are connected, we can say they are **neighbors** and that they are **adjacent** to one another.
- The notation G = (V, E) stands for “Graph G has a set of vertices V = {v_1, v_2, …} and set of edges E = {e_1, e_2, ... }”

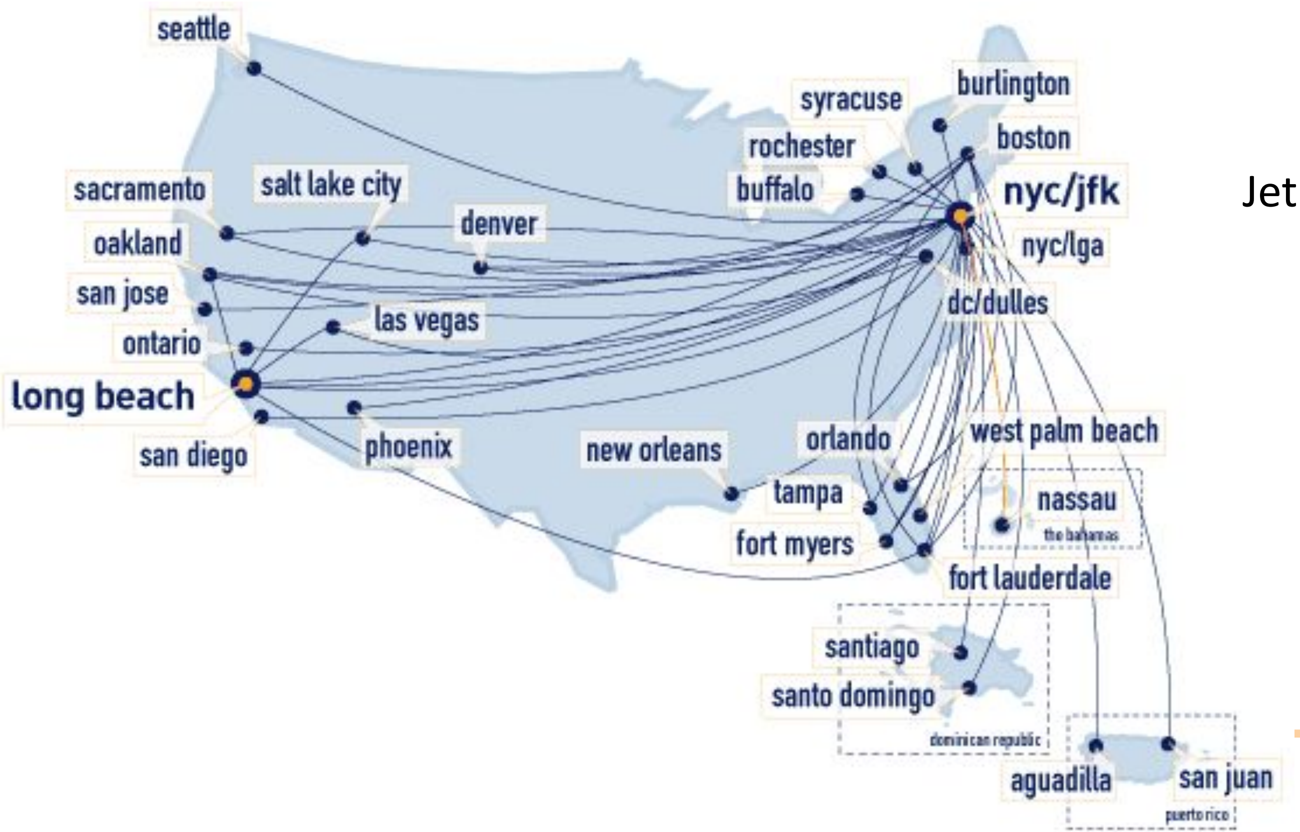


Graphs

The Office characters interaction network
why the different thicknesses?



Graphs



JetBlue flight route

Graph Representations

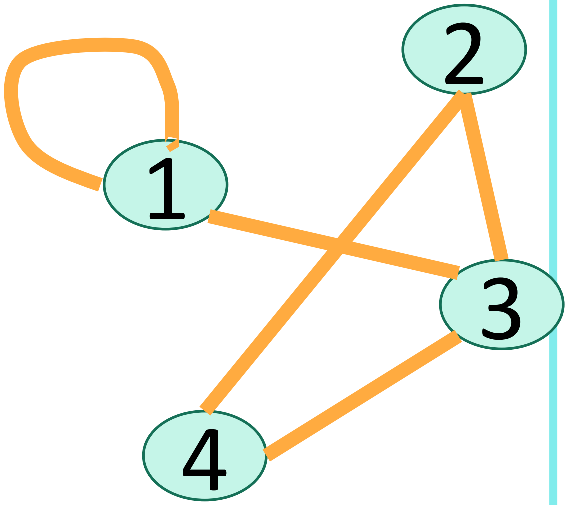
The two most common representations of Graphs:

- **Adjacency Matrix:** a 2D array (table) where the indices (rows and columns) represent vertices, and each entry at (i, j) will have a 1 if an edge is present (and have a 0 if no edge is present).
- **Adjacency List:** A list of lists, where each list at index i represents all neighbors for a vertex i.

How do we represent graphs?

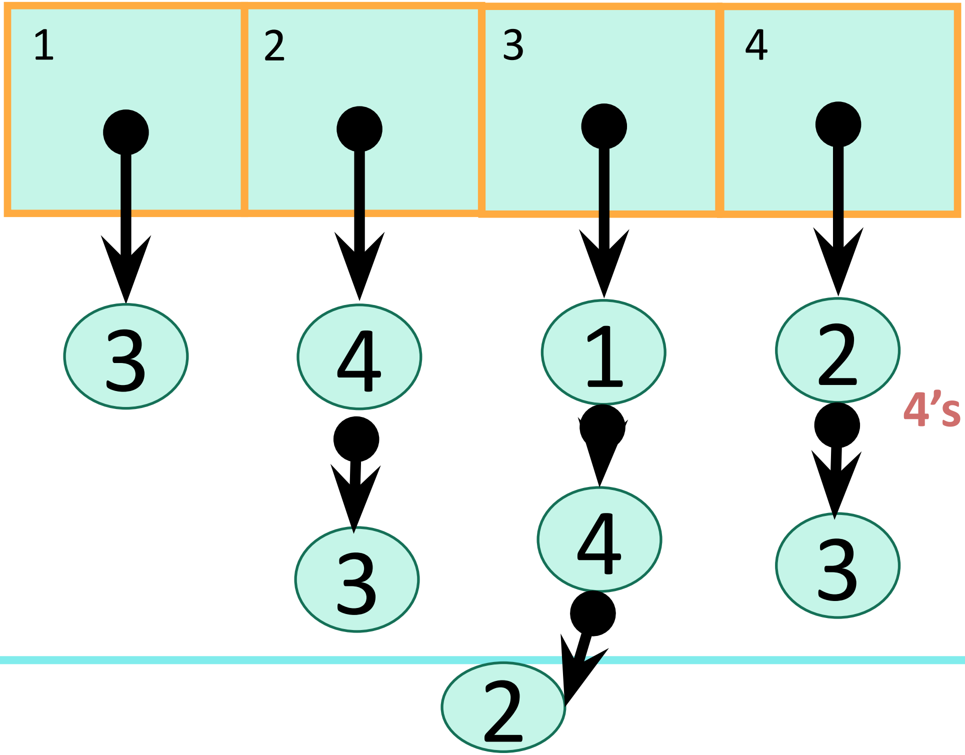
- Option 1: adjacency matrix

$$\begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & 1 & 0 & 1 & 0 \\ 2 & 0 & 0 & 1 & 1 \\ 3 & 1 & 1 & 0 & 1 \\ 4 & 0 & 1 & 1 & 0 \end{array}$$



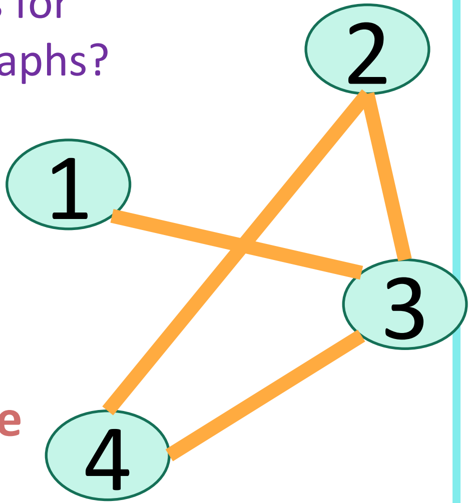
How do we represent graphs?

- Option 2: Adjacency lists

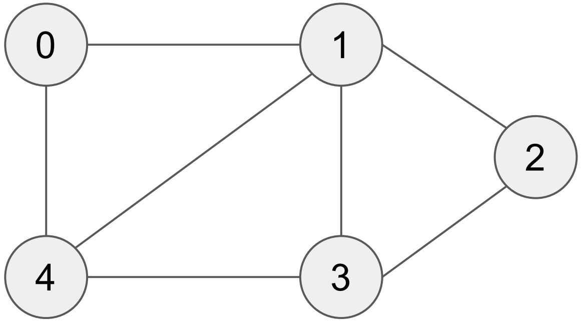


How would you modify this for directed graphs?

4's neighbors are 2 and 3



Graph Representation Examples



Graph

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

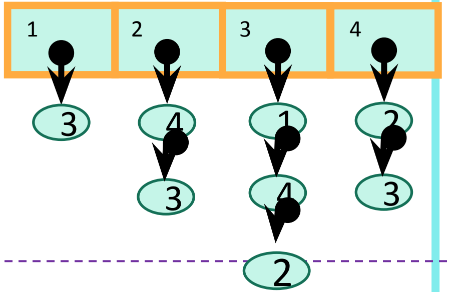
Adjacency Matrix

0: [1, 4]
1: [0, 4, 2, 3]
2: [1, 3]
3: [1, 4, 2]
4: [3, 0, 1]

Adjacency List

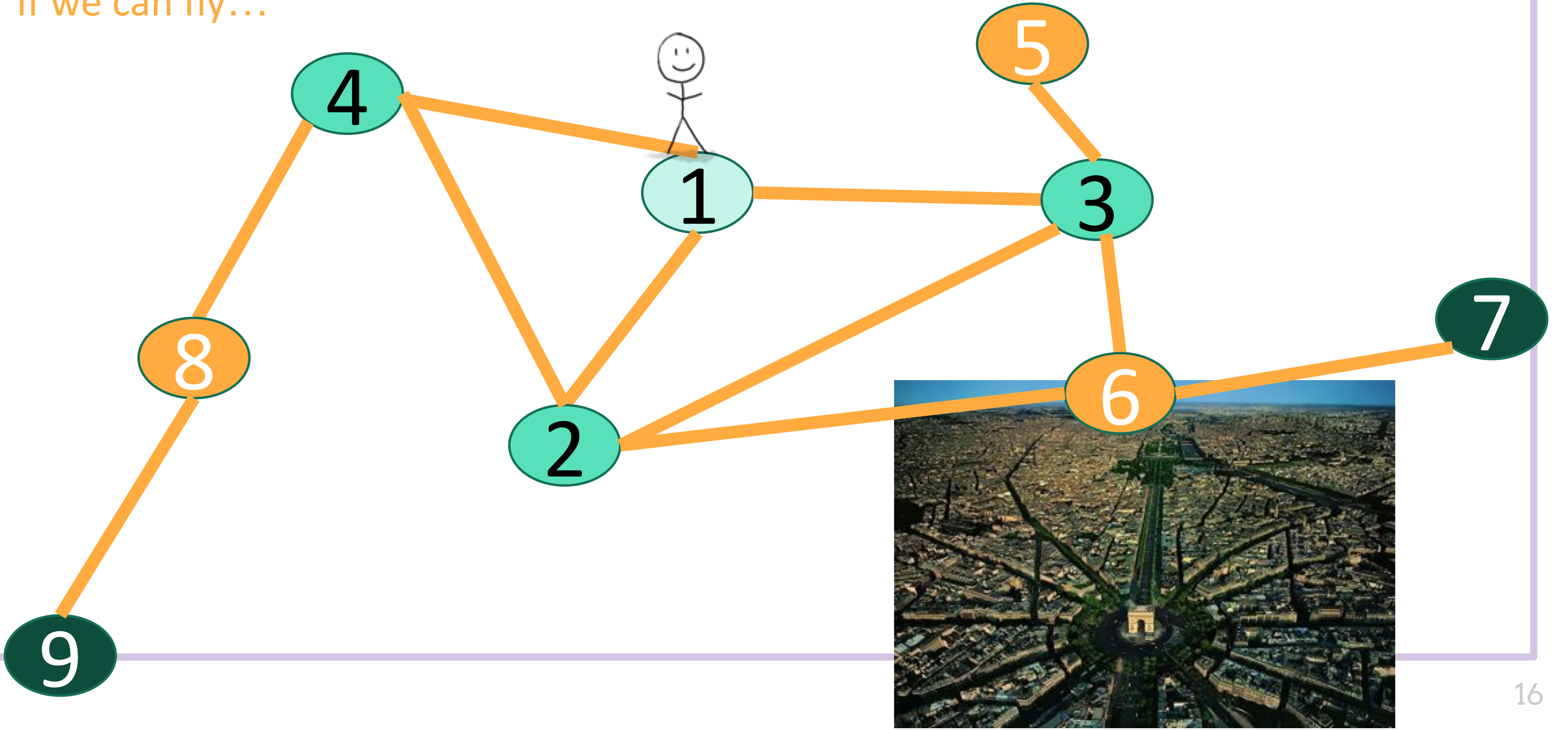
Generally better for **sparse** graphs (where $m \ll n^2$)

Trade-offs

Say there are V vertices and E edges.	$\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 \end{bmatrix}$	
Edge membership Is e = {v,w} in E?	O(1)	O(deg(V)) or O(deg(W))
Neighbor query Find all of v's neighbors.	O(V)	O(1)
Space requirements	$O(V^2)$	O(V + E)

How do we explore a graph?

If we can fly…



Big Questions!

- How to find a viable path in a graph?
- How to have a successful software technical interview?
- How to have a successful hardware technical interview?

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How do we explore a graph?

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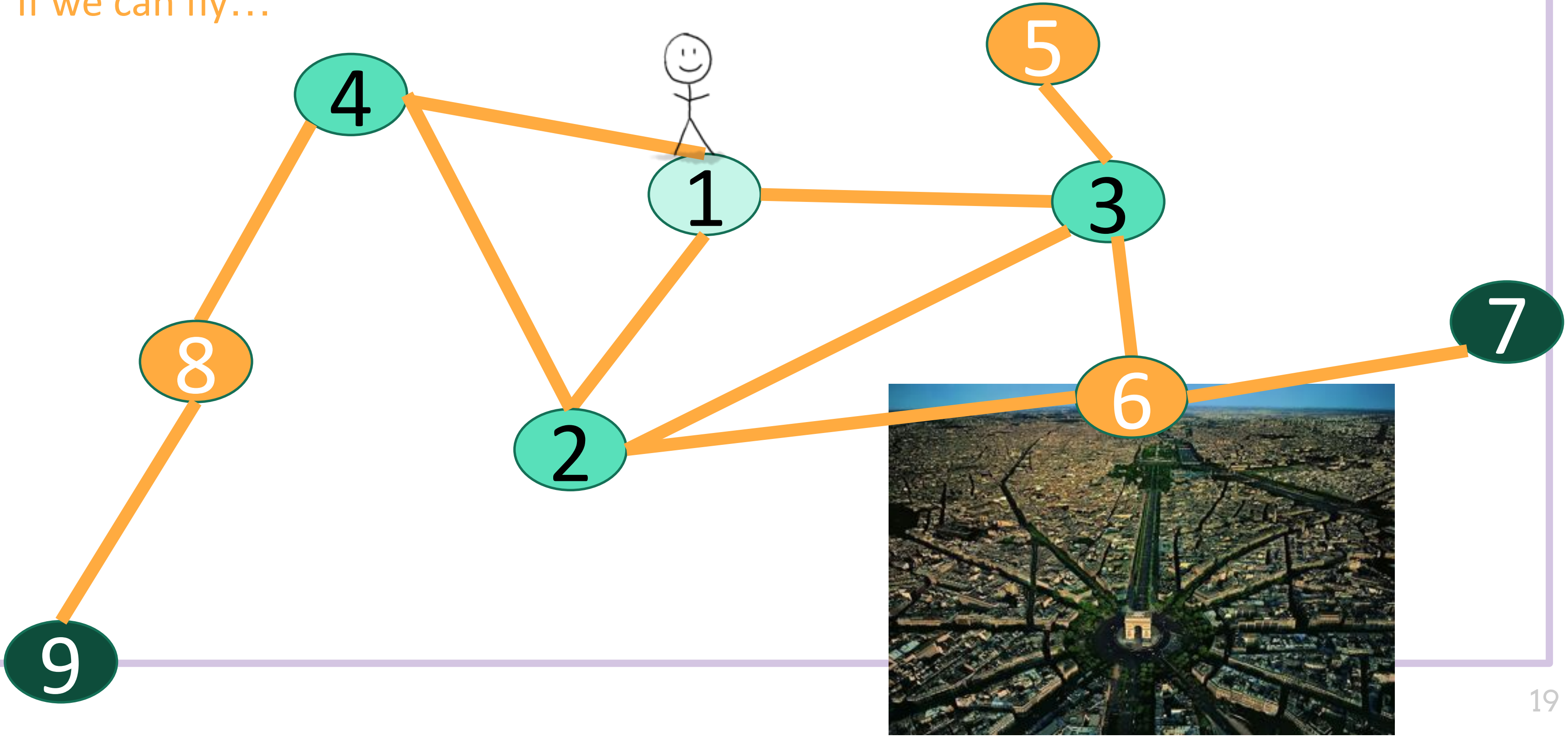
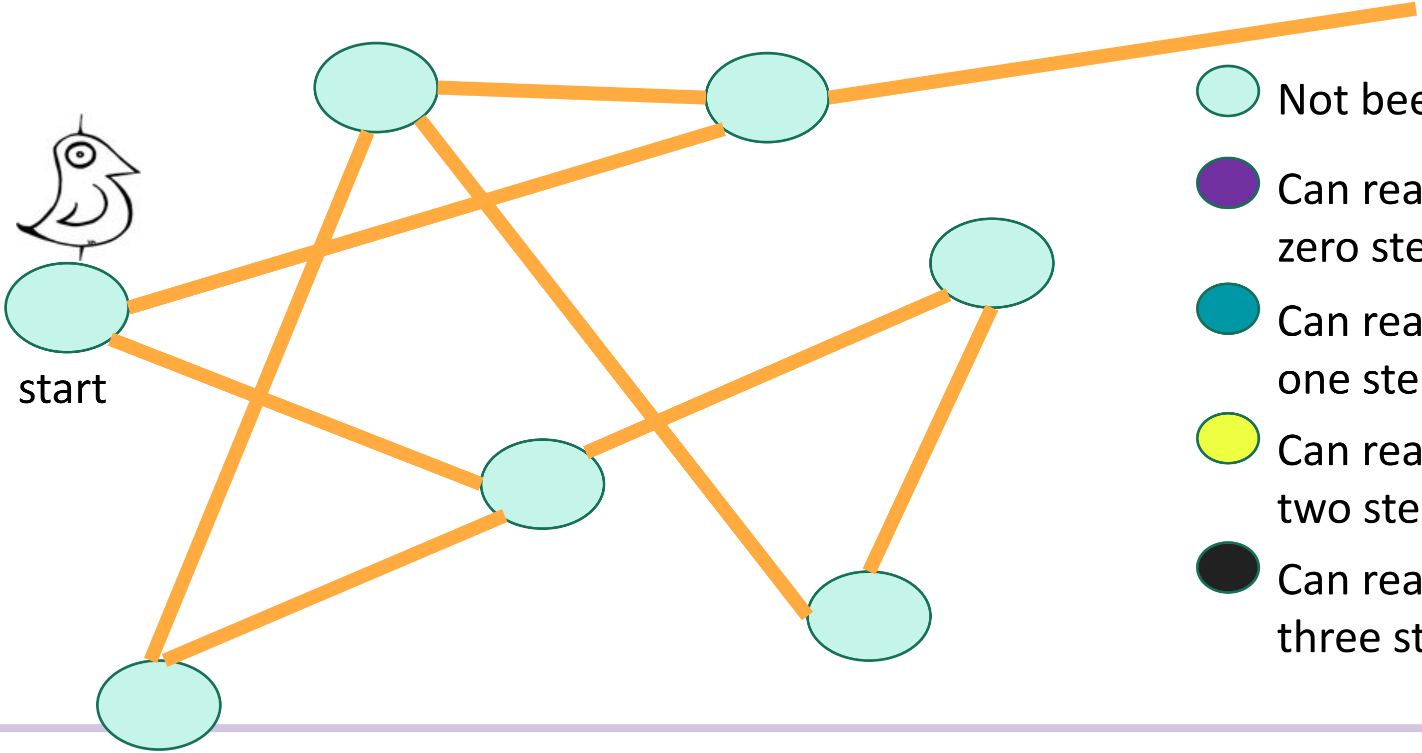


Breadth-First Search: Exploring the world with a bird’s-eye view



○ Not been there yet

🟣 Can reach there in zero steps

🔵 Can reach there in one step

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⚫ Can reach there in three steps

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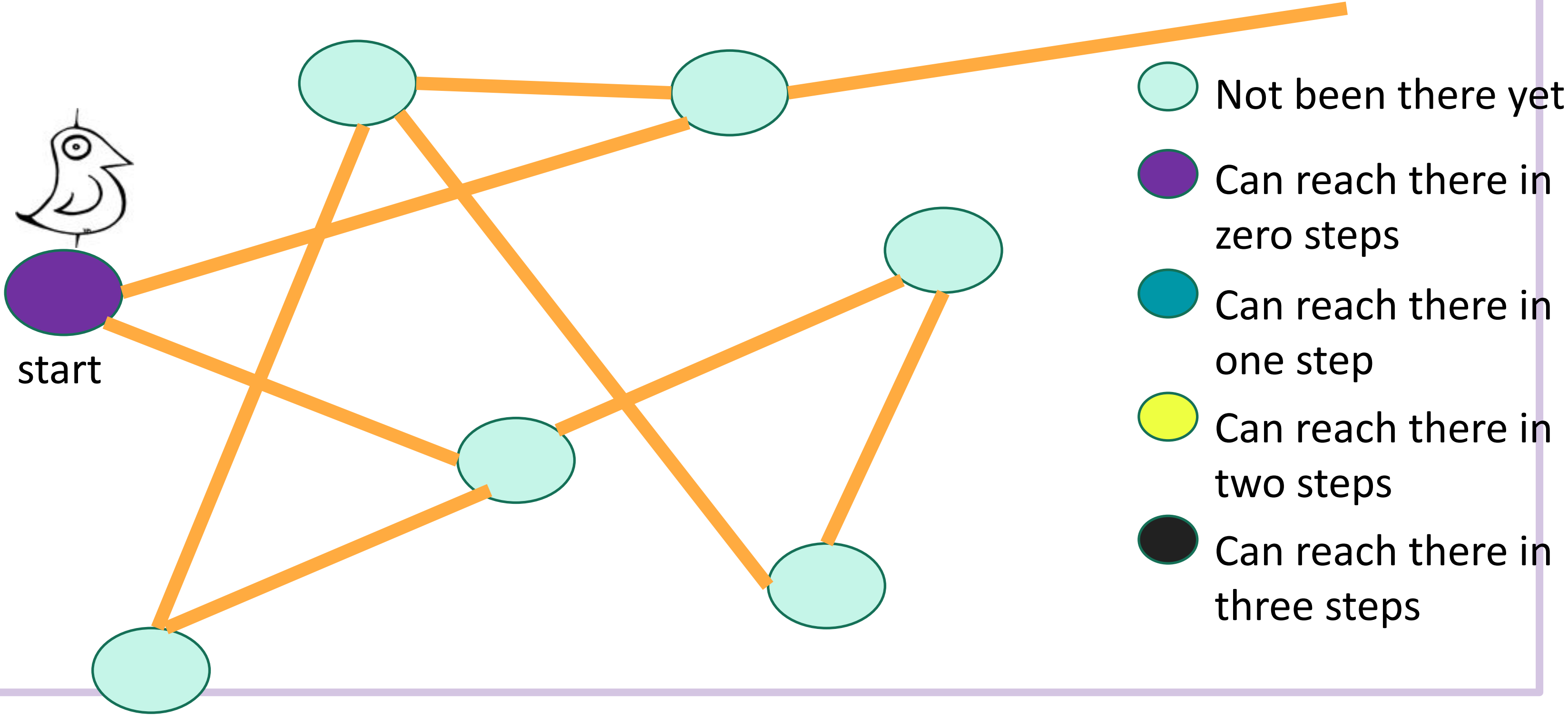

start

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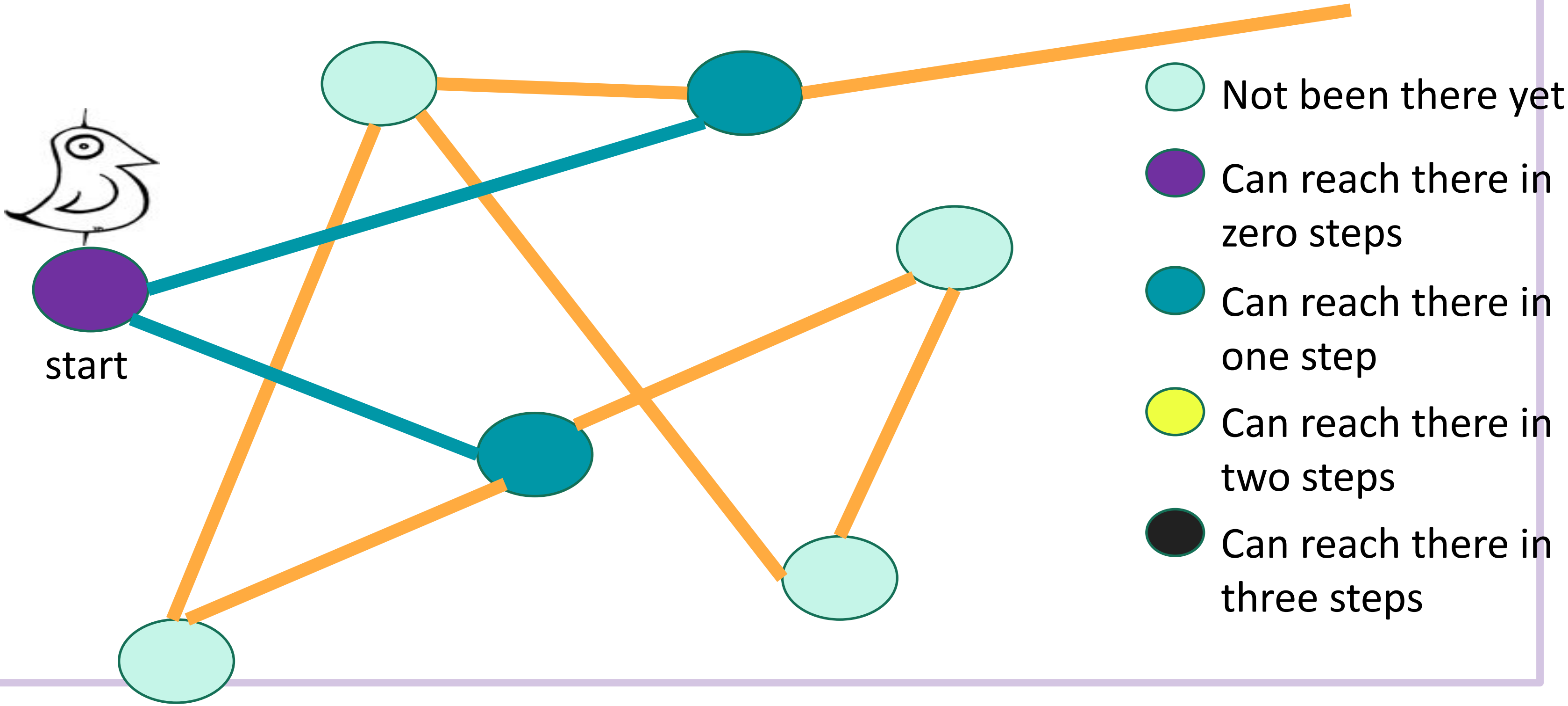

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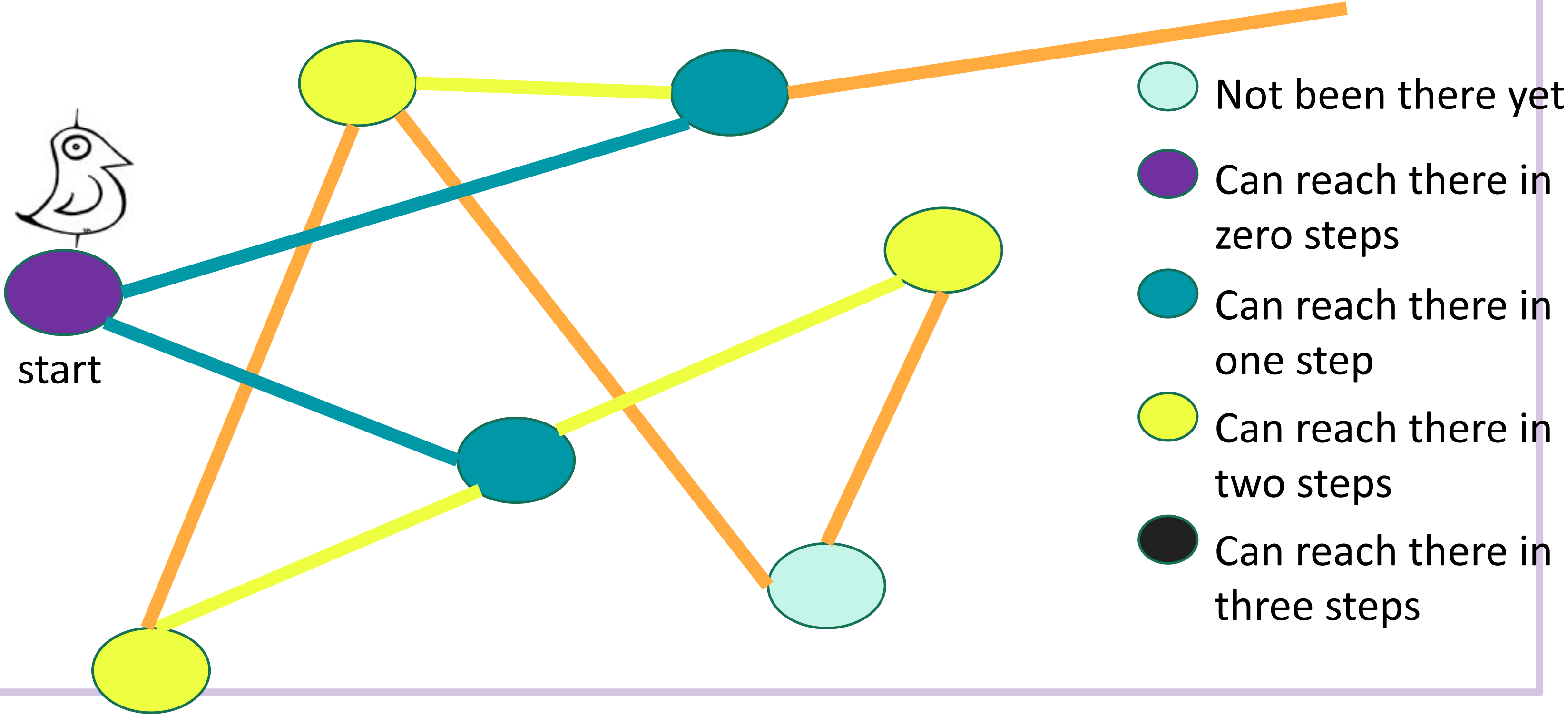

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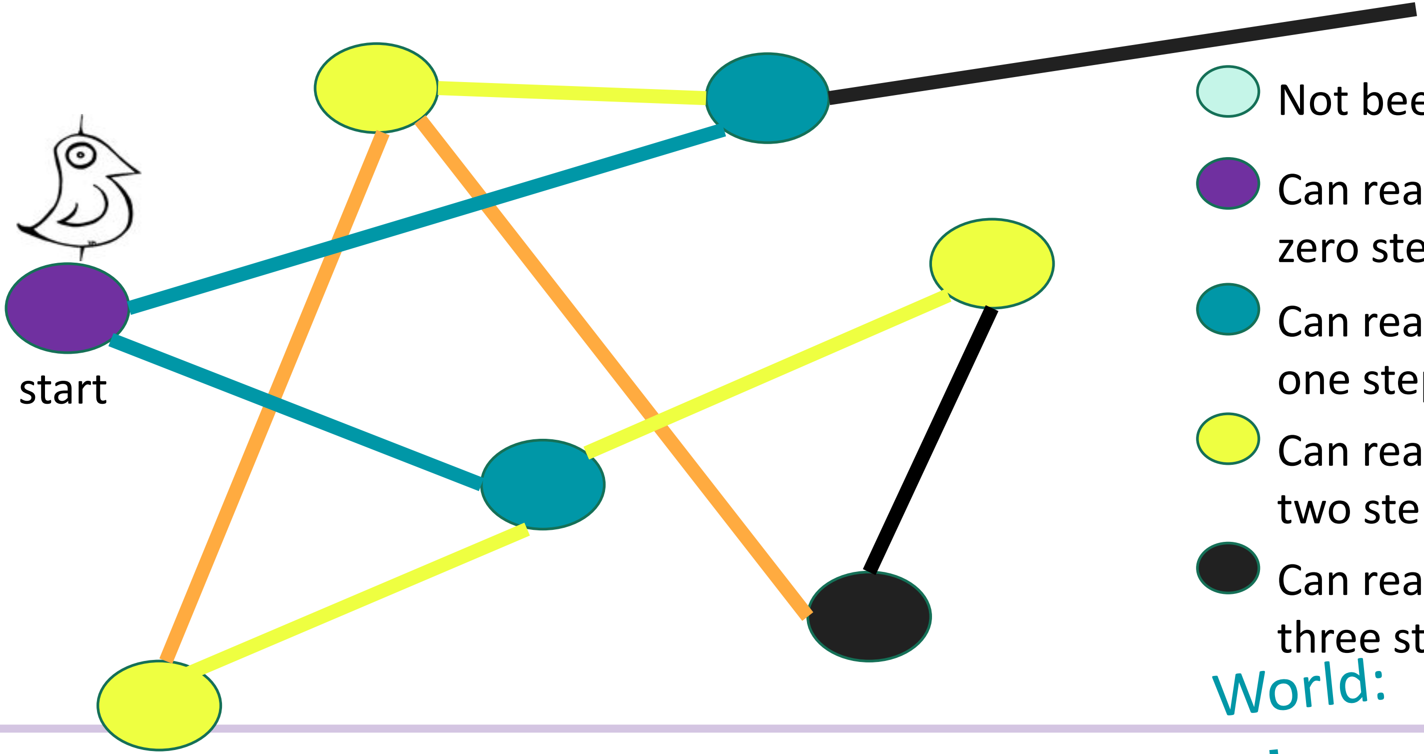

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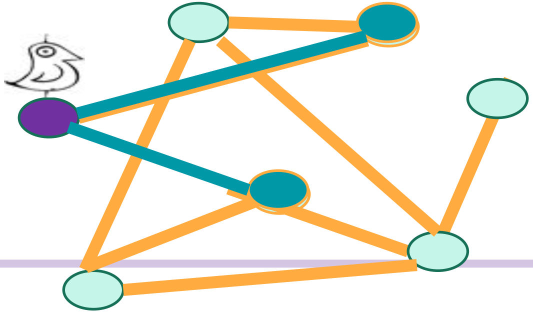
World: explored!

Breadth-First Search Pseudocode



Breadth-First Search Pseudocode

```
algorithm bfs
    Input: undirected graph G = (V,E), int s and int d
    Output: true if there's a path from s to d; false otherwise
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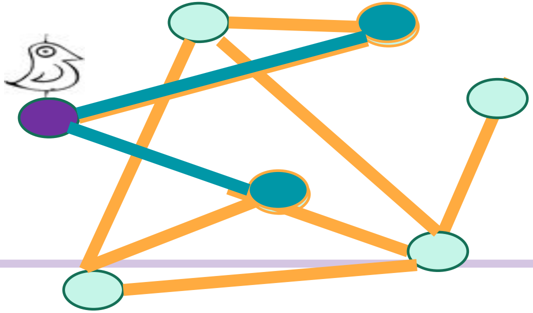

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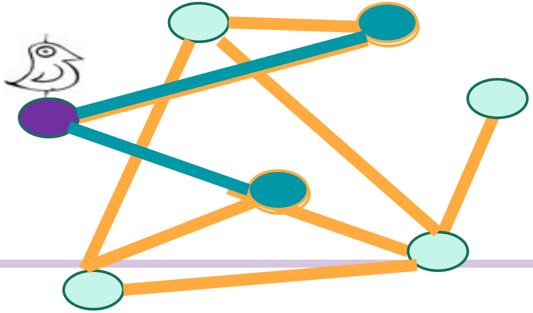

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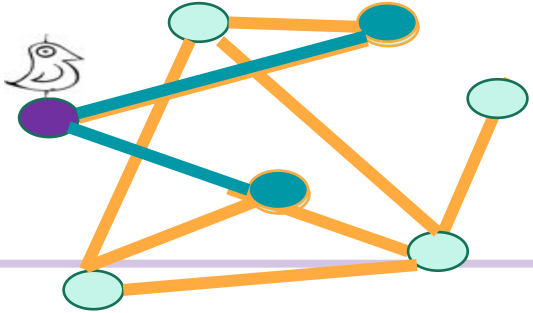

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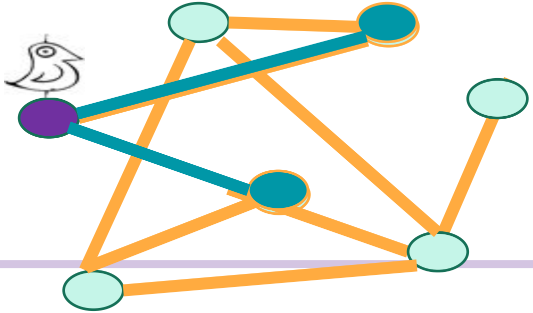

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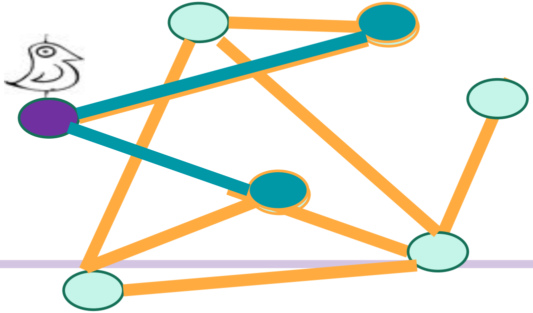

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      currNode = frontier.remove()
      if currNode == d
        return true
      for each neighbor of currNode
        // ???
          visited.insert(neighbor)
          frontier.add(neighbor)
```

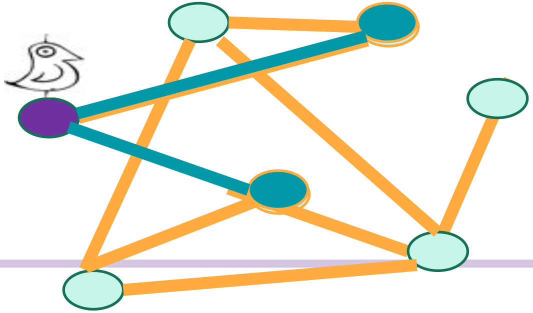

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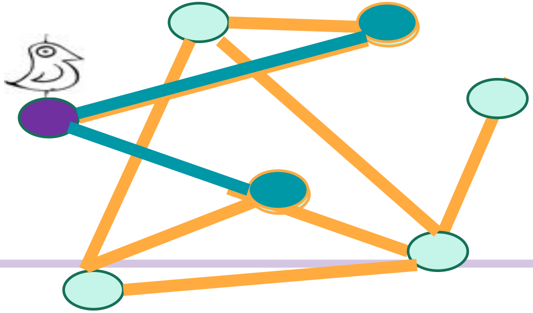

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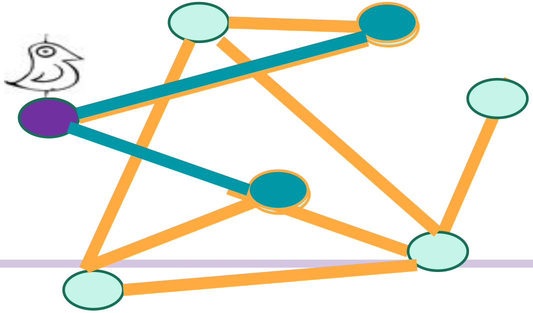

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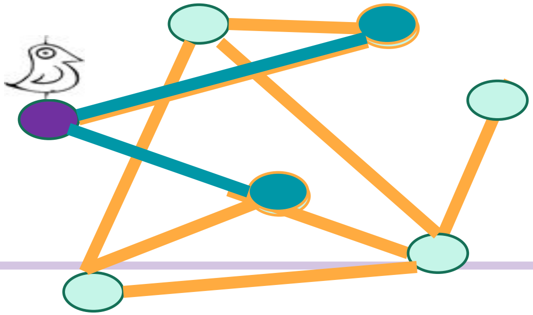
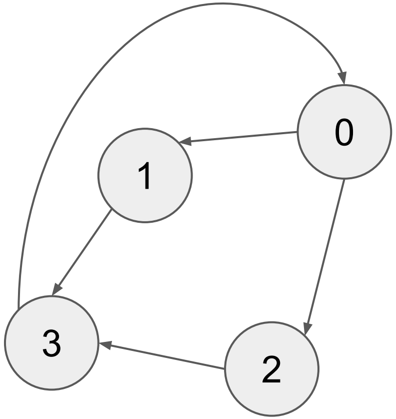


Running time and extension to directed graphs

- To explore the whole graph, explore the connected components one-by-one.
  - BFS running time is O(V + E)
- BFS also works fine on directed graphs.

Graph BFS

- Breadth-first search works on both Graphs and Trees. We'll be using a queue to store our pending nodes.
- Note that for graphs:
    - We may not reach every node.
    - We must keep track of **visited** nodes so you don't go in circles.
- Can be used to **find every node reachable from a source**, or **find the shortest paths to other nodes**.
- Demo: https://visualgo.net/en/dfsbfs



Big Questions!

- ○ How to find a viable path in a graph?
- ○ How to have a successful software technical interview?
- ○ How to have a successful hardware technical interview?

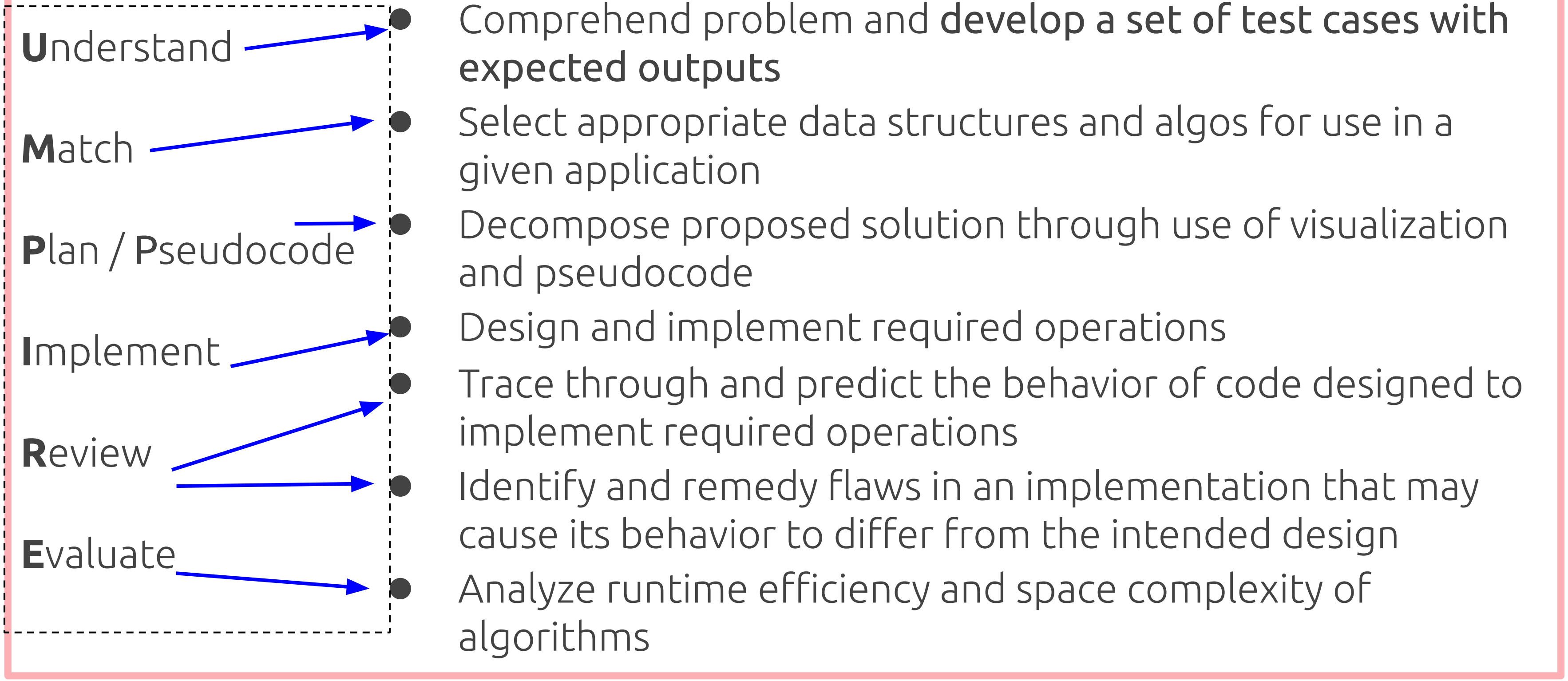
Motivation

- Knowing the sub-skills of “algorithmic problem-solving” allows us to practice metacognition, a fancy word for thinking about thinking.
    - Breaking down the process of “How do we think through solving problems with algorithms?”
    - This awareness gives us a way to more accurately evaluate our own strengths and weaknesses, and improve as needed.
- Knowing the sub-skills that exist can also help nudge the relevant muscle if we ever find ourselves hitting a wall / drawing a blank on a challenging problem.
- What are the sub-steps / sub-skills of algorithmic problem-solving?

UMPIRE METHOD

- Comprehend problem and **develop a set of test cases with expected outputs**
- Select appropriate data structures and algos for use in a given application
- Decompose proposed solution through use of visualization and pseudocode
- Design and implement required operations
- Trace through and predict the behavior of code designed to implement required operations
- Identify and remedy flaws in an implementation that may cause its behavior to differ from the intended design
- Analyze runtime efficiency and space complexity of algorithms

UMPIRE METHOD



Understand

Match

Plan / Pseudocode

Implement

Review

Evaluate

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*UMPIRE pneumonic created by CodePath (www.codepath.org)

Example: return whether or not an array contains duplicates

Example: return whether or not an array contains duplicates

1. **Understand**: So we want to find whether or not there are duplicates in the array. That means if I pass in {4, 1, 3, 89} I'll return false, but if there were an extra 3, for example, I'd return true.
2. **Match**: I think I might be able to use a hashset here to do this efficiently.
3. **Plan**: I'll insert each element into a hashset, but before doing so, check if I've already seen it before. If I have, return true. If we get to the end, we can return False.

Example: return whether or not an array contains duplicates

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4. Implement

```
#include <iostream>
#include <unordered_set>
#include <vector>

bool containsDuplicates(const std::vector<int>& arr)
{
 std::unordered_set<int> seenBefore;
 for (int i = 0; i < arr.size(); i++) {
   if (seenBefore.contains(arr[i])) {
     return true;
   } else {
     seenBefore.insert(arr[i]);
   }
 }
 return false;
}
```

5. **Review:** Line-by-line, everything looks good
6. **Evaluate:** We are iterating through our list of size n and doing O(1) work in each iteration,so our runtime is O(n)

Poll: Which skill in UMPIRE is being used?

"It sounds like we need to find if our input number is prime or not. That means if I input 7, we want to return true. But if we input 10, we would return false."

1. Understand
2. Match
3. Evaluate

Poll: Which skill in UMPIRE is being used?

“It sounds like we need to find if our input number is prime or not. That means if I input 7, we want to return true. But if we input 10, we would return false.”

1. [✓ Understand]
2. Match
3. Evaluate

Poll: Which skill in UMPIRE is being used?

“This algorithm should take $O(n^2)$ time, because for each element in the vector I am checking every element to the right of it.”

1. Understand
2. Match
3. Evaluate

Poll: Which skill in UMPIRE is used?

“This algorithm should take O(n^2) time, because for each element in the vector I am checking every element to the right of it.”

1. Understand
2. Match
3. [✓ Evaluate]

Poll: Which skill in UMPIRE is being used?

“I think a stack might be useful here”

1. Understand
2. Match
3. Evaluate

Poll: Which skill in UMPIRE is being used?

“I think a stack might be useful here”

1. Understand
2. [✓ Match]
3. Evaluate

Poll: Which skill in UMPIRE is being used?

“This sorting question is interesting because the input is mostly sorted. Maybe insertion sort makes sense.”

1. Understand
2. Match
3. Evaluate

Poll: Which skill in UMPIRE is being used?

“This sorting question is interesting because the input is mostly sorted. Maybe insertion sort makes sense.”

1. Understand
2. [✓ Match]
3. Evaluate

General Tips

- **Communicate. Communicate. Communicate.**
  - A perfect solution without communication would not pass.
  - You can communicate that you need a few minutes to think in silence.
  - If you get stuck or are going down the wrong track, your interviewer can identify that upfront rather than when you're 15 minutes into a solution.
- **Listen to your interviewer**
  - If they give you a hint or steer you in a different direction, listen to them and explore where they're taking you.
- **Remain positive**
  - Questions are meant to be challenging; they're pushing the boundaries of your problem-solving skills. (Breezing through an interview won't give them signal either).
  - Needing hints does not automatically disqualify you; it's all relative!
  - Good for your own well-being

General Tips (pt. 2)

- **Time is the Most Precious Resource**
  - 1-2 questions about your resume aren't atypical… focus on CONCISION (so you can maximize time spent on problem).
  - Don't utilize bathroom/water/snack breaks at beginning of interview, save for designated breaks in schedule.
- **Quickly Give a Solution (if you can)**
  - Duh!
  - Kidding lol, if you can only think of a brute force solution - that's still good! You can "get points" for verbalizing the solution, acknowledging the runtime is inefficient and start a conversation about how to optimize (ie. duplicated work)
- **Use Every Part of the Problem**
  - Especially if you're stumped or at suboptimal/inefficient solution, there's a reason for **every** part of the problem.
  - Even if you can't piece it together, acknowledge it: "I notice that I'm not using the fact that the array is sorted", "I know my algorithm ignores that the input won't contain duplicates…"

General Tips (pt. 3)

- **Trust your Instincts**
  - How are you able to solve the problem by hand/mentally?
  - Break down the steps you are performing in your head - usually a great starting point!
- **Code style matters!**
  - Write clean, concise, well-formatted code… (e.g. good variable names, helper methods, etc.)
  - Often times your code is photographed and sent to hiring committees
- **ALWAYS Prepare Questions**
  - Show enthusiasm for the role, no generic questions (ie. What are languages most used? How many hours do you work per day? What are the benefits? What’s the best/worst thing about your job?)
- **Notebook (Optional)**
  - It catches people off guard – in a good way!
  - Follow up interview email is unique, specific, personalized, differentiates you/demonstrates passion. Mention interviewers by name and include anecdotes from conversations.
  - Can be strategically used as a buffer while you think of an answer!
  - Follow your interviewer’s guidance if they object, (hasn’t happened to me though)

General Tips (pt. 3)

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Match

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- Communicate. Communicate. Communicate.
- Listen to your interviewer
- Remain positive
- Time is the Most Precious Resource
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General Tips (pt. 3)

Understand

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- he Problem
- your instincts.
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How can I practice?

Simulating Interview Environment

- Talk to yourself and walk through each of the letters in UMPIRE.
- Write code by hand on whiteboard (or paper if you don't have a whiteboard)
- Record yourself explaining your approach as you go. Listen back, are you able to follow your own explanations?
- **Repetition is the largest contributor to success**. It's a sport that requires practice, a muscle that requires exercise.
  - We'll be doing something like this for HW5
- Practice Problems:
  - Cracking the Coding Interview here!
  - Leetcode
- Sign up with me here!

Big Questions!

- How to find a viable path in a graph?
- How to have a successful software technical interview?
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What about Hardware?

- **More behavioral and knowledge-based questions**
  - Behavioral: Tell me about a time when … STAR method!
  - Knowledge-based: Specific questions about hardware engineering concepts (circuitry, memory, cache, capacitance, inductors, resistors, etc.)
  - More directly related to what you would study for an exam
- **Occasional software/coding questions**
  - So still should practice!
- **Resources:**
  - Prepfully has round-by-round breakdowns of interviews (here)
  - Recent interview questions asked at your company (here)
  - Laundry list of interview questions (here)

COMP - 285

Analysis of Algorithms

Welcome to COMP 285

Lecture 14: CS Job Hunting (Interview Training)

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