CS2020 Fun Quiz!

Herbert

Warmup

Warmup

In insertion sort, notice that when you search for the place to insert a new element, you can just binary search the previous elements. For example, in the array:

$$2 \quad 3 \quad 5 \quad 7 \quad \boxed{4} \quad 1$$

when inserting 4 to the previous elements, you can just binary search between 2, 3, 5, and 7. Why then does insertion sort not run in $O(n \log n)$?

Warmup

I have a hash table that contains all CS2020 AY16/17 students' names. Suppose that there are 100 students, and "Le Trung Hieu" is inside this hash table. Which one of these are correct?

1. If the hash table has size 10000, it is likely that searching a name takes $O(1)$ time.
2. It is possible that searching for "Le Trung Hieu" fails.
3. It is possible that searching for your lovely tutor "Herbert Ilhan Tanujaya" in the hash table succeeds.
4. With a hash table of size 200, the hash function that maps a student's name to the total score of the student's problem sets modulo 200 is a good choice of a hash function.

Warmup

What is the running time of Djikstra's algorithm, using an unsorted array as the priority queue?

Special Cases

Special Cases

Design an algorithm that returns the minimum spanning tree of a connected graph with n nodes and n edges in $O(n)$.

Special Cases

You are given an integer array A with length l, such that there exists k, $0 \leq k < l$ such that

$$A[k] < A[k+1] < \cdots < A[l] < A[0] < A[1] < \cdots < A[k-1].$$

You don't know what k is. This is an example of such an array:

$$4 \quad 5 \quad 10 \quad 12 \quad 1 \quad 2$$

Search for an integer in this array in $O(\log l)$.

Special Cases

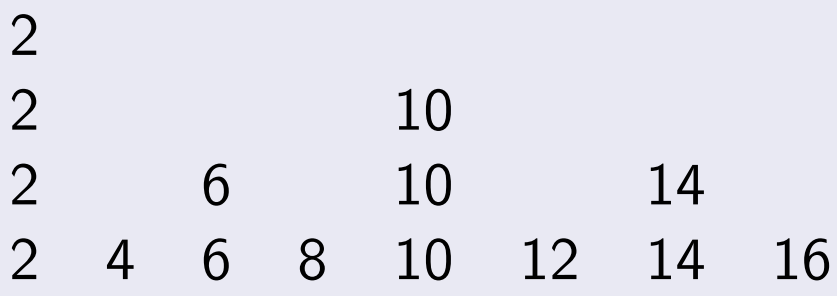
You are given a connected directed graph G with edges weighting either 2, 3, or 5. Suppose that G has V nodes and E edges. Design an algorithm that finds the shortest path between two nodes in $O(E)$ time.

I am the Computer

I am the Computer

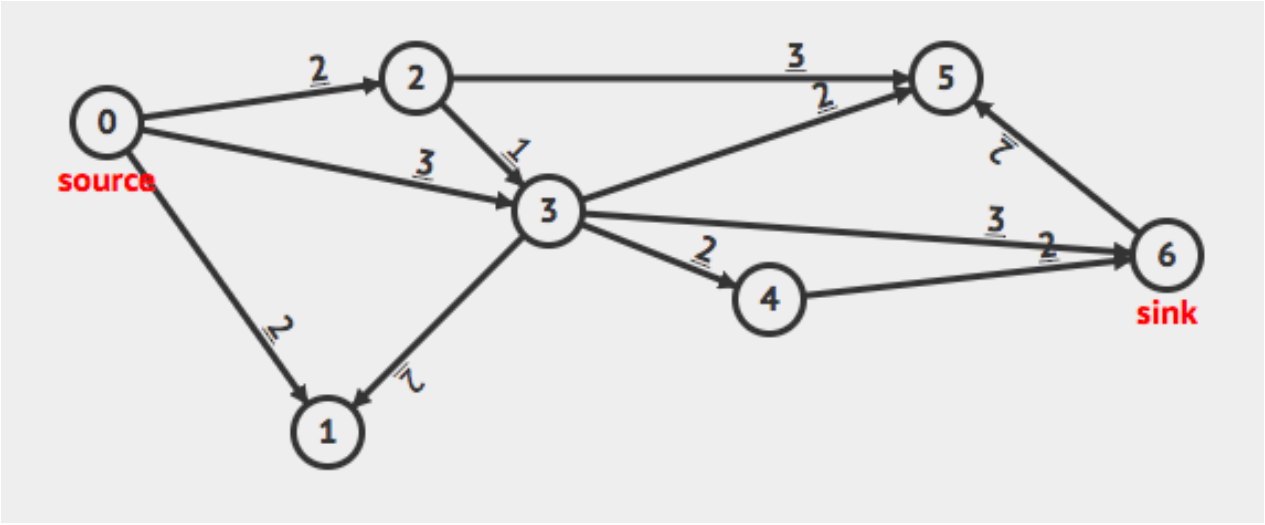
Given below is a skip list. Draw all possible results, with their probabilities, after inserting 9.

Skip List



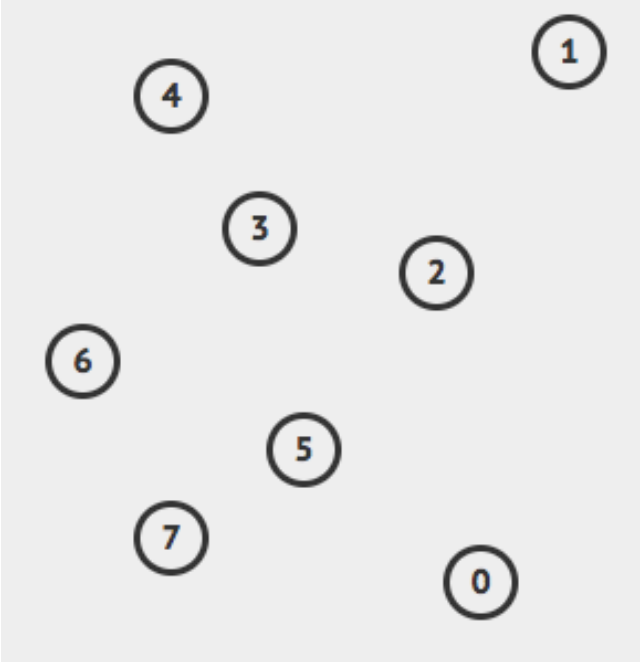
I am the Computer

Given below is a directed graph. Draw all possible results of the resulting graph after 2 iterations of Ford-Fulkerson.



I am the Computer

Given below is a set of points. Find the convex hull using the divide-and-conquer algorithm (or otherwise).



Funky Algorithms

Funky Algorithms

Consider the following algorithm to find if an element k exists on a sorted array A:

$DiceSearch(A, k, start, end)$

1. If $start == end$, return $A[start] == k$.
2. Throw a 6-sided fair dice. Let the resulting number be d.
3. Consider

$$new = A\left[start + \left\lfloor \frac{(end - start)}{d+1} \right\rfloor\right].$$

If this is $< k$, return $DiceSearch(A, k, new, end)$; if $> k$, return $DiceSearch(A, k, start, new)$; if $= k$, return true.

Will this algorithm return the correct answer? If so, what is the time complexity?

Funky Algorithms

Consider this hybrid algorithm in finding the minimum spanning tree of a graph:

Boruvprim's Algorithm

1. Do $O(\log \log V)$ Boruvka steps in the graph
2. Collapse the trees found in the Boruvka steps to form another graph.
3. Run Prim's algorithm on the resulting graph.

Does this algorithm work? What is the runtime of this algorithm?

Funky Algorithms

Consider this algorithm that sorts a deck of cards with an integer written on the cards: (assume all integers are distinct)

Patience Sort (legit name)

1. Initially, there are no piles.
2. For every card dealt from the deck, place it on the leftmost existing pile, such that the top card's value $\geq$ the new card's value. If not possible, form a new pile to the right.

For example, the deck of cards in order of $3-7-1-5-6-4-2$ is dealt into piles of $(3-1)$, $(7-5-4-2)$, (6).
Why does repeatedly picking the smallest card visible sorts the deck? How do you run this algorithm in $O(n \log n)$ time?

Lame Stuff

Lame Stuff

Which tutor relates the most with the operator ++?

Lame Stuff

Your friend just discovered this amazing new operator `-->` in Java 7 which he calls the "down to" operator! Consider the code snippet below:

"Down to" Operator usage

```
int x = 10;
while (x --> 5) System.out.println(x);
```

What is the output?

Lame Stuff

What is the most used language in programming?

Big O Analysis

Big O Analysis

Find the runtime of $f(n)$:

Java snippet

```
void f(int n) {
    if (n == 1) {
        System.out.println("hi");
    } else {
        for (int i = 0; i < n; i++) {
            f(n - 1);
        }
    }
}
```

Big O Analysis

Find the runtime of $f(n, k)$:

Java snippet

```
void f(int n, int k) {
    for (int i = 0; i < k * n; i++) {
        System.out.println("hi");
    }
    if (n > 1) {
        f(n / 2, k + 1);
    }
}
```

Big O Analysis

Find the runtime of $f(n)$:

Java snippet

```
void f(int n) {
    for (int i = 0; i < n; i++) {
        System.out.println(g(i));
    }
}
void g(int n) {
    if (n <= 1) return n;
    else return g(n - 1) + g(n - 2);
}
```

2 Java Truths, 1 Java Lie

2 Java Truths, 1 Java Lie

Among these three statements, two statements are correct and the other one is incorrect. Find out which one is incorrect and explain all three statements.

1. The String class is immutable.
2. Java's `HashMap` implementation of `containsValue` takes $O(1)$ time, assuming uniform hashing.
3. A static property of a class can be accessed by a non-static method of that class.

2 Java Truths, 1 Java Lie

Among these three statements, two statements are correct and the other one is incorrect. Find out which one is incorrect and explain all three statements.

1. The % operator in Java can only be used in two integers.
2. This results in a compile error:
   ```
   for(int i=0;i<3;i++) System.out.println(i);
   System.out.println(i);
   ```
3. You can inherit from many interfaces at once.

2 Java Truths, 1 Java Lie

Among these three statements, two statements are correct and the other one is incorrect. Find out which one is incorrect and explain all three statements.

1. The access level of an overriden method can be changed in a subclass.
2. An `int` is passed by value, whereas an `Integer` is passed by reference.
3. A Java array can store instances of different classes.

Finding a Path

Finding a Path

Design an algorithm that gives you the number of distinct shortest paths from a node S to the node T in the connected undirected graph G.

Finding a Path

Given a connected undirected graph that models a country's road network, with nodes representing cities and edges representing roads that connect cities. However, each road has a speed limit. Suppose that my car always travel in a constant speed (somehow). Find a path from a city S to a city T such that I can travel in the maximum speed possible.

Finding a Path

Given a connected undirected weighted graph that models a country's road network, with nodes representing cities and edges representing roads that connect cities, with the weights representing the distance of the roads. Suppose that I live in a city S and my girlfriend lives in a city T.
Design an algorithm, possibly involving preprocessing, such that I can answer queries of this type efficiently: if there's a road between city A and city B with distance l, will the shortest distance between me and my girlfriend be shorter?

History

History

Which one is discovered first - Prim's Algorithm, or Djikstra's Algorithm?

History

How many years difference are there between the year MergeSort is discovered, and the year QuickSort is discovered? Your answer must be accurate to 5 years.

History

What is the thing Djikstra believed “could only have originated in California”?

Finish Off Remaining Time

Finish Off Remaining Time

You are given an array with all the numbers from 1 to N appearing exactly once, except for two numbers missing. Find the two numbers in $O(N)$ time and constant additional space.

Finish Off Remaining Time

You have a $n \times n$ matrix where each cell is either 0 or 1. Find the biggest square matrix in the matrix such that all four borders (edges) contain 1, in $O(n^3)$ time.

Finish Off Remaining Time

Design a data structure that stores a collection of integers and supports inserting a number in $O(\log n)$ time and finding the median in $O(1)$ time.