Chris and Richard's Final Prep Packet

A Premium Selection of Handcrafted, Artisanal Practice Problems

Hashtables - 16 Au

1) [12 points total] Hash Tables

For a) and b) below, insert the following elements in this order: 50, 21, 29, 10, 39, 19. For each table, TableSize = 10, and you should use the primary hash function h(k) = k%10. If an item cannot be inserted into the table, please indicate this and continue inserting the remaining values.

a) Quadratic probing hash table

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

b) Separate chaining hash table – use a linked list for each bucket where the values are ordered by **increasing value**

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

c) What is the load factor in Table b)?

d) In a sentence or two, describe **double hashing**.

e) What is one advantage of **double hashing** over **quadratic probing**, **be specific**.

f) What is the big-O worst case runtime of a *find operation on a table like table b?*

g) What is the big-O worst case runtime of an *Insert in a* ***separate chaining hash table*** *containing N elements where each bucket points to an AVL tree?*

Sorting (Simple Algorithms) - 15 Wi

1) [10 points total] Sorting: (Assume that array `sun[]` has indices: `0` to `size-1`)

```
SunnySort(int[] sun) {
      for (int i = 1; i < size; i++) {
        int j;
        int temp = sun[i];
        for (j = i; j > 0 && temp < sun[j-1]; j--) {
           sun[j] = sun[j-1];
        }
        sun[j] = temp;
      }
}
```

a) **[2 points]** This is actually a sort mentioned in class. What sort is this?

b) **[4 points]** Describe the best and worst case data set for this sort. (If all cases behave similarly, please state that.) What is the big-O running time of those two data sets?

Best Case data set?

Best Case running time?

Worst Case data set?

Worst Case running time?

c) **[2 points]** Is it an **in-place** sort? Why or why not?
(no credit without a reason or a definition of in-place, for partial credit define in-place sorting)

d) **[2 points]** Is it a **stable** sort? Why or why not?
(no credit without a reason or definition of stable, for partial credit define stable sorting)

8) **[12 points] Sorting**

a) **Radix Sort:** Give a formula for the worst case big-O running time of radix sort. For full credit, your formula should include all of these variables:

max_value	– the values to be sorted range from 0 to max_value
radix	– the radix or base to be used in the sort
n	– the number of values to be sorted

Answer:

b) **Quicksort**: Give the ***recurrence*** for each of the following: (Note: We are NOT asking for the closed form.)

Quicksort (parallel sort & parallel partition) – best case span

Answer:

Quicksort (parallel sort & parallel partition) – worst case span

Answer:

c) Give big-O runtimes of the following in terms of n. For parallel sorts, give the span.

_____ Mergesort (sequential) – worst case

_____ Quicksort (parallel sort & parallel partition) – best case span

_____ Quicksort (parallel sort & parallel partition) – worst case span

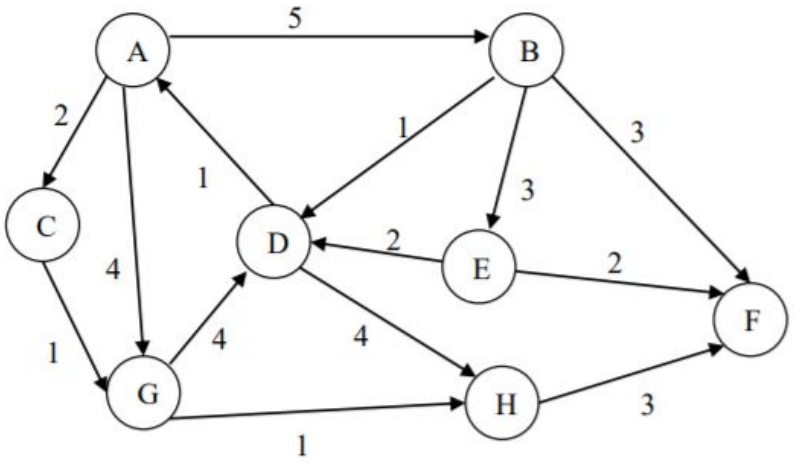
_____ Quicksort (sequential) – best case

_____ Quicksort (sequential) – worst case

Graphs (Path-finding) - 12 Wi

4) 10 points : Single-Source Shortest Paths

Consider the following directed, weighted graph:



a) Step through Dijkstra's algorithm to calculate the single-source shortest paths from vertex *A* to every other vertex. Show your steps in the table below. Cross out old values and write in new ones, from left to right in each cell, as the algorithm proceeds. Also list the vertices in the order which Dijkstra's algorithm marks them known:

Order vertices marked as known: ___ ___ ___ ___ ___ ___ ___ ___

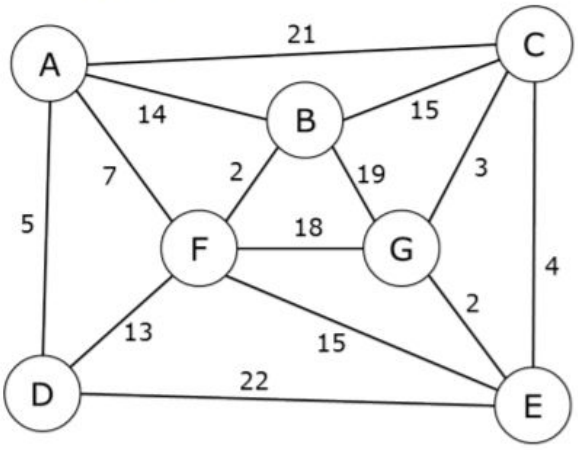
Vertex	Known	Distance	Path
A			
B			
C			
D			
E			
F			
G			
H			

b) What is the lowest-cost path from *A* to *F* in the graph, as computed above?

c) To guarantee correctness of Dijkstra's algorithm, all edge costs must be non-negative. Imagine the edge from A to B had cost -3. Why would this make it impossible for any algorithm to provide a correct answer for single-source shortest paths?

6. (continued)

For your convenience, here is the graph again.



(c) Step through **Kruskal's algorithm** to calculate a minimum spanning tree of the graph. Show your steps in the table below, including the disjoint sets at each iteration. If you can select two edges with the same weight, select the edge that would come alphabetically **last** (e.g., select E—F before B—C. Also, select A—F before A—B).

Edge Added	Edge Cost	Running Cost	Disjoint Sets
–	–	0	(A) (B) (C) (D) (E) (F) (G)

Parallelism (ForkJoin) - 15 Wi

4) **[10 points]** In Java using the ForkJoin Framework, write code to solve the following problem:

- **Input**: An array of ints (does not contain duplicates)
- **Output**: the *maximum* value and *its location* (index) in the Input array.

- Do **not** employ a sequential cut-off: **the base case should process one element**. (You can assume the input array will contain at least one element.)
- Give a class definition, `FindMax`, **along with any other code or classes needed**.
- We have provided some of the code for you, you should also **fill in** the _____ part.

```
import java.util.concurrent.ForkJoinPool;
import java.util.concurrent.RecursiveTask;


class Pair { // You are not required to use this class
      int a;
      int b;
      public Pair (int a, int b) {
            this.a = a;
            this.b = b;
      }
}


class Main{
      static final ForkJoinPool fjPool = new ForkJoinPool();
      _________ findMax (int[] array) {
        return fjPool.invoke(new FindMax(_____________________));
      }
}
```

Parallelism (Theory) - 15 Wi

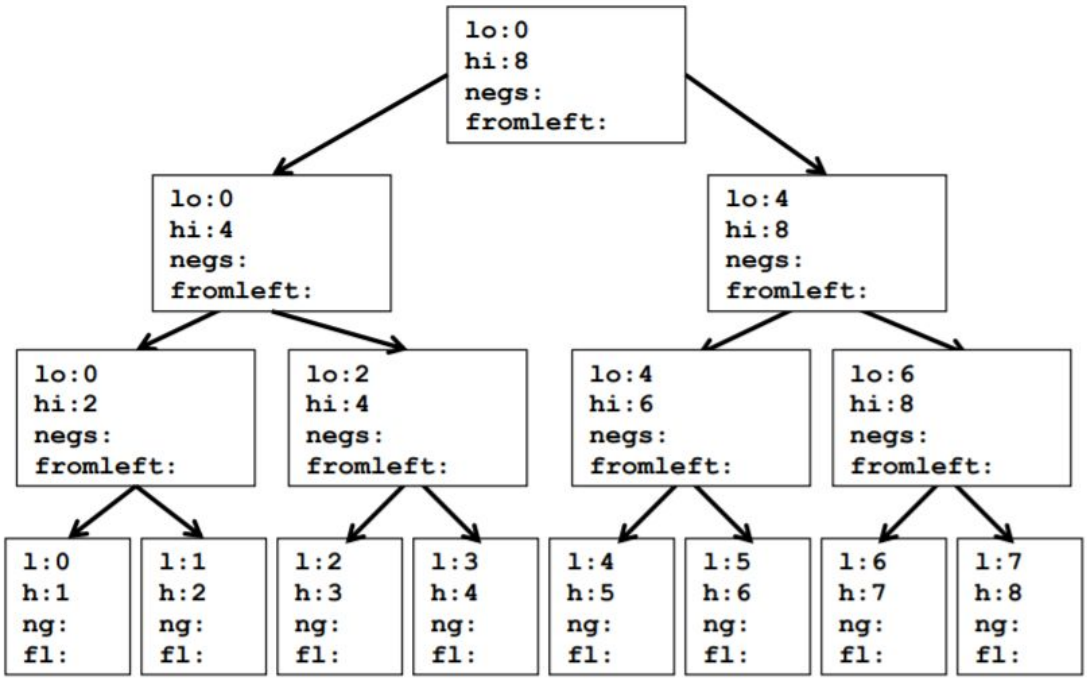
5) **[6 points] Speedup**

Given a program where 75% of it is parallelizable (and 25% of it must be run sequentially) what is the maximum ***speedup*** you would expect to get with 5 processors. Note: **You must show your work for any credit**. For full credit give your answer as a number or a simplified fraction (not a formula).

Parallelism (Parallel Prefix) - 15 Wi

4) [10 points] Parallel Prefix CountNegatives:

a) Given the following array as input, perform the parallel prefix algorithm to fill the **output** array with the **number of negative values contained in all of the cells to the left** (including the value contained in that cell) in the input array. Fill in the values for: **negs,** and **fromLeft** in the tree below. Do not use a sequential cutoff. **Note**: This is NOT sum!



Index	0	1	2	3	4	5	6	7
Input	-3	5	-4	-7	2	-8	9	-5
Output								

b) How is the **fromLeft** value computed for a node in the tree? Specifically, if you have a node with **negs** & **fromLeft** computed, how do you compute **fromLeft** for its left & right children (both of which have **negs** already computed).

Left child's fromLeft:

Right child's fromLeft:

7) 10 points : MoveToFrontList Concurrency

Consider this pseudocode for a MoveToFrontList, which is correct in a sequential context. It does not map keys to data items, but instead just tests whether a key is in the list.

```
01: class Node {
02:   Key  key;
03:   Node next;
04:
05:   Node(...) { // Constructor that stores these 2 fields }
06: }
07:
08: class MoveToFrontList {
09:   Node front = null;
10:
11:   void insert(Key key) {
12:     front = new Node(key, front);
13:   }
14:
15:   Boolean contains(Key find) {
16:     if(front == null) { return false; }
17:     if(front.key == find) { return true; }
18:
19:     Node prev = front;
20:     Node current = front.next;
21:     while(current != null) {
22:       if(current.key == find) {
23:         prev.next = current.next;
24:         current.next = front;
25:         front = current;
26:         return true;
27:       }
28:       current = current.next;
29:     }
30:     return false;
31:   }
32: }
```

We have numbered the lines of code so that you can reference them in your answers. Please do this, as it will be faster and will keep your answer more concise.

a) Describe an interleaving of `insert("a")` and `contains("b")` that results in the `insert("a")` being "missed" (i.e., `contains("a")` will return `false`).

b) Describe an interleaving of `insert("a")` and `insert("b")` that results in the `insert("a")` being "missed" (i.e., `contains("a")` will return `false`).

c) Describe an interleaving of `contains("a")` and `contains("a")` that results in them returning different values (i.e., one returns `true` and one returns `false`).

d) Using any of the mutual exclusion mechanisms discussed in lecture (including those unique to Java), describe how to fix this class so that it is correct in concurrent usage. Your only concern is correctness (i.e., performance is not a concern).

10) **[8 points] P, NP, NP-Complete**

a) "NP" stands for _____

b) What does it mean for a problem to be in NP?

c) Give two examples of NP-Complete problems:

_____ and _____

d) What should you do if you determine the problem you are trying to solve is NP-complete, yet you still need to solve it?