CSE 373

APRIL 12TH – TREES
ASSORTED MINUTIAE

• HW2 due tonight
  • Wrong submissions
• Static functions for your test cases
• HW3 out tonight
  • Dictionaries – LL, Array, BST
  • Empirical testing
• Regrade system up by Friday
LECTURE STYLE

• Too fast
  • More time-in-class examples
  • Lots of material to cover, but it isn’t doing any good if no one understands

• Too mathy
  • A bit tougher, abstract concepts are the most important part of the course
  • More physical examples
TODAY

• Review of Dictionaries
• BSTs as dictionaries
• Analysis of BSTs
• Tree traversals
DICTIONARY

• Data is inserted in `<Key,Value>` pairs.
• Keys must be comparable
• Implements three functions:
  • Insert (key, value)
  • Find (key)
  • Delete (key)
• Monday, we discussed 4 implementations
# IMPLEMENTATIONS

- **Simple implementations**

<table>
<thead>
<tr>
<th></th>
<th>insert</th>
<th>find</th>
<th>delete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsorted linked-list</strong></td>
<td>$O(1)^*$</td>
<td>$O(n)$</td>
<td>$O(n)$</td>
</tr>
<tr>
<td><strong>Unsorted array</strong></td>
<td>$O(1)^*$</td>
<td>$O(n)$</td>
<td>$O(n)$</td>
</tr>
<tr>
<td><strong>Sorted linked list</strong></td>
<td>$O(n)$</td>
<td>$O(n)$</td>
<td>$O(n)$</td>
</tr>
<tr>
<td><strong>Sorted array</strong></td>
<td>$O(n)$</td>
<td>$O(\log n)$</td>
<td>$O(n)$</td>
</tr>
</tbody>
</table>

* Unless we need to check for duplicates
IMPLEMENTATIONS

- Other implementations?
  - Binary Search Tree (BST)
  - Sort based on keys (which have to be comparable)
  - How do we implement this?
  - What changes need to be made?
    - Discuss how your 143 BST is different from a dictionary BST
    - Consider particularly how the BST Node changes
IMPLEMENTATIONS

• BST Node:
  • Before:
    • Node left
    • Node right
    • Value data
  • Now?
    • Node left
    • Node right
    • Key k
    • Value v
IMPLEMENTATIONS

• BST Changes:
  • Insert(), find() and remove() remain similar
  • Key is the primary comparison
  • Value is attached to the key
  • Dictionary fact: All values have an associated key
  • For now, assume all keys are unique, i.e. each key only has one value
IMPLEMENTATIONS

• BST Analysis:
  • What is our time for the three functions?
    • Insert()? Delete()? Find()?  
    • Take 5 minutes to discuss
    • Consider average and worst-case.
    • What are the inputs for average and worst-case?
IMPLEMENTATIONS

• BST Analysis:
  • Insert():
    • Worst case: $O(n)$
    • Average case: $O(\text{height})$
      • What is “average” data?
    • Best case: $O(\log n)$
AVERAGE CASE

• Interesting concept
  • Average to the user?
  • Average among all possible inputs?

• Random data trials
  • Produce random test cases and observe the result
    • Timer?
AVERAGE CASE

- Timing cases

- Advantages and disadvantages
  - + Actual runtime performance
  - – Can be skewed
  - + Easy to implement
  - – Difficult to ascertain asymptotic growth
AVERAGE CASE

• HW3 will have you do timing cases
  • Many runs will reduce hardware uncertainty
  • Running at many sizes will make trends more apparent
  • Demonstrate some real implementation behavior
How do we test average case for a dictionary?
We want varied input, without repetitions
One solution:
- Create a bunch of keys in a range
- Select without replacement
- Add into the dictionary

“Shape” of a dictionary is determined by insert() order, so ordering is critical.
INTRO FOR NEXT WEEK

• Tree traversals
  • How do we search through a tree?
  • Multiple ways? What if it isn’t a search tree?
INTRO FOR NEXT WEEK
INTRO FOR NEXT WEEK
INTRO FOR NEXT WEEK

If we have search!
INTRO FOR NEXT WEEK

If we have search!
INTRO FOR NEXT WEEK

What if we don’t? Say it’s a heap
INTRO FOR NEXT WEEK
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Possible to interrupt early
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Any other ways?
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