CS W3134: Data Structures in Java

Lecture #15: Sorts
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Administrivia
- No class on Tuesday – vote!
- HW#2 grades up Tuesday, can pick up on Thursday
- HW#3 due today
- HW#4 out tonight

Agenda
- Three major types of fast sorts
  - Mergesort
  - Radix sort
  - Quicksort
Mergesort

- Classic recursive algorithm
- Split arrays in half, sort each half, and then merge them together
  - “Divide and conquer”
- Sort is the “recursive” call
- Pseudocode?

Mergesort (II)

- Key aspect of code on page 287
- The header of the method contains enough information to perform the recursive call
  - In this case, partition information
- Efficiency?
  - Partition: $O(1)$
  - Merge: $O(n)$
  - How many times each have to be done? $O(\log n)$
  - Ergo, $O(n \log n)$
- Disadvantage: lots of memory required

Radix Sort

- Radix is the “base” of a system of numbers
- Very simple, fast algorithm (but a little tricky to implement)
- Sort by digit, one at a time
  - Sort on the 1s digit
  - Sort the 10s digit; keep relative order of equal 10s the same, i.e., go left-to-right on the 1s digit
  - Sort the 100s digit
  - Etc.
- Problem: where to store intermediate results?
- Can sort 100 numbers in 2 passes! $\sim O(2n)$
- But… that’s essentially $O(n \log n)$?
- There’s no free lunch, but this works very well for specialized keys
**Quicksort: Partition**

- Relies on concept of *partition*
  - A number s.t. two groups are formed: those smaller than the number, and those larger than the number
  - “Pivot”
  - Walk from both edges
    - If left is smaller than pivot, walk left
    - If right is larger than pivot, walk right
    - Otherwise, swap the two
  - What if we cross?
  - Last element is the pivot?
- Code? p. 338

**Quicksort: Recursion**

- Given pivot, we:
  - Partition the array in two;
  - Quicksort the left “half”; 
  - Quicksort the right “half”.
- And recurse!
- That’s it (p. 338)
  - Well, must be very, very careful
- Analysis?
  - Usually $O(n \log n)$, and in-memory
  - But there are some problems…

**Quicksort: Picking the pivot**

- Imagine a reverse-sorted array
- How long does Quicksort take? $O(n^2)$!
- How can we fix this?
  - Pick pivot more intelligently
  - Two popular mechanisms:
    - Random
    - Median-of-three
- Also, inefficient for small arrays
  - Use insertion sort as a degenerate case…
Trees

- Linked Lists are generally connected to one other link
- What if we connect to multiple other links?
- A Tree is one generalization of a Linked List
- Key definition: no “cycles” amongst children
  - Graphs are more general
- Terminology
  - Node, Edge, Path, Root, Parent, Child, Leaf,
    Subtree, Level

Next time

- Start trees