Measuring and Predicting Running Time

Victor Milenkovic

Department of Computer Science
University of Miami

CSC220 Programming II – Spring 2022

Outline

Running times of different implementations

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- We have two implementations of PhoneDirectory: ArrayBasedPD and SortedPD.

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Running times of different implementations

- We have two implementations of PhoneDirectory: ArrayBasedPD and SortedPD.
- Each has implementations of find, add, and remove.
- Can we compare their speeds?

find

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- ArrayBasedPD.find

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- SortedPD.find
  - Only really helpful when n (size) is large.

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  - Look for Vic?
  - Have to compare Vic with n entries, where $n =$ size, which is 6.
- SortedPD.find
  - Only really helpful when n (size) is large.
  - Requires $\log_2 n$ comparisons

addOrChangeEntry

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  - find uses n comparisons

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  - Abe, Ann, Bob, Eve, Ian, Jay, Zoe
  - add uses n array accesses. Actually $n - 1$ reads and n writes, where n is 7. So $2n - 1$.
  - Total time is $\log_2 n$ comparisons (find) plus $2n - 1$ array accesses (add).

removeEntry

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  - find takes 1 comparison to find Jay.

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  - What about Eve? (Last entry)

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  - Call to find takes n comparisons.

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  - remove takes 2 array accesses to remove Jay.
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  - What about Eve? (Last entry)
  - Call to find takes *n* comparisons.
  - add still uses 2 array accesses to “remove” Eve (but it could be smarter).

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  - Eve, Bob, Zoe, Ian, Ann
  - remove takes 2 array accesses to remove Jay.
  - Total time for 1 comparison and 2 array accesses.
  - What about Eve? (Last entry)
  - Call to find takes n comparisons.
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  - So Eve is worst case, requiring time for n comparisons (find) and 2 array accesses (remove).
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  - Ann, Bob, Eve, Ian, Jay, Zoe
  - Who is the worst to remove?
  - Did you figure out it was Ann?

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  - Who takes longest to remove? Jay?
  - removeEntry calls find.
  - find takes 1 comparison to find Jay.
  - removeEntry calls remove.
  - Eve, Bob, Zoe, Ian, Ann
  - remove takes 2 array accesses to remove Jay.
  - Total time for 1 comparison and 2 array accesses.
  - What about Eve? (Last entry)
  - Call to find takes n comparisons.
  - add still uses 2 array accesses to “remove” Eve (but it could be smarter).
  - So Eve is worst case, requiring time for n comparisons (find) and 2 array accesses (remove).
- SortedPD.removeEntry
  - Ann, Bob, Eve, Ian, Jay, Zoe
  - Who is the worst to remove?
  - Did you figure out it was Ann?
  - find takes $\log_2 n$ comparisons to locate Ann.

removeEntry

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  - Jay, Bob, Zoe, Ian, Ann, Eve
  - Who takes longest to remove? Jay?
  - removeEntry calls find.
  - find takes 1 comparison to find Jay.
  - removeEntry calls remove.
  - Eve, Bob, Zoe, Ian, Ann
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- SortedPD.removeEntry
  - Ann, Bob, Eve, Ian, Jay, Zoe
  - Who is the worst to remove?
  - Did you figure out it was Ann?
  - find takes $\log_2 n$ comparisons to locate Ann.
  - add takes n array reads and writes to move everyone else back.

removeEntry

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  - Jay, Bob, Zoe, Ian, Ann, Eve
  - Who takes longest to remove? Jay?
  - removeEntry calls find.
  - find takes 1 comparison to find Jay.
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  - remove takes 2 array accesses to remove Jay.
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  - What about Eve? (Last entry)
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- SortedPD.removeEntry
  - Ann, Bob, Eve, Ian, Jay, Zoe
  - Who is the worst to remove?
  - Did you figure out it was Ann?
  - find takes $\log_2 n$ comparisons to locate Ann.
  - add takes n array reads and writes to move everyone else back.
  - Bob, Eve, Ian, Jay, Zoe

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- SortedPD.removeEntry
  - Ann, Bob, Eve, Ian, Jay, Zoe
  - Who is the worst to remove?
  - Did you figure out it was Ann?
  - find takes $\log_2 n$ comparisons to locate Ann.
  - add takes n array reads and writes to move everyone else back.
  - Bob, Eve, Ian, Jay, Zoe
  - Total is $\log_2 n$ comparisons (find) and $2n$ array accesses (remove).

Summary

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- ArrayBasedPD

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- ArrayBasedPD
  - find: *n* comparisons

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  - find: n comparisons
  - add: 1 array access (usually)

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  - find: *n* comparisons
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  - addOrChangeEntry: *n* comparisons plus 1 array access (usually)

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  - removeEntry: n comparisons plus 2 array accesses

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  - find: n comparisons
  - add: 1 array access (usually)
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  - addOrChangeEntry: n comparisons plus 1 array access (usually)
  - removeEntry: n comparisons plus 2 array accesses
- SortedPD

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  - addOrChangeEntry: n comparisons plus 1 array access (usually)
  - removeEntry: n comparisons plus 2 array accesses
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  - find: $\log_2 n$ comparisons

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  - removeEntry: n comparisons plus 2 array accesses
- SortedPD
  - find: $\log_2 n$ comparisons
  - add: $2n$ array accesses

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  - addOrChangeEntry: n comparisons plus 1 array access (usually)
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  - add: $2n$ array accesses
  - remove: $2n$ array accesses

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  - add: $2n$ array accesses
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- Now suppose SortedPD.find takes 50 microseconds for $n = 100$.
- More complicated methods often take longer for small n.
- This is the same reason that you don't drive your car to go next door.
- By the time you have opened the garage door, got in, started it up, etc., you will spend more time than just walking there.
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- Notice that I used the same log base 10. You can't switch log bases in the middle, or you will get a different (and wrong) answer.

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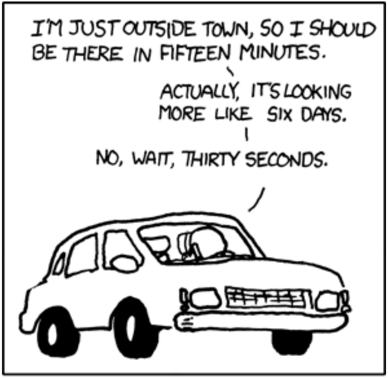
- Different log. Same answer!



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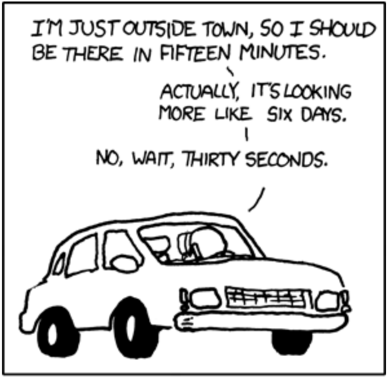

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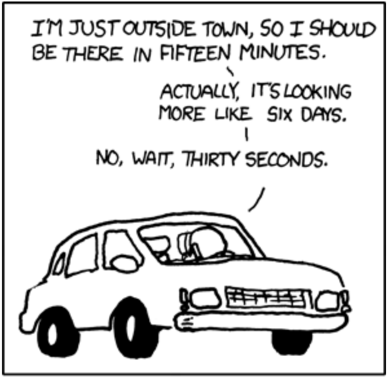

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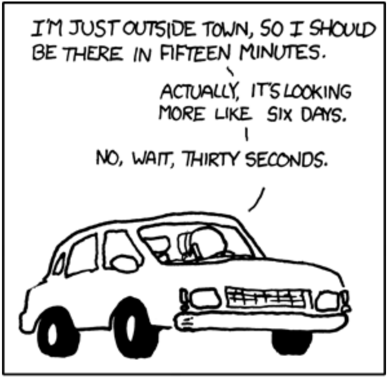

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- Answer: repeat the experiment many times and take the average.

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- The average time 1010203 / 20000 = 50.51015 microseconds.
- Much more accurate. We can trust 5 digits (maybe).

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- Accurate predictions can make or break a business and save millions of dollars.
- To improve the accuracy of a measurement, repeat it many times and take an average.
- For example, run it once to get an approximate time. Figure out how many times you can run it in one second. Run it that many times and take the average running time.