COMPSCI 105 Lecture 19: Simple Searching and Sorting

Also relevant to CMPSCI 145

Why do we Care?

- It is estimated that around 70% of what any computer does over its entire operational lifetime is either ***searching*** or ***sorting***.
- ***Searching***: Looking for an item in a group of items. Can be a simple list or something much more complicated.
- ***Sorting***: Arranging items into some order (numerical or alphabetical), either for our convenience or to make searches faster.

Big-O Notation

- There are N items in the list to search or sort.
- Mathematically, we describe the "goodness" or ***worst-case performance*** of a technique as an expression involving N, called "big-O" notation.
  - O(1) = constant performance, regardless of N.
  - O(N) = performance directly proportional to N.
  - $O(\log_2(N))$ = performance proportional to the logarithm base 2 of N.
  - $O(N^2)$ = performance proportional to the square of N.
  - Etc., etc., etc.

Big-O Example

- For example, suppose we can describe the performance of a technique precisely as:

$$f(N) = 3N^2 - 4N + 2$$

- As N grows, the dominant term is the $3N^2$ (grows much faster than the 4N term).
- The coefficient 3 is largely irrelevant (could be 5 or 2 and doesn't change the N^2 effect).
- This is considered an $O(N^2)$ technique.

Linear Search

- Items can be in any order,
- Have to examine first record, then second record, then third record, etc., until item is found or all items have been examined,
- Worst case search time (item not found) is O(N) for N items,
- Search time grows *linearly* as a function of N.

Self-Organizing Lists

- What if we move every item searched closer to the front of the list, so it can be found faster next time?
- Several self-organizing list techniques:
  - Swap with front (fast to move, no clustering)
  - Move to front (slow to move on simple lists, fast on more complicated structures, excellent clustering)
  - Promote by one slot (fast to move, slow clustering)
  - Promote by half the list length (OK but not great move and clustering performance)
- Can improve *average* performance, but <u>not</u> worst case. Still O(N) worst case!

Binary Search

- Items <u>must be sorted</u> on search field,
- Examine <u>middle</u> record, stop if found, but if not found discard half of list known to not contain item, repeat until found or list empty,
- Worst case search time (item not found) is $O(\log_2(N))$ for N items,
- Search time grows *logarithmically* as a function of N,
- $O(\log_2(N))$ grows more slowly than $O(N)$, so binary search is much faster than linear search for large N.

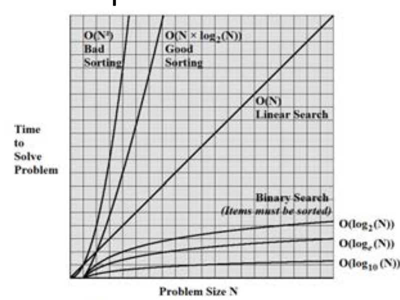
Sorting

- Very time expensive,
- Worst case sort time is $O(N^2)$ for bad sorting algorithms (usually simple to program),
- Worst case sort time is $O(N \times \log_2(N))$ for N items for good (more complex) sorting algorithms,
- Worth it to sort once if binary search can be used many times.

SUMMARY

- Linear Search: $O(N)$, but items can be in any order.
- Binary Search: $O(\log_2(N))$, but items must be sorted.
- Sorting: $O(N^2)$ for bad (i.e., simple) sorts.
- Sorting: $O(N \times \log_2(N))$ for good sorts.

Comparison of Times



"Big-O" Running Times

What if we need to see a table in several different orders?

- Option #1: Re-sort table each time a new view is needed.
  - Only one table, but…
  - …takes lots of unnecessary time.
- Option #2: Make several copies of table, each sorted on a different field.
  - Many copies means <u>lots</u> of disk space used, and…
  - Adding/Deleting/Changing record in one means same change must be made to all (data consistency).
- Option #3: Use Indexes. (Next Lecture!)