122COM: Searching

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Overview

Introduction

Searching is used everywhere in computing.

- Obvious applications.
  - Text files.
  - Databases.
  - File systems.
  - Search engines.
- Hidden applications.
  - Computer games.
    - Field Of View (FOV) search for objects in view.
    - Path finding `https://www.youtube.com/watch?v=19h1g22hby8`.
  - Network routing.
  - Sat Nav.
  - Recommender systems.
    - Netflix What-to-watch.
    - Amazon recommended items.

Linear search

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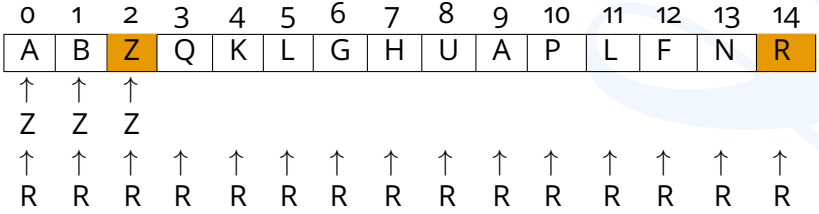
Simplest searching algorithm.

- Also called sequential search.
- Iterate over elements.
- Until found or until end of sequence.
- Potentially slow.
  - Worst case if the value isn't in the sequence at all.
- $O(n)$
  - Discuss $O()$ notation last week.



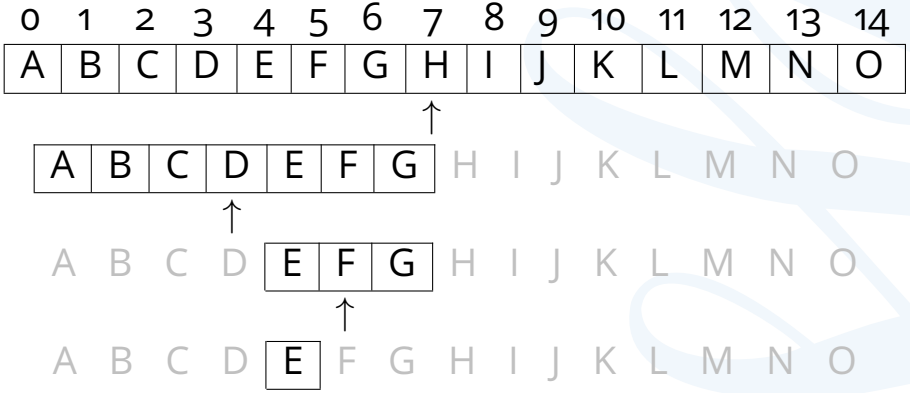
Binary search

A Divide & conquer algorithm.

- Pro: Muuuuuuch faster than linear search.
- Con: Only works on sorted sequences.
- The algorithm:
  1. Find middle value of the sequence.
  2. If search value == middle value then success.
  3. If search value is $<$ middle value then forget about the top half of the sequence.
  4. If search value is $>$ middle value then forget about the bottom half of the sequence.
  5. Repeat from step 1 until `len(sequence)==0`.

Binary search II

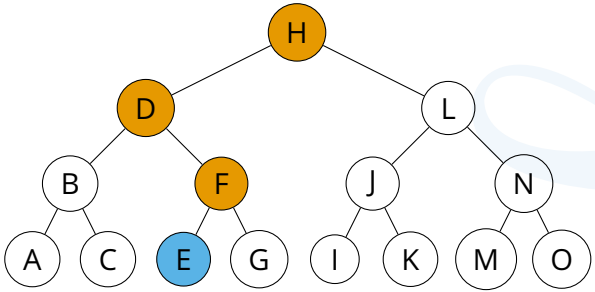
Find E.



Complexity

Maximum number of comparisons needed? Binary Search Trees.

- How many times can we divide our sequence in half?
- Ideal depth of the tree is $\log_2(n)$
  - $n = 15$ in this example.
  - $\log_2(15) = 3.9 \Rightarrow 3$
- Binary search has a complexity of $O(\log n)$.
  - Covered $O()$ complexity last week.
- Find E.



It's HOW much faster?!?!!

Clearly much faster than linear search.

- To search a trillion elements linearly could mean a trillion comparisons.
- Binary search does it in 39.

But...

- Have to sort the list first.
- Sorting lists can be expensive.
  - Will cover sorting in a later week.
- Can't always sort sequences.
- Ordering can be important.
  - E.g. Words in text documents.
  - E.g. Genes in genetic chromosomes.

String searching

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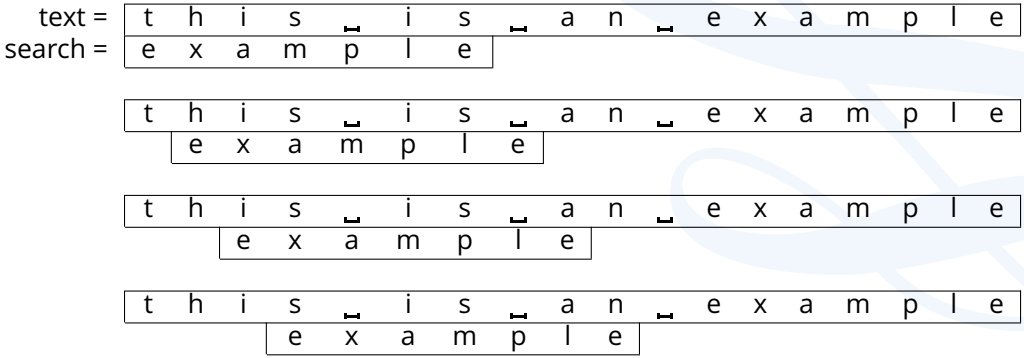
I.e. Text searching.

- Finding one sequence in another sequence.
- Naive search.
  - Like linear search but with multiple values to compare.
  - Is very slow.



etc, etc, etc.

Why do I care?

Everyone

- Searching algorithms are key to understanding many data type.
  - I.e. sets and maps/dicts.
- Key to writing efficient code.
- Key to understanding memory/processor trade offs.

Recap

- Searching
  - Applications everywhere.
- Linear search.
  - Simple.
  - Slow.
- Binary search.
  - Ordered sequence.
  - Very fast.
  - Divide & Conquer.
- String searching.
  - Finding subsequence in sequence.

The End