Sorting algorithms

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February 24, 2016

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   - Stable sort
   - In-place

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Sorting

Sorting is one of the classic problems for learning algorithms.

- Requirement for everything.
- Obvious applications like sorting text, statistics (median calculations).

- Less obvious, sorting objects in games for FOV calculations.
- Route planning.

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Bubblesort

Very simple sort.

- Compares each item to the next in the sequence.
  - Swap items if in wrong order.

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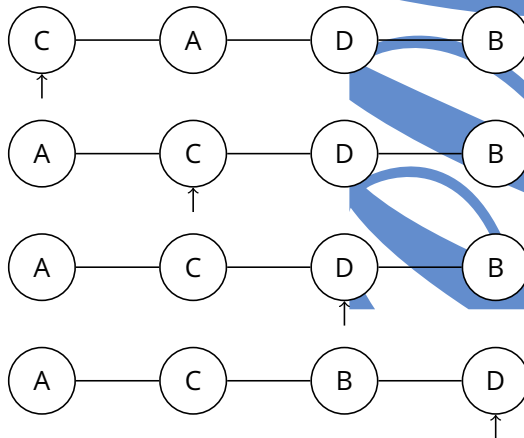
Bubblesort

Iterating over the sequence once isn't typically enough.

- Keep iterating over the sequence until elements are sorted.

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Stable sort

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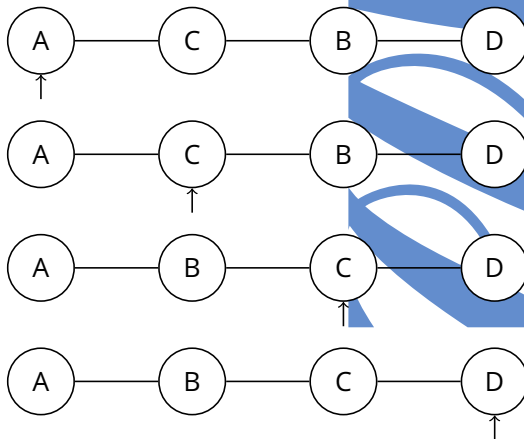
Bubble sort is what's known as an stable in-place sort.

Stable meaning that equivalent elements do not change their relative orders.

- Not important if e.g. sorting people by height.
- Important if e.g. priority queues.
    - Imagine a queue in an emergency room.
    - Treat the most serious conditions first, sort people on how bad injury is.
    - If many people have same injury then should be seen based on when entered queue.

With unstable sorting algorithm the relative orders of equivalent elements can be changed.

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In-place

In-place meaning that it only needs a small amount of additional memory in order to work.

- More memory efficient than the alternative.
- Can be important if...
  - ...dealing with large amounts of data.
  - ...have limited resources (i.e. embedded systems).
- Bubble sort only needs a few extra variables to swap the elements and to step through the sequence.

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Bubblesort

One of the simplest sorting algorithms.
- Explained here to introduce you to sorting concepts.
  - In-place, stable.

- Is rubbish.
  - Horrible performance, average is $O(n^2)$.
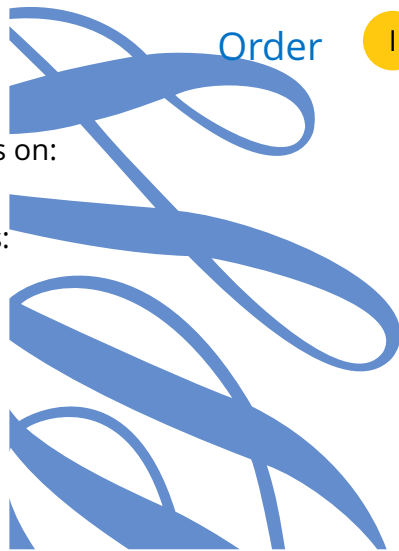 - But best case is only $O(n)$.

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The time taken to sort a sequence depends on:
- The starting order of the sequence.

For example, Bubblesorting a 100 elements:
- Best case, are already sorted.
  - Iterate over sequence once.
  - 100 comparisons.
- Worst case, in reverse order.
  - Iterate over sequence 100 times.
  - 10,000 comparisons.
- Average case, random order.
  - Somewhere in between.

So sorting algorithms have 3 $O()$ values.

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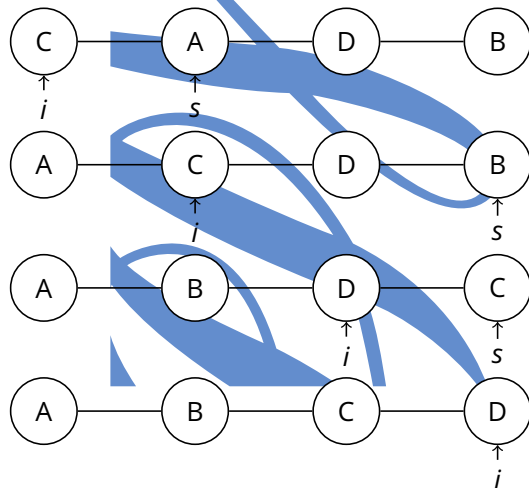Quicksort
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Selection sort

C

- Divides sequence into sorted and unsorted regions.
- Not stable.
- In place.

1. Iterate over sequence.
2. For each element search the remaining elements on its right for the smallest value.
3. Swap smallest element with current element.

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Selection sort II

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1. Iterate over sequence.
2. For each element search the remaining elements on its right for the smallest value.
3. Swap smallest element with current element.

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$O()$ A

Bubblesort is $O(n^2)$.
Selection sort is $O(n^2)$.

- Selection sort is generally faster than bubble.
    - But have same $O()$ complexity.

    - What?

- $O()$ notation describes how an algorithm will grow.

- Not good at absolute performances.

- Selection sort typically does fewer comparisons and swaps than bubblesort.
    - Therefore faster.

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Sorting Algorithms

Many sorting algorithms

- Different trade-offs, performances. `https://www.youtube.com/watch?v=ZZuD6iUe3Pc`
- Some are just jokes.

1 Bead
2 Bogo
3 Bubble
4 Circle
5 Cocktail
6 Comb
7 Counting
8 Cycle

9 Gnome
10 Heap
11 Insert
12 Merge
13 Pancake
14 Patience
15 Permutation
16 Quick

17 Radix
18 Selection
19 Shell
20 Sleep
21 Stooge
22 Strand
23 Tree

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Quicksort

C

Neither bubble or selection sort are very good.

- Simple algorithms but slow.
- Not used in real life.

One of the fastest sorting algorithms.

- Used in real life.
- Recursively breaks the sequence in half.
  - Divide & Conquer.

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1. Select a value from the sequence, this is the pivot.
2. Put all values $<$ pivot in one group.
3. Put all values $>$ pivot in another group.
4. Treat each group as a new sequence and repeat from step 1.

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Quicksort III

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1 Select a value from the sequence, this is the pivot.

2 Put all values < pivot in one group.

3 Put all values > pivot in another group.

4 Treat each group as a new sequence and repeat from step 1.

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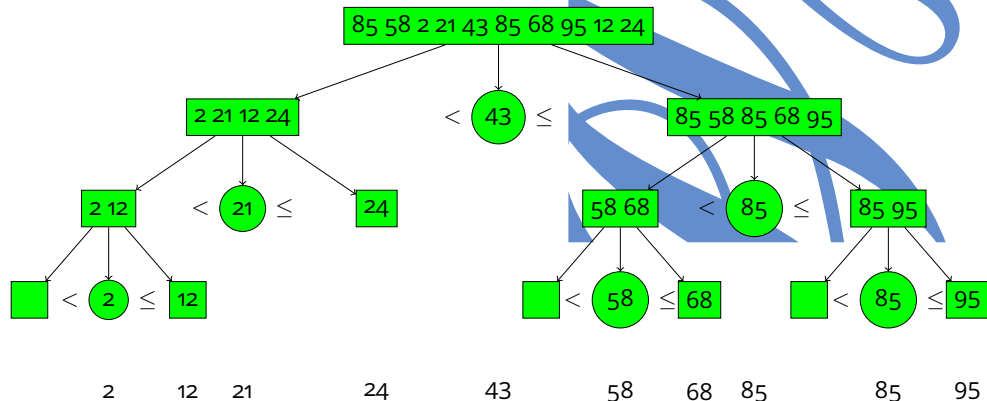
Quicksort

Quicksort is...
- ...sometimes in-place.
  - Depends on implementation.
- ...sometimes stable.
  - Depends on implementation.

Some issues with the original algorithms (1959).
- Choosing the pivot.
  - First element.
  - Middle element.
  - Average of first, middle and last.
- Repeated elements.
  - Fat partition.

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Divide and Conquer

Quicksort is a divide and conquer algorithm.

- Too hard to sort the whole sequence?
- Divide the problem.
  - Still too hard?
  - Divide the problem.
    - Still too hard?
    - Divide the problem.
    - Etc, etc, etc.

Naturally suited for parallelism.

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Comparing algorithms

Have seen there are many ways to sort.

- Best sorting algorithm depends on multiple factors.
- Good in one situation is bad in another.

- Stability? In place?
- What are you sorting?
    - Linked lists?
    - Sequential memory (arrays)?
- 🔴 Where are you sorting?
    - RAM?
    - EEPROM? cheap to read, expensive to write.
- 🔴 Size of n.
    - Insertion sort with small n.
- 🔴 Consistent performance.
    - Selection sort.

Quiz

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Recap

- Many sorting algorithms.
- Bubblesort.
- Selection sort.
- Quicksort
- Advantages/disadvantages.
  - In place.
  - In order.
  - Divide and Conquer.
- Performance
  - O()
  - Sequence type.
  - Read/writes.
  - Size of n.

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The End

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