Sorting algorithms

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Overview

Sorting

C

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 (Field Of View) calculations.
- Route planning.

Bubblesort

C

Very simple sort.

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

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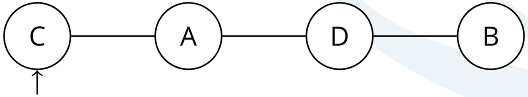

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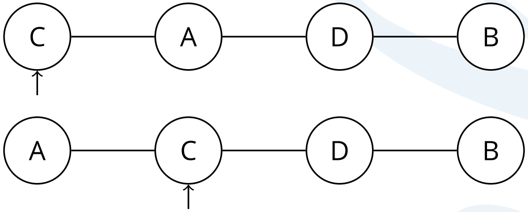

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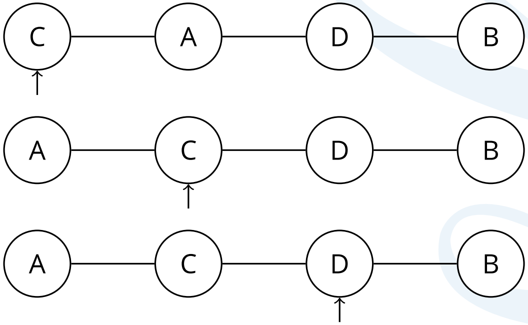

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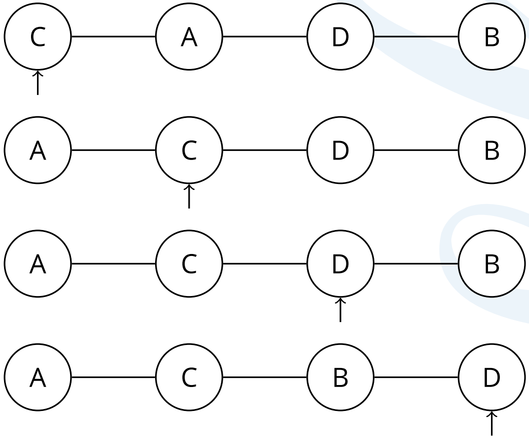

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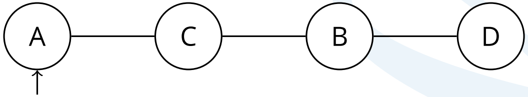

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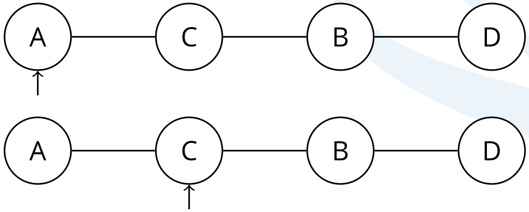

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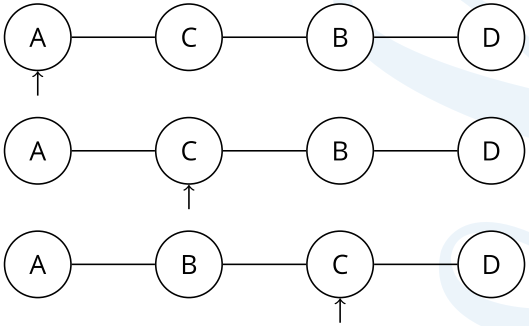

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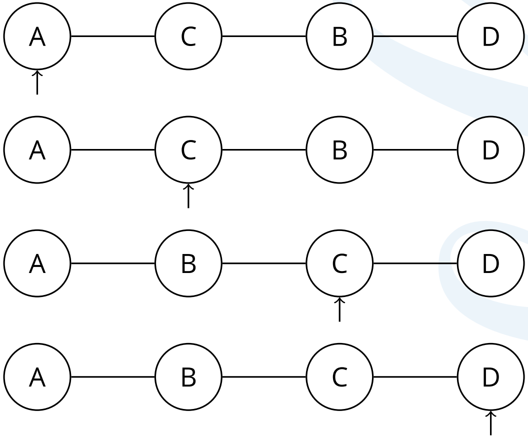

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Stable meaning that equivalent elements do not change their relative orders.

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

In-place

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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.

Bubblesort

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

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

Order

The time taken to sort a sequence depends on:

- The starting order of the sequence.

For example, Bubblesorting a 100 elements:

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

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- Best case, are already sorted.
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- Worst case, in reverse order.
  - Iterate over sequence 100 times.
  - 10,000 comparisons.

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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.

Selection sort

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- Divides sequence into sorted and unsorted regions.
- Stable/Unstable, depends on implementation.
- 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.

Selection sort II

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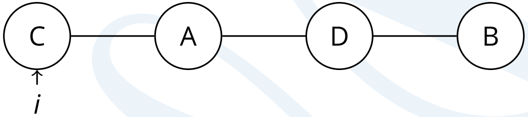

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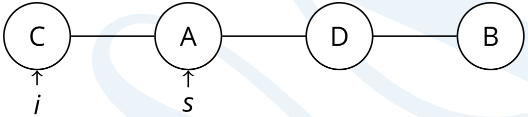

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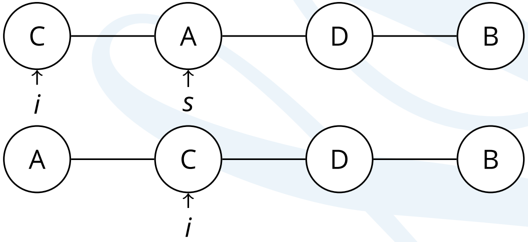

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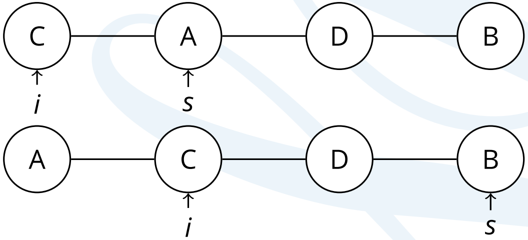

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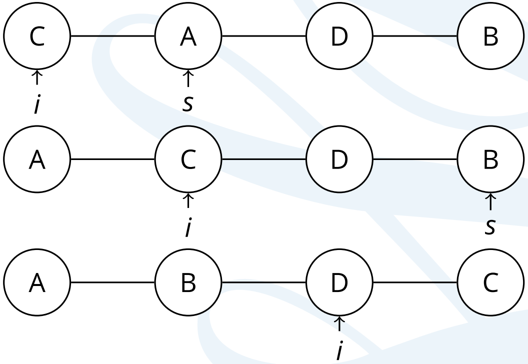

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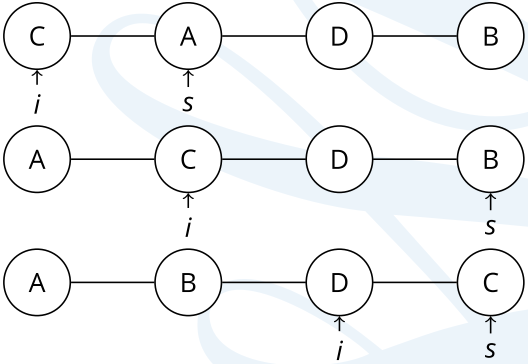

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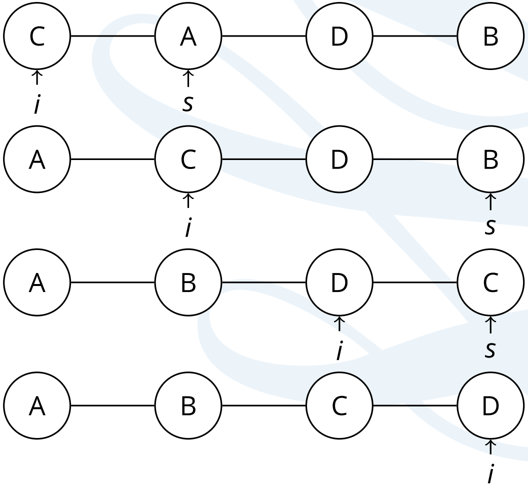

$O()$

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Bubblesort is $O(n^2)$ worst and average case .
Selection sort is $O(n^2)$ worst and average case.

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

O()

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Selection sort is $O(n^2)$ worst and average case.

- 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 typically faster.

- Best case bubblesort is $O(n)$, selection is $O(n^2)$.
  - Occasionally faster.

Sorting Algorithms

A

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

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.

Quicksort II

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

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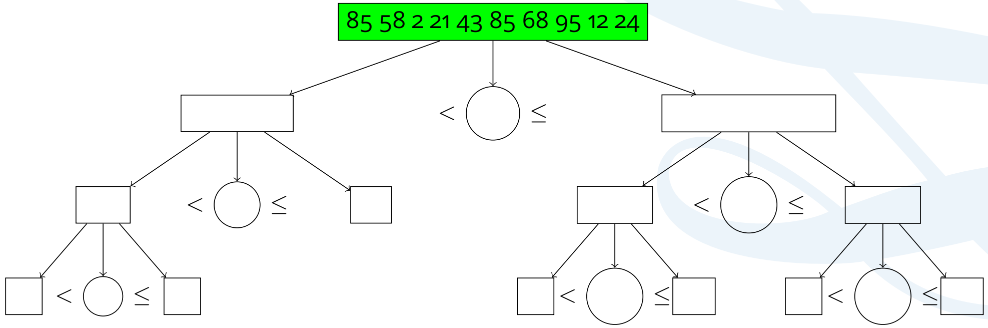

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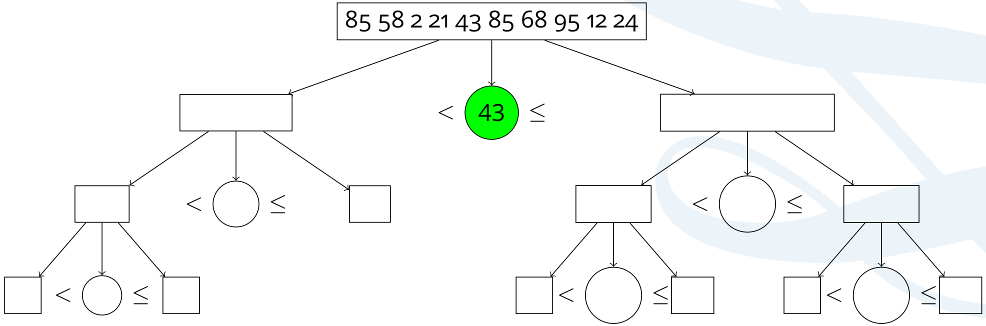

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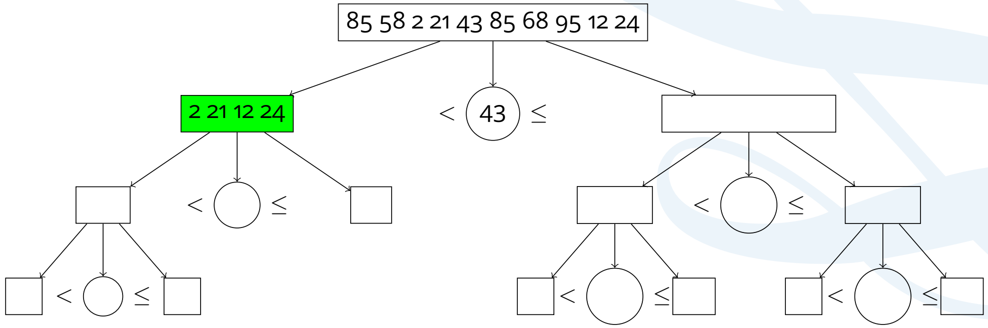

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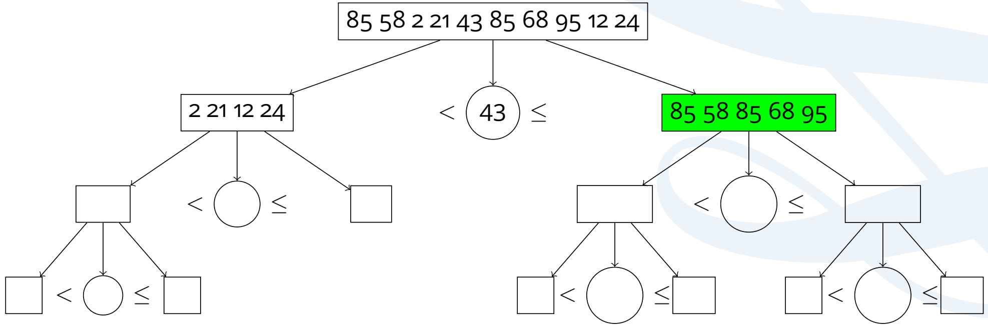

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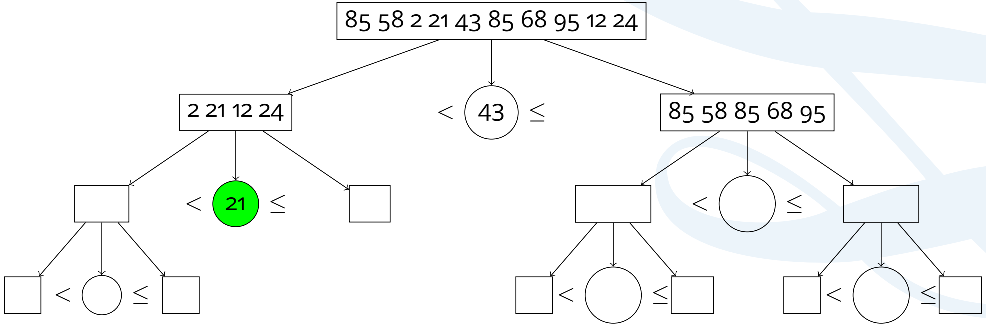

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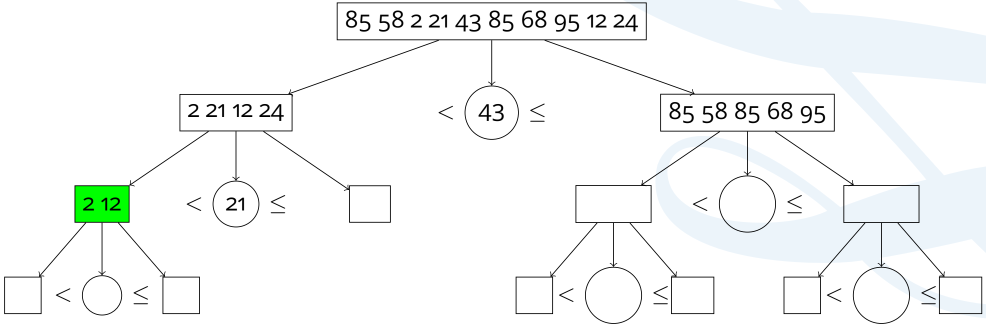

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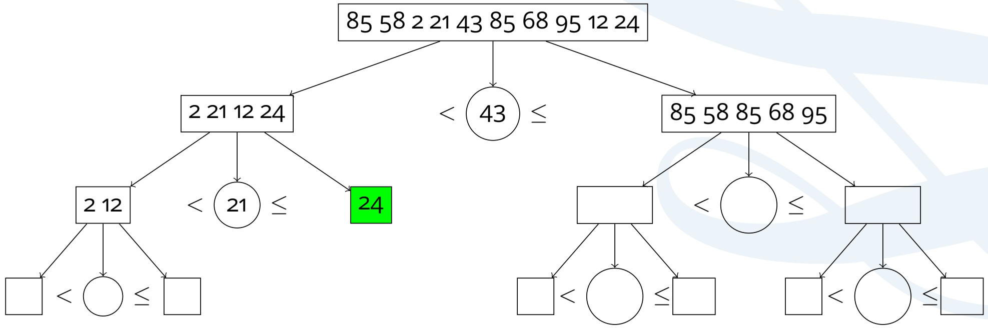

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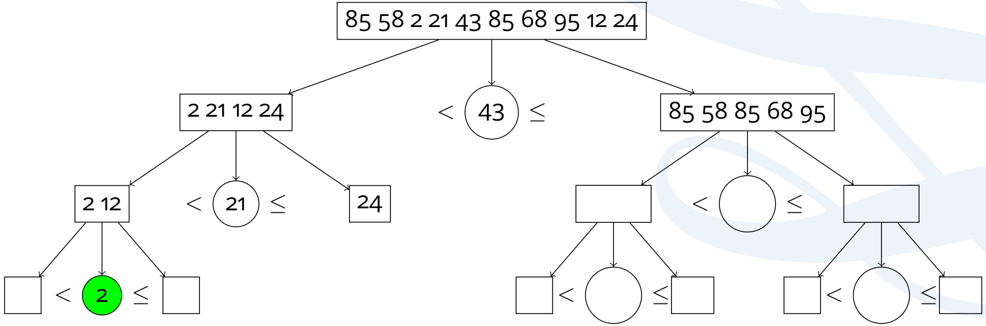

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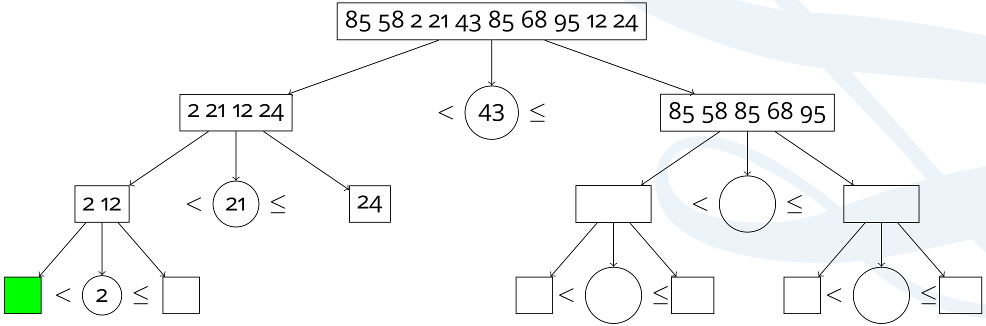

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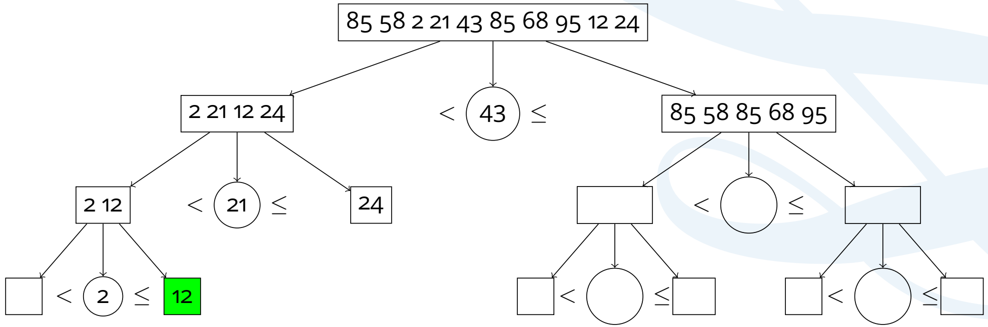

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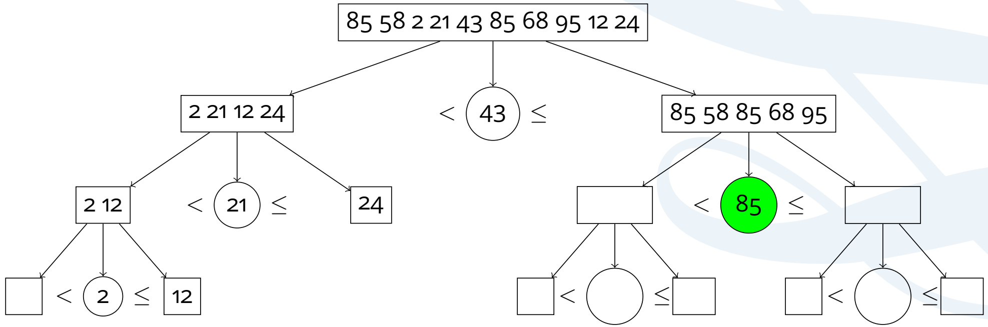

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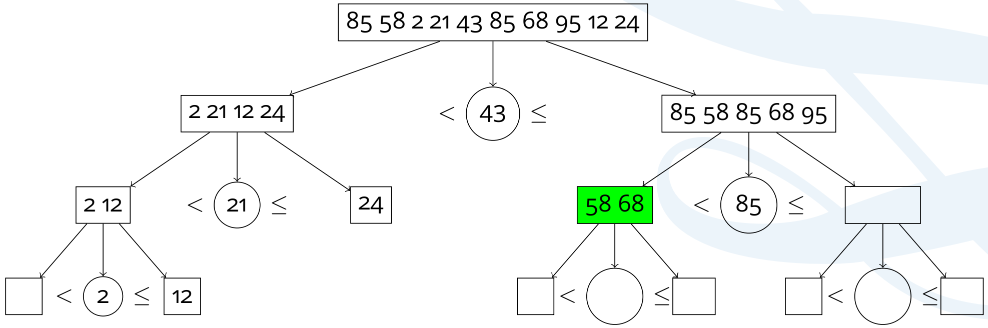

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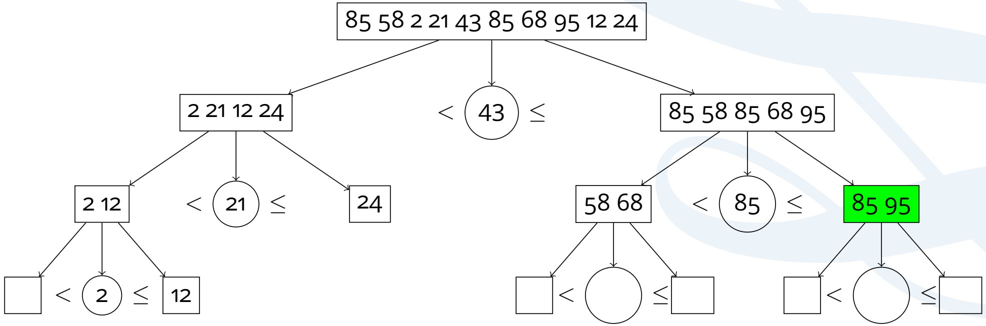

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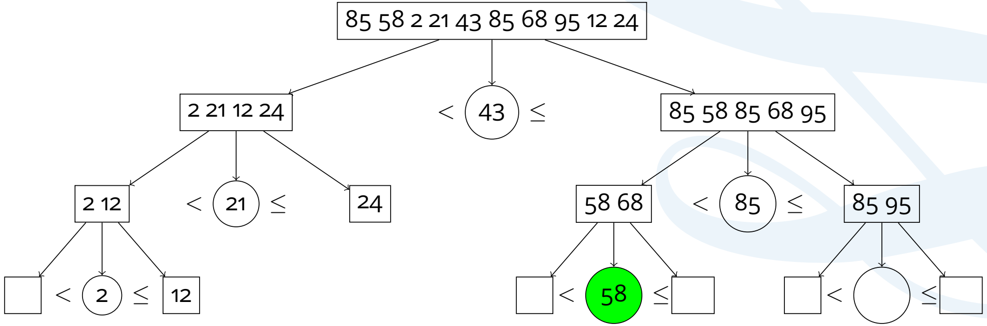

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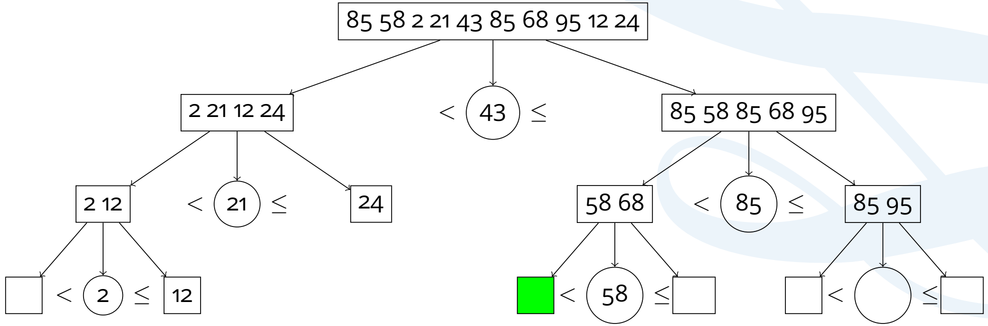

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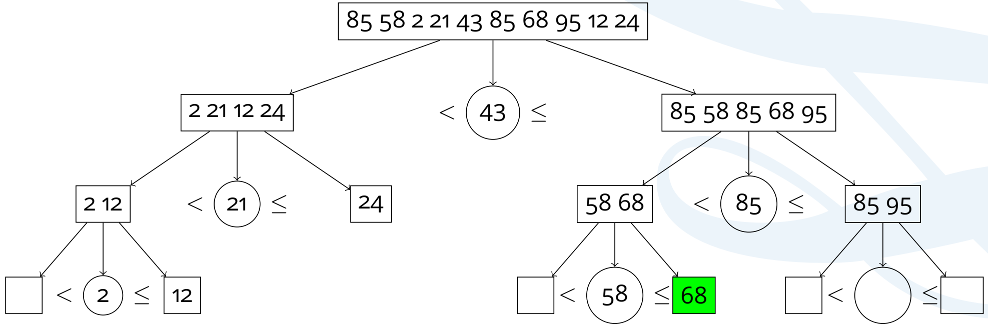

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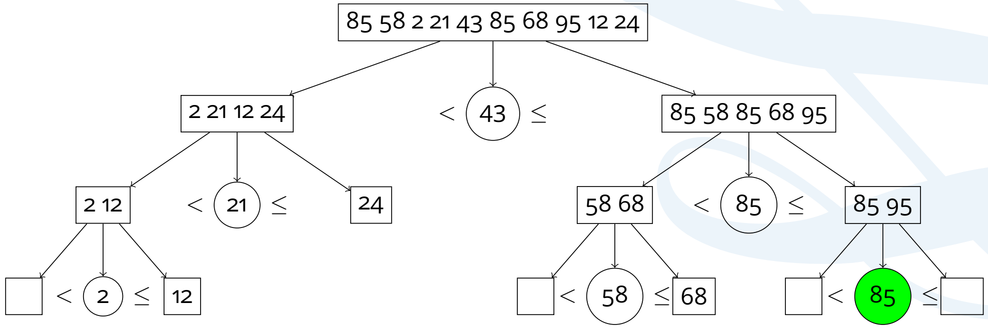

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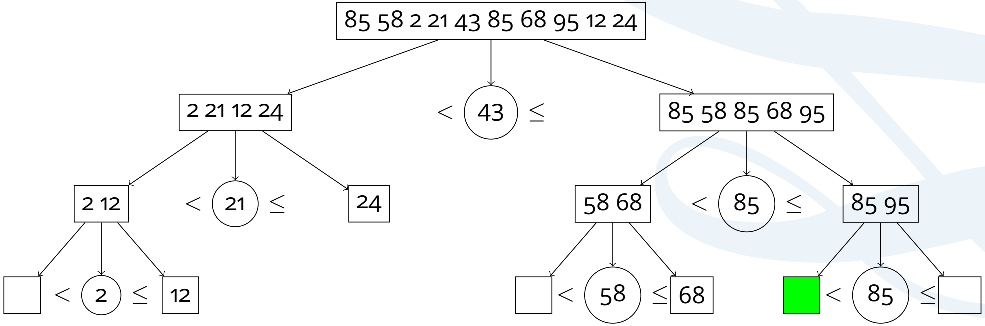

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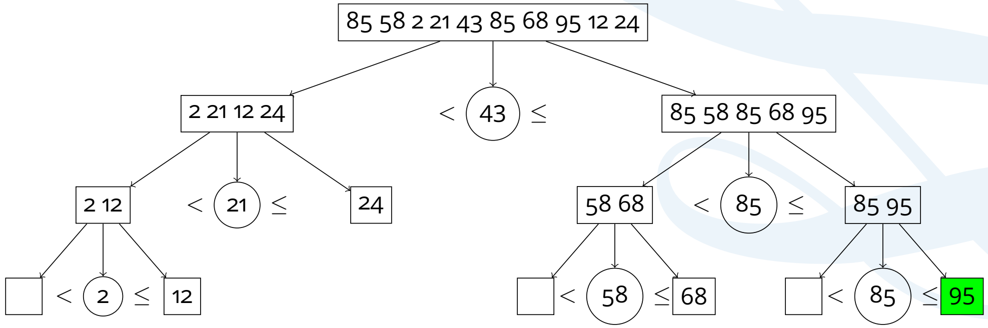

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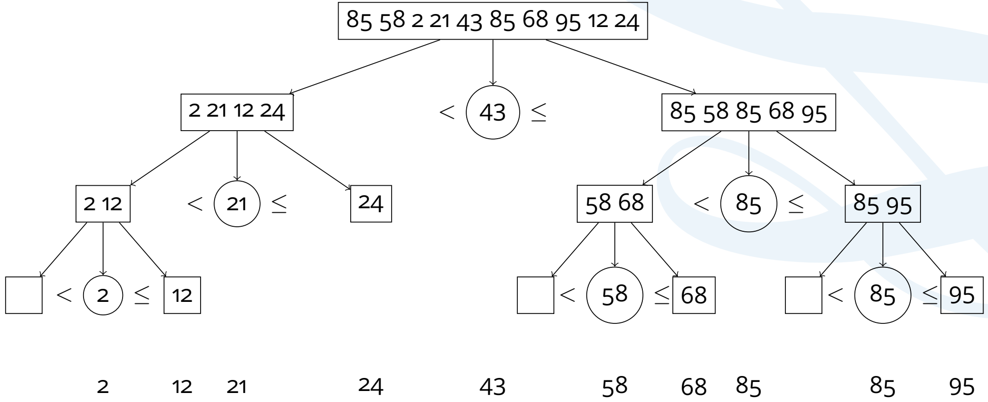

Quicksort

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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.

Divide and Conquer

C

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.

Comparing algorithms

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Have seen there are many ways to sort.

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

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  - Linked lists?
  - Sequential memory (arrays)?

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- Where are you sorting?
  - RAM?
  - EEPROM? cheap to read, expensive to write.

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  - RAM?
  - EEPROM? cheap to read, expensive to write.
- Size of n.
  - Insertion sort with small n.

Comparing algorithms

I

Have seen there are many ways to sort.

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

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Quiz

Recap

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

The End