Sorting algorithms

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Overview

1 Introduction

2 Bubblesort
- Stable sort
- In-place

3 Selection sort

4 Other algorithms

5 Quicksort
- Divide & Conquer

6 Comparing

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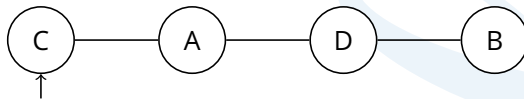Sorting is one of the classic problems for learning algorithms.

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

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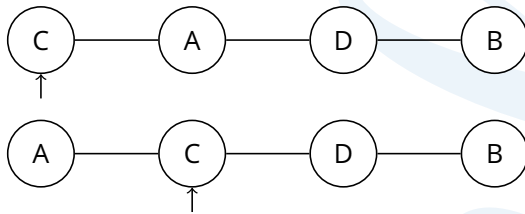- Route planning.

Bubblesort

Very simple sort.

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

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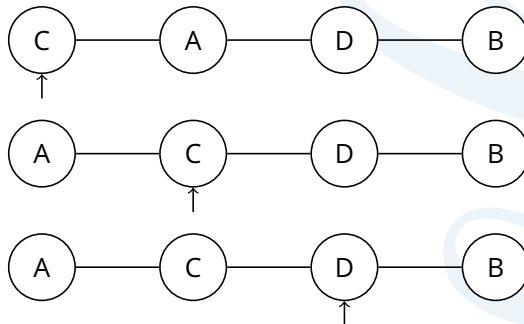University

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Bubblesort   C

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Iterating over the sequence once isn't typically enough.

- Keep iterating over the sequence until elements are sorted.

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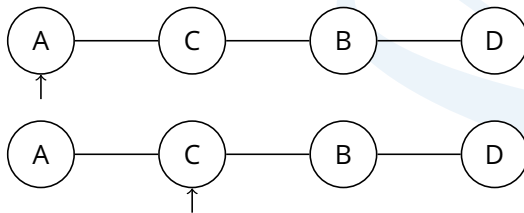
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Stable sort

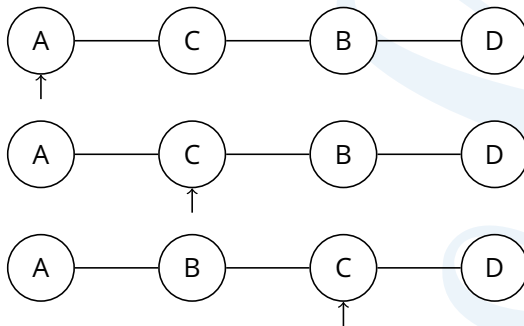Bubble sort is what's known as an stable in-place sort.

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

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    - Imagine a queue in an emergency room.

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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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One of the simplest sorting algorithms.

- Explained here to introduce you to sorting concepts.
  - In-place, stable.

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  - 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:

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

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Order

The time taken to sort a sequence depends on:

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For example, Bubblesorting a 100 elements:

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    - Iterate over sequence once.
    - 100 comparisons.

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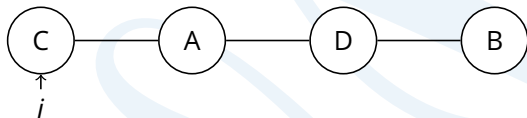
- Best case, are already sorted.
  - Iterate over sequence once.

  - 100 comparisons.

- Worst case, in reverse order.
  - Iterate over sequence 100 times.

  - 10,000 comparisons.

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

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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

- Divides sequence into sorted and unsorted regions.
- Not stable.
- In place.
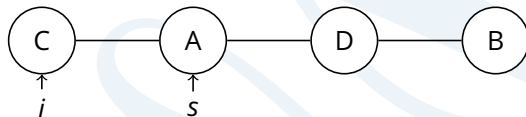
1. Iterate over sequence.
2. For each element search the remaining elements on its right for the smallest value.
3. Swap smallest element with current element.

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Selection sort II

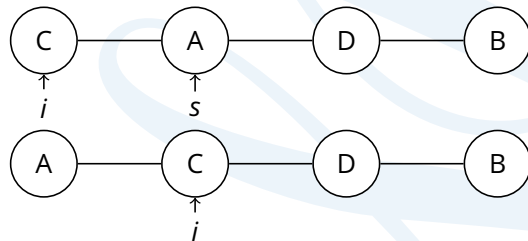C

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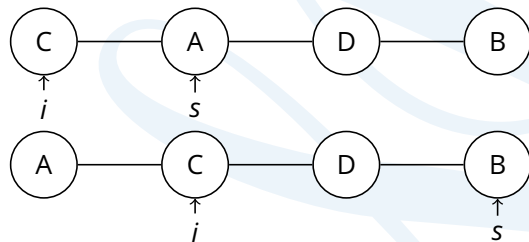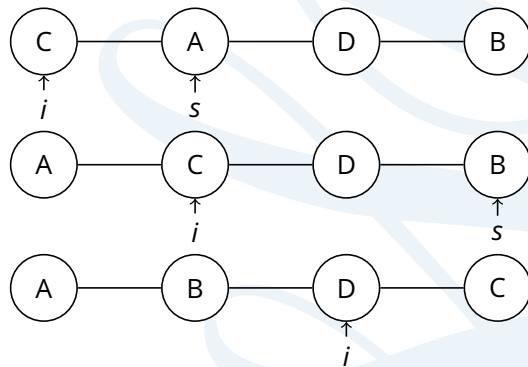
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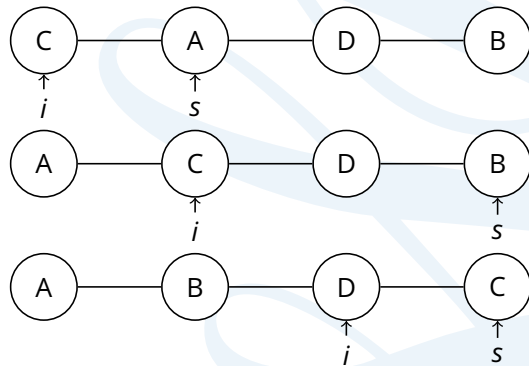3 Swap smallest element with current element.
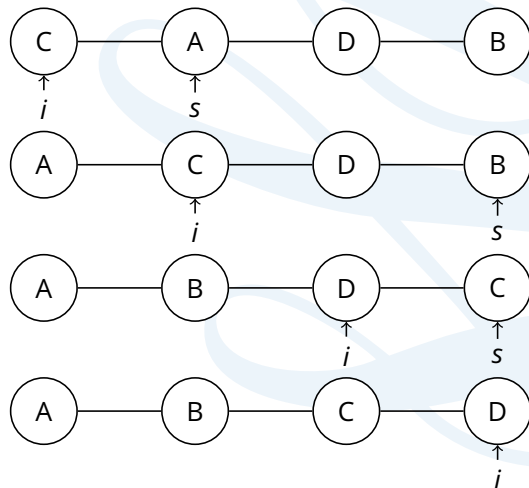
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$O()$ A

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

- Selection sort is generally faster than bubble.
    - But have same $O()$ complexity.
    - WTF?
- $O()$ 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	9	Gnome	17	Radix
2	Bogo	10	Heap	18	Selection
3	Bubble	11	Insert	19	Shell
4	Circle	12	Merge	20	Sleep
5	Cocktail	13	Pancake	21	Stooge
6	Comb	14	Patience	22	Strand
7	Counting	15	Permutation	23	Tree
8	Cycle	16	Quick		

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Quicksort

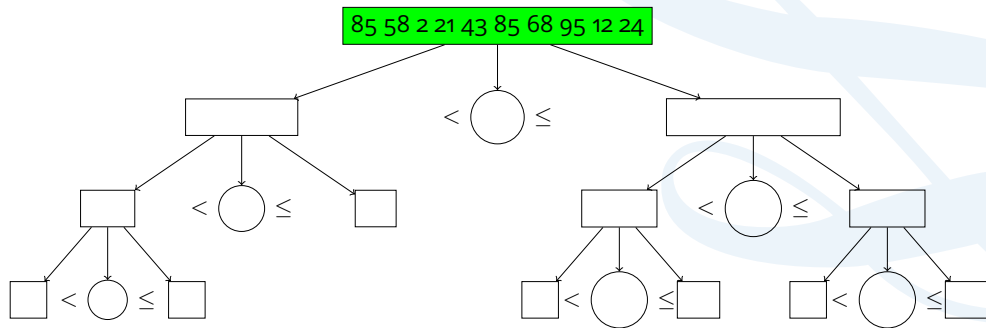Neither bubble or selection sort are very good.

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

One of the fastest sorting algorithms.

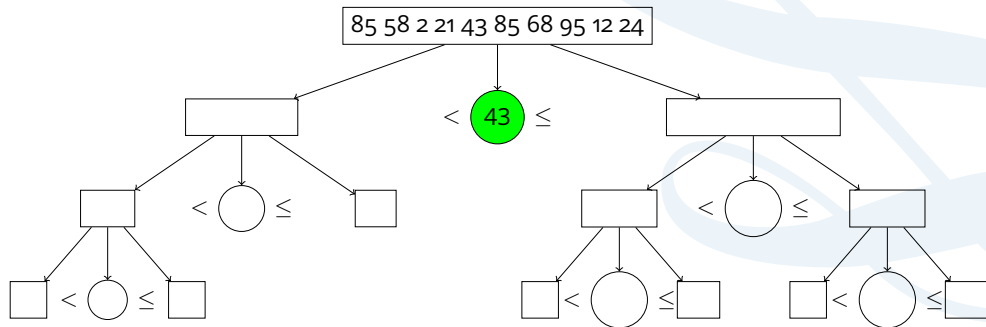- Used in real life.
- Recursively breaks the sequence in half.
  - Divide & Conquer.

Quicksort II

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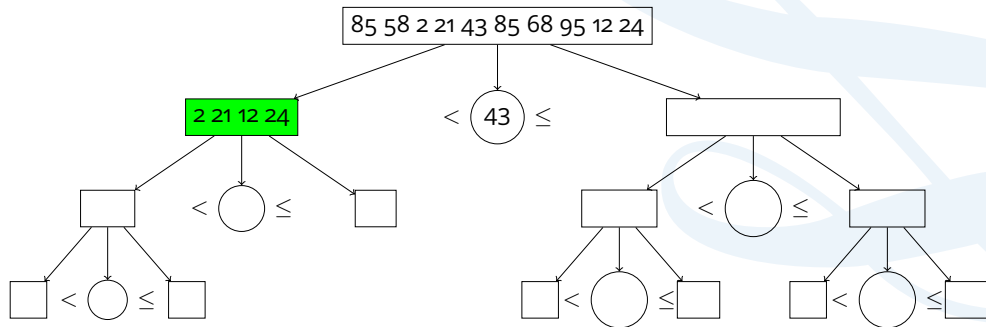4. Treat each group as a new sequence and repeat from step 1.

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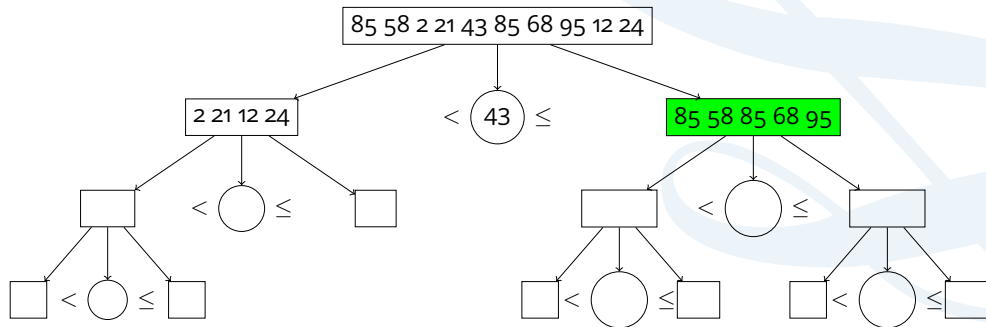4. Treat each group as a new sequence and repeat from step 1.

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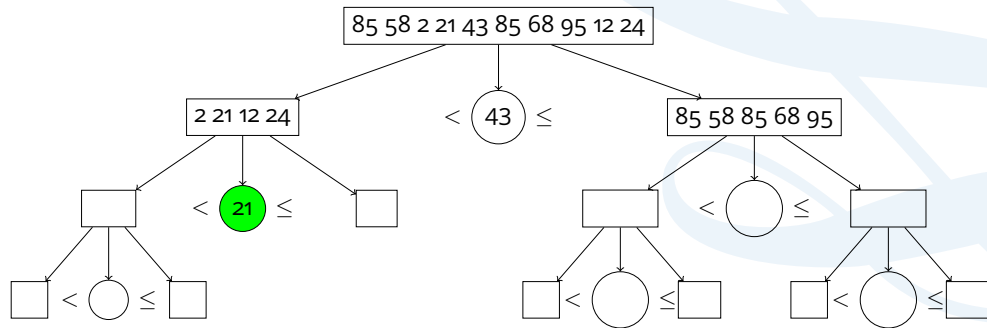4. Treat each group as a new sequence and repeat from step 1.

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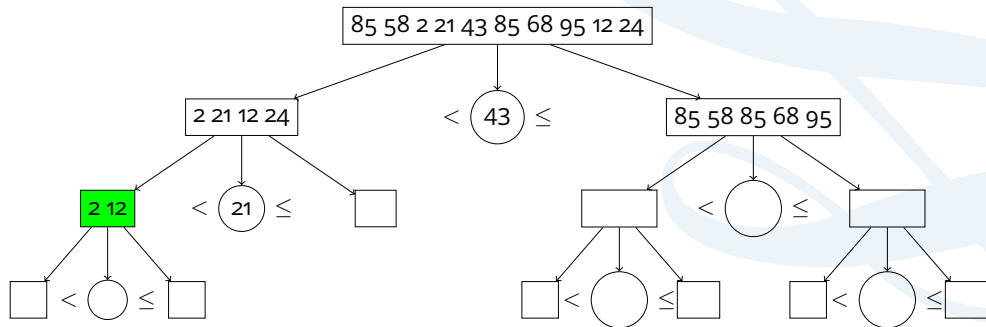4. Treat each group as a new sequence and repeat from step 1.

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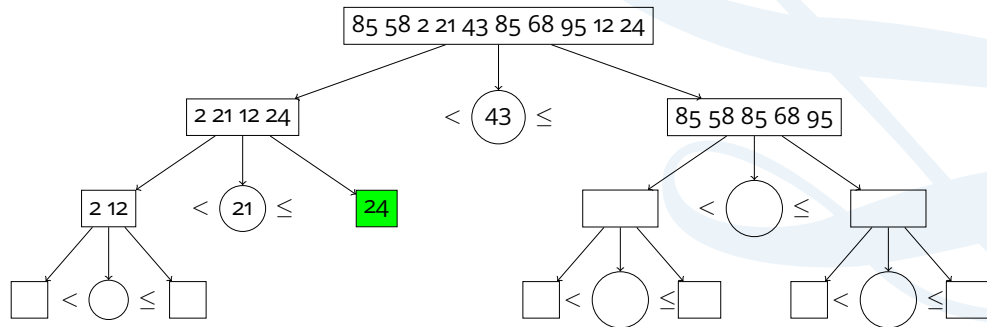4. Treat each group as a new sequence and repeat from step 1.

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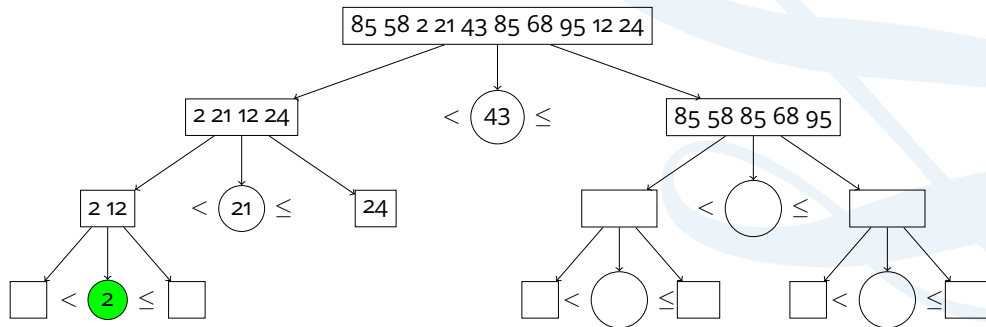4. Treat each group as a new sequence and repeat from step 1.

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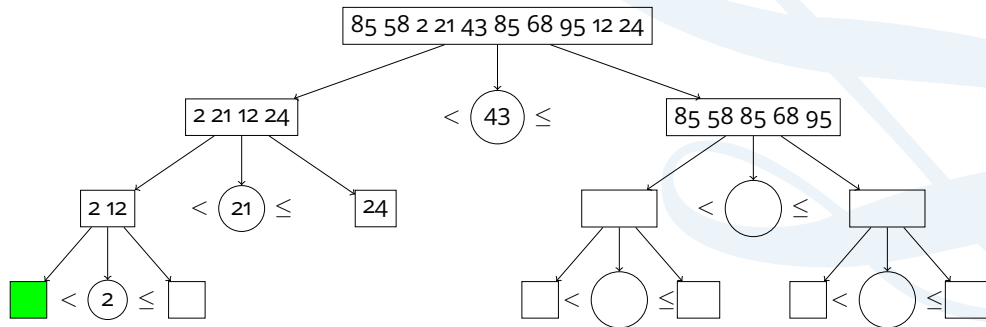4. Treat each group as a new sequence and repeat from step 1.

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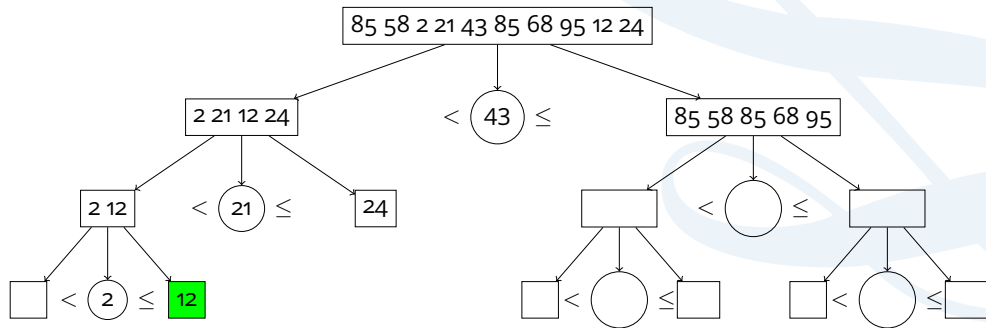4. Treat each group as a new sequence and repeat from step 1.

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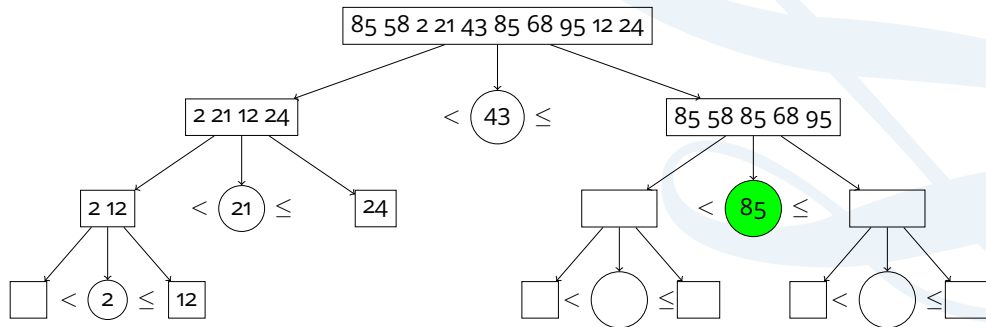4. Treat each group as a new sequence and repeat from step 1.

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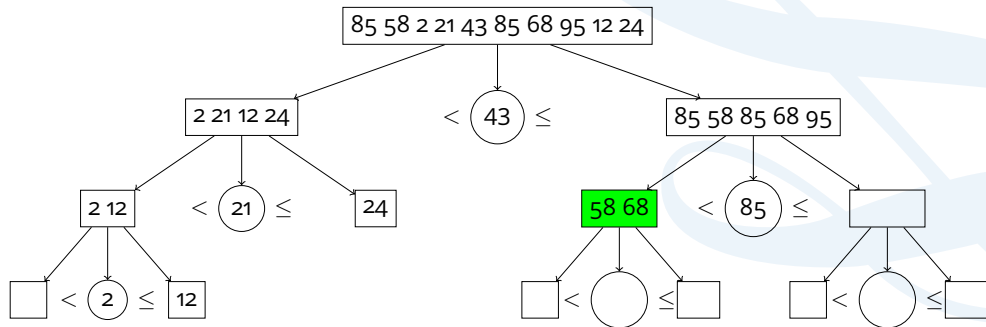4. Treat each group as a new sequence and repeat from step 1.

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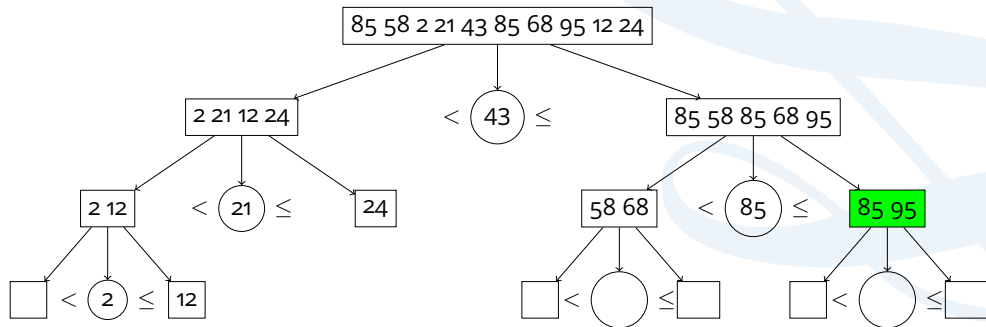4. Treat each group as a new sequence and repeat from step 1.

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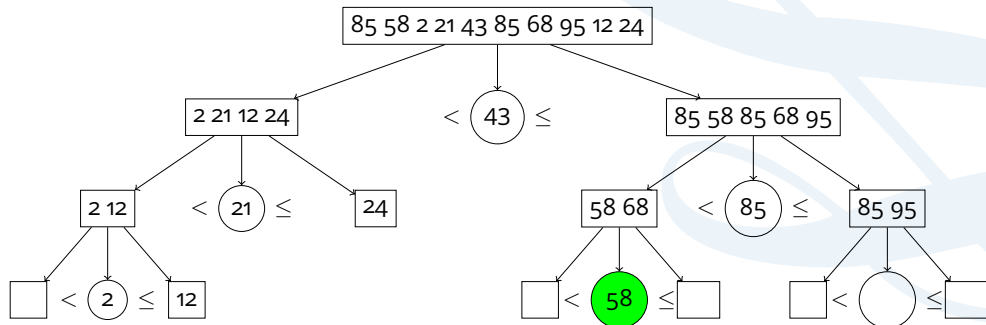4. Treat each group as a new sequence and repeat from step 1.

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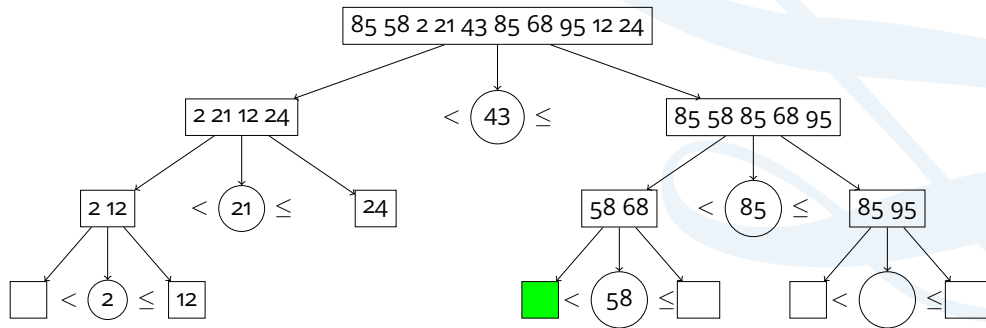4 Treat each group as a new sequence and repeat from step 1.

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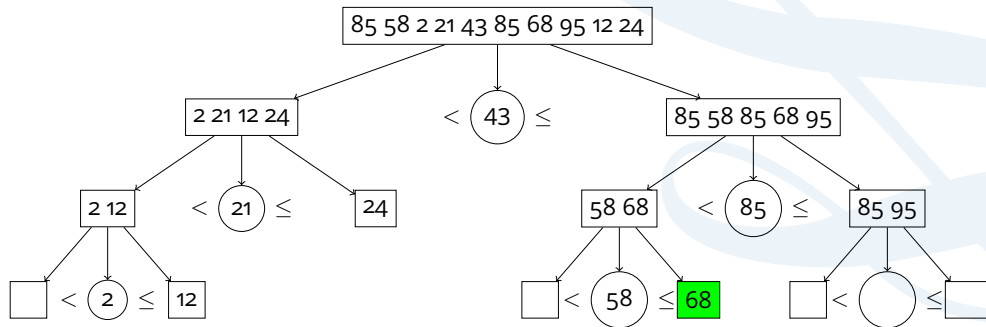4. Treat each group as a new sequence and repeat from step 1.

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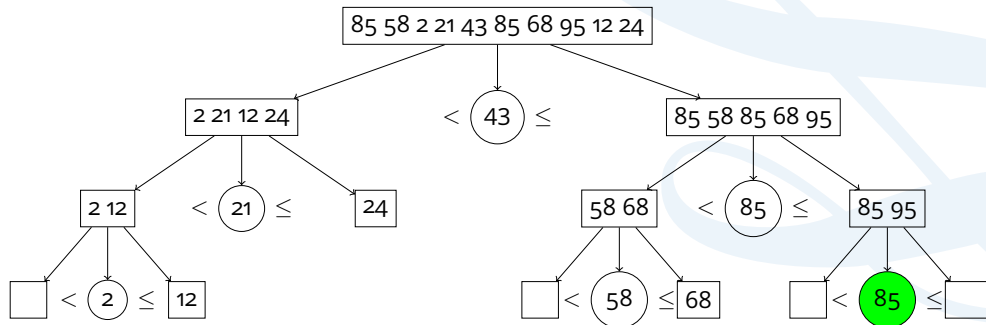4 Treat each group as a new sequence and repeat from step 1.

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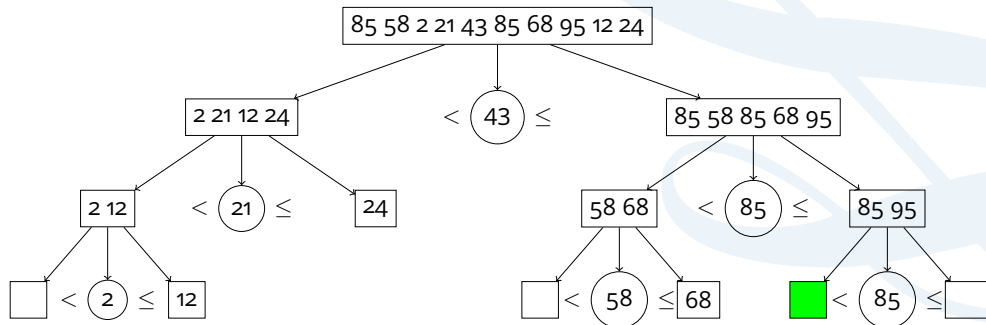4. Treat each group as a new sequence and repeat from step 1.

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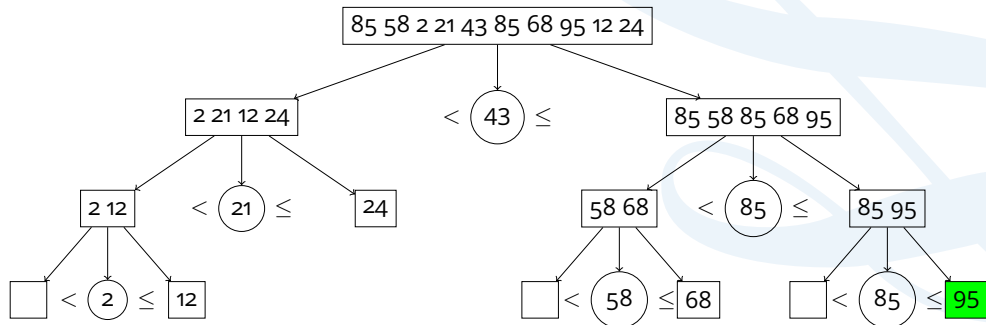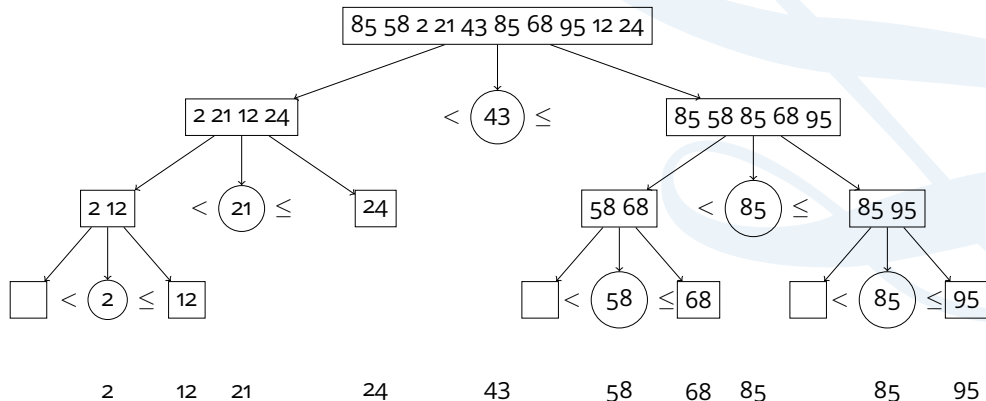4. Treat each group as a new sequence and repeat from step 1.

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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.

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.

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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)?

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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.

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Sorting

David Croft

Introduction

Bubblesort
Stable sort
In-place

Selection sort

Other
algorithms

Quicksort
Divide & Conquer

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- ● Consistent performance.
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Quiz

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