Sorting algorithms

Johan Montelius

KTH

HT22

selection sort

- an $O(n^2)$ algorithm
- few write operations
- useful when iteratively searching for the smallest elements

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insertion sort

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- many write operations (in an array)
- useful when data set almost sorted
- always used when inserting a new element in a sorted data set

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merge sort

```
private static void sort(int[] org, int[] aux, int lo, int
   if (lo != hi) {
     int mid = lo + (hi-lo)/2;
     sort(org, aux, lo, mid);
     sort(org, aux, mid+1, hi);
     merge(org, aux, lo, mid, hi);
    }
}
```

merge sort work

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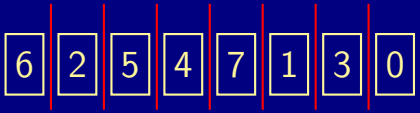
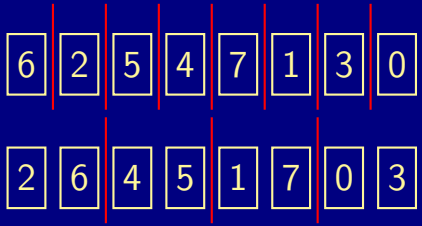


merge sort work



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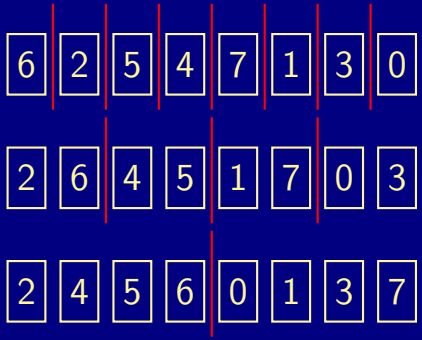

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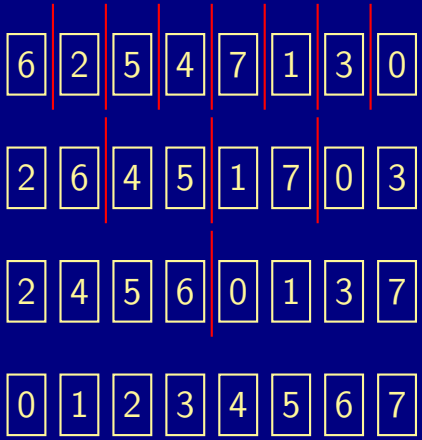

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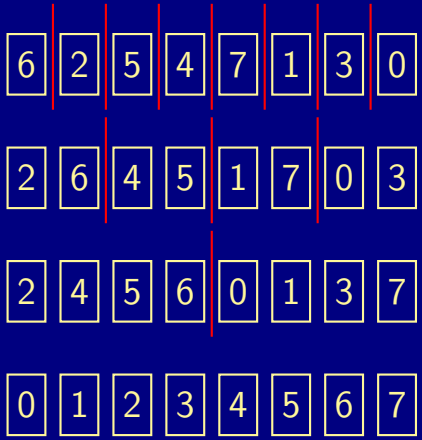
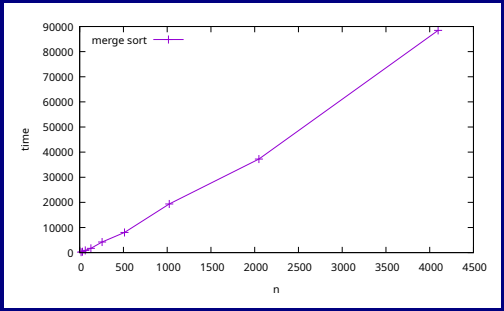
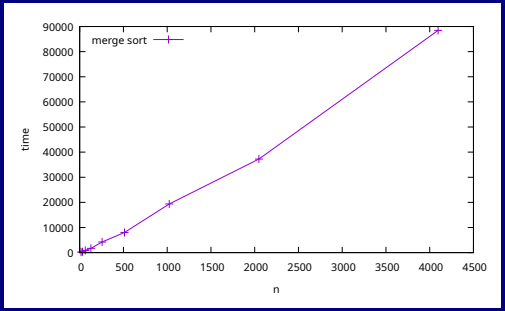


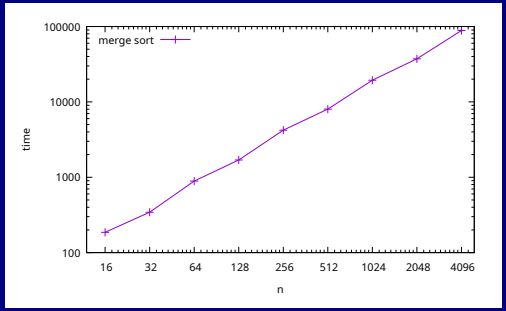
merge sort executes in $O(n \times lg(n))$

benchmark


merge sort
time
n
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
0
500
1000
1500
2000
2500
3000
3500
4000
4500

benchmark


merge sort
time
n
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
0
500
1000
1500
2000
2500
3000
3500
4000
4500


merge sort
time
n
100
1000
10000
100000
16
32
64
128
256
512
1024
2048
4096

benchmark

n	t	t/n
16	186	11.6
32	343	10.7
64	889	13.9
128	1695	13.2
256	4217	16.5
512	8018	15.7
1024	19358	18.9
2048	37242	18.2
4096	88452	21.6

benchmark

n	t	t/n	$t/(n \times log(n))$
16	186	11.6	4.2
32	343	10.7	3.1
64	889	13.9	3.3
128	1695	13.2	2.7
256	4217	16.5	3.0
512	8018	15.7	2.5
1024	19358	18.9	2.7
2048	37242	18.2	2.4
4096	88452	21.6	2.6

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- requires additional space (could be avoided but complicated)

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- an $O(n \times lg(n))$ algorithm
- requires additional space (could be avoided but complicated)
- robust i.e. no worst case scenarios

quick sort

Merge sort divides the array on the way down and sorts it on the way up.

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Quick sort sorts the array on the way down and assemble it on the way up.

quick sort

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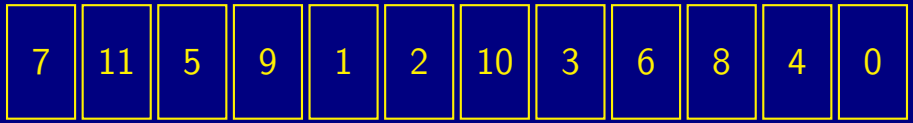

quick sort

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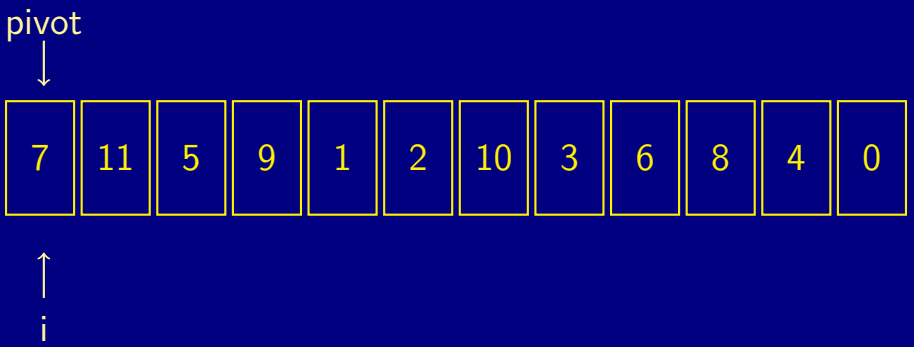

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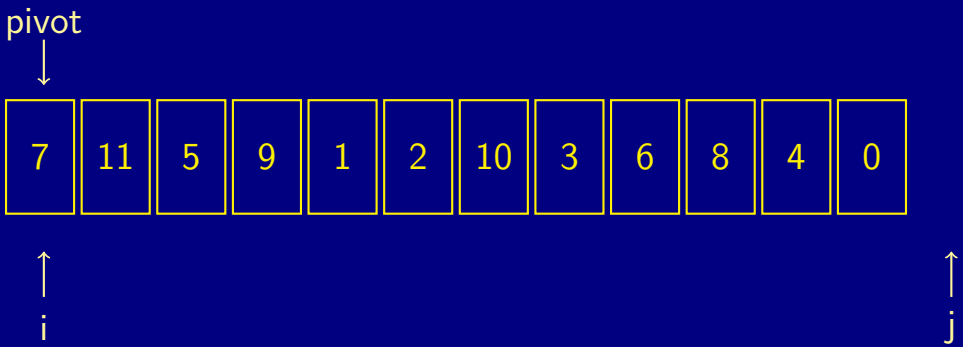

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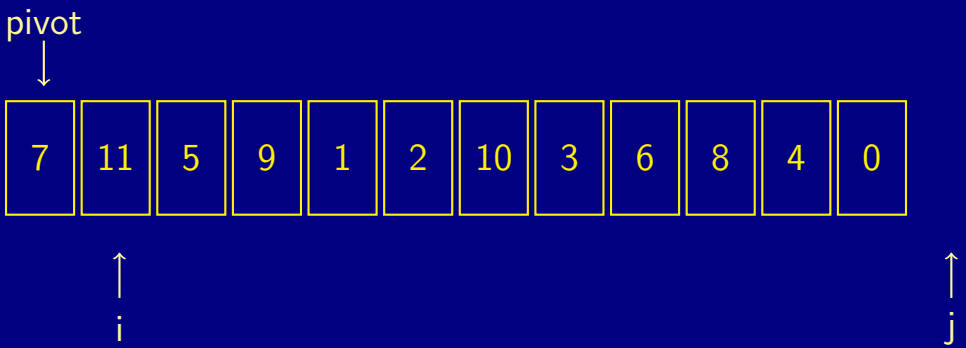

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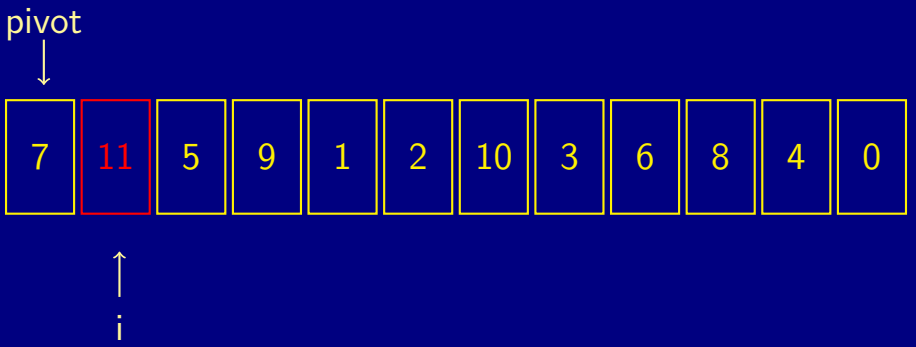

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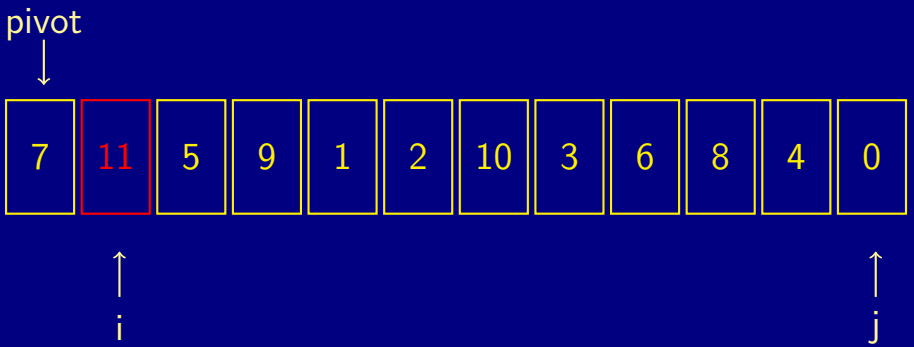

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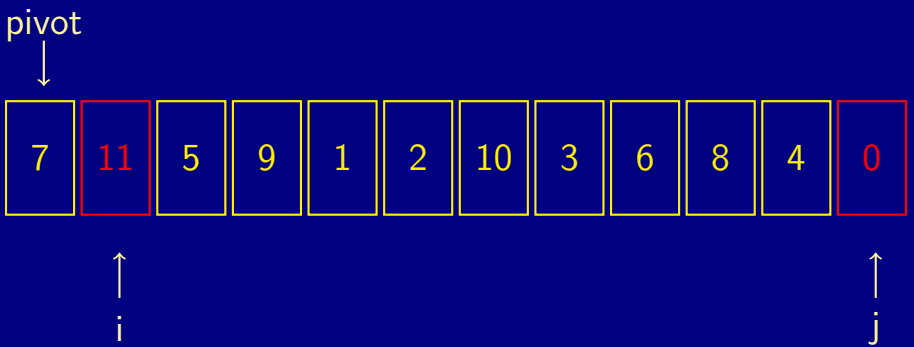

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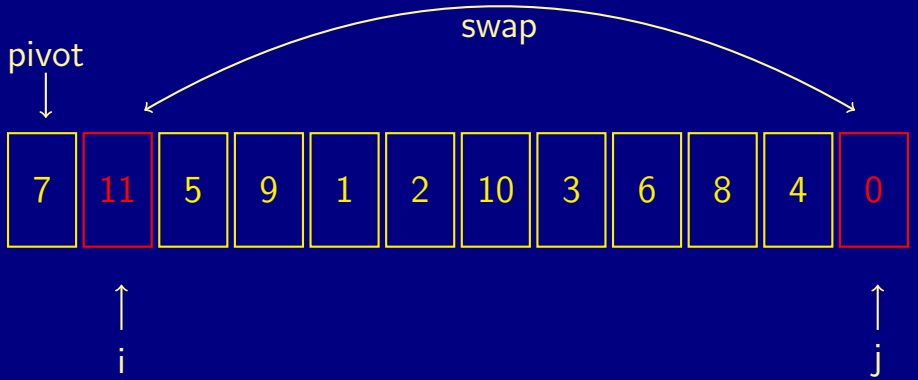

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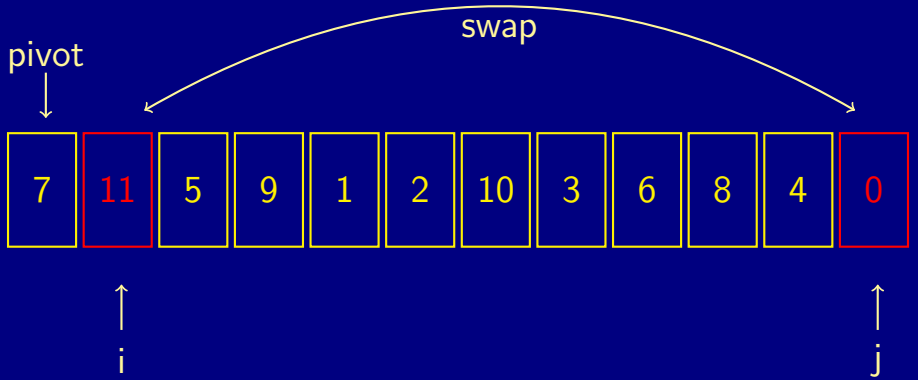

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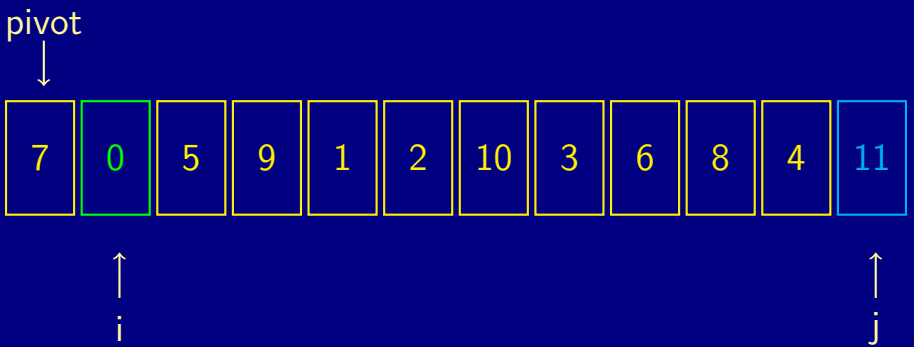

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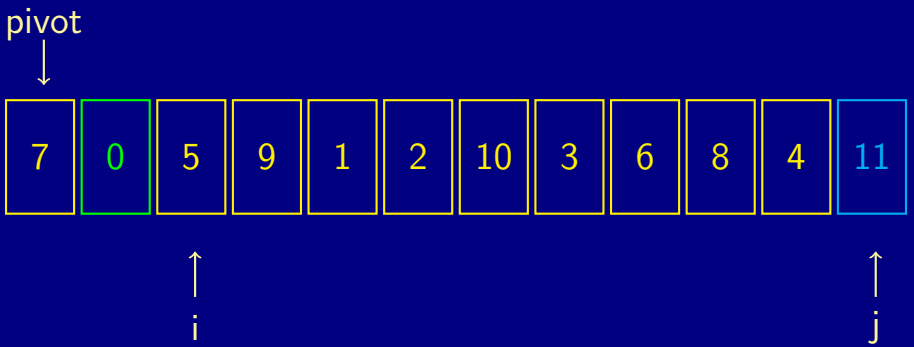

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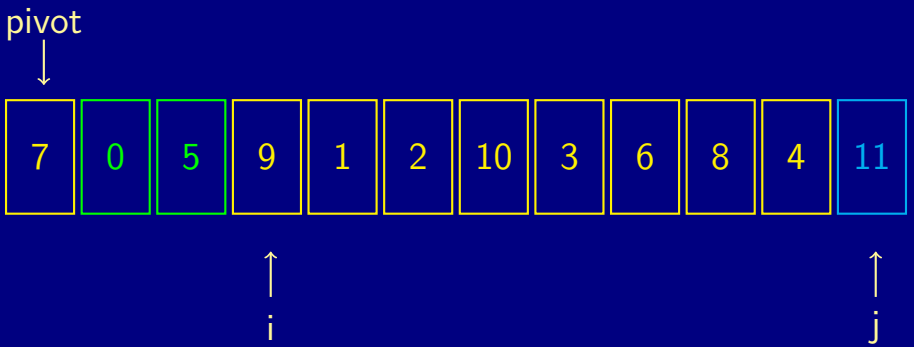

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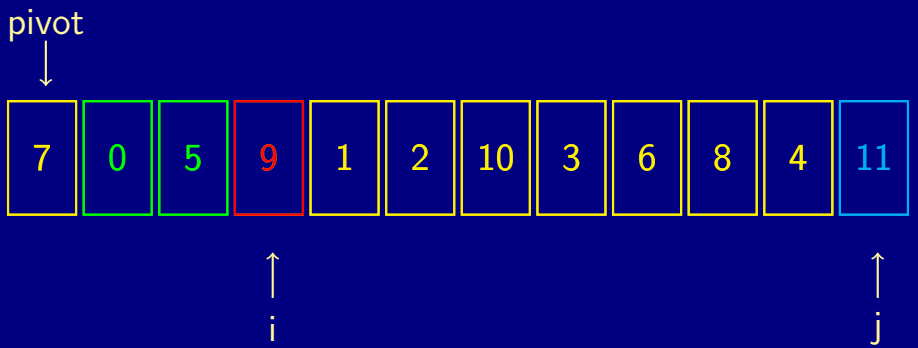

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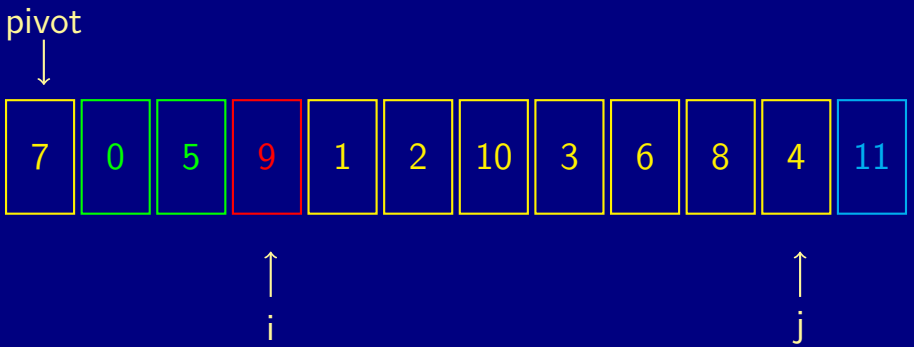

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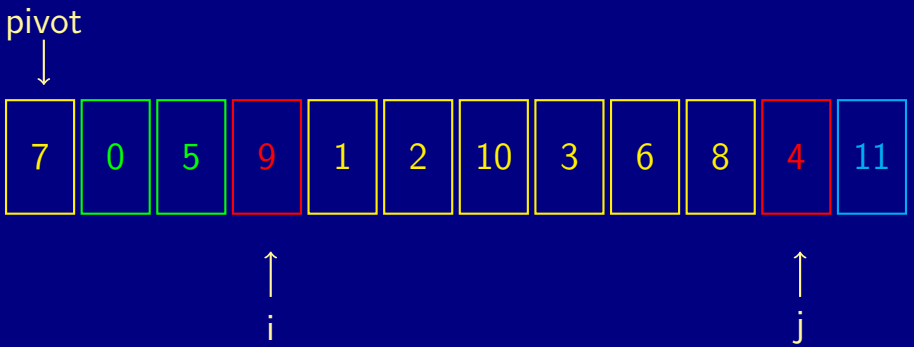

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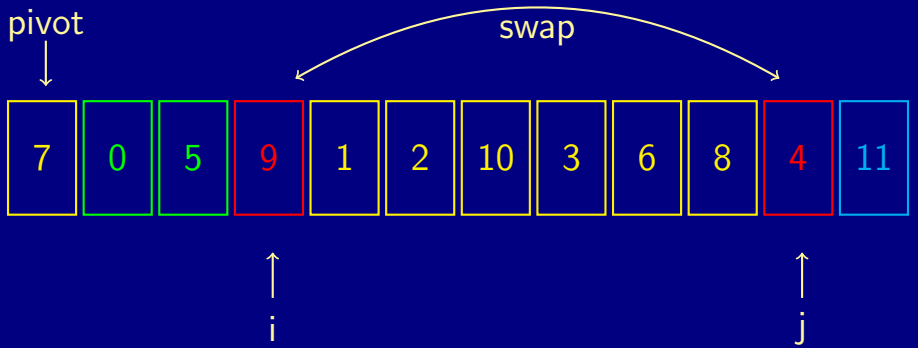

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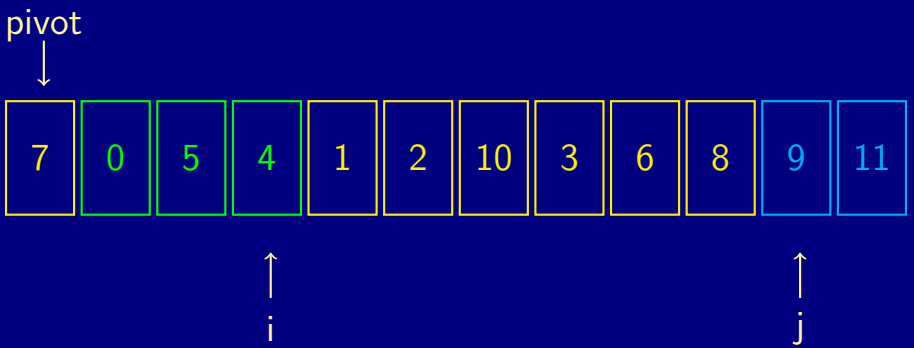

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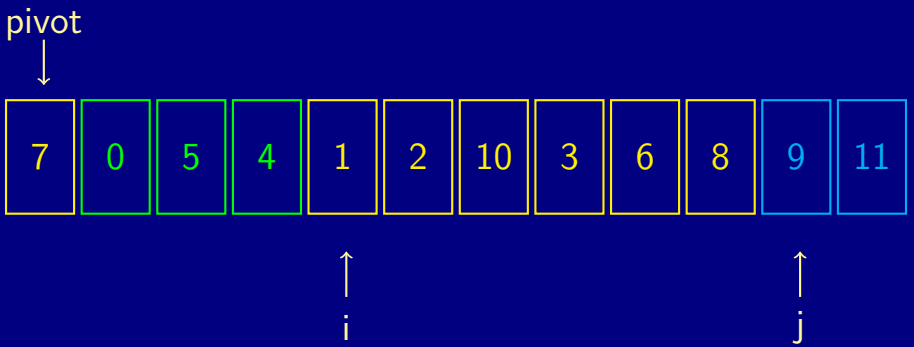

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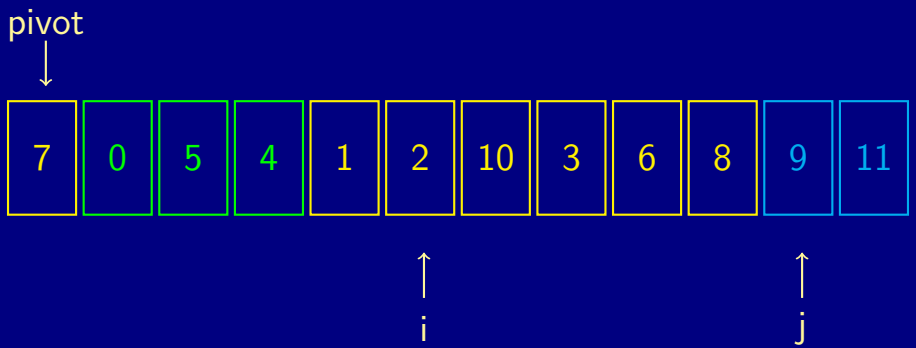

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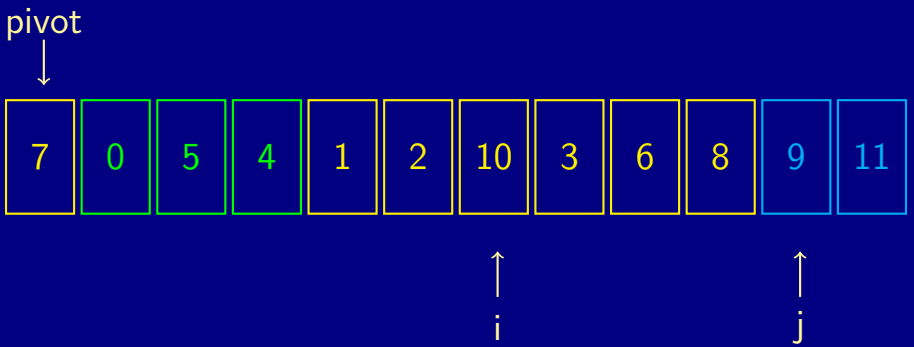

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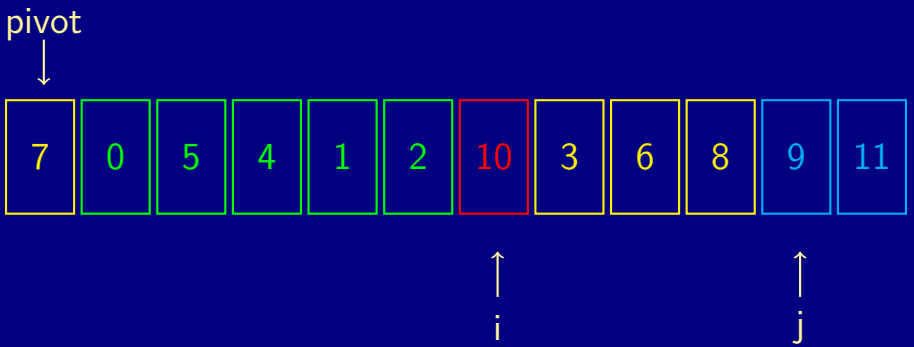

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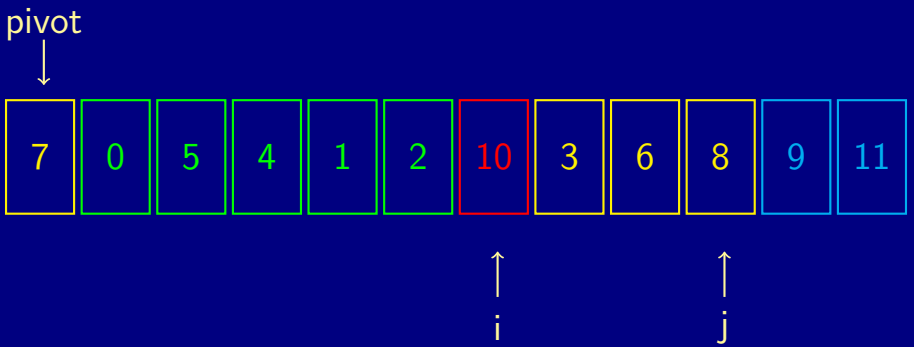

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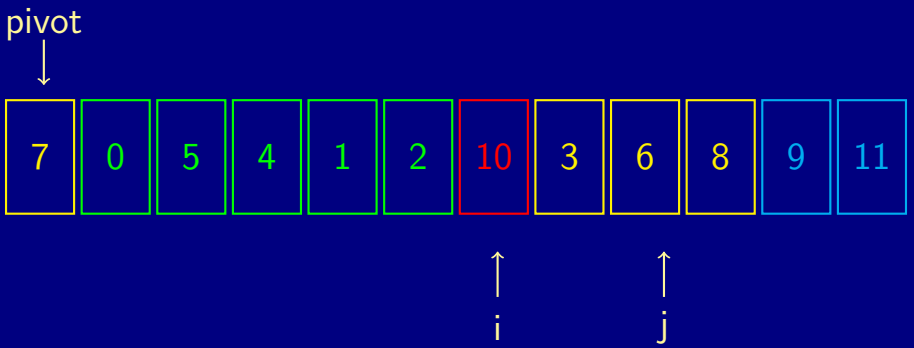

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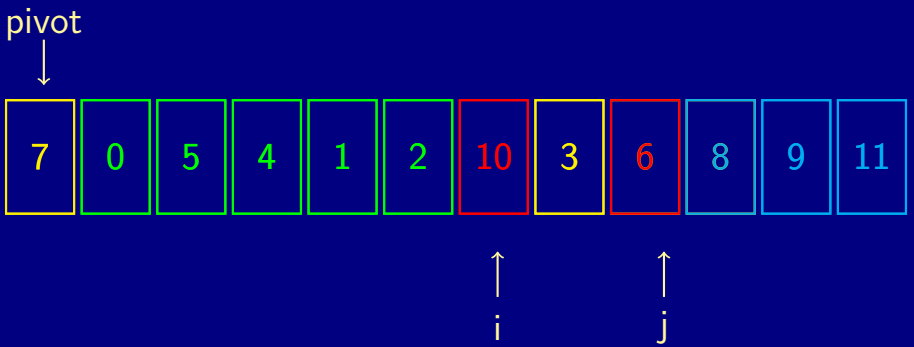

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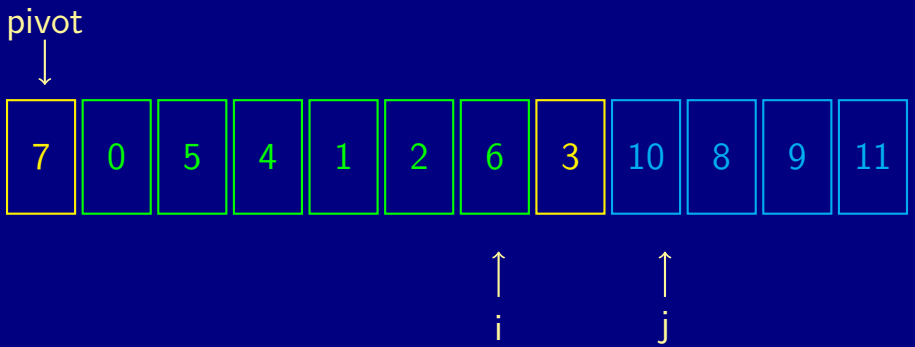

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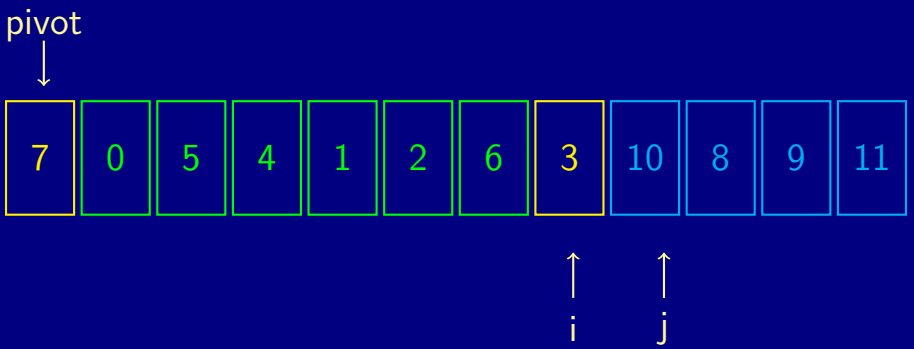

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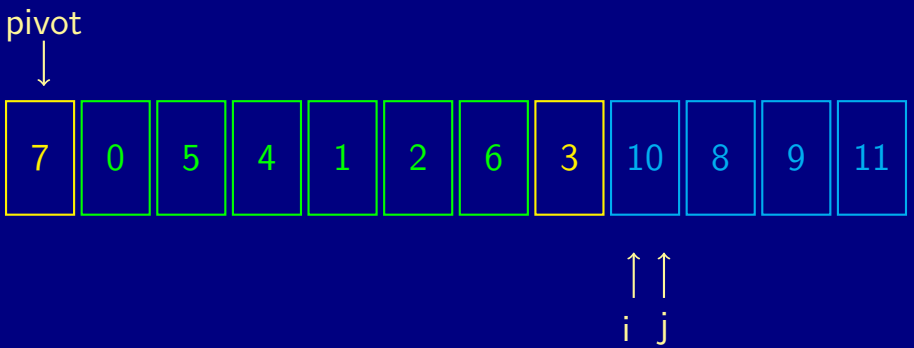

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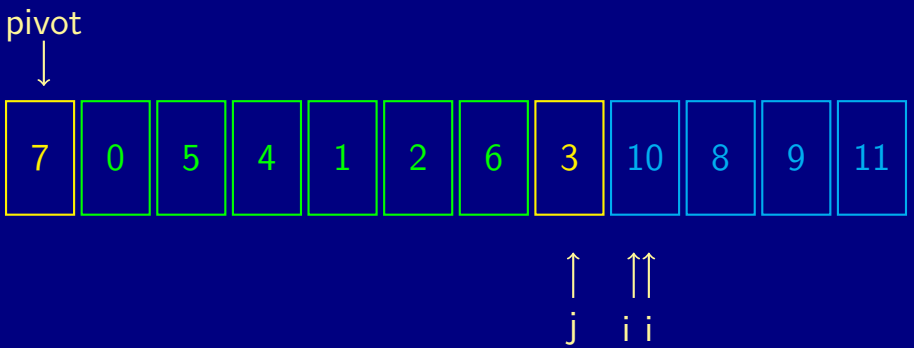

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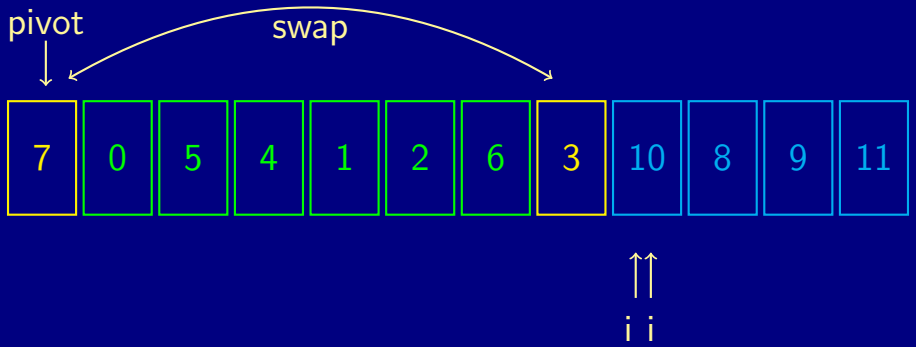

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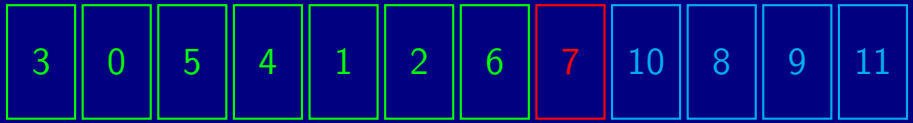

quick sort work

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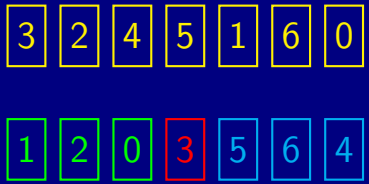

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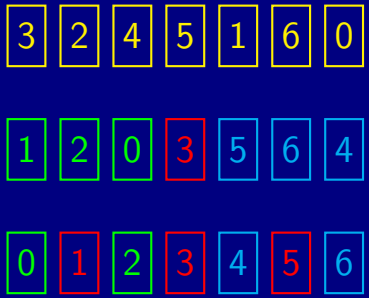

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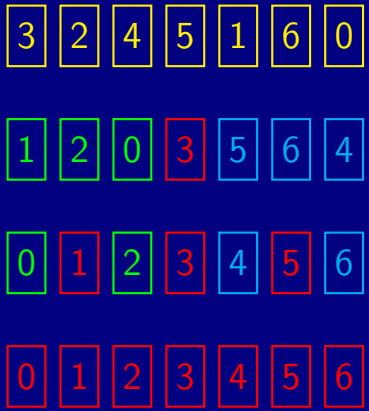

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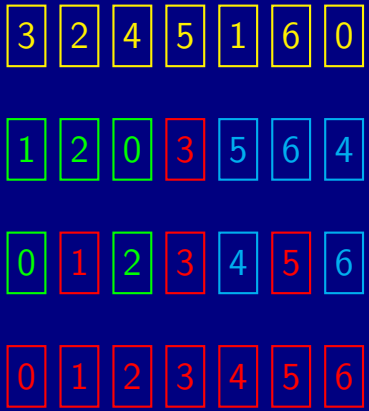

quick sort executes in $O(n \times lg(n))$

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quick sort

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- no additional space

quick sort

- an $O(n \times lg(n))$ algorithm
- no additional space
- worst case scenario if array is sorted - $O(n^2)$

stability

A sorting algorithm is *stable* if the given order is preserved when sorting two equal elements.

stability

Why stability matters:

Gustav Bengtsson
Adam Bengtsson
Fredrik Andersson

stability

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sorting algorithms

stable algorithms

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- insertion sort

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- insertion sort
- merge sort

unstable algorithms

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