{EPITECH. TECHNOLOGY}

Kick-off Pushswap

B-CPE-110

Algorithms

- **Muḥammad ibn Mūsā al-Khwārizmī** (محمد بن موسى خوارزمی)
- … But many algorithms already existed !

Algorithms: Definition

Description of a finite sequence of instructions, that allows to produce an output from a sequence of inputs.

Example:

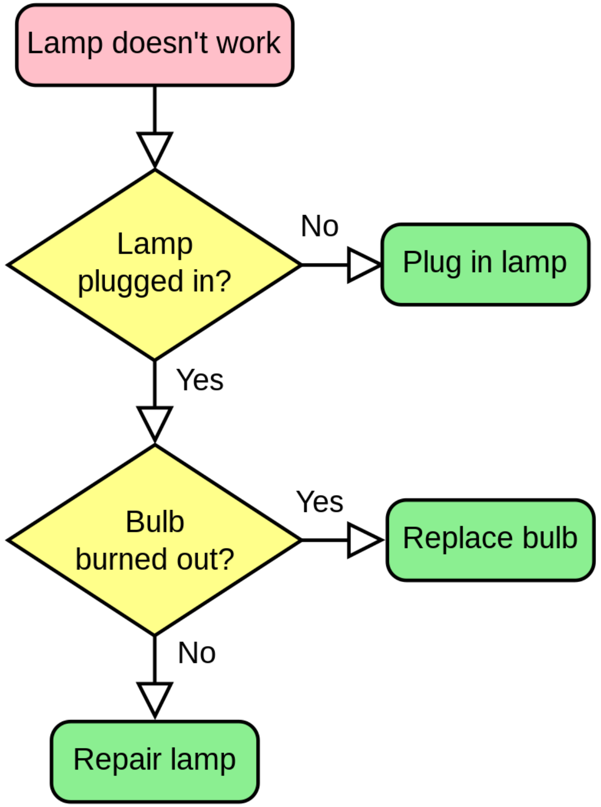
- Cooking recipe
- Numbers multiplication
- The path given by a journey app on your smartphone
- …

Algorithms in history

- -2000: Multiplication of 2 numbers
- -200: Sieve of Eratosthenes
- 1842: Ada Lovelace’s first algorithm for computers
- 1936: Turing Machine (Alan Turing)
- 1973: RSA encryption algorithm

Algorithms

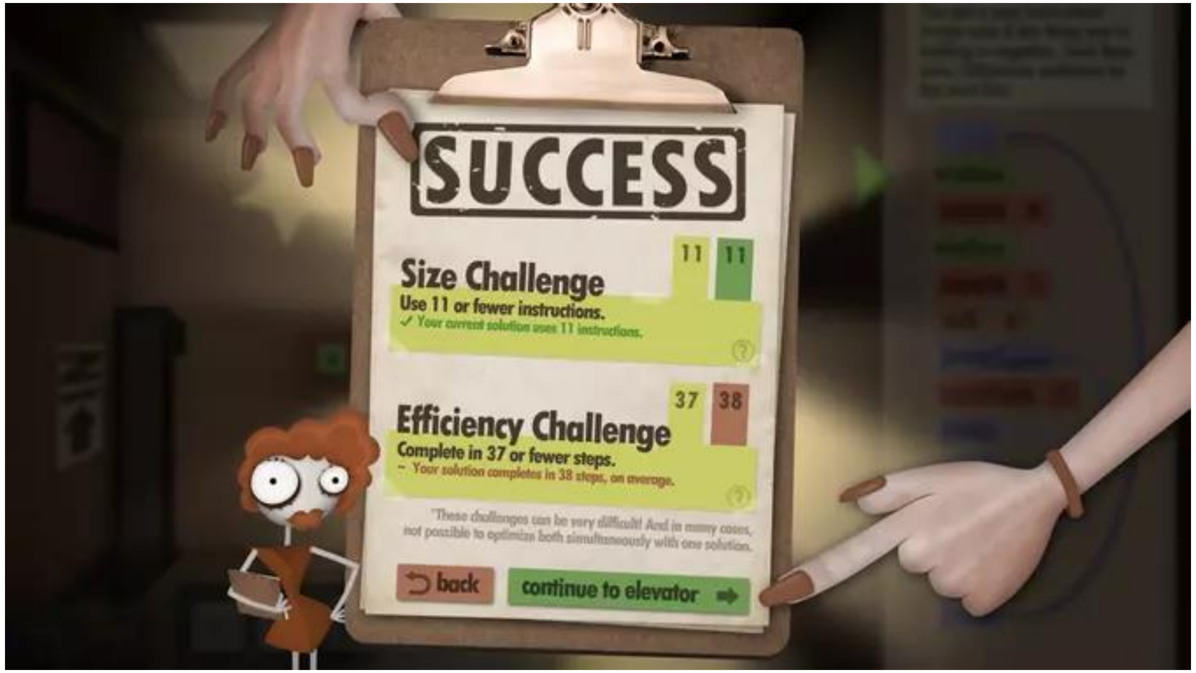
Can be described using flow charts:



Algorithms

- Many algorithms can achieve the same result
- How to measure their respective efficiency ?

Algorithms: Efficiency


SUCCESS

Size Challenge 11 11

Use 11 or fewer instructions.

✓ Your current solution uses 11 instructions.

Efficiency Challenge 37 38

Complete in 37 or fewer steps.

– Your solution completes in 38 steps, on average.

"These challenges can be very difficult! And in many cases, not possible to optimize both simultaneously with one solution.

Algorithms: Efficiency

EXECUTION TIME
(~ NUMBER OF INSTRUCTIONS)

MAX AMOUNT OF MEMORY
USED

Algorithms: Efficiency

Efficiency can be described using Big-Oh notation.
=> General behavior of the function when $n \rightarrow \infty$

- Drop all factors:
  - $n + a \cong n$
  - $cn \cong n$
  - $O(1)$: constant time
  - $O(\log(n))$: logarithmic time
  - $O(n)$: linear time
  - $O(n^k)$: polynomial time
  - $O(2^n)$: exponential time

Algorithms: Efficiency

EXAMPLE

```
let a: List of size n
m = a[0]
for i from 1 to n - 1
    if a[i] > m
        m = a[i]
return m
```

Number of operations ?

-> Depends on the size of a

- Best case: $4n + 1$
- Worst case: $6n - 1$

Time complexity: $O(n)$

Big-Oh notation

- Keep the higher degree factor of the expression
  - $f(n) = 7n^3 + 3n^2 + 32n - 6 \quad \Rightarrow \quad O(n^3)$

- Be careful !
  - $O(n)$ better than $O(n^2)$…
  - …But only when n is big enough !
  - Example:
    - $f(n) = 23\,789n + 91\,234$
    - $g(n) = n^2 - 12$
    - $g >$ f only for $n \;>\; 115\,025$!!
  - We need to take into account the real world (real datasets sizes, hardware optimizations, etc.)

Big-Oh notation

- All cases are not the same !
  - Quicksort:
    - Best case $O(n \log n)$
    - Average case $O(n \log n)$
    - Worst case $O(n^2)$
  - $O(n) \neq O(n)$
  - In some cases, memory usage must be considered too…

$\Rightarrow$ In general, Big-Oh notation is to be completed using:

  - Real-life benchmarking
  - Further analysis

Going further…

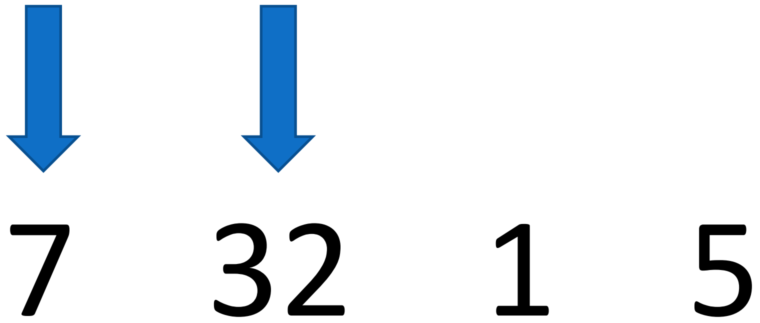
- O/Theta/Omega notation
- MapReduce
- Algorithm correctness

Sorting algorithms

- Some useful:
  - Bubble sort
  - Insertion sort
  - Merge sort
  - Quick sort
  - Heap sort
  - Bucket sort
  - …

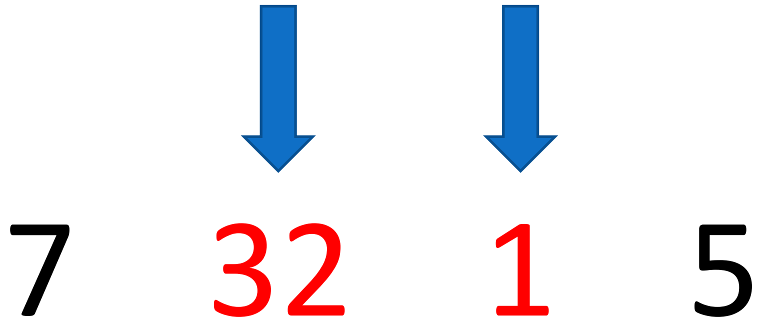
- Some less useful:
  - Sleep sort
  - Stooge sort
  - Bogo sort
  - Quantum bogo sort

Sorting algorithm: Bubble sort



7 32 1 5

Sorting algorithm: Bubble sort



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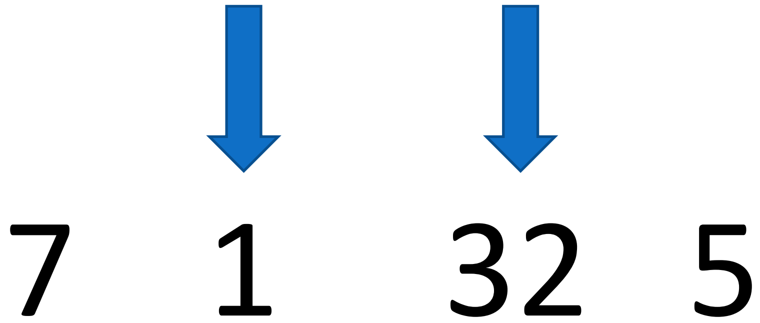
Sorting algorithm: Bubble sort



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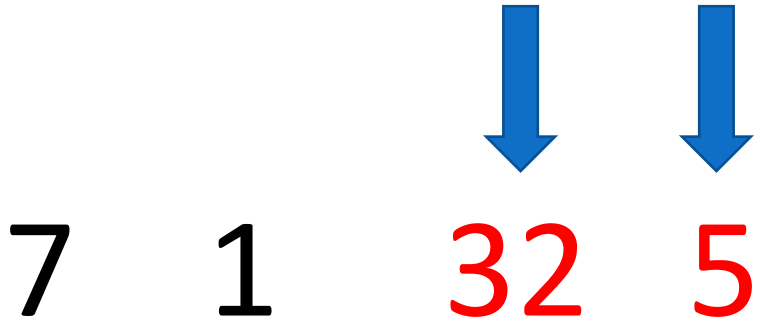
Sorting algorithm: Bubble sort



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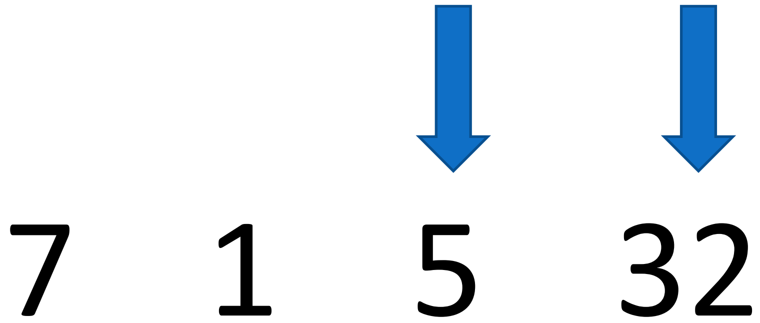
Sorting algorithm: Bubble sort



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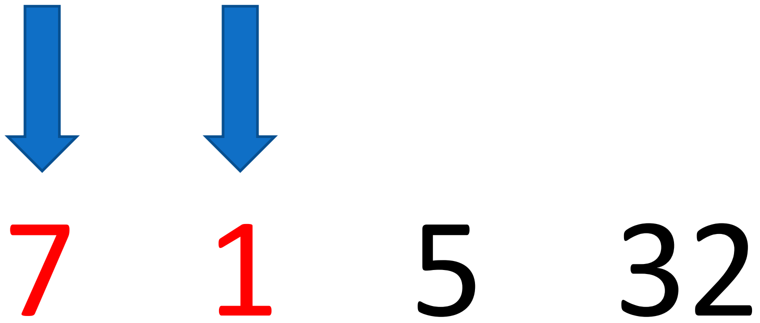
Sorting algorithm: Bubble sort



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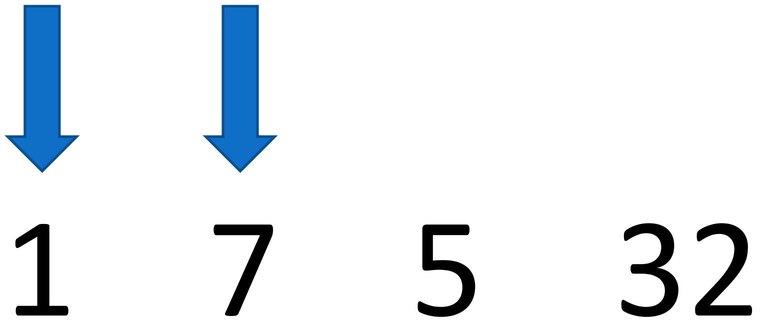
Sorting algorithm: Bubble sort



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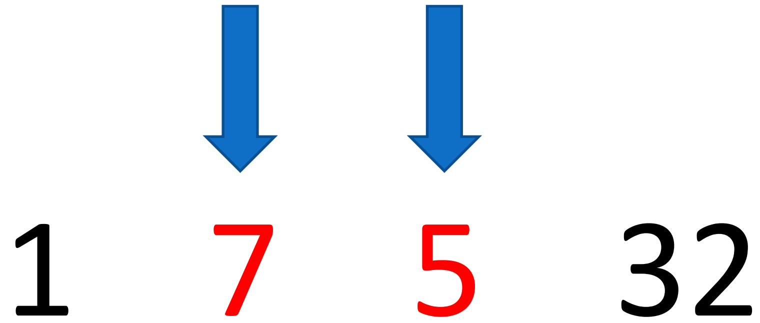
Sorting algorithm: Bubble sort



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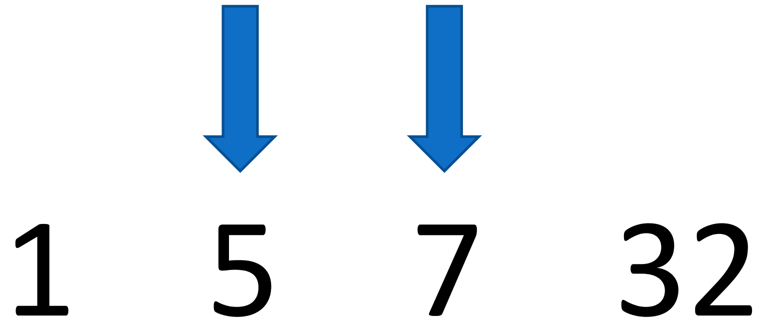
Sorting algorithm: Bubble sort



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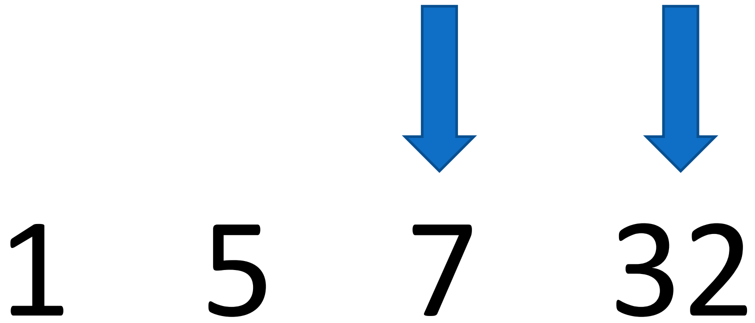
Sorting algorithm: Bubble sort



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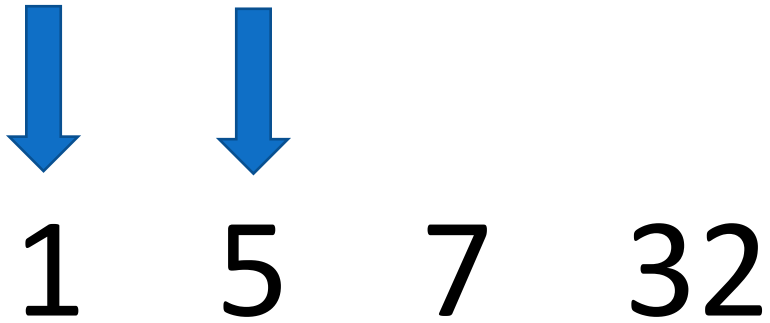
Sorting algorithm: Bubble sort



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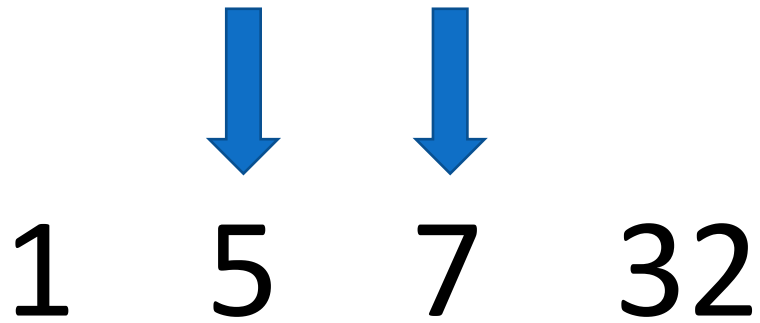

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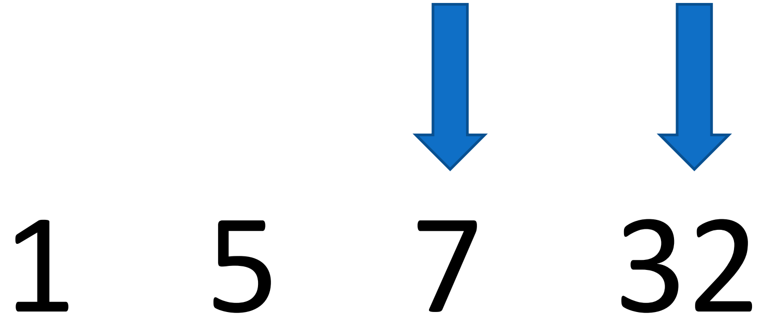
Sorting algorithm: Bubble sort



1 5 7 32

End of sorting !

Bubble sort implementation

Live coding…

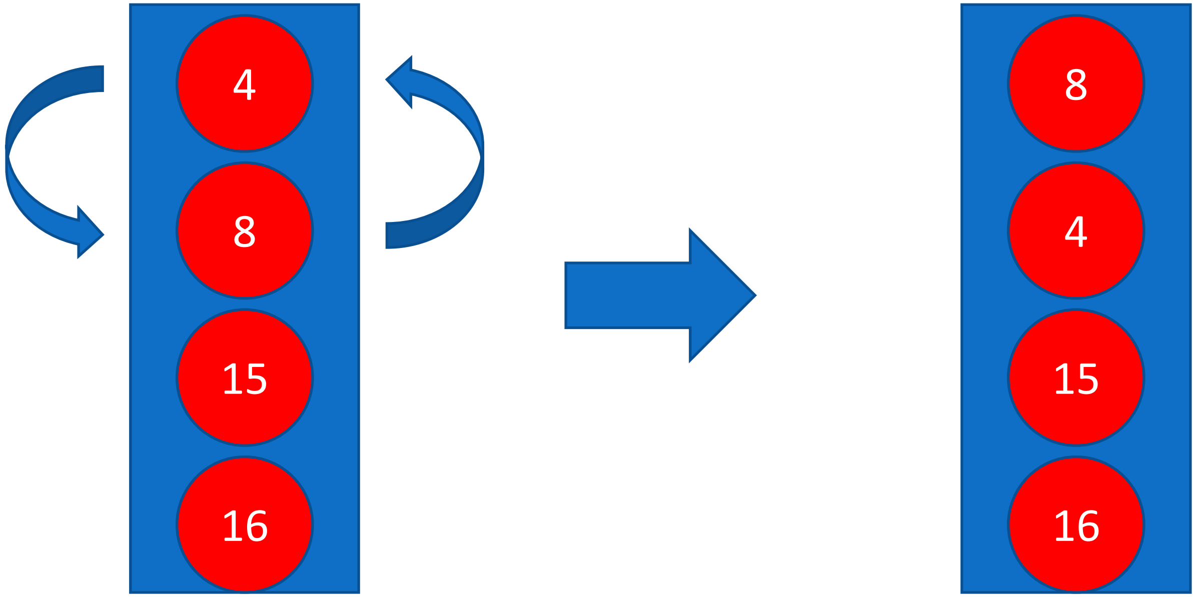
Pushswap

- 3 weeks
- 2 lists: l_a and l_b
- Input: list of unsorted integers (initialized into l_a)
- Output: Steps required to sort the list
- If input is already sorted, just print a newline

Pushswap

3 kinds of operations:

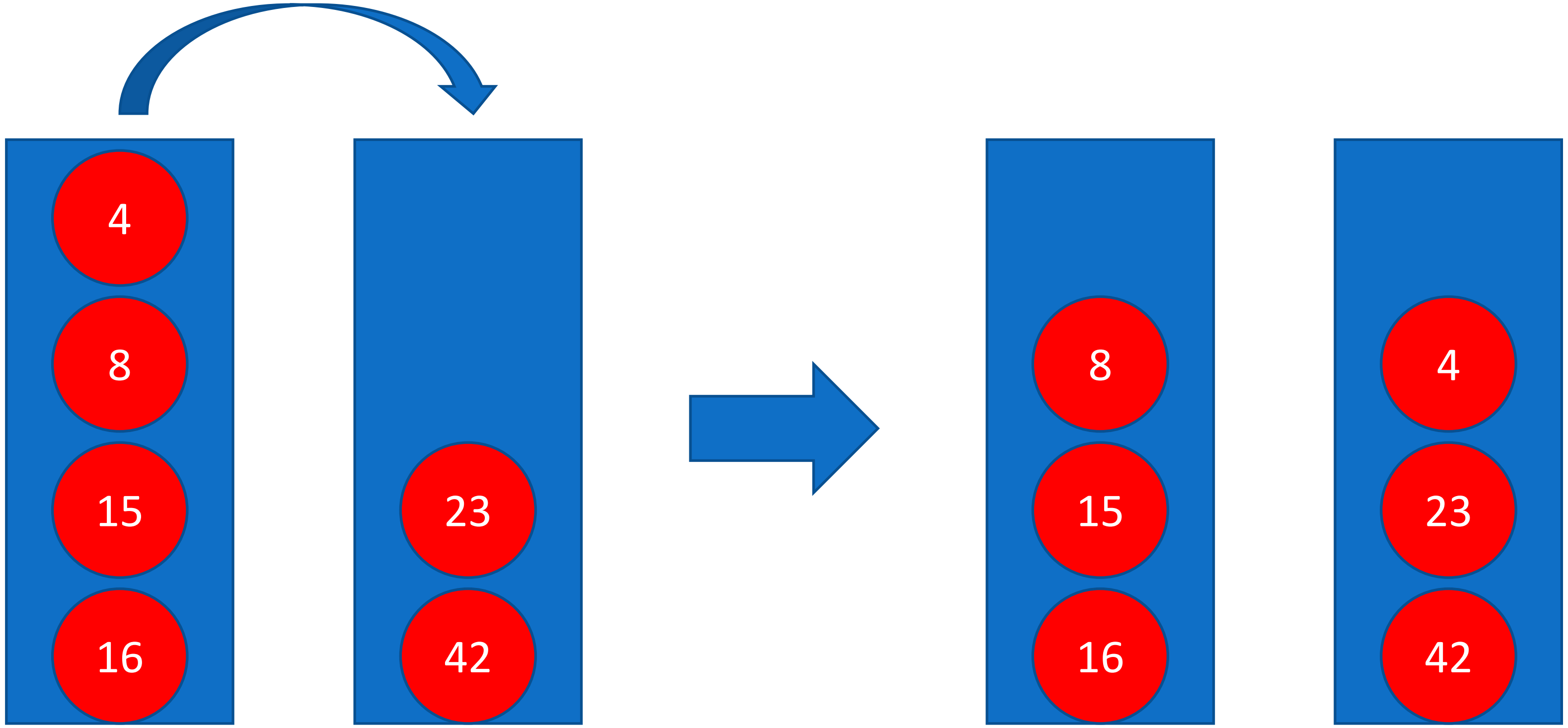
- Swap (sa, sb, sc)



Pushswap

3 kinds of operations:

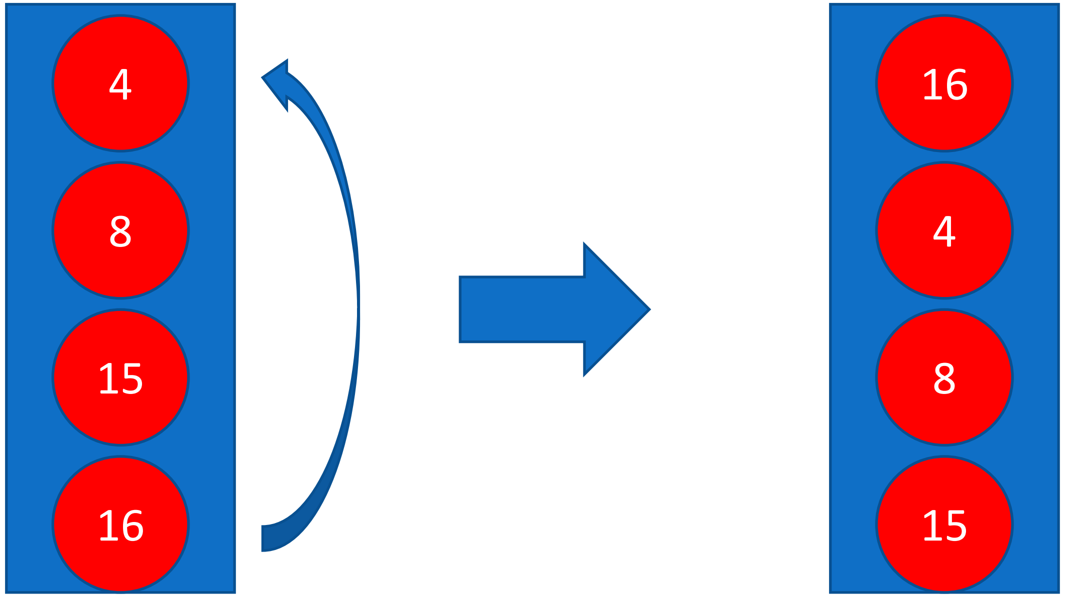
- Push (pa, pb)



Pushswap

3 kinds of operations:

- Rotate (ra, rb, rr, rra, rrb, rrr)



Points of attention

- Fast algorithm vs shortest amount of steps
- Error handling (as always ☺)
- Don’t forget to test…
- … And re-test !!

Thank you !

Any question ?