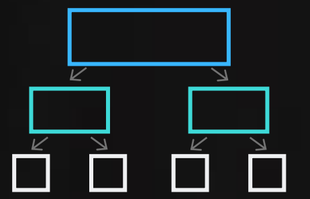


ALGORITMOS DE ORDENAÇÃO

Merge Sort

Sumário

Contexto Histórico

1940

John Von Neumann propõe o algoritmo Merge Sort

1945

EDVAC (Electronic Discrete Variable Automatic Computer)

1950

O Merge Sort começa a ganhar popularidade

1960

O paradigma "divisão e conquista" é formalizado

1970

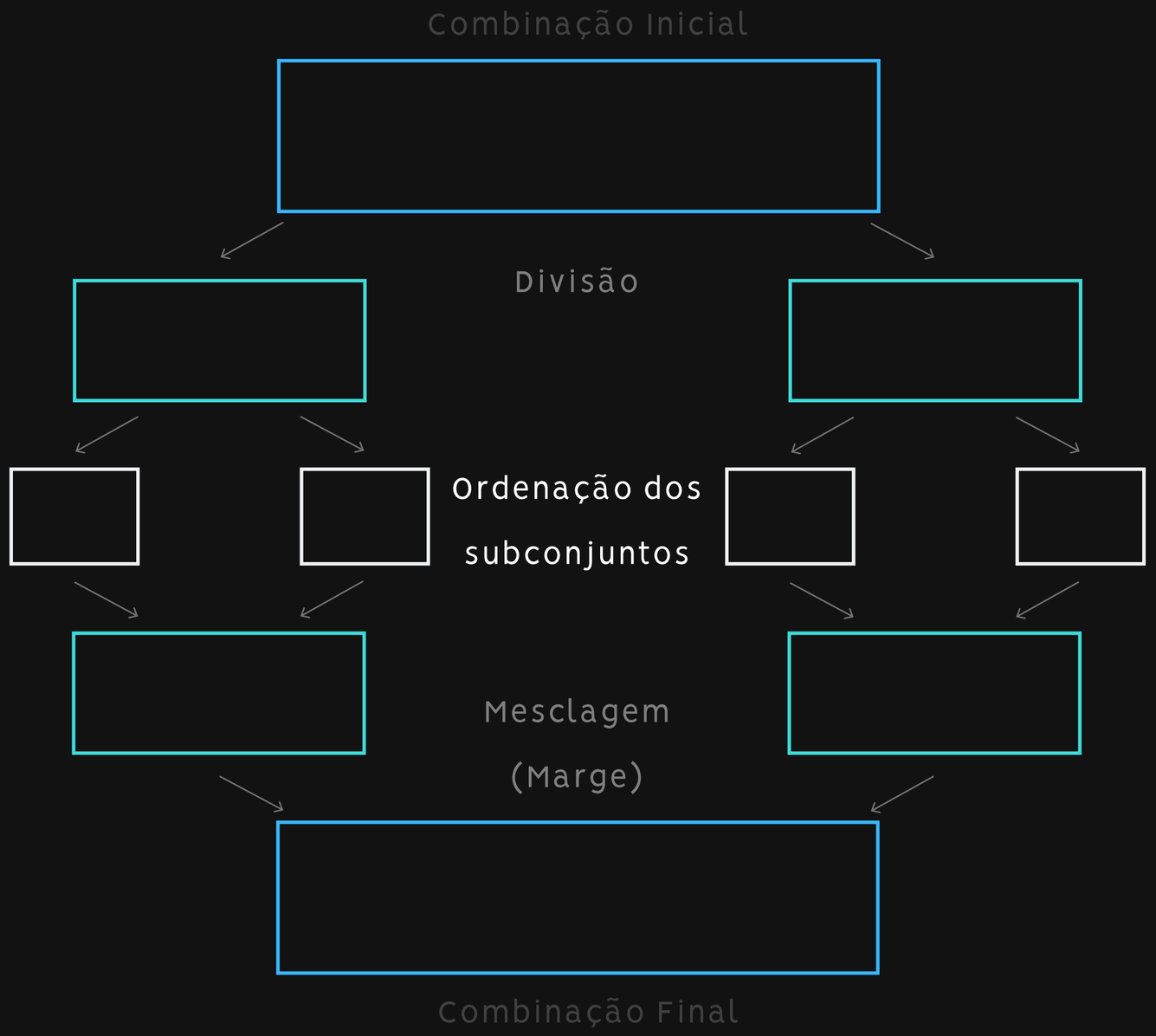
Pesquisadores exploram a otimização do Merge Sort.

1980-1990

Avanço dos computadores e a necessidade crescente de ordenação eficiente

ATUAL

O Merge Sort continua sendo um algoritmo amplamente estudado e aplicado na ciência da computação.



ORDENAÇÃO ADOTADA

Divisão e conquista

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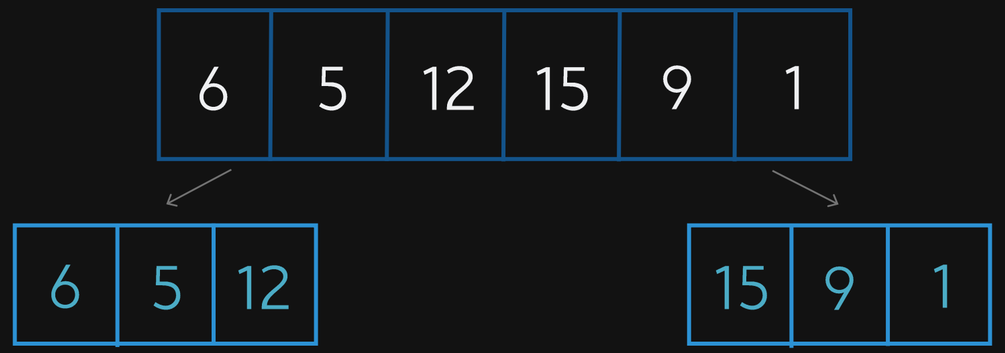

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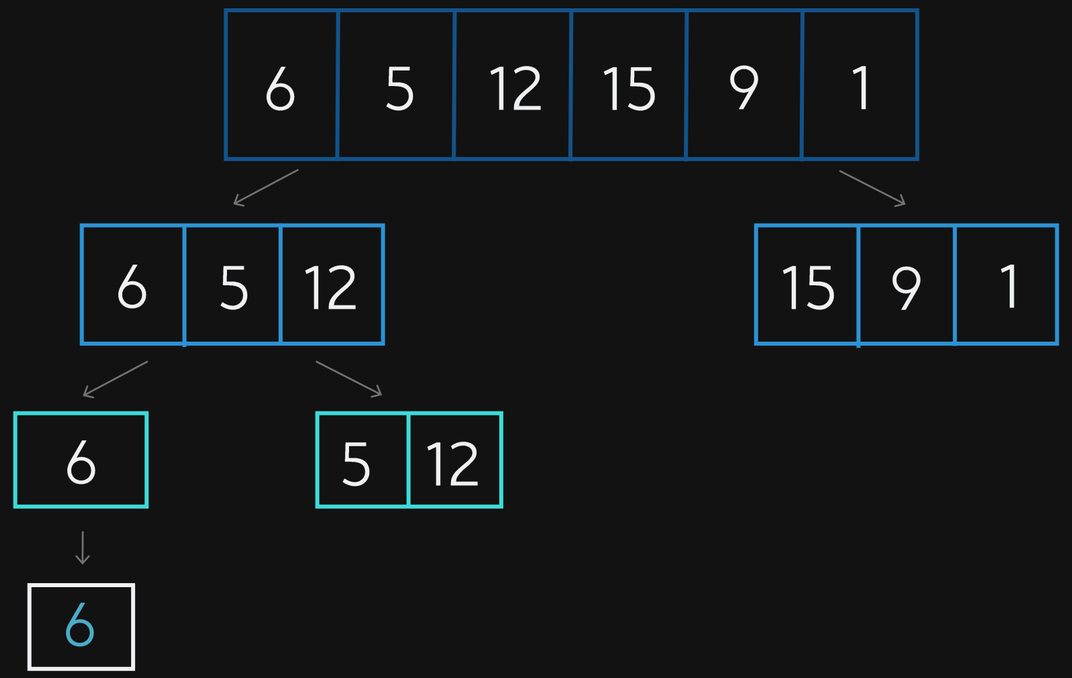

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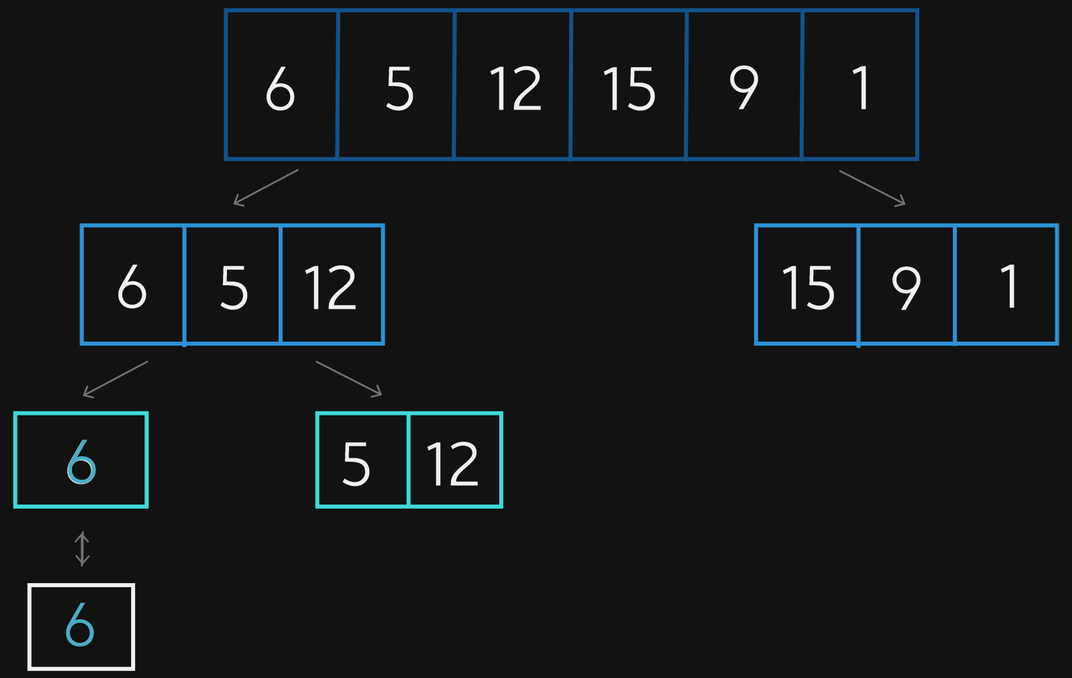

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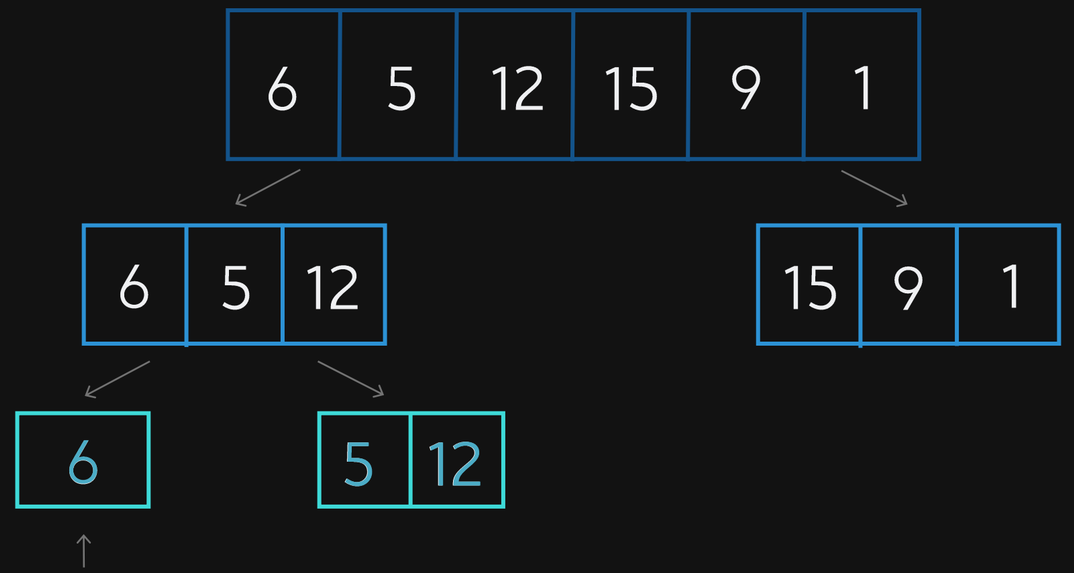

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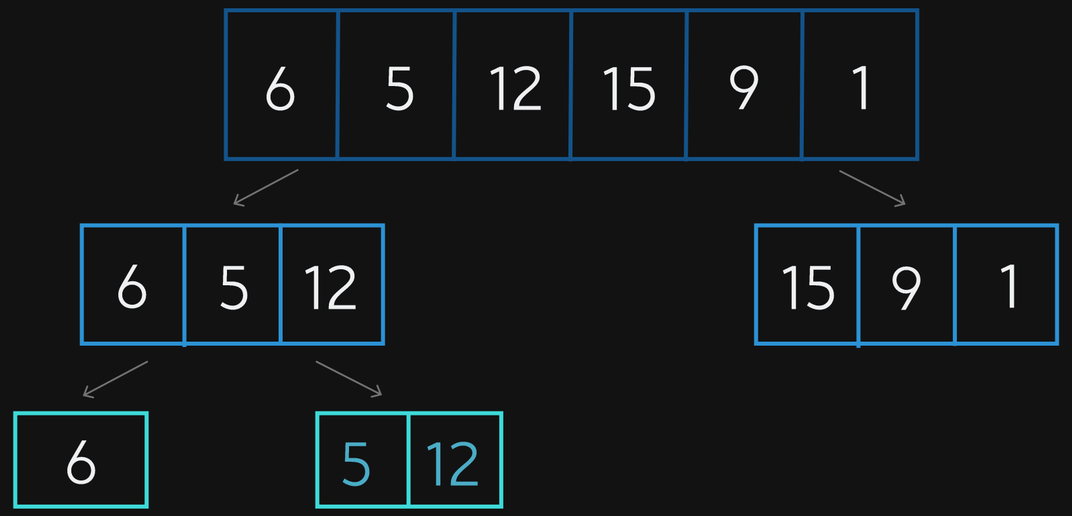

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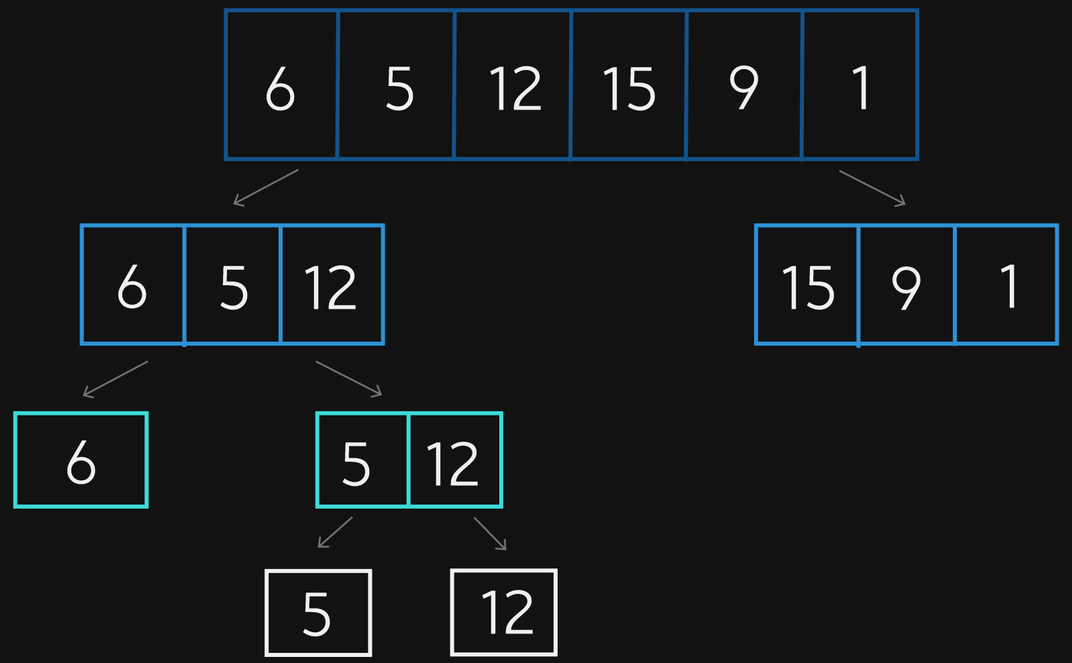

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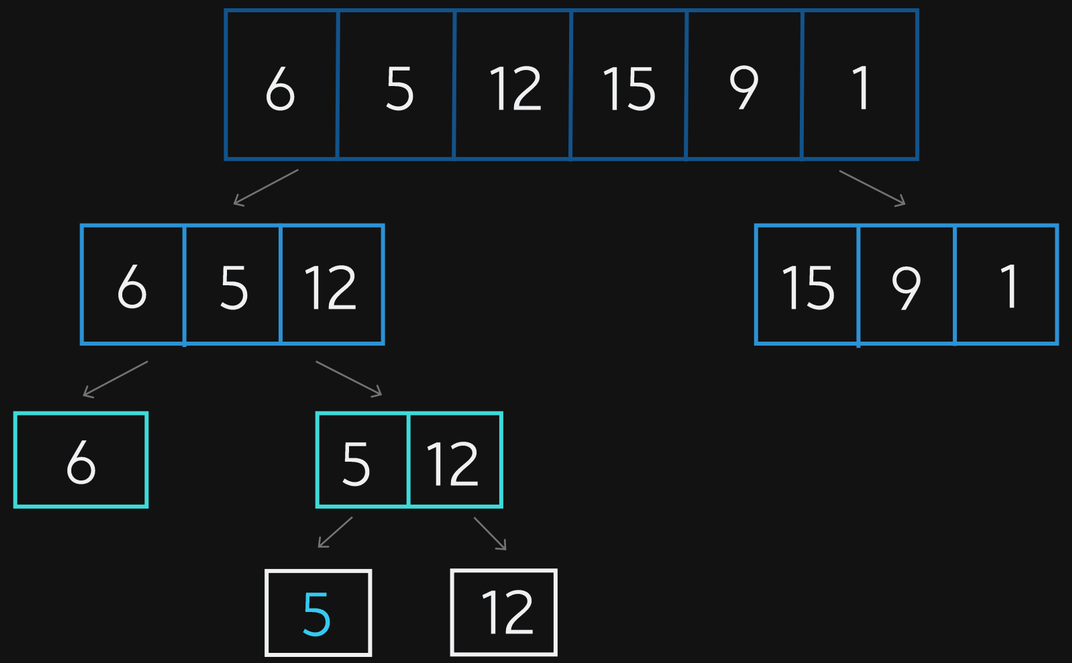

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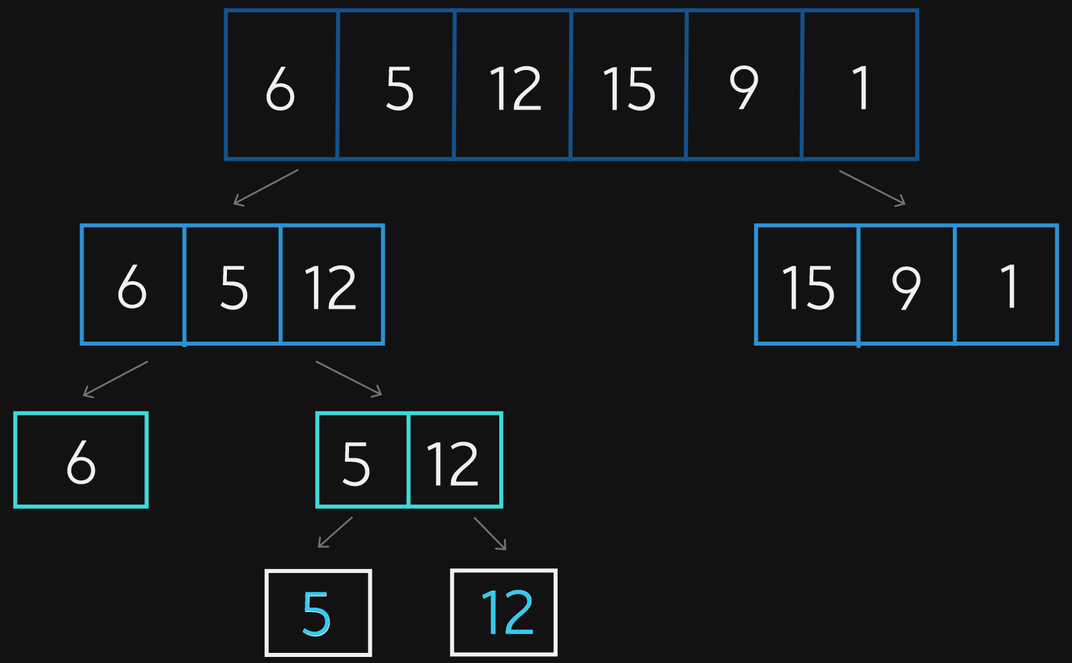

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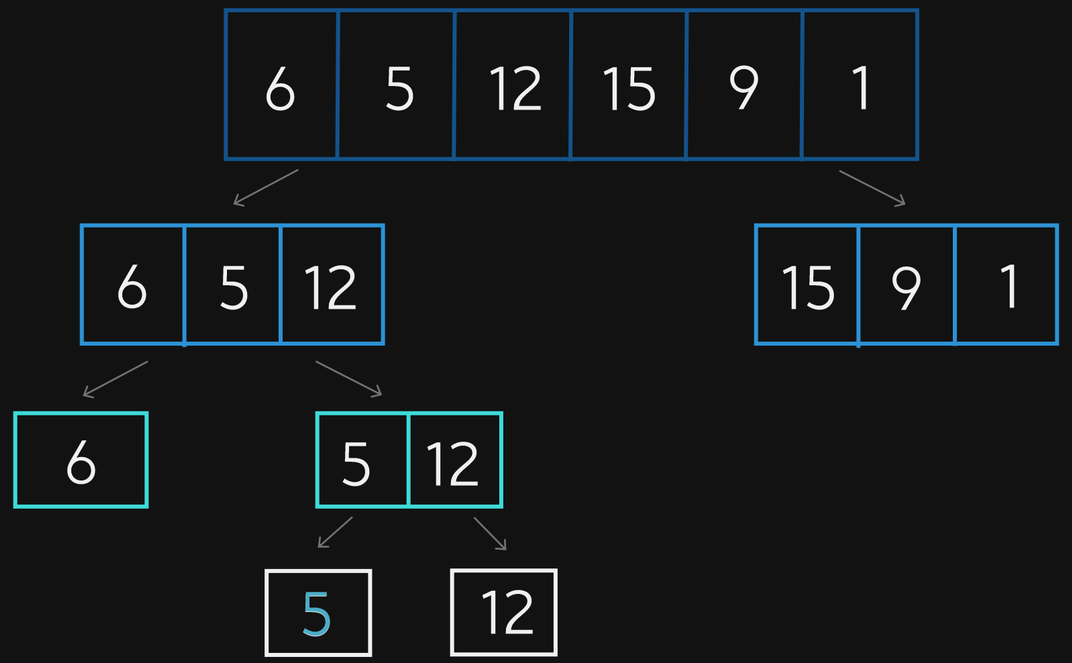

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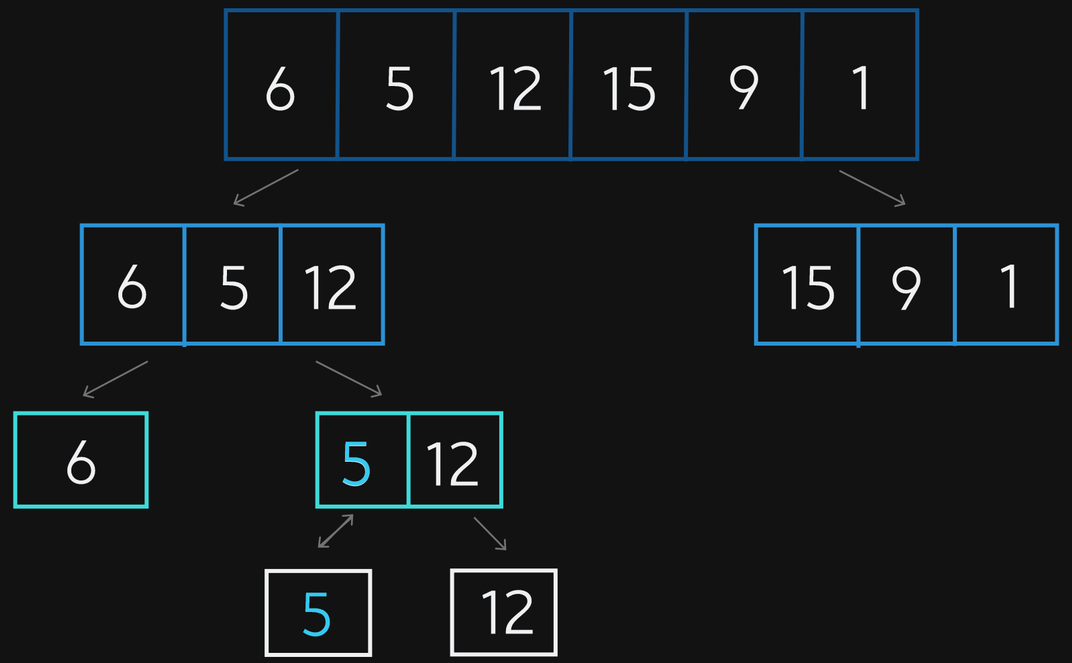

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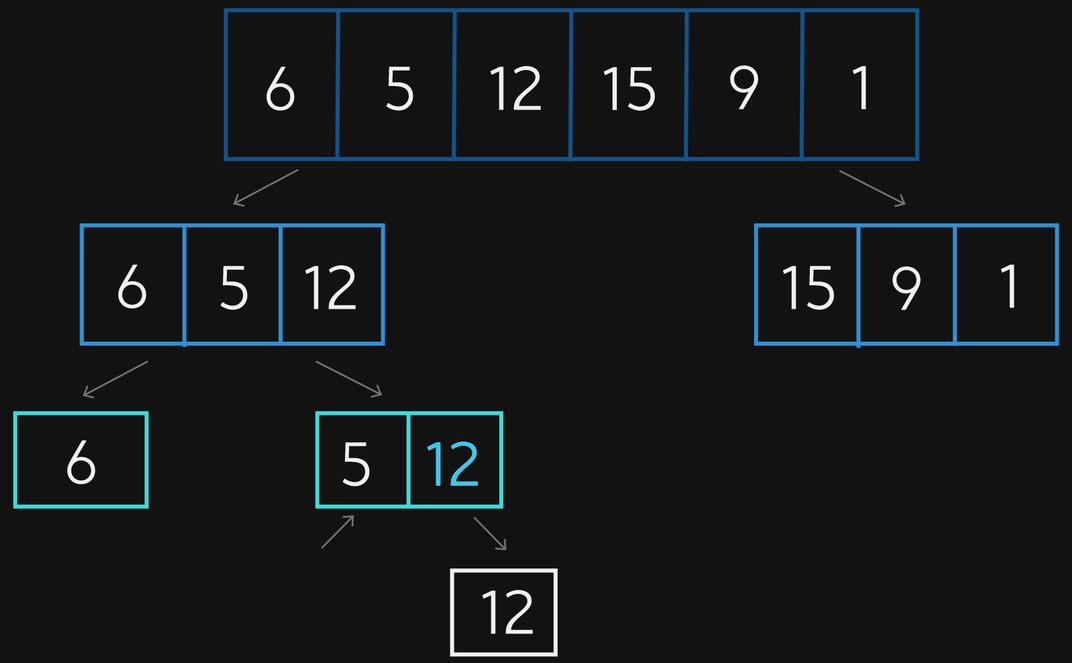

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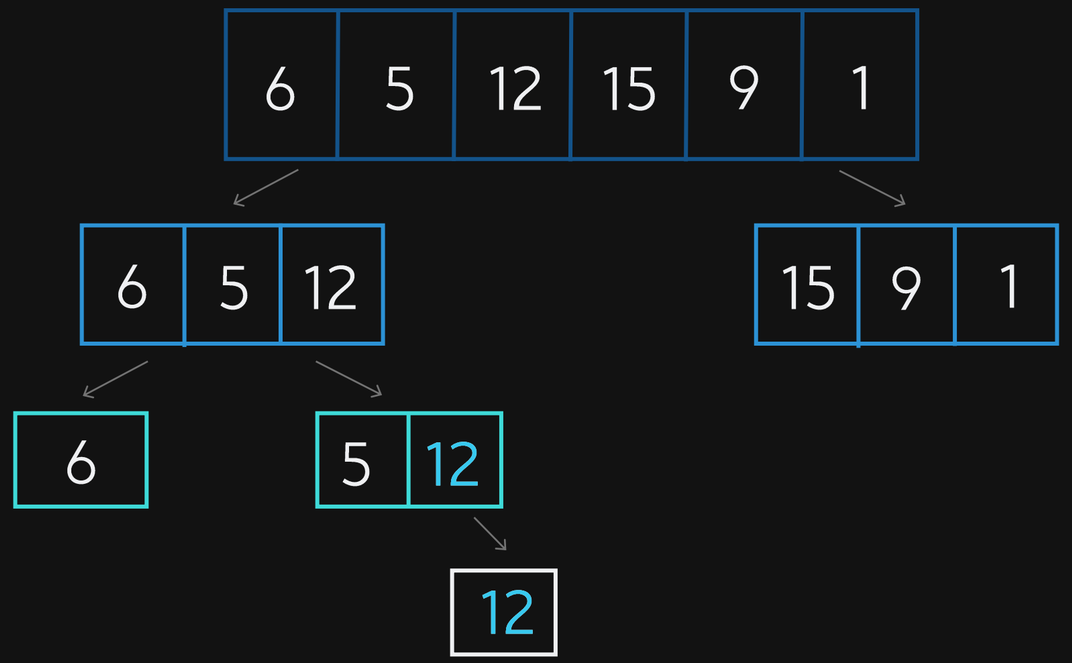

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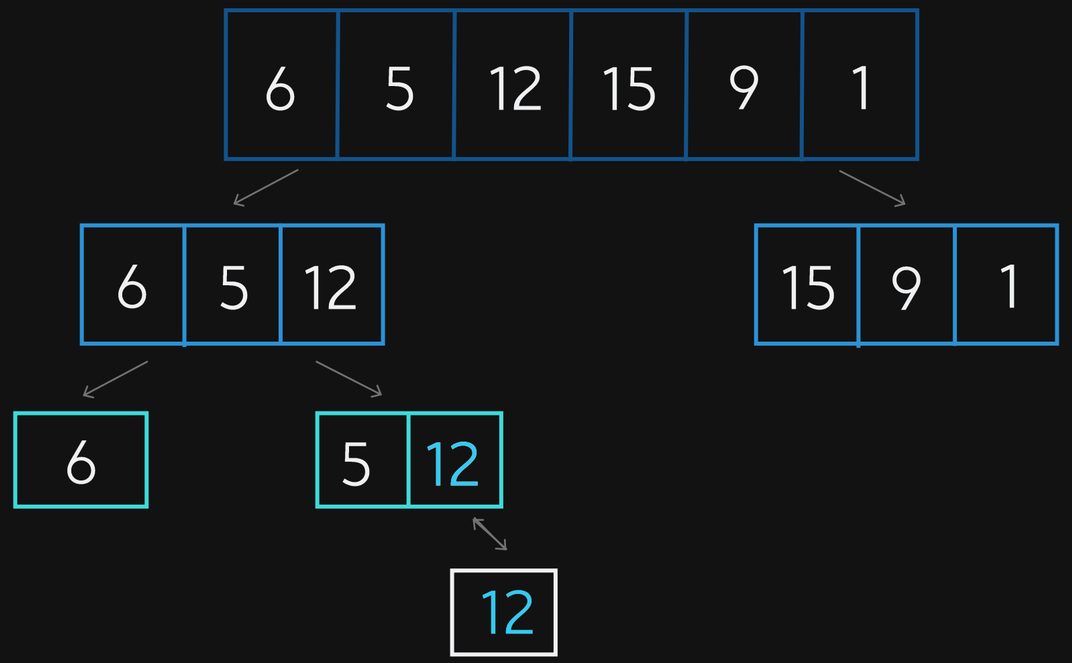

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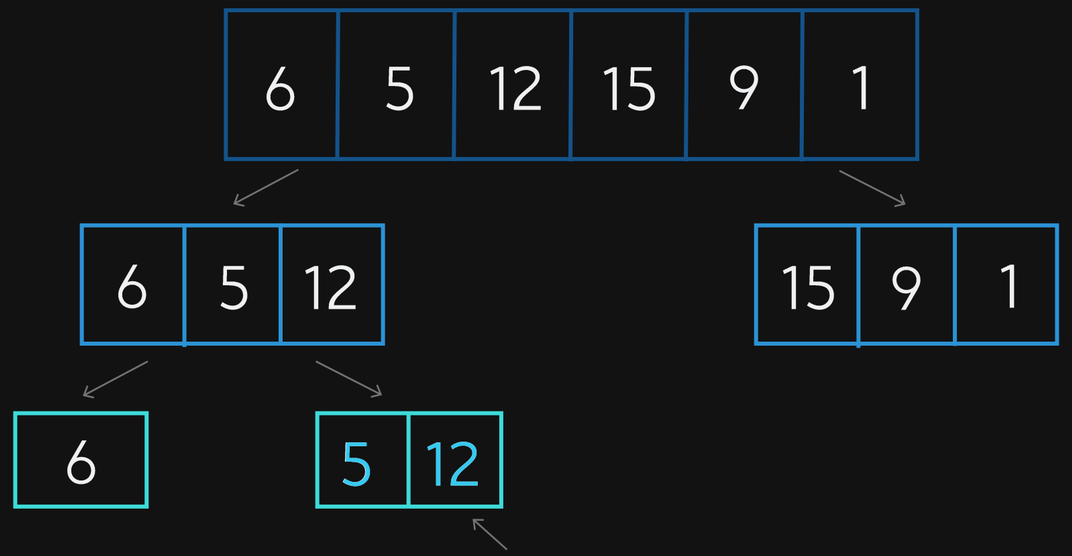

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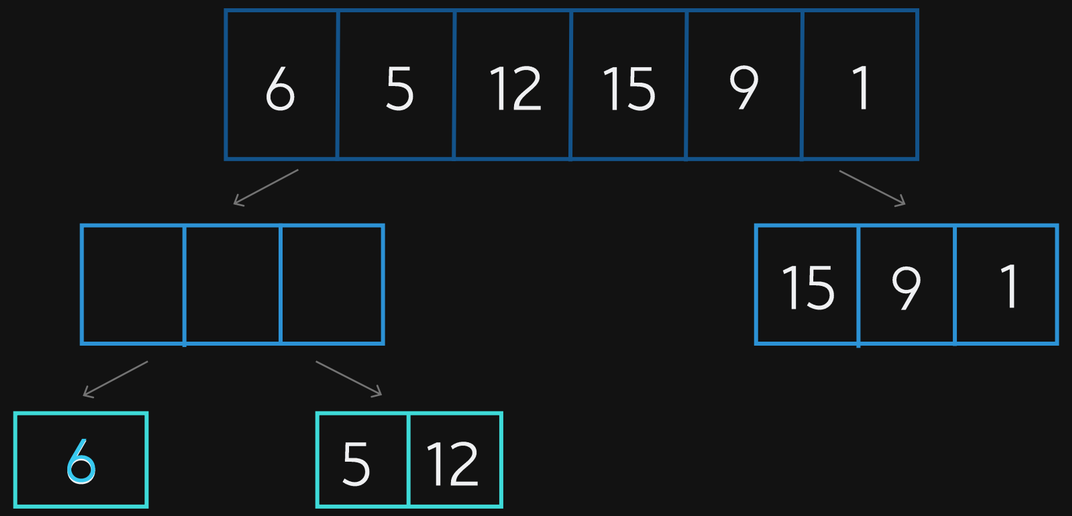

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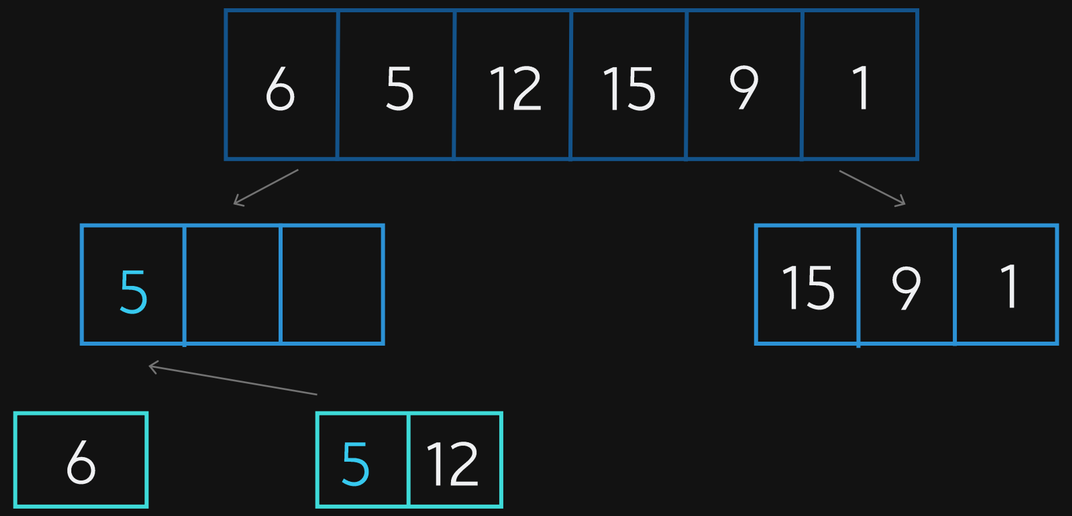

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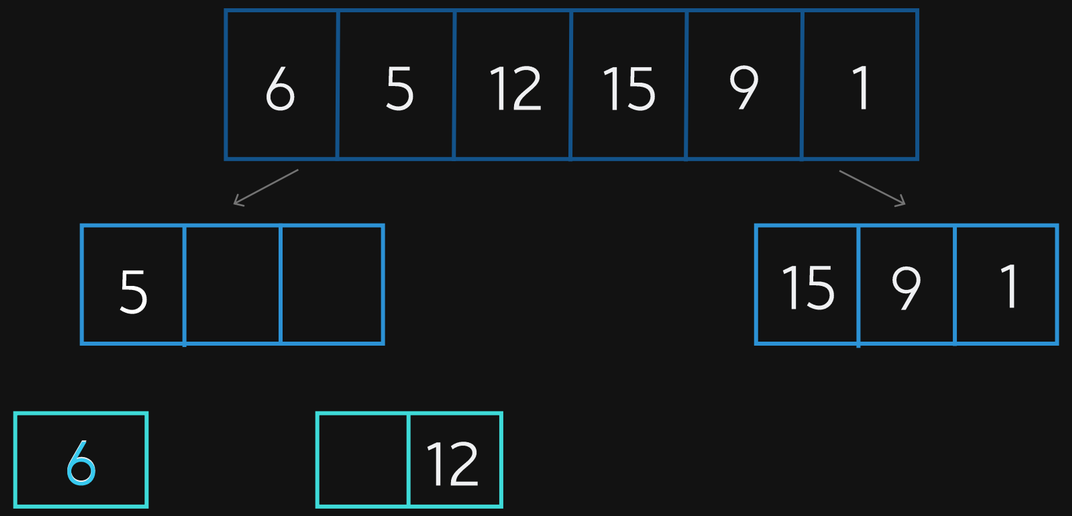

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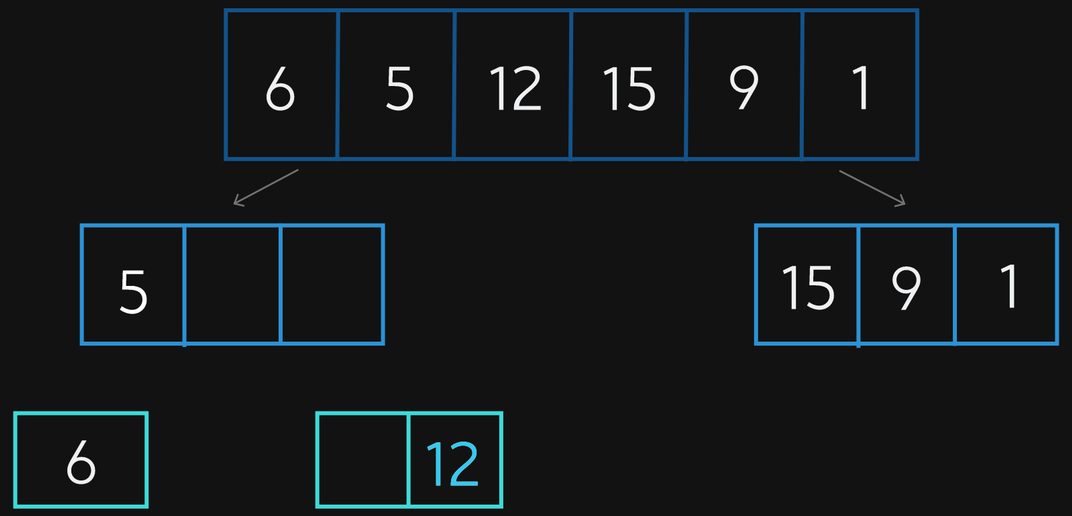

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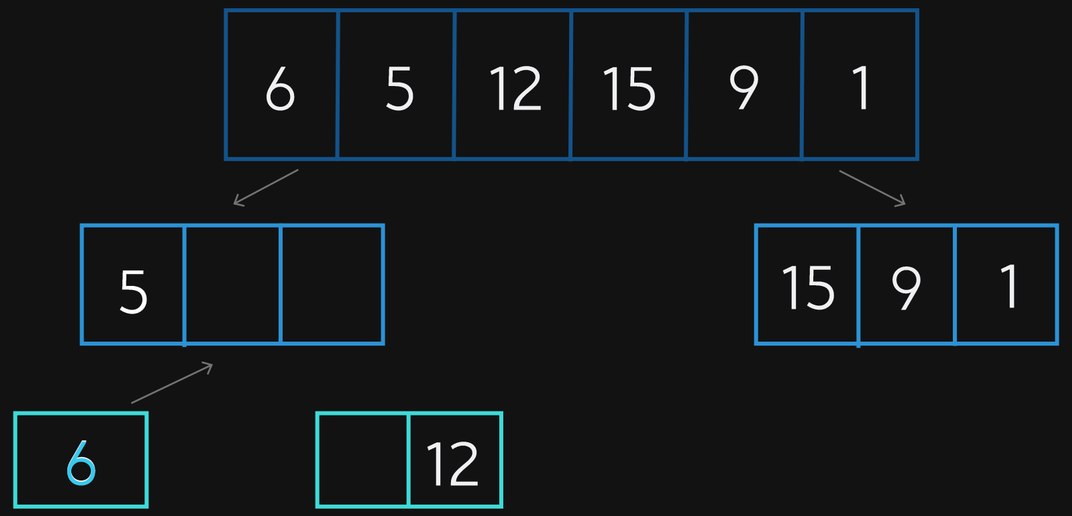

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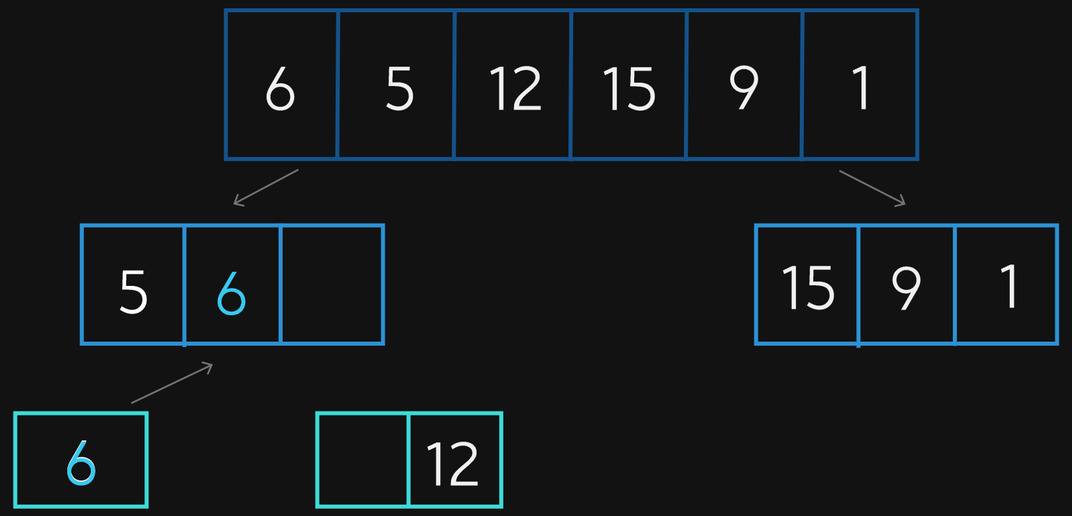

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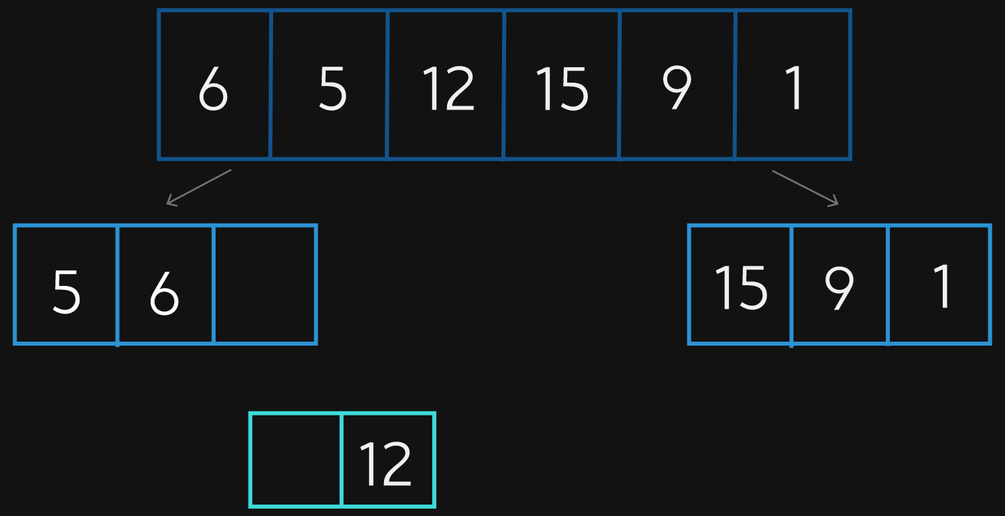

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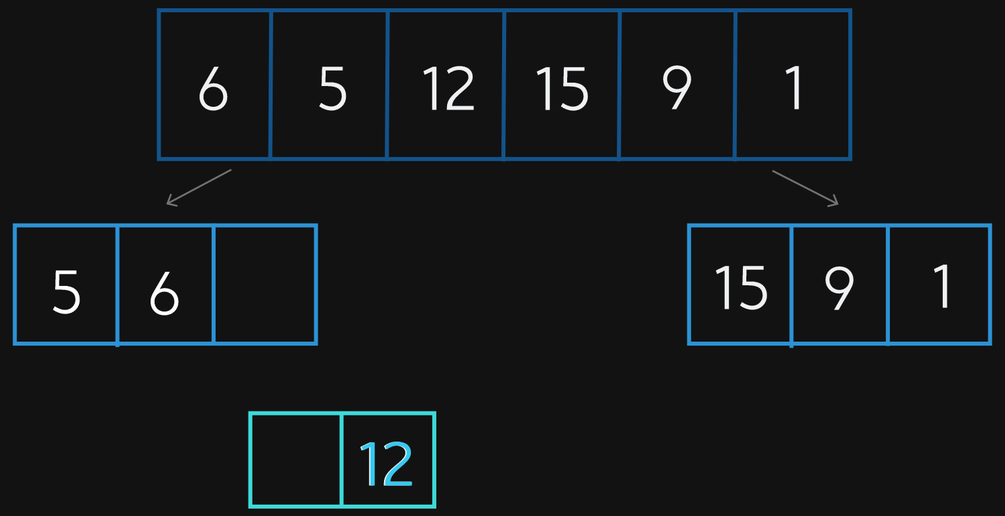

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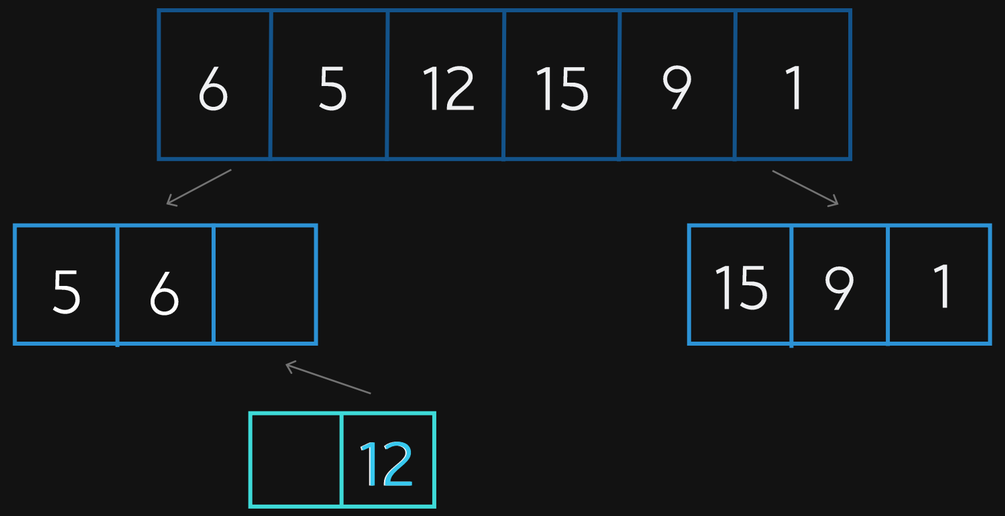

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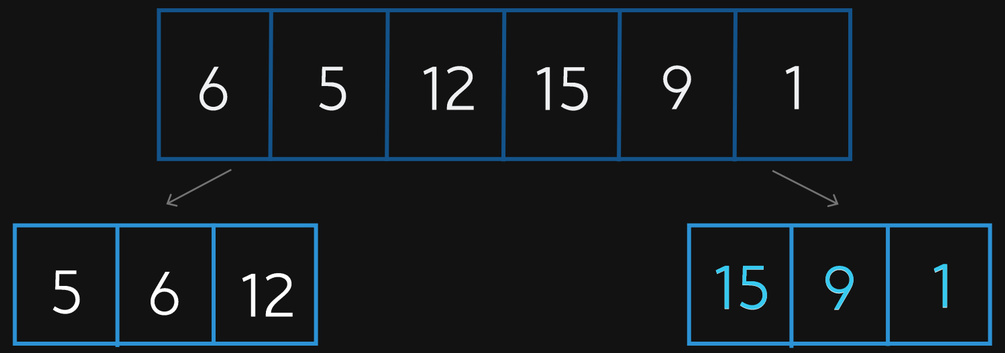

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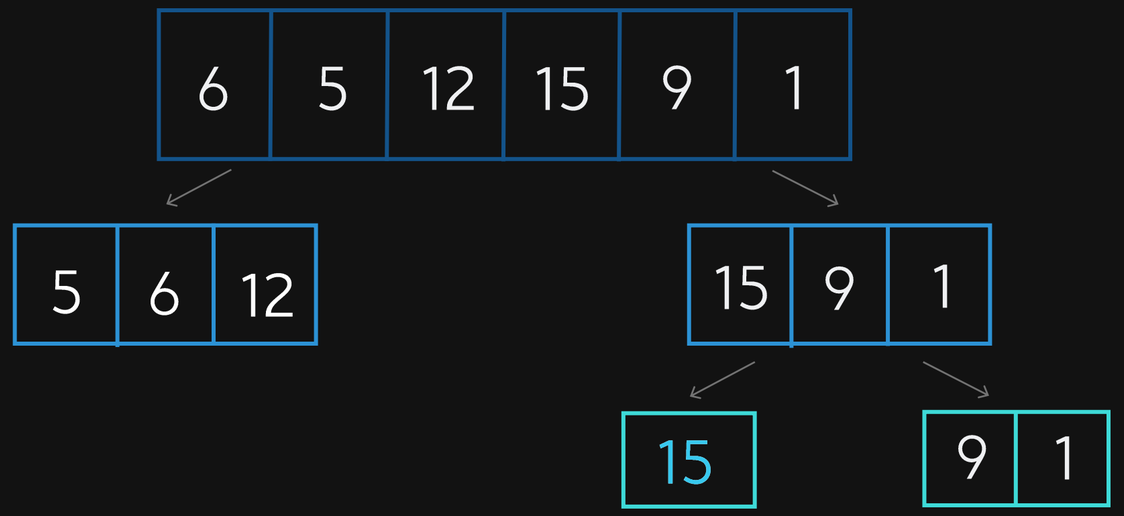

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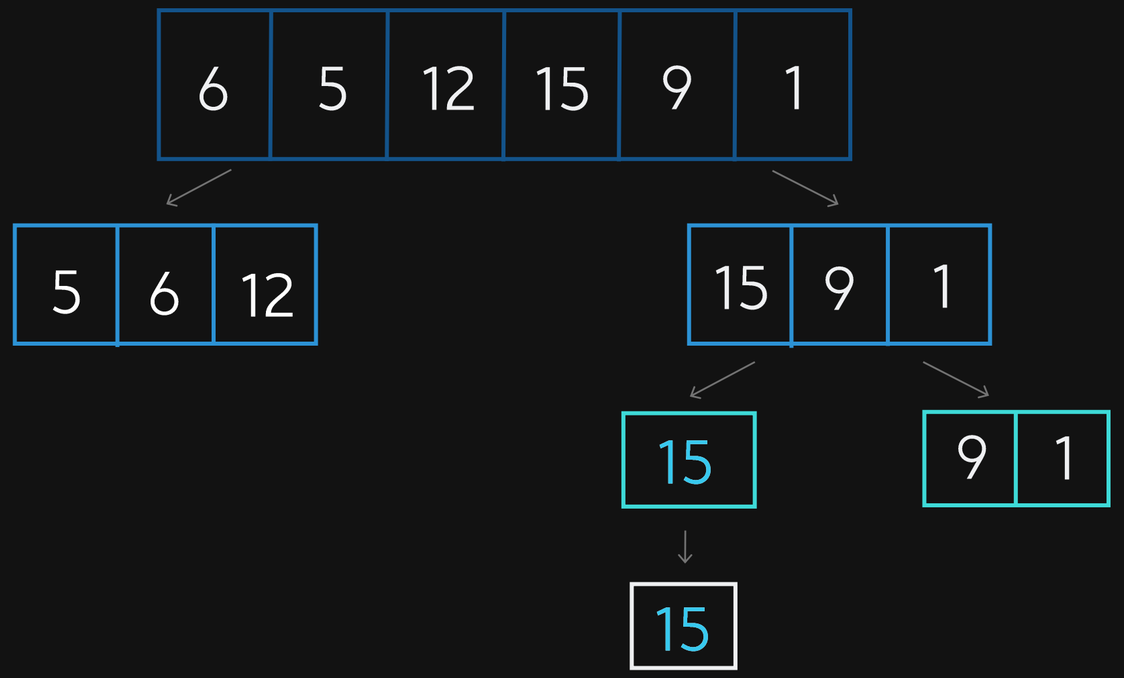

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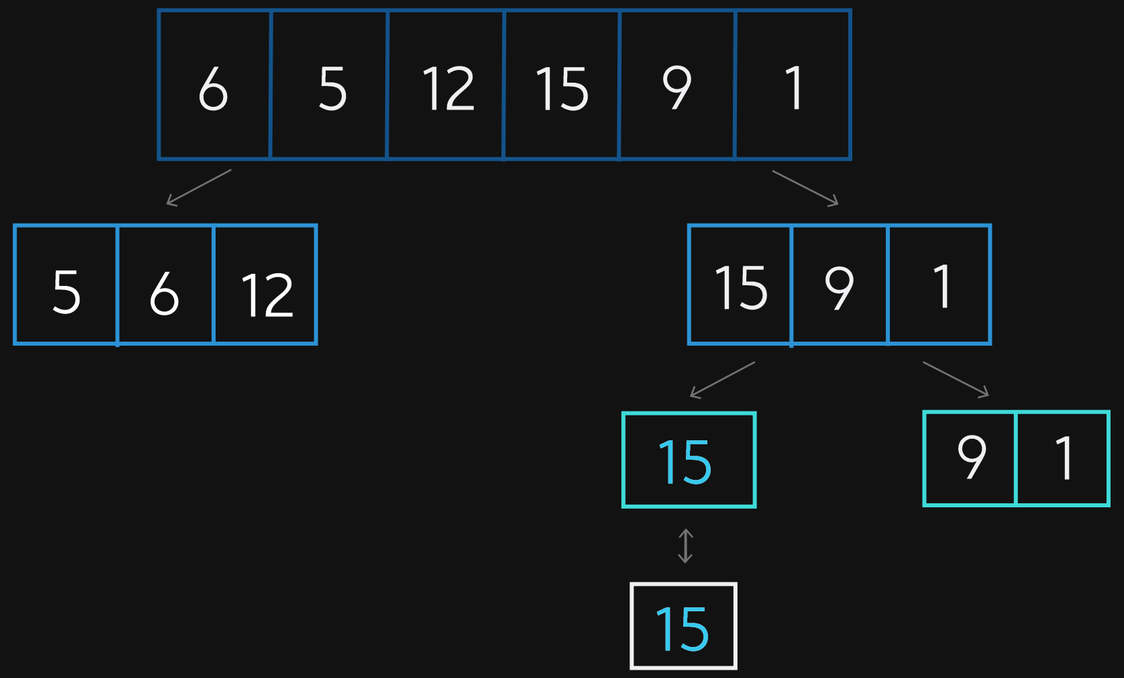

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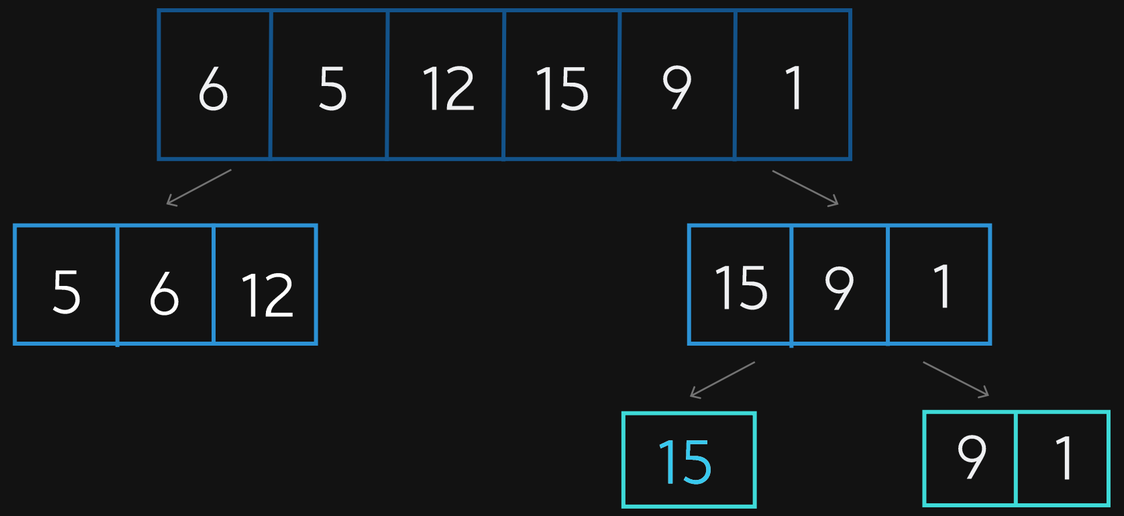

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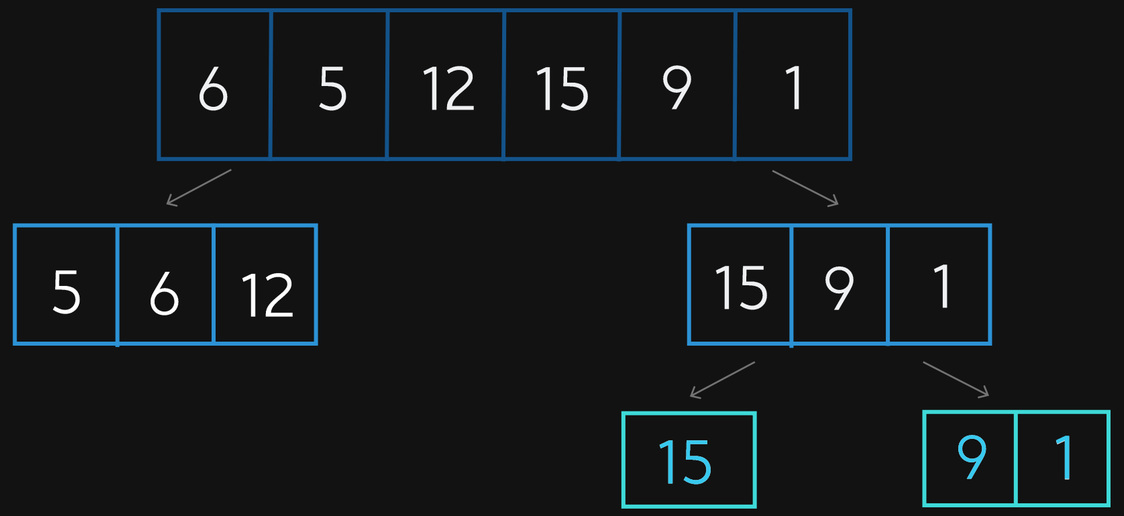

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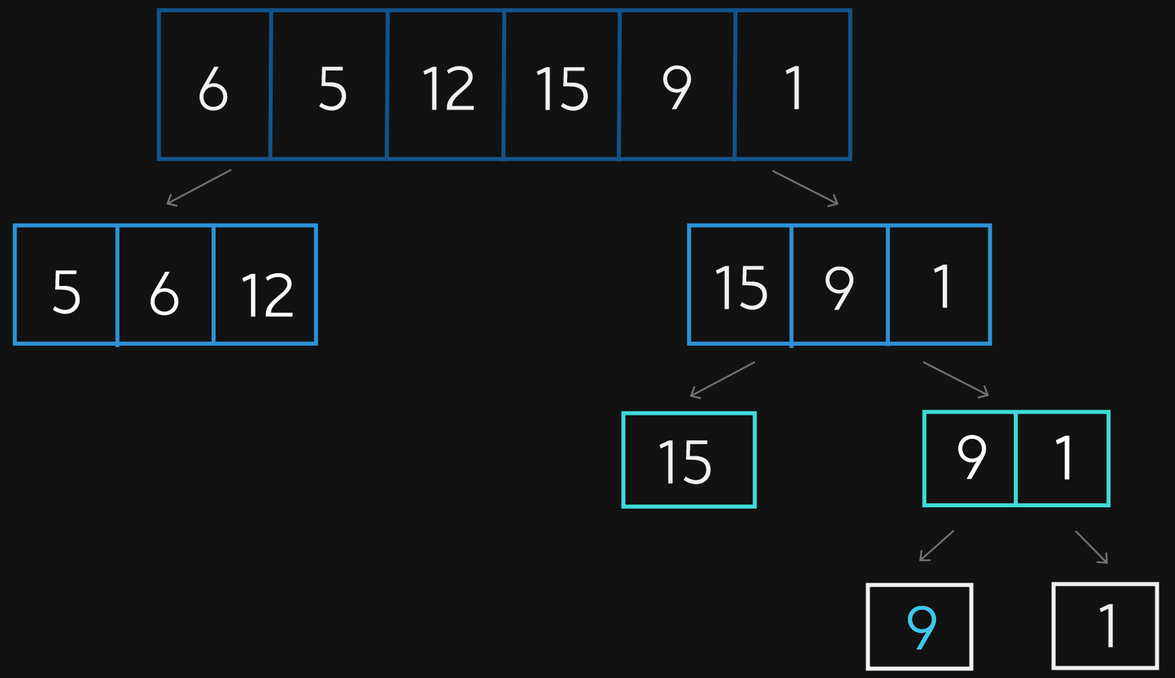

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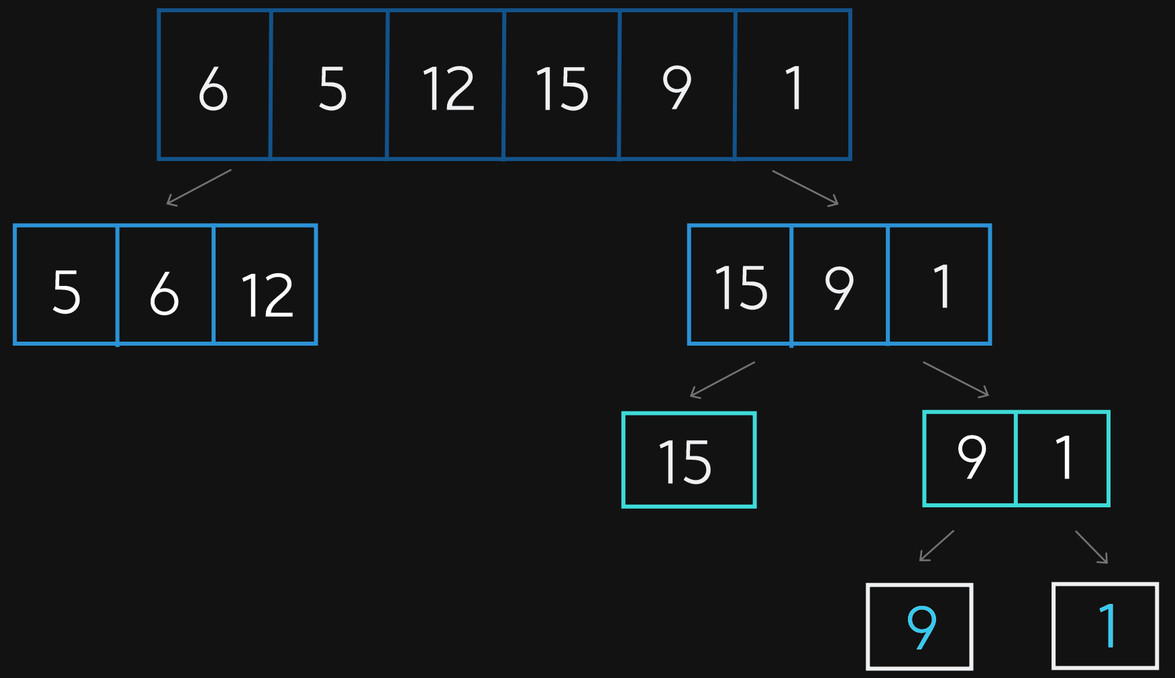

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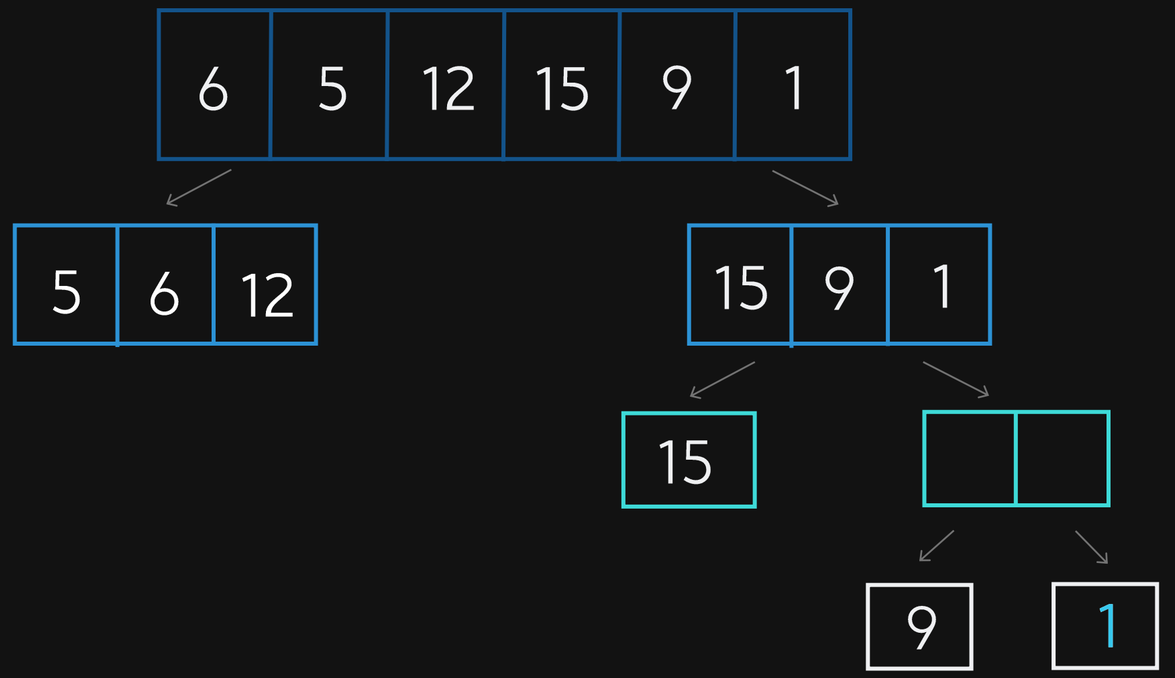

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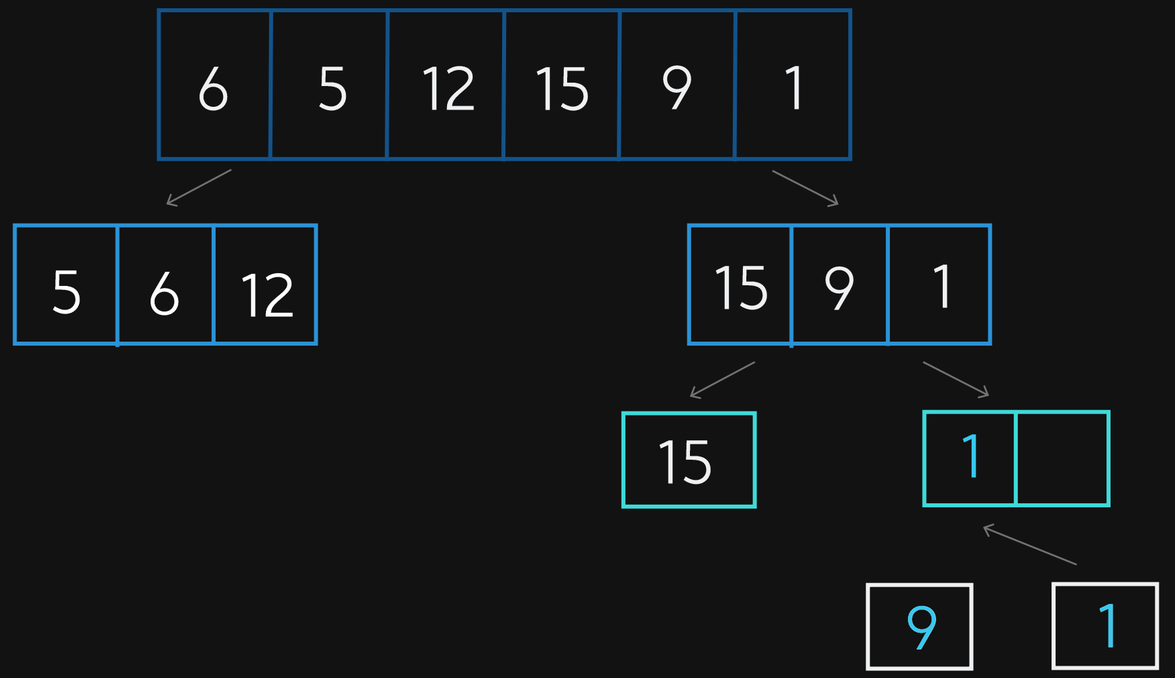

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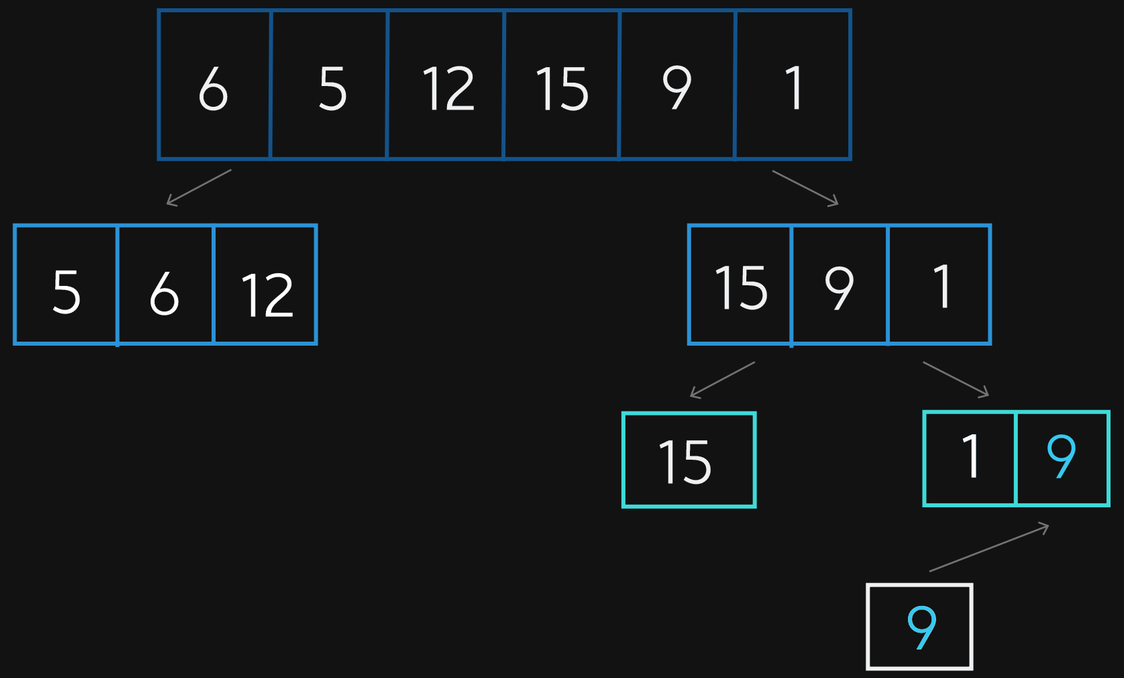

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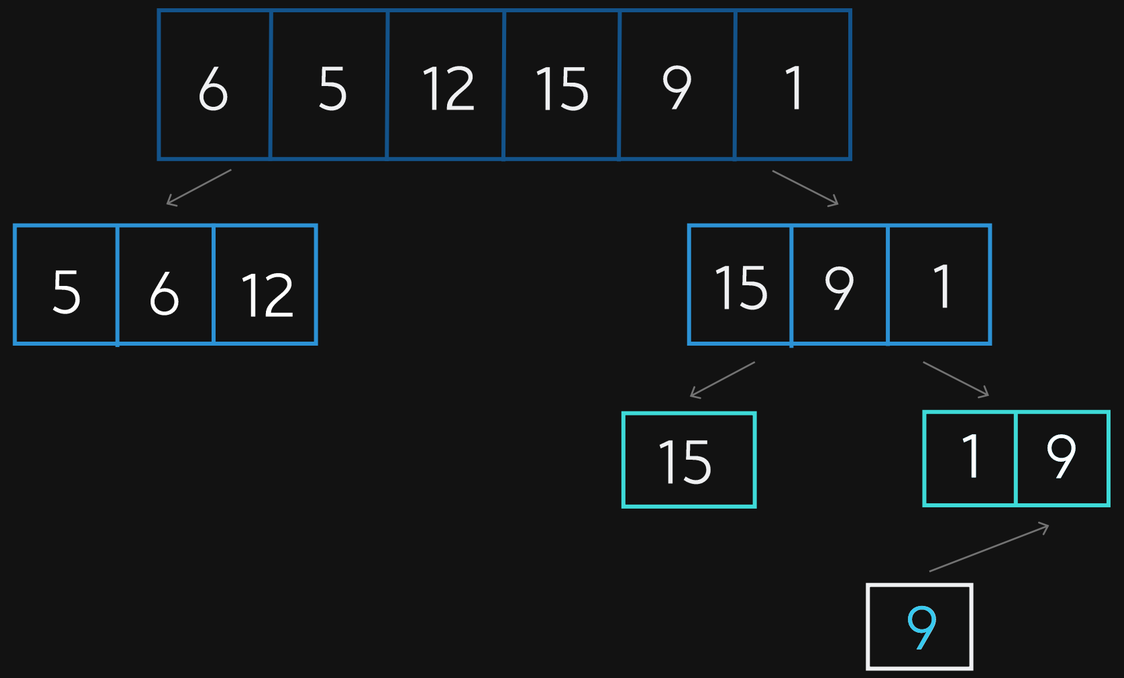

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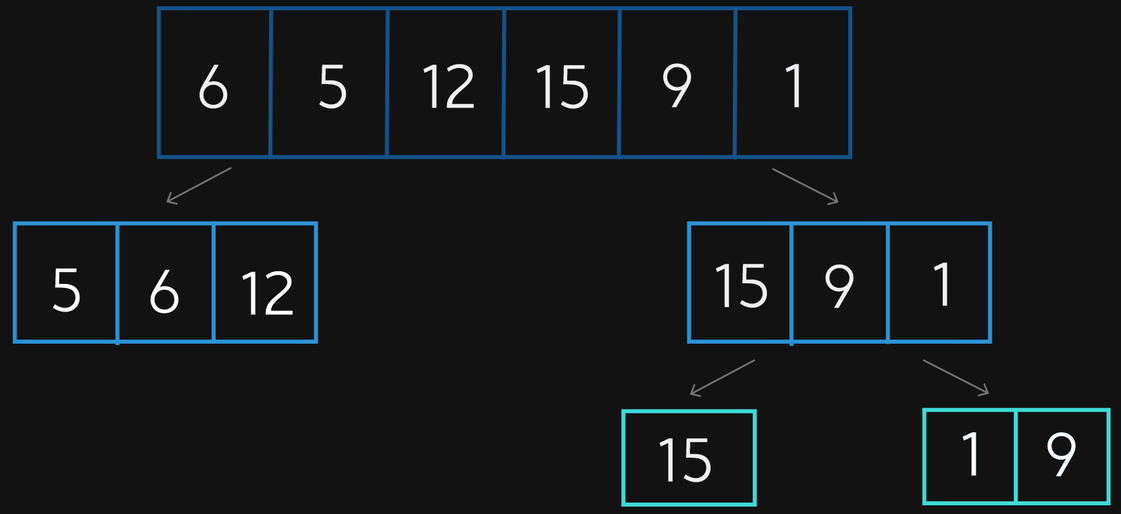

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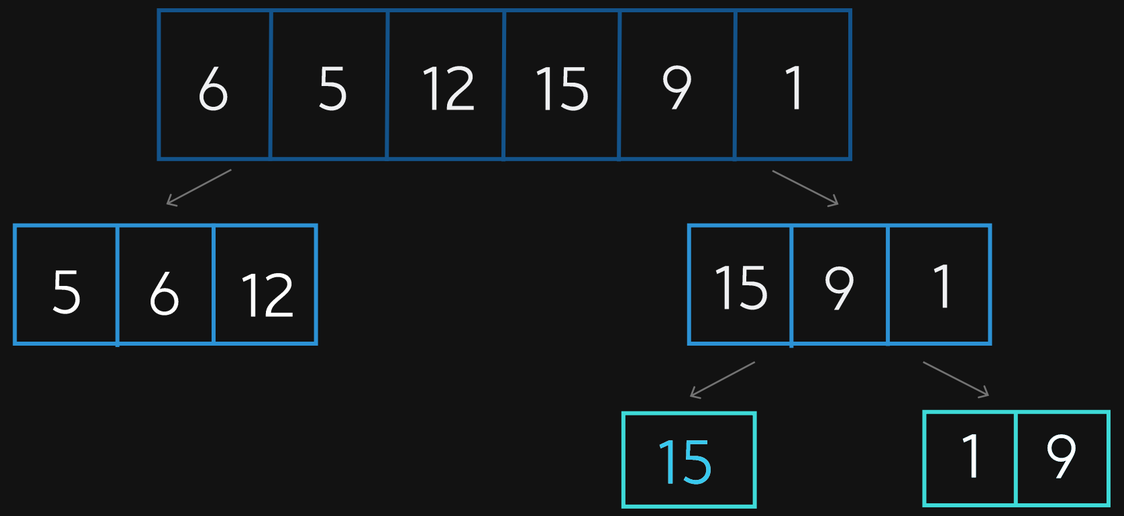

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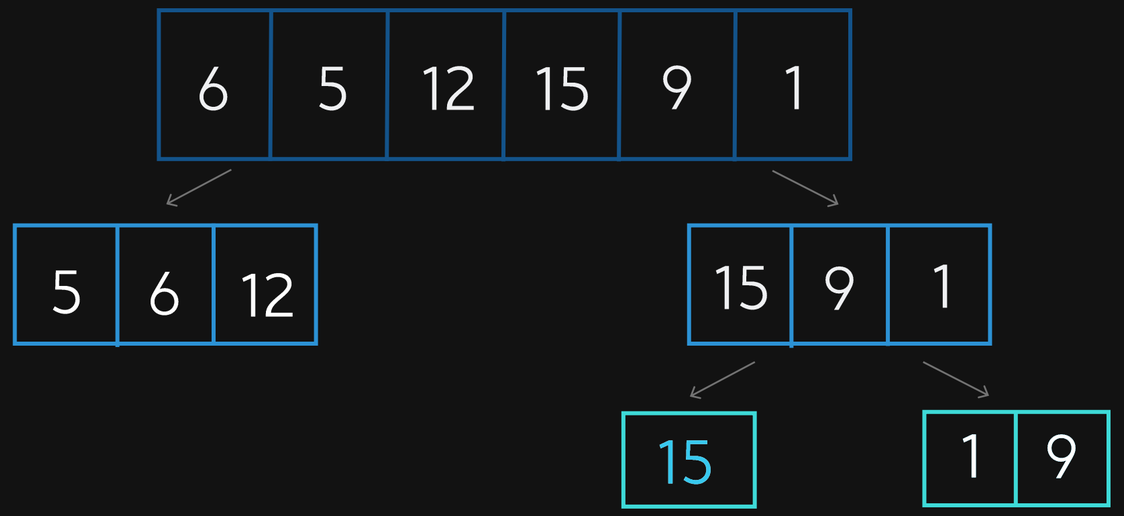

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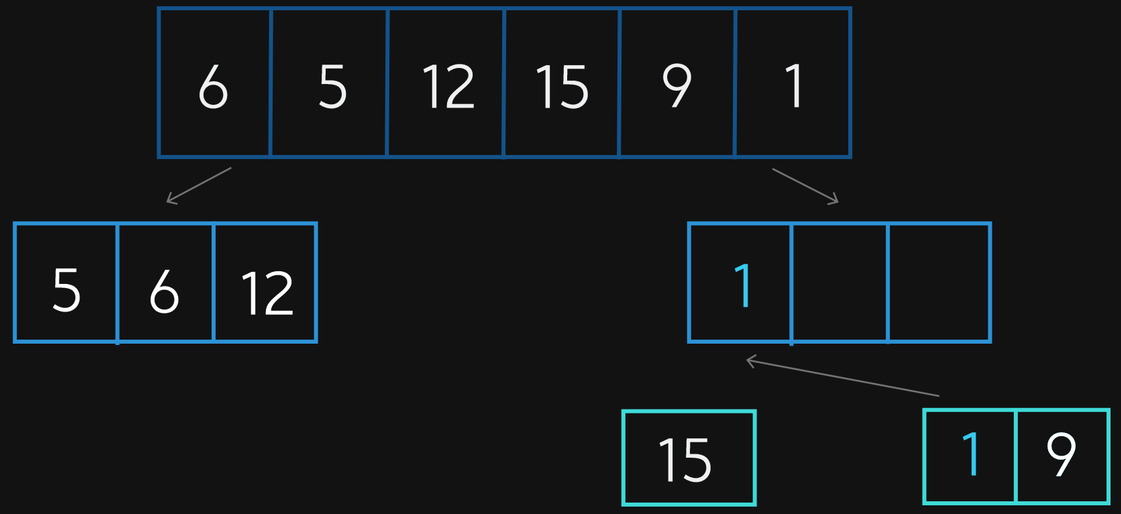

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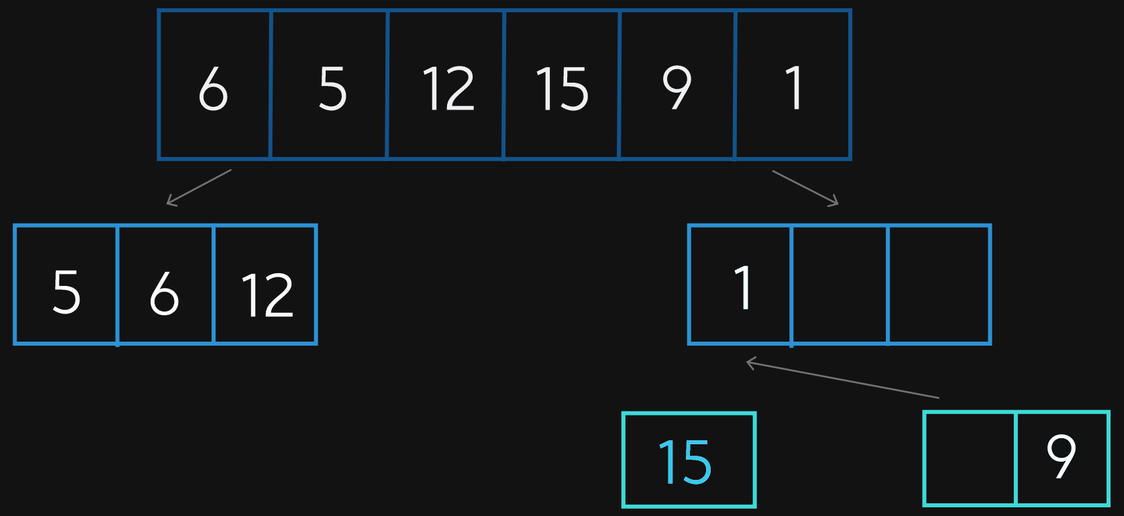

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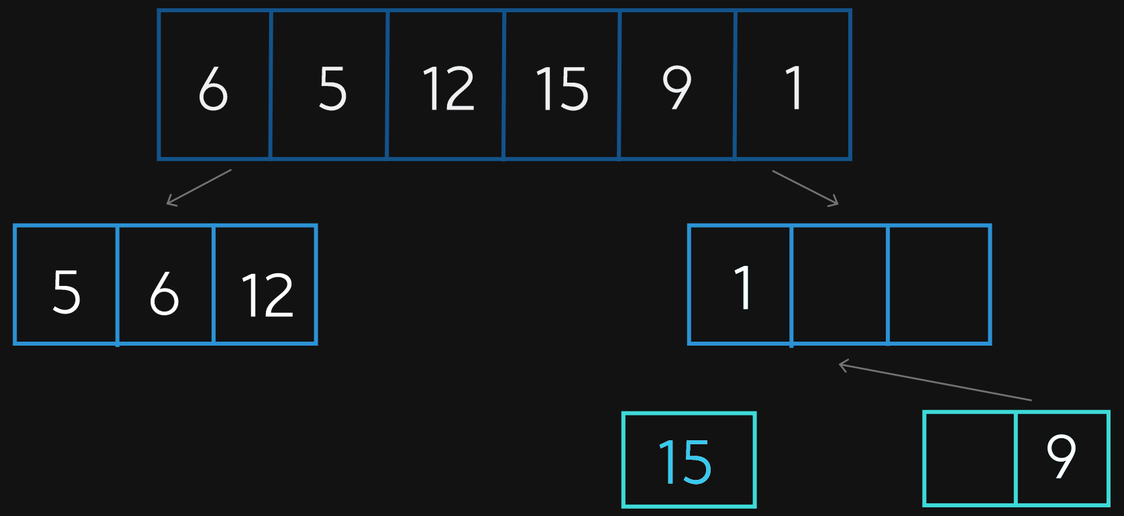

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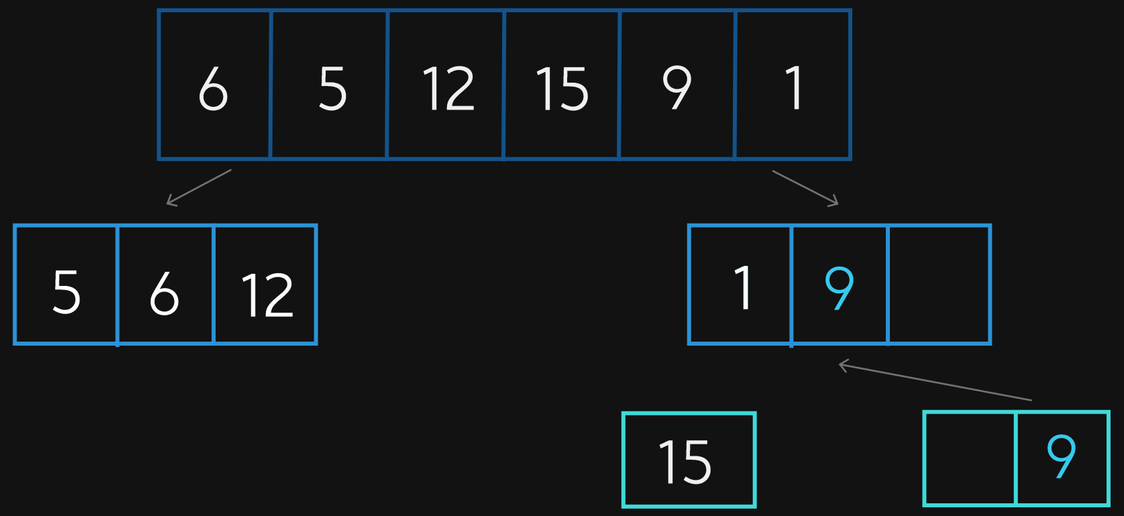

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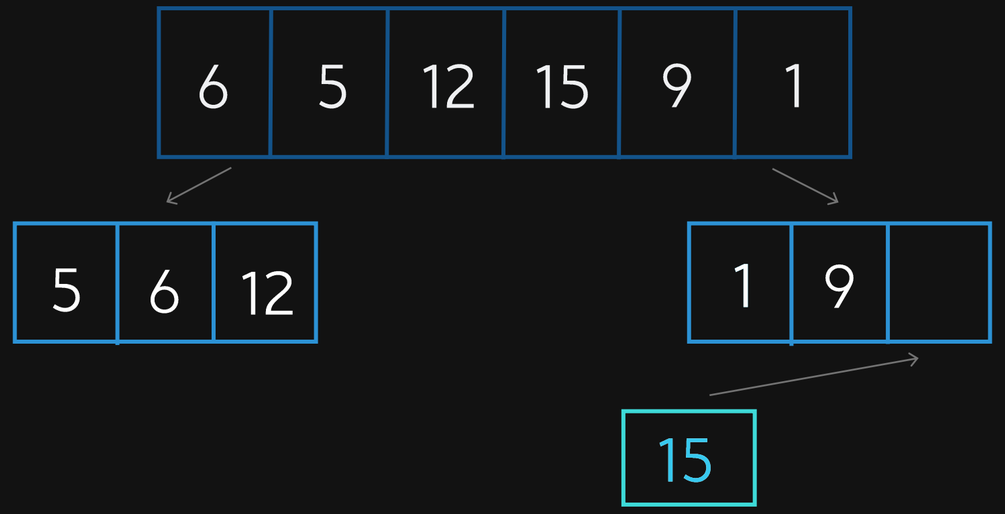

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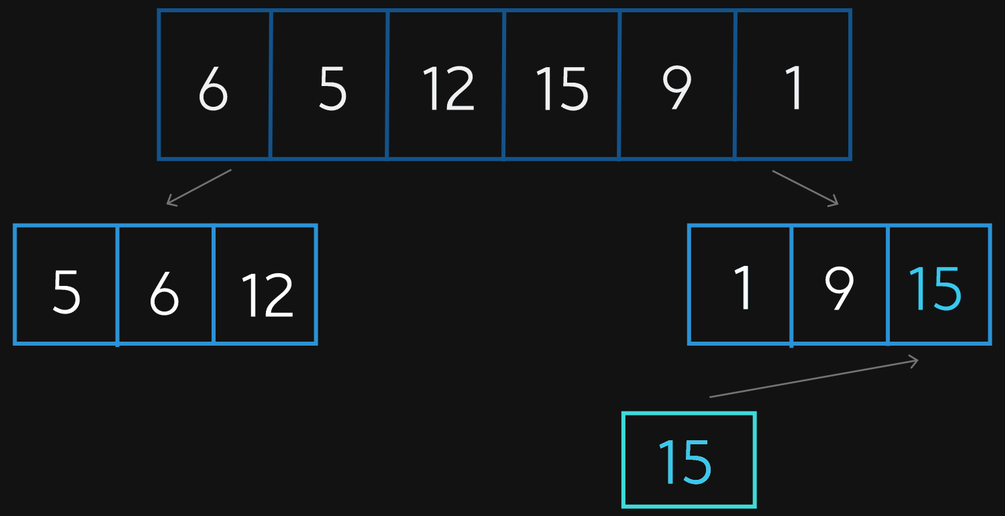

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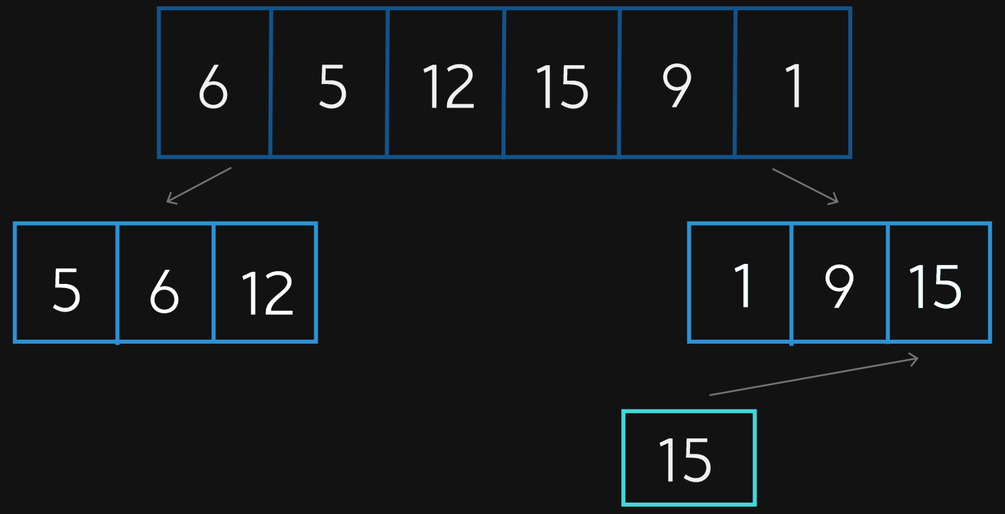

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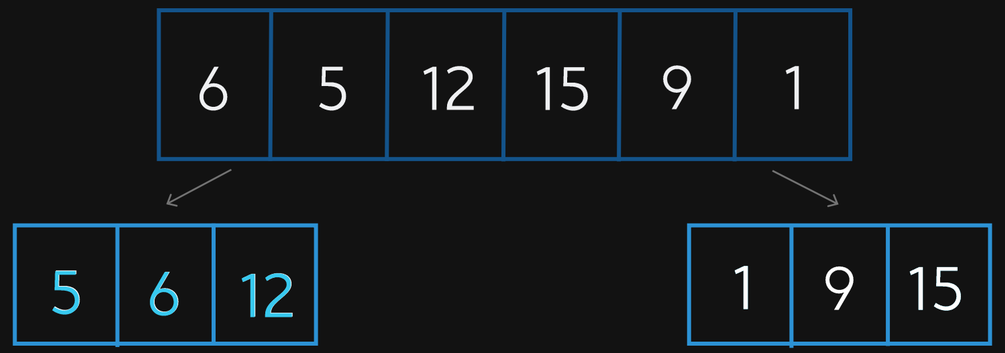

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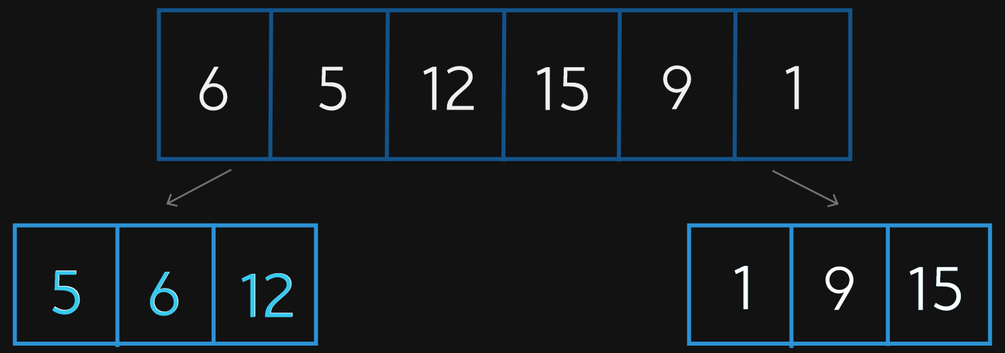

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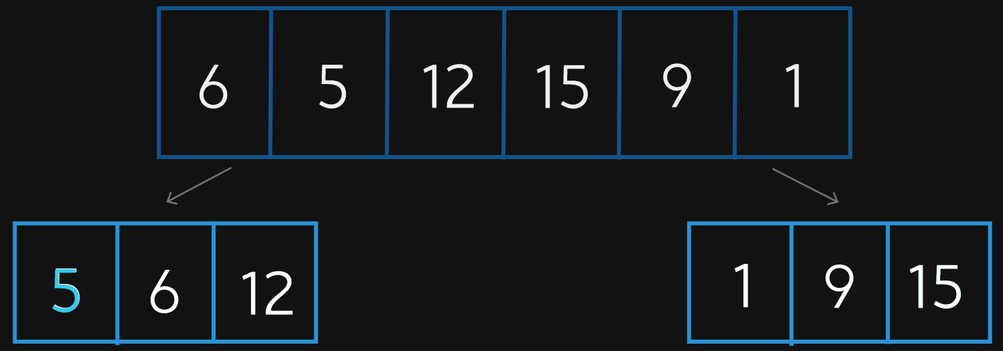

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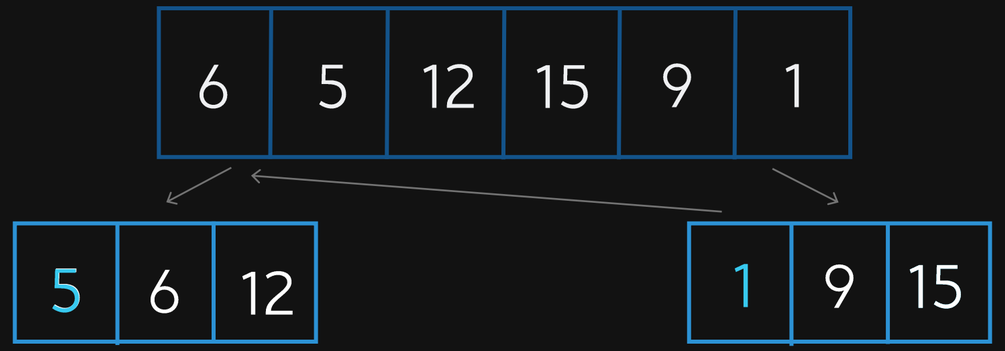

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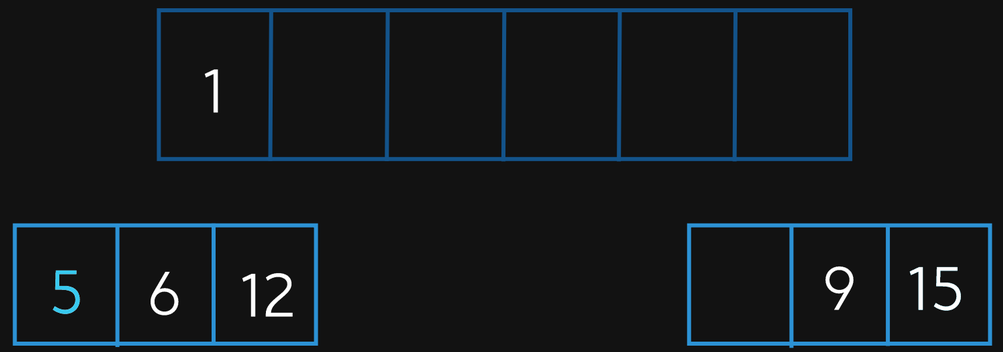

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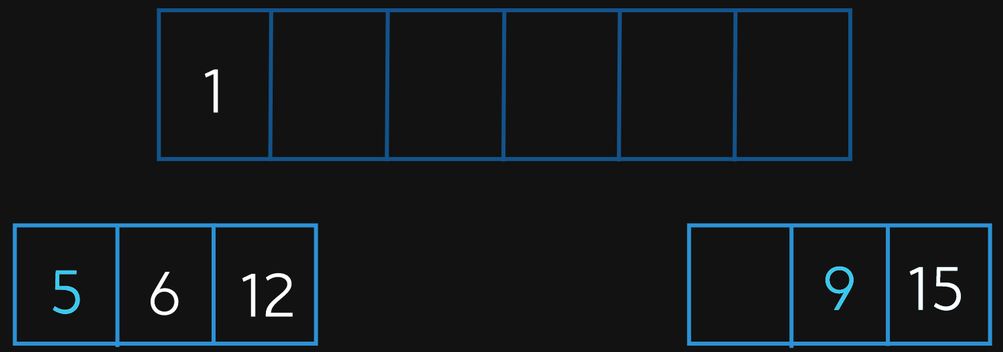

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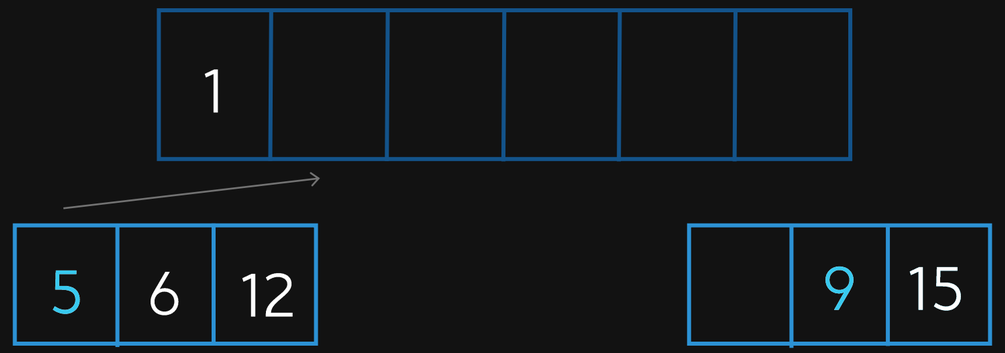

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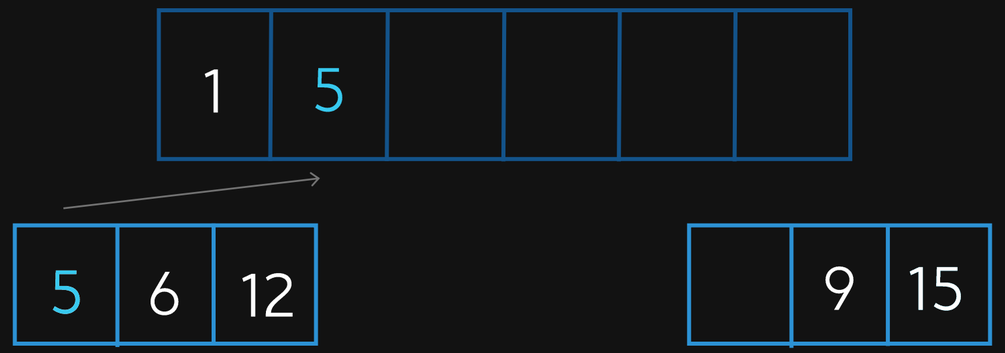

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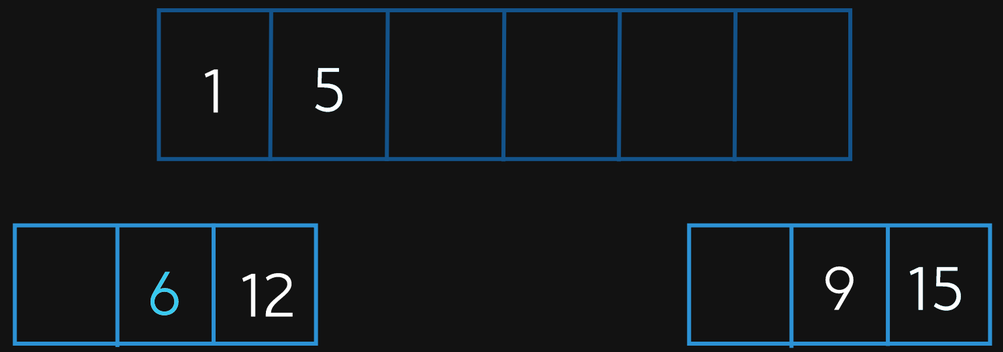

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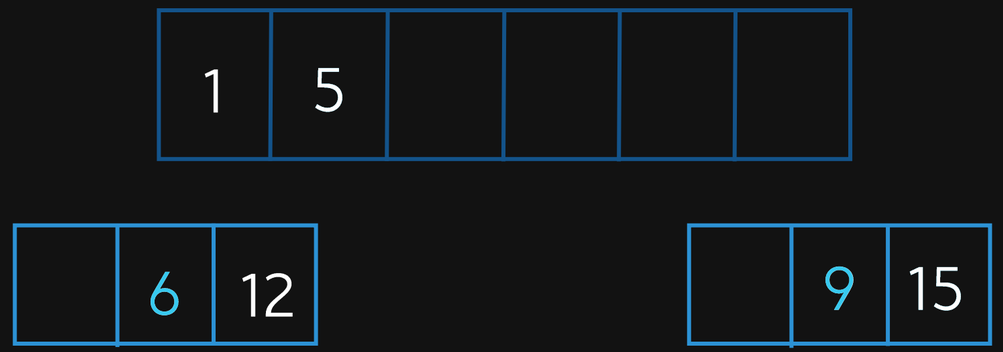

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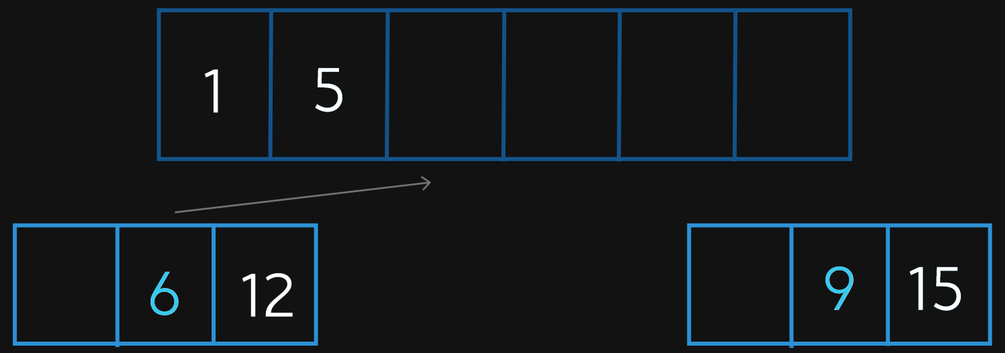

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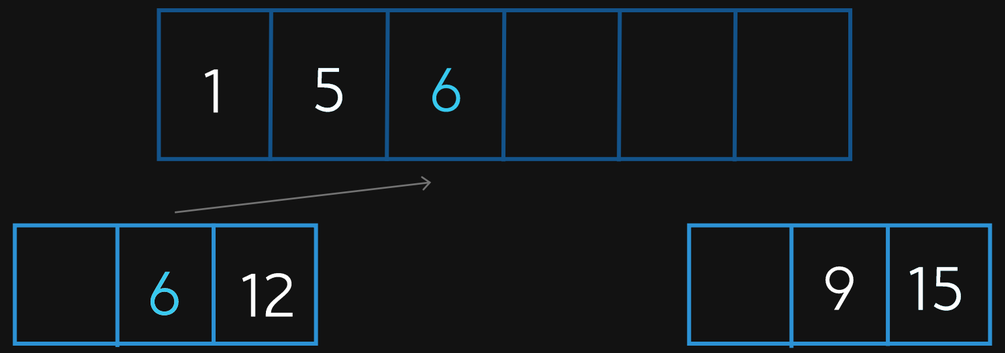

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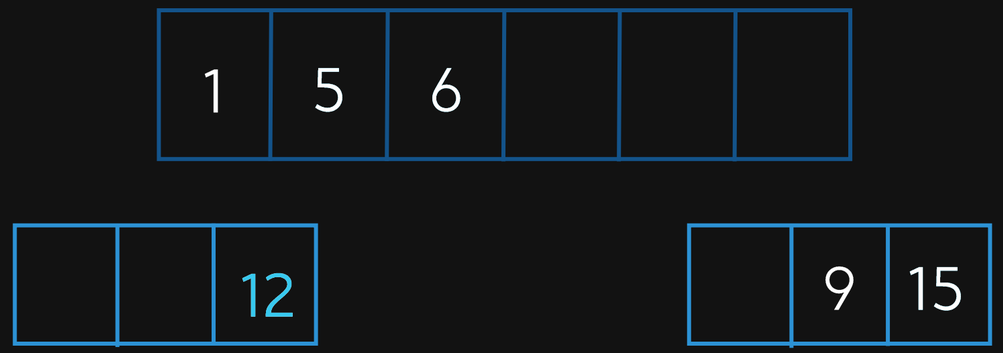

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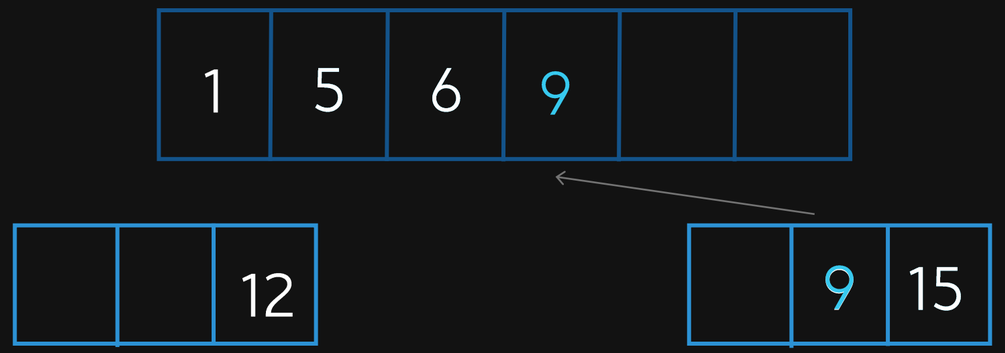

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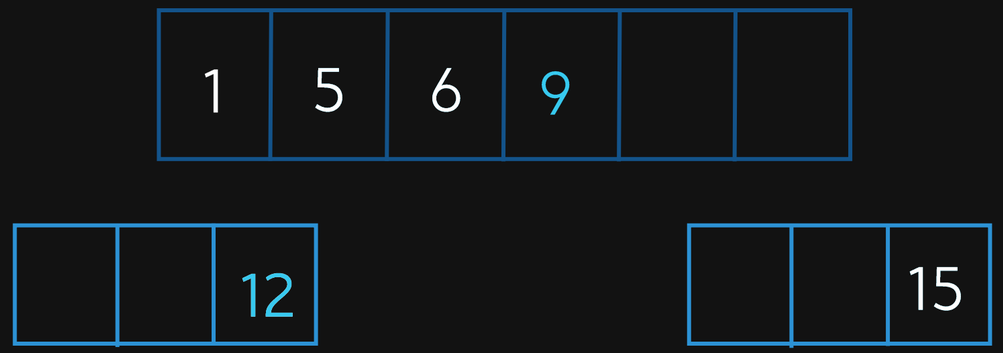

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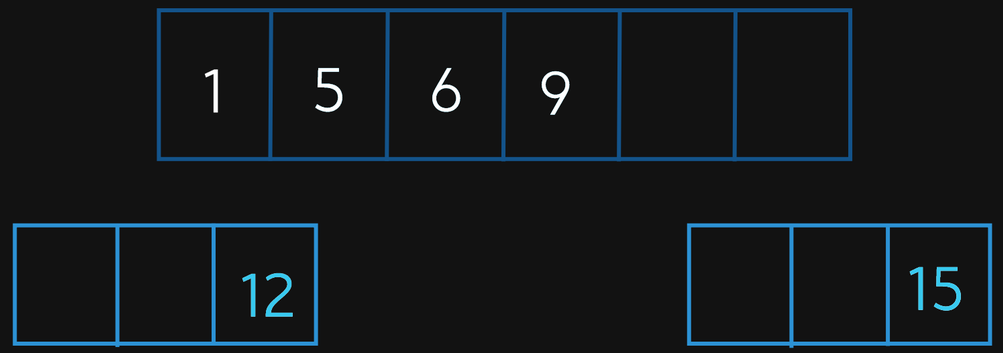
FUNÇÃO MERGE()



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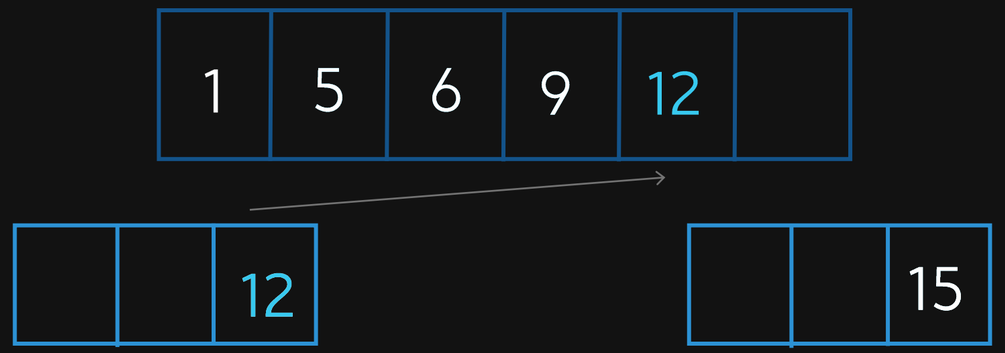

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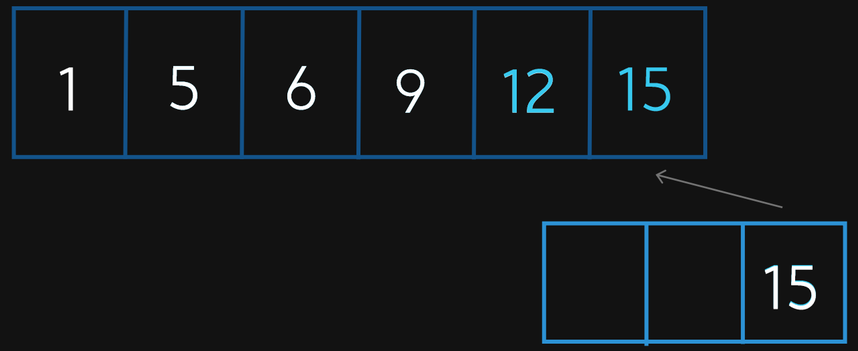

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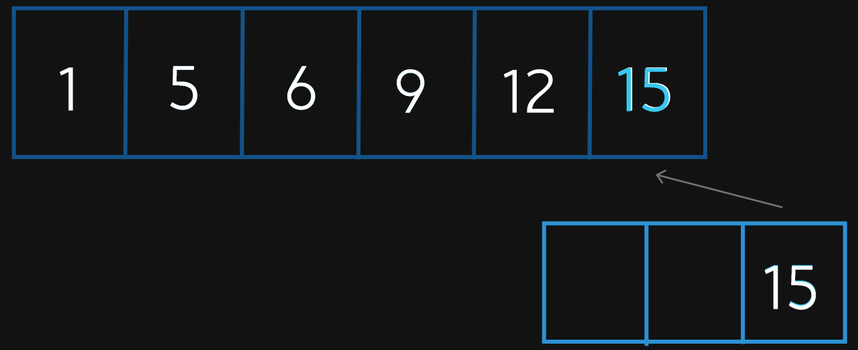
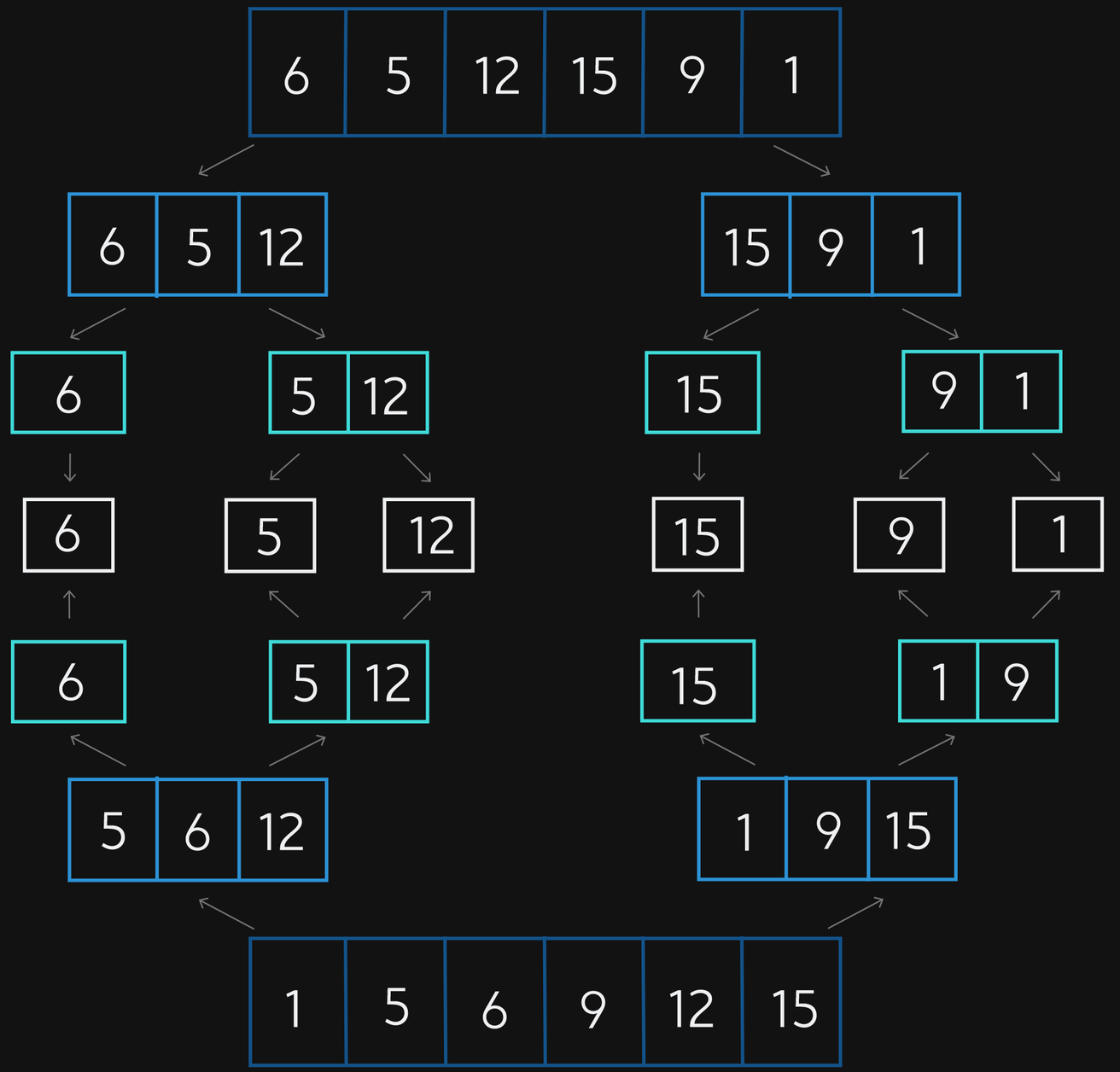


1	5	6	9	12	15

FUNÇÃO MERGE()

FUNÇÃO MERGE()

FUNÇÃO MERGE()



```
Merge(A, p, q, r)
  n1 = q − p + 1
  n2 = r − q
  sejam L[1..n1 + 1] e R[1..n2 + 1] novos arranjos
  for i = 1 to n1 do
      L[i] = A[p + i − 1]
  end for
  for j = 1 to n2 do
      R[j] = A[q + j]
  end for
  L[n1 + 1] = ∞
  R[n2 + 1] = ∞
  i = 1
  j = 1
  for k = p to r do
      if L[i] ≤ R[j] then
        A[k] = L[i]
        i = i + 1
      else
        A[k] = R[j]
        j = j + 1
      end if
  end for
```

```
MERGESORT(A, p, r):
    if p < r then
        q ← ⌊(p + r)/2⌋
        MERGESORT(A, p, q)
        MERGESORT(A, q + 1, r)
        MERGE(A, p, q, r)
    end if
end
```

PSEUDOCÓDIGO

ANÁLISE DE COMPLEXIDADE

Complexidade de Tempo

- O(n log n) onde n é o número total de elementos.
- Usa recursão e a técnica de "dividir e conquistar"
- O Teorema Mestre é utilizado para resolver a recorrência

$$T(n) = 2T\left(\frac{n}{2}\right) + \theta(n)$$

- A complexidade de tempo do Merge Sort é $\theta(n \log n)$

Complexidade de Espaço

- Espaço Adicional
- Fase de divisão
- O(n)

ANÁLISE DE COMPLEXIDADE

CEFET-MG

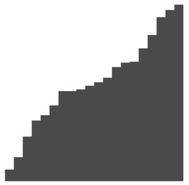
Visualização Merge Sort

Disciplina: Algoritmos e Estruturas de Dados I
Professor: Michel Pires
Curso: Engenharia de Computação
2024/1

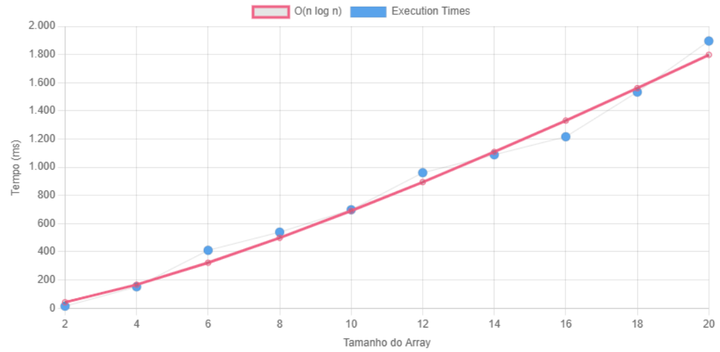
Array size: 20

Number of executions: 10

New Values



Execução	Tamanho do Array	Tempo de Execução (ms)
1	2	14.00
2	4	151.50
3	6	410.40
4	8	539.40
5	10	698.30
6	12	960.90
7	14	1088.30
8	16	1216.30
9	18	1533.10
10	20	1895.50



Desenvolvido por: Maira Lacerda, Maria Eduarda Teixeira e Sergio Henrique
Acesse o trabalho completo

AMBIENTE DE EXECUÇÃO

- Processador: Intel Core i7-1360P (18MB Cache, up to 5.00 GHz)
- Memória: 16GB 4800MHz LPDDR5 Memory Onboard
- Sistema Operacional: Ununtu 24.04 LTS - 64 bits

DADOS DE ENTRADA

- Aleatórios
- Crescentes
- Decrescentes
- Quase crescentes
- Quase decrescentes

MODELOS DE APLICAÇÃO

MODELOS DE APLICAÇÃO

Vantagens do Merge Sort

- Eficiência Assintótica
- Estabilidade
- Adaptação a Diferentes Estruturas de Dados
- Facilidade de Implementação

MODELOS DE APLICAÇÃO

Uso de Memória

Desvantagens do Merge Sort

Desempenho em certos casos

MODELOS DE APLICAÇÃO

EXEMPLOS PRÁTICOS

- Ordenação de Grandes Arquivos de Dados
- Rede de Telecomunicações
- Integração de Dados
- Aplicações em Bioinformática
- Aplicações Web

GENERALIZAÇÃO

1

Custom Sequence

2

Field Based

3

K-Way Merge Sort

4

Parallel Merge Sort

Linguagens Compiladas vs. Interpretadas

Linguagens Compiladas

Simplicidade e eficiência - Gestão precisa da memória através de ponteiros

Baixo nível, orientada objetos e recursos de alto nível - Como utilização do vector, em que o usuário não possui manipulação total

Desenvolvida pela Microsoft, poderosa e com recursos de alto nível - Pode perder desempenho rodando em outros S.O.

Baixo nível, permite manuseamento de memória (qntd. utilizada) - Busca trazer o melhor da linguagem interpretada e compilada. Levando performance e produtividade.

Linguagens Compiladas vs. Interpretadas

Linguagens Interpretadas

Alto nível, JVM que converte os bytecodes em tempo de execução. Acesso a memória restrito pelo usuário.

Roda em qualquer navegador, alta taxa de leitura de dados com a tecnologia assíncrona do Node.js - Utilizando uma thread somente para o processamento de dados da execução, enquanto outras realizam a execução de outras tarefas - Alta complexidade.

Alto nível. Interpretado em just-in-time(JIT).

Alto nível - Apesar da facilidade de implementação como grande ecossistema de bibliotecas, sua execução perde desempenho devido a interpretação em tempo de execução e acesso a memória e manipulação de vetores sem controle do usuário.

Linguagens Compiladas vs. Interpretadas

Porcentagem - RANDOM 1

47%

<

94%

>

50%

>

51,26%

>

89%

>

245%

<

79,4%

>

72%

>

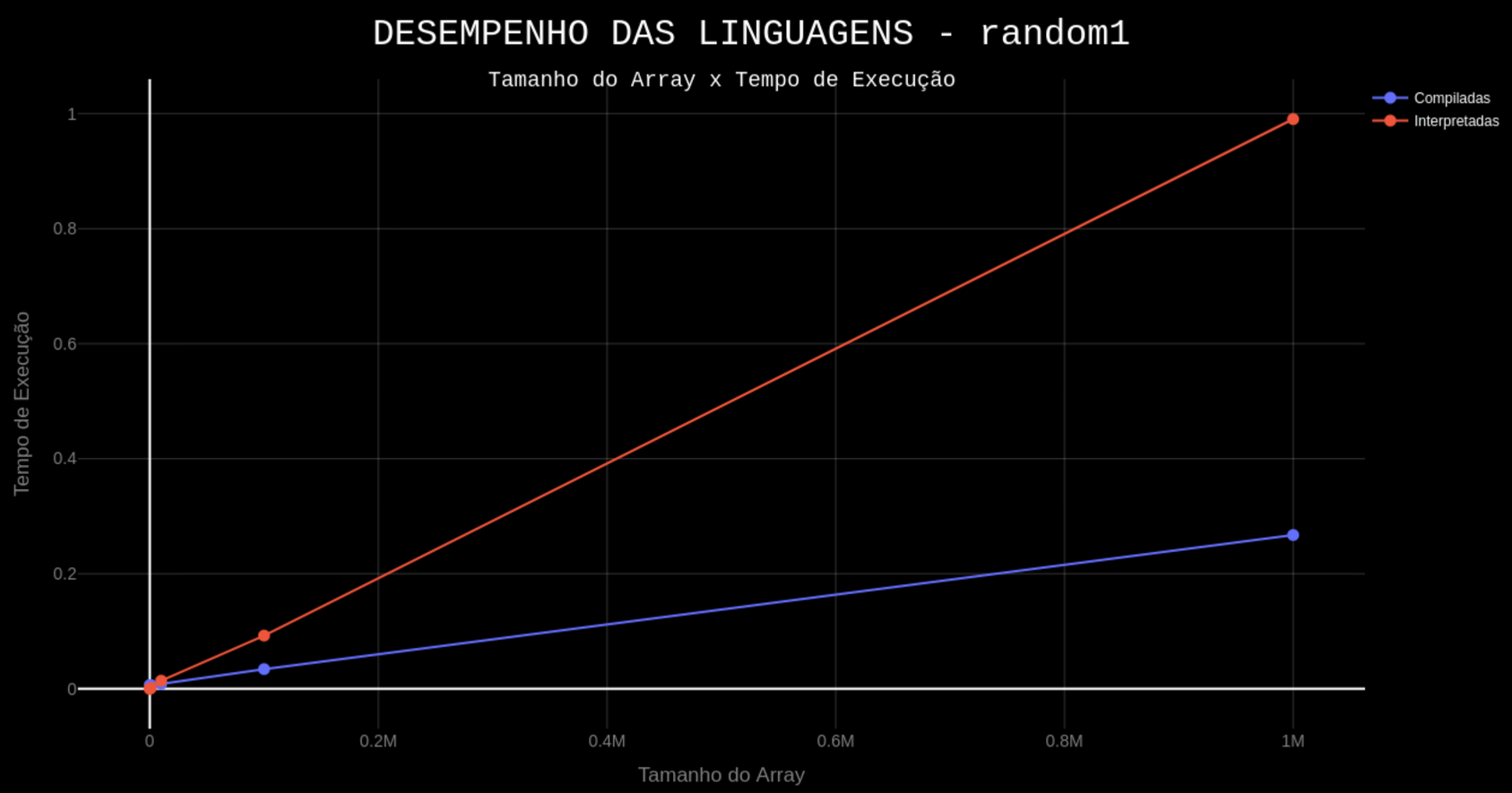
Linguagens Compiladas vs. Interpretadas

Linguagens Compiladas

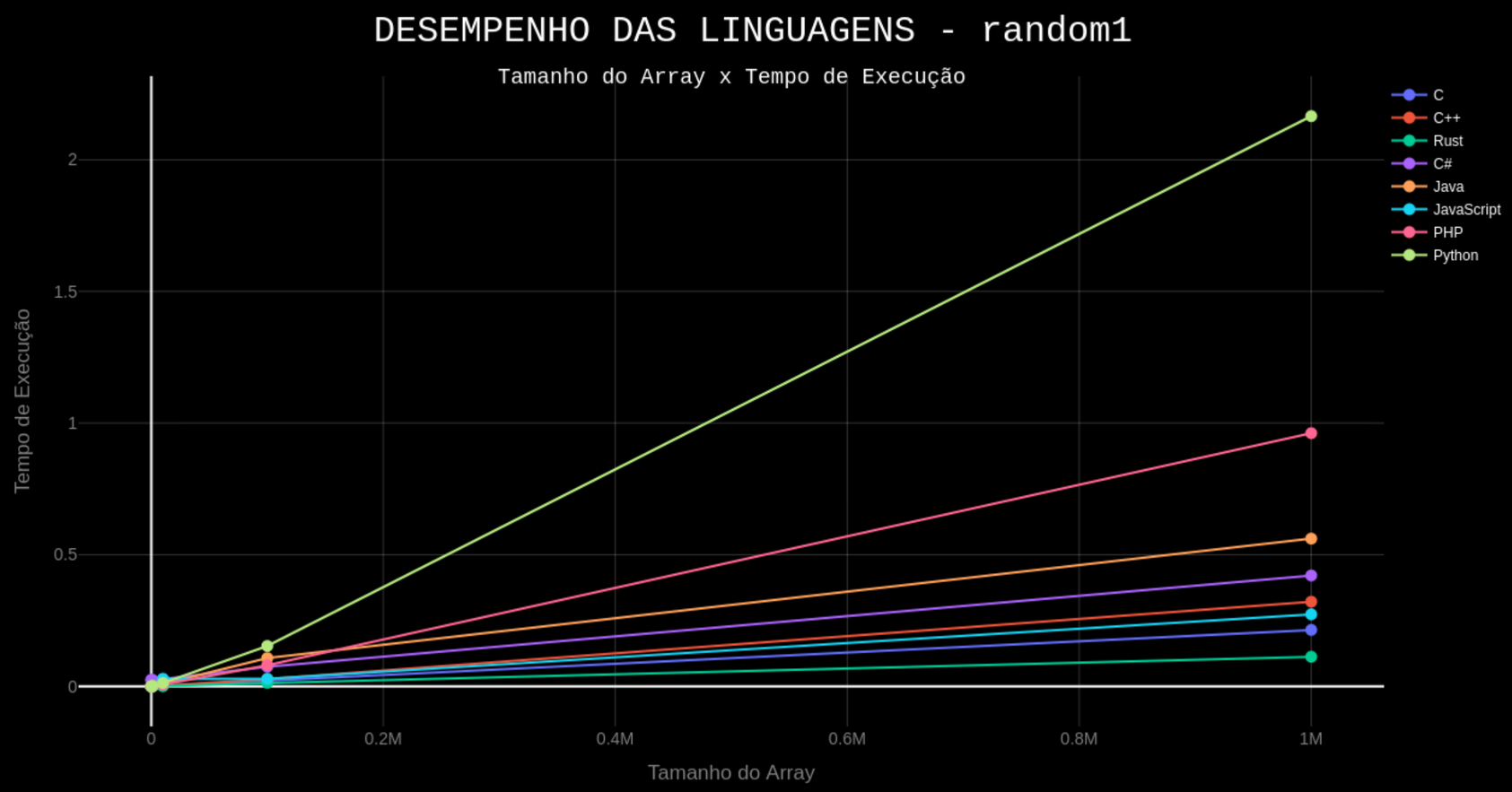
- C
- C++
- C#
- Rust

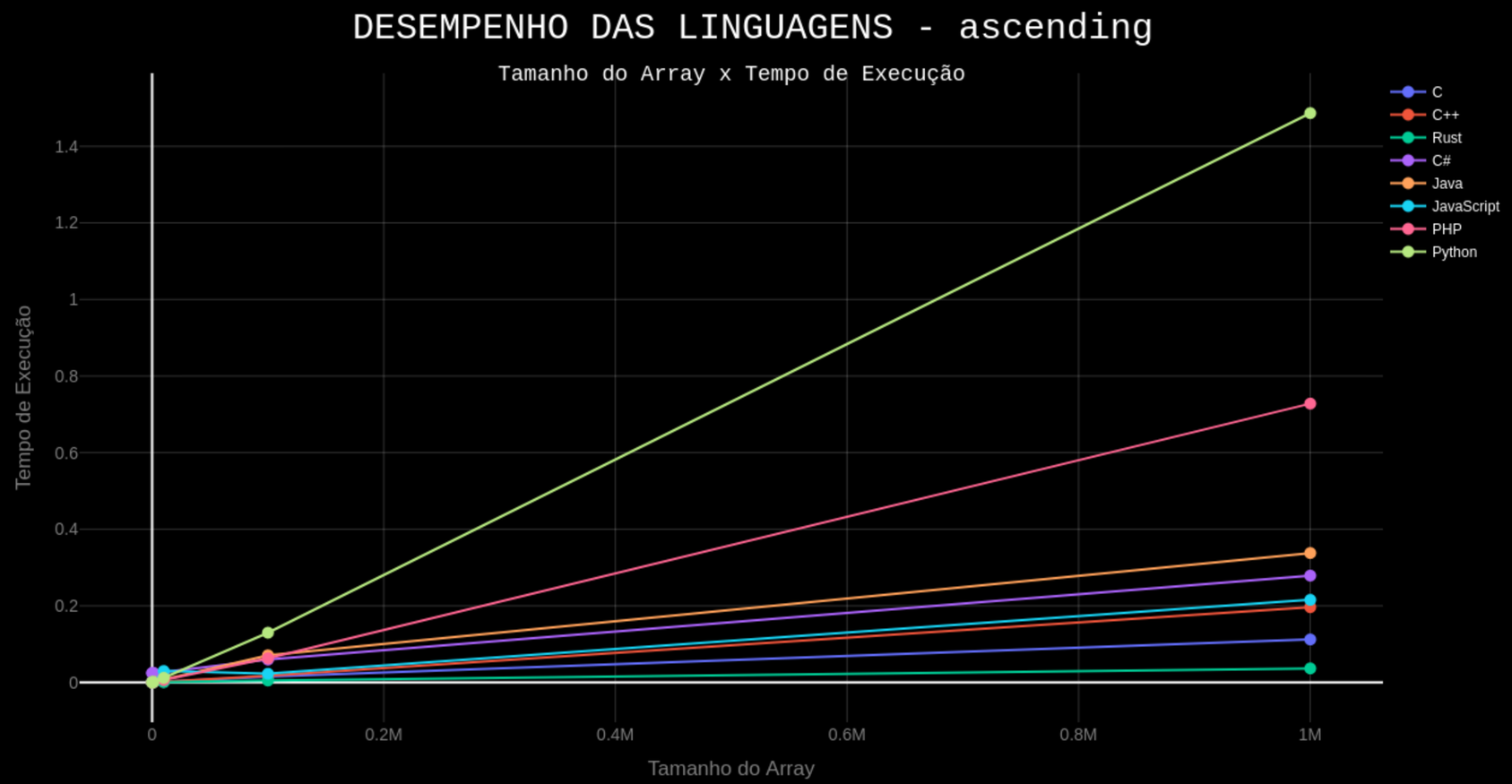
Linguagens Interpretadas

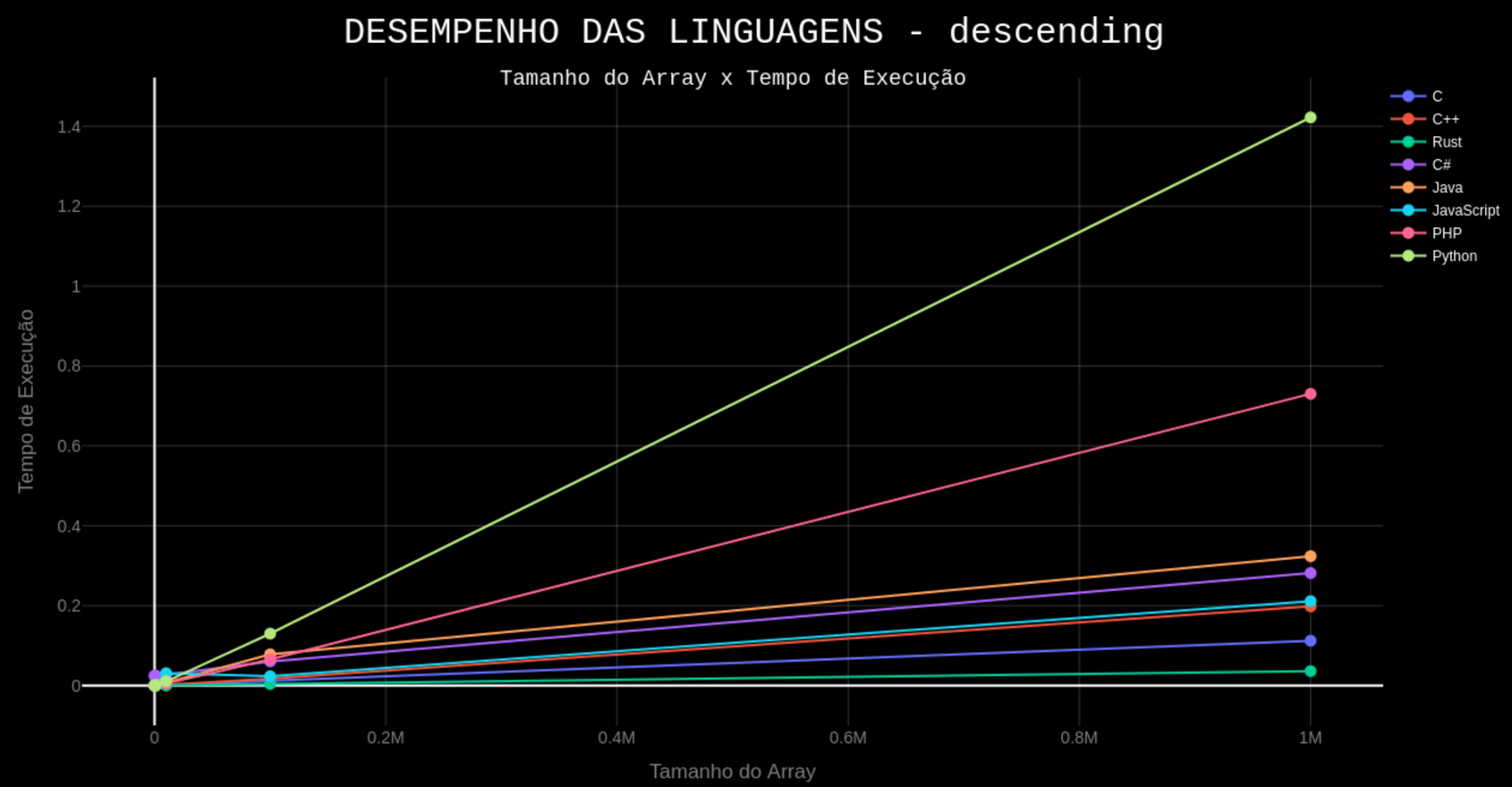
- Java
- Java Script
- PHP
- Python

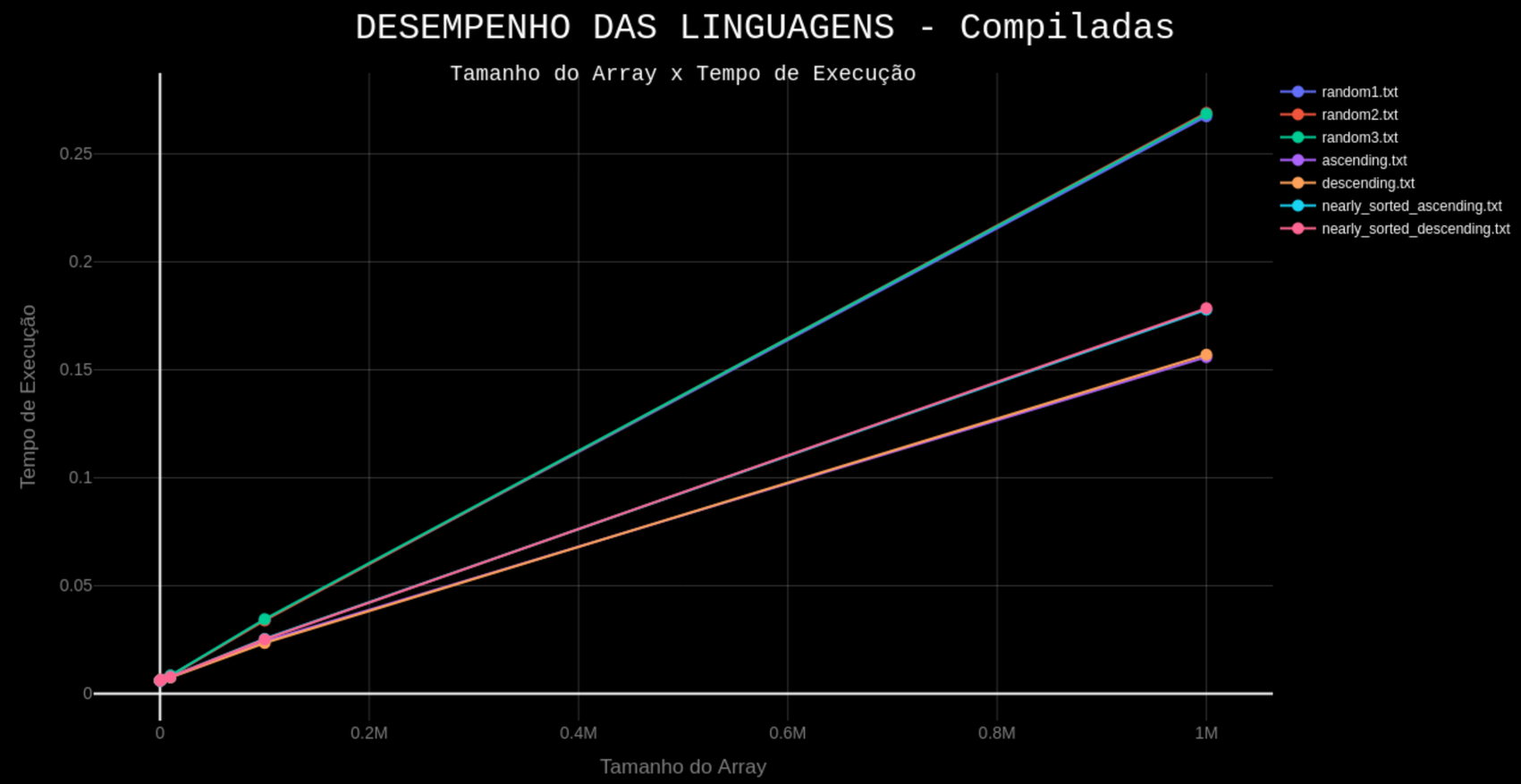


RESULTADOS

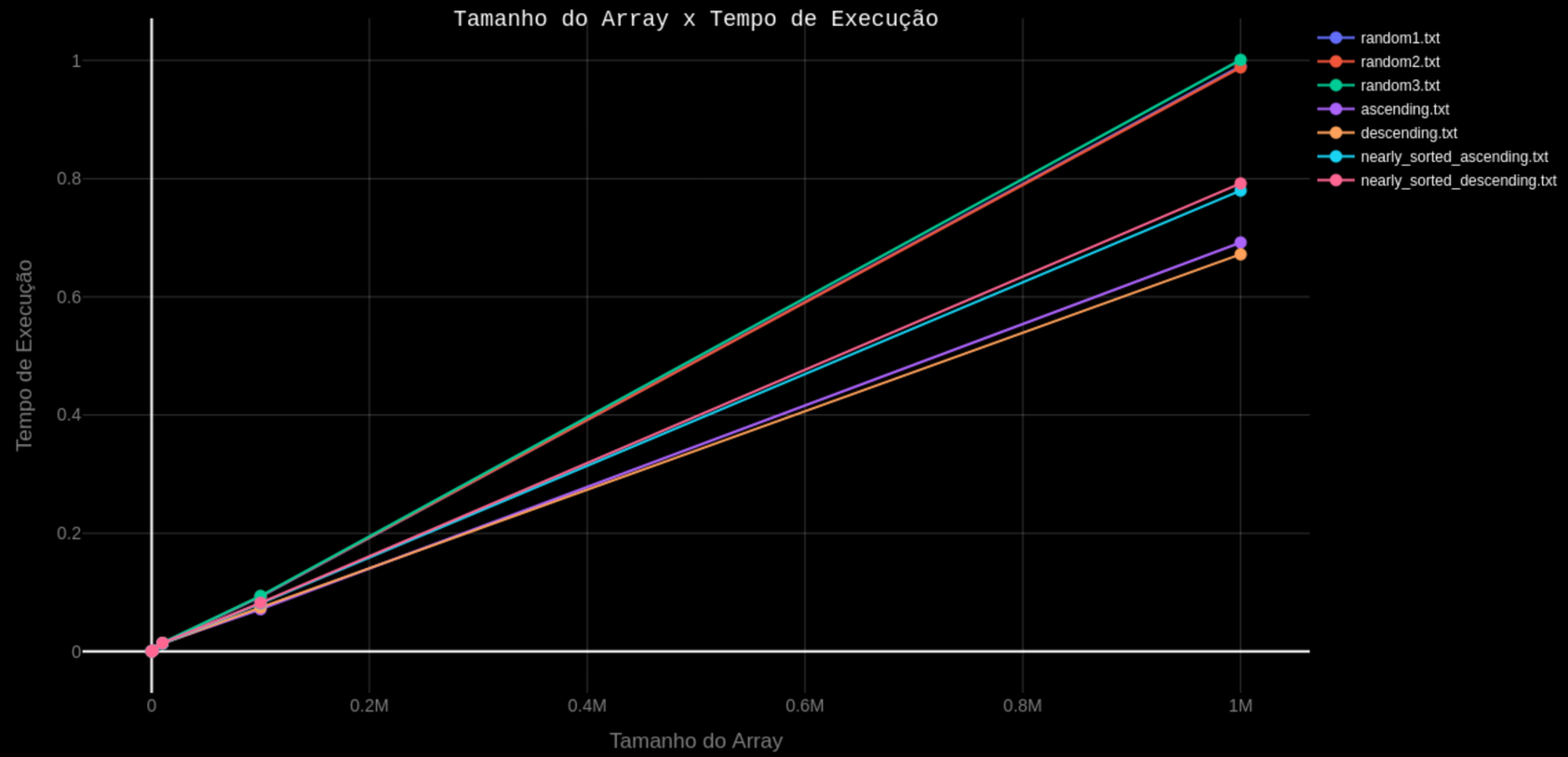

DESEMPENHO DAS LINGUAGENS - random1
Tamanho do Array x Tempo de Execução
Tempo de Execução
Tamanho do Array
0
0.5
1
1.5
2
0
0.2M
0.4M
0.6M
0.8M
1M
C
C++
Rust
C#
Java
JavaScript
PHP
Python


DESEMPENHO DAS LINGUAGENS - ascending
Tamanho do Array x Tempo de Execução
Tempo de Execução
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2M
0.4M
0.6M
0.8M
1M
Tamanho do Array
C
C++
Rust
C#
Java
JavaScript
PHP
Python


DESEMPENHO DAS LINGUAGENS - descending
Tamanho do Array x Tempo de Execução
Tempo de Execução
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2M
0.4M
0.6M
0.8M
1M
Tamanho do Array
C
C++
Rust
C#
Java
JavaScript
PHP
Python


DESEMPENHO DAS LINGUAGENS - Compiladas
Tamanho do Array x Tempo de Execução
Tempo de Execução
0.25
0.2
0.15
0.1
0.05
0
0
0.2M
0.4M
0.6M
0.8M
1M
Tamanho do Array
random1.txt
random2.txt
random3.txt
ascending.txt
descending.txt
nearly_sorted_ascending.txt
nearly_sorted_descending.txt

DESEMPENHO DAS LINGUAGENS - Interpretadas



CONCLUSÃO

- Visão mais aprofundada sobre algoritmos de ordenação e como podem ser implementados em diferentes linguagens
- Diferenças de desempenho entre linguagens e as diferenças que afetam o desempenho
- As generalizações e como elas são usadas para otimizar o desempenho em diferentes cenários

DÚVIDAS

Porque mesmo que o Merge Sort tenha complexidade de tempo O(n log n) no pior, melhor e caso médio, ele apresentou uma pequeníssima diferença de tempo de execução entre os diferentes tipos de arquivos de entrada, como os aleatórios e os já ordenados?

Como as generalizações do Merge Sort podem ser usadas para otimizar o desempenho do algoritmo em diferentes cenários?

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OBRIGADO PELA ATENÇÃO!