Program Structures and Algorithms

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**Task:** The task given to is to solve the 3-SUM problem using three different algorithmic approaches: Quadrithmic, Quadratic with Calipers and Quadratic. We are expected to show the results in table format and in chart form also. The relation between N and time taken T for various approaches will be evident.

**Relationship Conclusion:**

The relationship between N and T (time taken) for each approach depends on the specific algorithm being used:

1. The Cubic approach has a time complexity of O(n^3) which means that as the size of the input (N) increases, the time taken (T) will increase at a rate of N cubed. This means that as N doubles, T will increase by a factor of eight.
2. For the Quadratic approach, the time complexity is O(n^2), meaning that as the size of the input (N) increases, the time taken (T) will increase at a rate of N squared. This means that as N doubles, T will increase by a factor of four.
3. For the Quadratic with Calipers approach, the time complexity is also O(n^2) in the worst-case scenario, but it can be significantly better in practice, especially when the input has a large number of duplicate values.
4. For the Quadrithmic approach, the time complexity is O(n^2\*log(n)), meaning that the time taken increases at a rate of N squared multiplied by log(N).

The performance sequence of the 4 approaches in terms of time complexity is:

Quadratic with Calipers <= Quadratic < Quadrithmic < Cubic

**Evidence to support that conclusion:**

**Below is the chart showing time taken for different approaches for different number of elements in the array(N):**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **N** | **Raw/Normalised** | **Quadratic** | **QuadraticWithCalipers** | **Quadrithmic** | **Cubic** |
| **250** | **Raw** | **0.31** | **0.44** | **0.53** | **2.74** |
|  | **Normalized** | **4.96** | **7.04** | **1.06** | **0.18** |
| **500** | **Raw** | **0.72** | **0.62** | **2.04** | **21.06** |
|  | **Normalized** | **2.88** | **2.48** | **0.91** | **0.17** |
| **1000** | **Raw** | **2.65** | **2.4** | **11.4** | **163.8** |
|  | **Normalized** | **2.65** | **2.4** | **1.14** | **0.16** |
| **2000** | **Raw** | **10.2** | **13** | **60.1** | **1291.7** |
|  | **Normalized** | **2.55** | **3.25** | **1.37** | **0.16** |
| **4000** | **Raw** | **52** | **93.8** | **298** | **10320** |
|  | **Normalized** | **3.25** | **5.86** | **1.56** | **0.16** |
| **8000** | **Raw** | **242.67** | **474.33** | **1501** |  |
|  | **Normalized** | **3.79** | **7.41** | **1.81** |  |
| **16000** | **Raw** | **917** | **1913** | **6167** |  |
|  | **Normalized** | **3.58** | **7.47** | **1.73** |  |

**Graphical Representation:**

**Chart, line chart

Description automatically generated**

**Unit Test Screenshots:**

**Graphical user interface, text

Description automatically generated**