

國立臺南大學資訊工程學系

資工三「演算法」課程
第三次作業

題目：Dictionary

班級：資工三

姓名：謝昊君

學號：S11059006

老師：陳宗禧

中華民國 112 年 12 月 02 日

目錄

(一) 簡介及問題描述.....	1
1. 簡介.....	2
2. 問題.....	4
(二) 理論分析.....	8
(三) 演算法則.....	10
(四) 程式設計環境架構.....	12
(五) 程式.....	14
(六) 執行結果、討論與心得.....	18
參考文獻.....	22

(一) 簡介及問題描述

1. 簡介

利用 Binary Search Tree (BST), Splay Tree (SPT), and Treap 分別建構相對應的 Dictionary，並且利用該 Dictionary 做 Searching 以及其時間分析，包括分析查詢的時間、成功率與失敗率等，並討論 Dictionary size and Searching file size 與執行時間與效率的關係。

2. 問題

Functions:

- i. Build BST, SPT, and Treap with a Text File Input test.txt
 - a. 定義 Token & Words in Dictionary
- ii. Searching with an input test file, part of the Text File test.txt
- iii. Search a word (input from file or keyboard)
- iv. Add a word (input from file or keyboard)
- v. Delete a word (input from file or keyboard)

(二) 理論分析

1. BST

- BST 是一種有序樹結構，每個節點包含一個鍵、一個左指針和一個右指針。左子樹中的所有鍵都小於節點的鍵，右子樹中的所有鍵都大於節點的鍵。
- 插入：從根節點開始，依次與插入值比較，根據大小決定是向左子樹還是右子樹移動，直到找到一個空位插入新節點。
- 搜索：從根節點開始，與目標值比較，根據大小決定是搜索左子樹還是右子樹，直到找到該值或到達空節點。
- 刪除：有三種情況：無子節點（直接刪除）、一個子節點（刪除後用子節點替代）和兩個子節點（找到右子樹的最小節點或左子樹的最大節點替代，然後刪除該節點）。

2. Splay Tree

- Splay Tree 是一種自平衡二元搜尋樹。每次進行操作後，該操作的節點會通過一系列的旋轉操作移動到樹根。
- Splaying：當一個節點被訪問後，透過旋轉將該節點移動至樹根。這通常透過 Zig-Zig、Zig-Zag 和 Zig 操作來完成。
- 搜索、插入和刪除：與 BST 類似，但在操作完成後，進行 splaying 將操作節點或最近訪問的節點移至樹根。

3. Treap

- Treap 結合了二元搜尋樹和最小（或最大）堆的特性。每個節點包含一個鍵和一個優先級。樹根據鍵來排序，而堆則根據優先級來維護。
- 插入：首先按 BST 規則插入節點，然後使用旋轉操作按堆的規則調整樹，使節點的優先級符合堆性質。
- 搜索：與 BST 相同。
- 刪除：首先找到要刪除的節點，然後通過旋轉將其移至樹葉，最後刪除。

(三) 演算法則

1. 第一個演算法(Algorithm) : BST

- i. 演算法時間複雜度(time complexity)
 - 1. 搜索、插入、刪除：在平均情況下為 $O(\log n)$ ，但在最壞情況（樹變成線性結構）下為 $O(n)$ 。
- ii. 演算法空間複雜度(space complexity)
 - 1. $O(n)$ 。這是因為每個節點都需要固定的空間來儲存其值和指針。

2. 第二個演算法(Algorithm) : SPT

- i. 演算法時間複雜度(time complexity)
 - 1. 搜索、插入、刪除：平均時間複雜度為 $O(\log n)$ ，但具有自我調整特性，可能在某些使用情況下有更好的效能。
- ii. 演算法空間複雜度(space complexity)
 - 1. $O(n)$ 。雖然 Splay Tree 在操作過程中會進行節點的旋轉，但這並不會增加額外的空間需求。

3. 第三個演算法(Algorithm) : Treap

- i. 演算法時間複雜度(time complexity)
 - 1. 搜索、插入、刪除：平均時間複雜度為 $O(\log n)$ 。
- ii. 演算法空間複雜度(space complexity)
 - 1. $O(n)$ 。儘管每個節點包含額外的優先級信息，但這仍然是每個節點固定的空間需求的一部分，不會隨著節點數量的增加而增加。

每個結構都需要為每個節點分配一定的空間來儲存數據和指針，這個需求隨著節點數量的增加而線性增加，所以這三種資料結構在空間複雜度方面都是 $O(n)$ 。

(四) 程式設計環境架構

程式設計語言、工具、環境與電腦硬體等規格說明...

1. 程式語言

C++ in MS Windows

2. 程式開發工具

Visual C++ 2022

3. 電腦硬體

CPU: AMD R7

Main Memory: 16GB

(五) 程式 (含 source code, input code, and output code)

1. 主程式

```
1. #include <iostream>
2. #include <fstream>
3. #include <sstream>
4. #include <string>
5. #include<chrono>
6. using namespace std;
7.
8.
9. struct BSTNode {
10.     string key;
11.     BSTNode* left, * right;
12.     BSTNode(string x) : key(x), left(nullptr), right(nullptr) {}
13. };
14. struct SPTNode {
15.     string key;
16.     SPTNode* left, * right, * parent;
17.     SPTNode(string key) : key(key), left(nullptr), right(nullptr),
18.     parent(nullptr) {}
19. };
20. struct TreapNode {
21.     int priority;
22.     string key;
23.     TreapNode* left, * right;
24.     TreapNode(string key) : key(key), priority(rand()), left(nullptr),
25.     right(nullptr) {}
26. };
27. enum Tree {
28.     BST_enum,
29.     SPT_enum,
30.     Treap_enum,
31.     Total
32. };
33. static bool IsSuccess = 0;
34.
35. double avgSearchTime[3] ;
36.
37. class BSTTree {
38. public:
39.
40.     BSTTree() : root(nullptr) {}
41.
42.     void insert(string key) {
43.         IsSuccess = 0;
44.         root = insert(root, key);
45.     }
46.
47.     void deleteKey(string key) {
48.         IsSuccess = 0;
49.         root = deletE(root, key);
50.     }
```

```

51.
52.     bool contains(string key) {
53.         auto start = std::chrono::high_resolution_clock::now();
54.
55.         bool boolean = search(root, key);
56.
57.         auto end = std::chrono::high_resolution_clock::now();
58.         auto duration =
59.             std::chrono::duration_cast<std::chrono::microseconds>(end - start);
60.         cout << "Running time of search is " << duration.count() << "
61.             microseconds." ;
62.         avgSearchTime[BST_enum] += static_cast<double>(duration.count());
63.         return boolean;
64.     }
65. private:
66.     BSTNode* root;
67.     BSTNode* findMin(BSTNode* node) {
68.         while (node->left != nullptr) {
69.             node = node->left;
70.         }
71.         return node;
72.     }
73.     BSTNode* search(BSTNode* root, string target) {
74.
75.         if (root == nullptr || root->key == target) {
76.             return root;
77.         }
78.         if (target < root->key) {
79.             return search(root->left, target);
80.         }
81.
82.
83.         return search(root->right, target);
84.
85.     }
86.     BSTNode* insert(BSTNode* root, string value) {
87.         if (root == nullptr) {
88.             IsSuccess = 1;
89.             return new BSTNode(value);
90.
91.         }
92.
93.         if (value < root->key) {
94.             root->left = insert(root->left, value);
95.         }
96.         else if (value > root->key) {
97.             root->right = insert(root->right, value);
98.         }
99.         return root;
100.
101.     }
102.     BSTNode* deletE(BSTNode* root, string target) {
103.         if (root == nullptr) {
104.             // 如果樹為空，直接返回
105.             return root;
106.         }
107.
108.         if (target < root->key) {

```



```

109.         root->left = deletE(root->left, target);
110.     }
111.     else if (target > root->key) {
112.         root->right = deletE(root->right, target);
113.     }
114.     else {
115.         // 找到了要刪除的節點
116.
117.         // case 1: 無子節點或只有一個子節點
118.         if (root->left == nullptr) {
119.             BSTNode* temp = root->right;
120.             delete root;
121.             IsSuccess = 1;
122.             return temp;
123.         }
124.         else if (root->right == nullptr) {
125.             BSTNode* temp = root->left;
126.             delete root;
127.             IsSuccess = 1;
128.             return temp;
129.         }
130.
131.         // case 2: 有兩個子節點
132.         // 尋找右子樹中的最小節點 (或左子樹中的最大節點)
133.         BSTNode* temp = findMin(root->right);
134.
135.         // 複製最小節點的數據到當前節點
136.         root->key = temp->key;
137.
138.         // 刪除右子樹中的最小節點
139.         root->right = deletE(root->right, temp->key); //需用 return 連接待
刪除下的 node
140.
141.     }
142.     return root;
143. };
144. };
145. };
146. class SplayTree {
147. public:
148.     SplayTree() : root(nullptr) {}
149.     void insert(string key) {
150.         IsSuccess = 0;
151.         SPTNode* node = new SPTNode(key);
152.         this->root = insertRec(this->root, node);
153.         splay(node);
154.     }
155.     void deleteKey(string key) {
156.         IsSuccess = 0;
157.         root = deleteNode(root, key);
158.     }
159.     SPTNode* contains(string key) {
160.         auto start = std::chrono::high_resolution_clock::now();
161.
162.         SPTNode* result = searchRec(root, key);
163.         if (result != nullptr) {
164.             splay(result);
165.         }
166.         auto end = std::chrono::high_resolution_clock::now();
167.

```

```

168.         auto duration =
std::chrono::duration_cast<std::chrono::microseconds>(end - start);
169.         cout << "Running time of search is " << duration.count() << "
microseconds." ;
170.         avgSearchTime[SPT_enum] += static_cast<double>(duration.count());
171.
172.         return result;
173.     }
174.
175.     void inorder(SPTNode* root) {
176.         if (root != nullptr) {
177.             inorder(root->left);
178.             std::cout << root->key << " ";
179.             inorder(root->right);
180.         }
181.     }
182.
183. private:
184.     SPTNode* root;
185.
186.     void rightRotate(SPTNode* x) {
187.         SPTNode* y = x->left;
188.         x->left = y->right;
189.         if (y->right != nullptr) {
190.             y->right->parent = x;
191.         }
192.         y->parent = x->parent;
193.         if (x->parent == nullptr) {
194.             this->root = y;
195.         }
196.         else if (x == x->parent->right) {
197.             x->parent->right = y;
198.         }
199.         else {
200.             x->parent->left = y;
201.         }
202.         y->right = x;
203.         x->parent = y;
204.     }
205.     void leftRotate(SPTNode* x) {
206.         SPTNode* y = x->right;
207.         x->right = y->left;
208.         if (y->left != nullptr) {
209.             y->left->parent = x;
210.         }
211.         y->parent = x->parent;
212.         if (x->parent == nullptr) {
213.             this->root = y;
214.         }
215.         else if (x == x->parent->left) {
216.             x->parent->left = y;
217.         }
218.         else {
219.             x->parent->right = y;
220.         }
221.         y->left = x;
222.         x->parent = y;
223.     }
224.     void splay(SPTNode* x) {
225.         while (x->parent != nullptr) {

```

```

226.         if (x->parent->parent == nullptr) {
227.             if (x->parent->left == x) {
228.                 rightRotate(x->parent);
229.             }
230.             else {
231.                 leftRotate(x->parent);
232.             }
233.         }
234.         else if (x->parent->left == x && x->parent->parent->left == x-
>parent) {
235.             rightRotate(x->parent->parent);
236.             rightRotate(x->parent);
237.         }
238.         else if (x->parent->right == x && x->parent->parent->right == x-
>parent) {
239.             leftRotate(x->parent->parent);
240.             leftRotate(x->parent);
241.         }
242.         else if (x->parent->left == x && x->parent->parent->right == x-
>parent) {
243.             rightRotate(x->parent);
244.             leftRotate(x->parent);
245.         }
246.         else {
247.             leftRotate(x->parent);
248.             rightRotate(x->parent);
249.         }
250.     }
251. }
252. SPTNode* searchRec(SPTNode* root, string key) {
253.     if (root == nullptr || root->key == key) {
254.         return root;
255.     }
256.
257.     if (root->key > key) {
258.         return searchRec(root->left, key);
259.     }
260.     else {
261.         return searchRec(root->right, key);
262.     }
263. }
264. SPTNode* insertRec(SPTNode* root, SPTNode* node) {
265.     if (root == nullptr) {
266.         IsSuccess = 1;
267.
268.         return node;
269.     }
270.     if (node->key < root->key) {
271.         root->left = insertRec(root->left, node);
272.         root->left->parent = root;
273.     }
274.     else if (node->key > root->key) {
275.         root->right = insertRec(root->right, node);
276.         root->right->parent = root;
277.     }
278.
279.     return root;
280. }
281. }
282. SPTNode* deleteNode(SPTNode* root, string key) {

```

```

283.     if (root == nullptr) return root;
284.     // 將要刪除的節點 splay 到根部
285.     root = searchRec(root, key);
286.     if (root == nullptr) return nullptr; // 如果沒有找到，直接返回
287.
288.     splay(root);
289.
290.     if (root->left == nullptr) {
291.         // 如果沒有左子樹，直接用右子樹替換
292.         SPTNode* temp = root;
293.         root = root->right;
294.         delete temp;
295.     }
296.     else {
297.         SPTNode* temp = root;
298.         // 將左子樹的最大節點 splay 到根部
299.         SPTNode* leftMax = root->left;
300.         while (leftMax->right != nullptr) leftMax = leftMax->right;
301.
302.         splay(leftMax);
303.         leftMax->right = temp->right;
304.         if (temp->right != nullptr) temp->right->parent = leftMax;
305.
306.         root = leftMax;
307.         delete temp;
308.     }
309.
310.     if (root != nullptr) root->parent = nullptr;
311.
312.     IsSuccess = 1;
313.     return root;
314.
315. }
316. };
317. };
318. class TreapTree {
319. public:
320.     TreapTree() : root(nullptr) {}
321.
322.     void insert(string key) {
323.         IsSuccess = 0;
324.         root = insert(root, key);
325.     }
326.
327.     void deleteKey(string key) {
328.         IsSuccess = 0;
329.         root = deleteNode(root, key);
330.     }
331.
332.     bool contains(string key) {
333.         auto start = std::chrono::high_resolution_clock::now();
334.
335.         bool boolean = search(root, key);
336.
337.         auto end = std::chrono::high_resolution_clock::now();
338.         auto duration =
339.             std::chrono::duration_cast<std::chrono::microseconds>(end - start);
340.         cout << "Running time of search is " << duration.count() << "
341.             microseconds." ;
342.         avgSearchTime[Treap_enum] += static_cast<double>(duration.count());

```

```

341.
342.     return boolean;
343. }
344. private:
345.     TreapNode* root;
346.
347.     TreapNode* rotateLeft(TreapNode* root) {
348.         TreapNode* R = root->right;
349.         root->right = R->left;
350.         R->left = root;
351.         return R;
352.     }
353.
354.     TreapNode* rotateRight(TreapNode* root) {
355.         TreapNode* L = root->left;
356.         root->left = L->right;
357.         L->right = root;
358.         return L;
359.     }
360.
361.     TreapNode* insert(TreapNode* node, string key) {
362.         if (node == nullptr) {
363.             IsSuccess = 1;
364.             return new TreapNode(key);
365.         }
366.
367.         if (key < node->key) {
368.             node->left = insert(node->left, key);
369.             if (node->left->priority > node->priority)
370.                 node = rotateRight(node);
371.         }
372.         else if (key > node->key) {
373.             node->right = insert(node->right, key);
374.             if (node->right->priority > node->priority)
375.                 node = rotateLeft(node);
376.         }
377.         return node;
378.     }
379. }
380.
381.     TreapNode* deleteNode(TreapNode* root, string key) {
382.         if (root == nullptr)
383.             return root;
384.
385.         if (key < root->key)
386.             root->left = deleteNode(root->left, key);
387.         else if (key > root->key)
388.             root->right = deleteNode(root->right, key);
389.         else {
390.             if (root->left == nullptr) {
391.                 TreapNode* temp = root->right;
392.                 delete root;
393.                 IsSuccess = 1;
394.                 return temp;
395.             }
396.             else if (root->right == nullptr) {
397.                 TreapNode* temp = root->left;
398.                 delete root;
399.                 IsSuccess = 1;
400.                 return temp;

```

```

401.         }
402.
403.         if (root->left->priority < root->right->priority)
404.             root = rotateLeft(root);
405.         else
406.             root = rotateRight(root);
407.
408.         root = deleteNode(root, key);
409.     }
410.     return root;
411. }
412.
413. bool search(TreapNode* root, string key) {
414.     if (root == nullptr)
415.         return false;
416.     if (root->key == key)
417.         return true;
418.     if (key < root->key)
419.         return search(root->left, key);
420.     return search(root->right, key);
421. }
422. };
423.
424. int main(void) {
425.
426.     BSTTree BSTtree;
427.     SplayTree SPTtree;
428.     TreapTree Treaptree;
429.     int accuracyCount[4] = { 0 };
430.
431.     int sourceText, testText;
432.     while (1) {
433.         cout << "Select No. of TestFile.txt to be tested (1: TestFile1.txt,
434.         2: TestFile2.txt, others: leave) > ";
435.         cin >> sourceText;
436.         if (sourceText != 1 && sourceText != 2)break;
437.
438.         ifstream inputFile(L"TestFile" + to_wstring(sourceText) + L".txt");
439.         if (!inputFile.is_open()) {
440.             std::cerr << "Cannot open file" << std::endl;
441.             return 1;
442.         }
443.
444.         //Construct 3 trees in three type with TestFile.txt
445.         string word;
446.         int wordCount = 0;
447.         while (inputFile >> word) {
448.             // keep alpha and lower case
449.             string cleanedWord;
450.             for (char c : word) {
451.                 if (isalpha(c)) {
452.                     cleanedWord += tolower(c);
453.                 }
454.             }
455.             //cout << cleanedWord<<" ";
456.             if (!cleanedWord.empty()) {
457.                 BSTtree.insert(cleanedWord);
458.                 SPTtree.insert(cleanedWord);
459.

```

```

460.         Treaptree.insert(cleanedWord);
461.         wordCount++;
462.     }
463. }
464. inputFile.close();
465.
466. cout << "wordCount: " << wordCount << endl;
467.
468. int testMethod = 0;
469. cout << "Select a method to Test (0: txt, 1: manual, others: leave)
    > ";
470. cin >> testMethod;
471. //Test by txt for TestFile.txt
472. if (testMethod == 0) {
473.     while (1) {
474.         cout << "Enter No. of TestFile.txt to test(1, 2, 3, others
            to leave)> ";
475.         cin >> testText;
476.         if (testText != 1 && testText != 2 && testText != 3)exit(0);
477.         ifstream inputFileTest(L"TestFile" + to_wstring(sourceText)
            + to_wstring(testText) + L".txt");
478.         if (!inputFileTest.is_open()) {
479.             std::cerr << "Cannot open file" << std::endl;
480.             return 1;
481.         }
482.
483.         cout << "TestFile" << to_string(sourceText) << ".txt tested
            by TestFile" << to_string(sourceText) << to_string(testText) << ".txt :> <<
            endl;
484.         while (inputFileTest >> word) {
485.             string cleanedTarget;
486.             for (char c : word) {
487.                 if (isalpha(c)) {
488.                     cleanedTarget += tolower(c);
489.                 }
490.             }
491.             if (!cleanedTarget.empty()) {
492.                 cout << "Try to find \"" << cleanedTarget << "\" in
                    three ways" << endl;
493.                 if (BSTtree.contains(cleanedTarget)) { cout << " BST:
                    successful" << endl; accuracyCount[BST_enum]++; }
494.                 else cout << " BST: unsuccessful" << endl;
495.                 if (SPTtree.contains(cleanedTarget)) { cout << " SPT:
                    successful" << endl; accuracyCount[SPT_enum]++; }
496.                 else cout << " SPT: unsuccessful" << endl;
497.                 if (Treaptree.contains(cleanedTarget)) { cout << "
                    Treap: successful" << endl; accuracyCount[Treap_enum]++; }
498.                 else cout << " Treap: unsuccessful" << endl;
499.                 accuracyCount[Total]++;
500.
501.                 cout << "-----" << endl;
502.             }
503.         }
504.     }
505.     inputFileTest.close();
506.     cout << "Accuracy of BST is " << accuracyCount[BST_enum] /
        (double)accuracyCount[Total] * 100 << "%" << endl;
507.     cout << "Accuracy of SPT is " << accuracyCount[SPT_enum] /
        (double)accuracyCount[Total] * 100 << "%" << endl;

```

```

508.         cout << "Accuracy of Treap is " << accuracyCount[Treap_enum]
/ (double)accuracyCount[Total] * 100 << "%" << endl;
509.
510.         cout << "-----" << endl;
511.
512.         cout << "The Average Searching Time of BST is "<<
avgSearchTime[BST_enum] / (double)accuracyCount[Total] << endl;
513.         cout << "The Average Searching Time of SPT is " <<
avgSearchTime[SPT_enum] / (double)accuracyCount[Total] << endl;
514.         cout << "The Average Searching Time of Treap is " <<
avgSearchTime[Treap_enum] / (double)accuracyCount[Total] << endl;
515.         cout << "searchCount: " << accuracyCount[Total] << endl;
516.         for (int i = 0; i < 3; ++i) avgSearchTime[i] = 0;
517.         for (int i = 0; i < 4; ++i) accuracyCount[i] = 0;
518.         cout << "-----" << endl;
519.
520.     }
521.
522. }
523. //Test manually for TestFile.txt
524. else if (testMethod == 1) {
525.
526.     while (1) {
527.
528.         int manageMethod = 0;
529.         cout << "Select a method to manage the tree(0: Find, 1:
Delete, 2: Insert, others: leave)> ";
530.         cin >> manageMethod;
531.         if (manageMethod != 0 && manageMethod != 1 &&
manageMethod != 2)exit(0);
532.         string target, word = "";
533.
534.         cin.ignore(numeric_limits<streamsize>::max(), '\n'); // 清除
换行符之前的任何内容
535.         cout << "Enter a string to test> ";
536.         getline(cin, target);
537.         /*string target = "Added to the mixture has been Terry";*/
538.
539.         istringstream iss(target);
540.         while (iss >> word) {
541.             string cleanedTarget;
542.             for (char c : word) {
543.                 if (isalpha(c)) {
544.                     cleanedTarget += tolower(c);
545.                 }
546.             }
547.
548.             if (!cleanedTarget.empty()) {
549.                 cout << "Try to manipulate \"" << cleanedTarget <<
"\" << endl;
550.                 switch (manageMethod) {
551.                     case 0:
552.                         if (BSTtree.contains(cleanedTarget)) { cout << "
BST: successful" << endl; accuracyCount[BST_enum]++; }
553.                         else cout << " BST: unsuccessful" << endl;
554.                         if (SPTtree.contains(cleanedTarget)) { cout << "
SPT: successful" << endl; accuracyCount[SPT_enum]++; }
555.                         else cout << " SPT: unsuccessful" << endl;
556.                         if (Treaptree.contains(cleanedTarget)) { cout << "
Treap: successful" << endl; accuracyCount[Treap_enum]++; }

```



```

557.         else cout << " Treap: unsuccessful" << endl;
558.
559.
560.         accuracyCount[Total]++;
561.         break;
562.
563.         case 1:
564.             BSTtree.deleteKey(cleanedTarget);
565.             cout << " BST: Delete" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
566.             SPTtree.deleteKey(cleanedTarget);
567.             cout << " SPT: Delete" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
568.             Treaptree.deleteKey(cleanedTarget);
569.             cout << " Treap: Delete" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
570.             break;
571.
572.         case 2:
573.             BSTtree.insert(cleanedTarget);
574.             cout << " BST: Insert" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
575.             SPTtree.insert(cleanedTarget);
576.             cout << " SPT: Insert" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
577.             Treaptree.insert(cleanedTarget);
578.             cout << " Treap: Insert" << ((IsSuccess) ? "
successfully" : " unsuccessfully") << endl;
579.             break;
580.
581.         default:
582.             exit(0);
583.     }
584.
585.     cout << "-----" << endl;
586.
587. }
588.
589.
590. }
591.     if (manageMethod == 0) {
592.         cout << "Accuracy of BST is " << accuracyCount[BST_enum]
/ (double)accuracyCount[Total] * 100 << "%" << endl;
593.         cout << "Accuracy of SPT is " << accuracyCount[SPT_enum]
/ (double)accuracyCount[Total] * 100 << "%" << endl;
594.         cout << "Accuracy of Treap is " <<
accuracyCount[Treap_enum] / (double)accuracyCount[Total] * 100 << "%" <<
endl;
595.         cout << "-----" << endl;
596.
597.         cout << "The Average Searching Time of BST is " <<
avgSearchTime[BST_enum] / (double)accuracyCount[Total] << endl;
598.         cout << "The Average Searching Time of SPT is " <<
avgSearchTime[SPT_enum] / (double)accuracyCount[Total] << endl;
599.         cout << "The Average Searching Time of Treap is " <<
avgSearchTime[Treap_enum] / (double)accuracyCount[Total] << endl;
600.         for (int i = 0; i < 3; ++i) avgSearchTime[i] = 0;
601.         for (int i = 0; i < 4; ++i) accuracyCount[i] = 0;
602.
603.     }

```

```

604.
605.         cout << "-----" << endl;
606.     }
607.
608.
609.     }
610.     //leave
611.     else {
612.         break;
613.
614.     }
615. }
616. system("pause");
617. return 0;
618. }

```

TestFile1:

TAIPEI: Talks between Taiwan's two main opposition parties on forming a joint presidential bid teetered on collapse on Thursday (Nov 23) after a dramatic showdown broadcast live on television in which party leaders bickered and revealed sensitive private conversations.

The dramatic scenes came less than a day before the opposition has to register its presidential candidates with the election commission ahead of the Jan 13 polls, which are happening as China steps up its military pressure to try and force the island to accept Beijing's sovereignty claims.

The opposition Kuomintang (KMT) and much smaller Taiwan People's Party (TPP), both campaigning to forge better ties with China, had previously agreed to work together against the ruling Democratic Progressive Party (DPP) but had made no progress on plans for a united presidential ticket.

Added to the mixture has been Terry Gou, the billionaire founder of major Apple supplier Foxconn who is standing as an independent but has also not registered his candidacy and had this week been trying to bring the KMT and TPP together.

Gou on Thursday invited the KMT's presidential candidate Hou Yu-ih and TPP's candidate Ko Wen-je to meet at a Taipei luxury hotel to bash out their differences. Hou initially refused to go, but then turned up with KMT Chairman Eric Chu and former president Ma Ying-jeou, a senior KMT member, in tow.

The five then gathered in a conference room where they had invited reporters and proceeded to argue and reveal previously confidential conversations in public in

footage shown live on Taiwanese television stations.

In one of the most dramatic moments, Hou read out a private text message from Ko in which Ko said Gou needed to "find a reason" to drop out of the presidential race.

Ko sat stony-faced as Hou continued to read out other messages, and when finally given the chance to respond said that reading out private messages was not something presidential candidates do.

After more than an hour of talks and further arguments, the KMT team walked out.

But the party subsequently said talks had not broken down.

KMT spokesperson Yang Chih-yu told reporters that despite senior party leaders being "greatly humiliated in public" during the meeting, the KMT will continue to work hard to make the joint ticket happen.

"The KMT will not give up until the last moment," she said.

Following that press conference, the TPP announced that Ko would register his candidacy to be president with the election commission on Friday morning, along with a running mate the party did not identify.

Gou, who stepped down as chairman of iPhone maker Foxconn in 2019, did not answer reporter questions as he left the room and it remains unclear if he will register for president on Friday.

The DPP, meanwhile, has been powering ahead in its campaign having registered its presidential ticket on Tuesday - current Vice President Lai Ching-te who is leading the polls, and his running mate Hsiao Bi-khim, previously Taiwan's high-profile de facto ambassador to the United States.

Hsiao, speaking to international media earlier on Thursday, discussed the sanctions China has placed on her - Beijing believes both she and Lai are dangerous

separatists - and the importance of dialogue.

"It's also important that the international community, who also agrees with our position in continuing peace and stability in the Taiwan Strait, make clear to our counterparts across the Taiwan Strait that dialogue is the only way to resolve differences. War is not an option," she said.

TestFile11:

In one of the most dramatic moments, Hou read out a private text message from Ko in which Ko said Gou needed to "find a reason" to drop out of the presidential race.

TestFile12:

opposition opposition opposition opposition opposition opposition
opposition opposition opposition opposition presidential presidential presidential
presidential presidential presidential presidential

TestFile13:

The DPP, meanwhile, has been powering ahead in its campaign having registered its presidential ticket on Tuesday - currentt Vicet President Lai Ching-te who is leading the polls, and hist running mate Hsiao Bi-khimt, previously Taiwan's high-profilet de factot ambassador to the Unitedt States.

Hsiaot, speaking to international media earliert on Thursday, discussedt the sanctions China has placed on her - Beijingt believes both she and Lai are dangerous separatists - and the importance of dialogue.

TestFile2:

SINGAPORE: Tai Tzu Ying cemented her status as the world's top female shuttler as she beat reigning Olympic

champion and world number two Carolina Marin in straight games at the Singapore Open on Sunday (Apr 16).

World number one Tai took just 38 minutes to seal a clinical 21-15, 21-15 victory at the Singapore Indoor

Stadium.

It was Tai's fifth consecutive Super Series title and her second victory over Marin in

less than two weeks, having

already triumphed at the Malaysian Open final.

The usually unflappable Marin had no answers to Tai's excellent defensive work and quick smashes as the

diminutive 22-year-old edged ahead at 13-10 and eventually took the first game.

The Spaniard still failed to find her rhythm in the second, as a composed Tai dictated the pace and saw out the

game comfortably.

Tai said she was pleased with her performance but unfazed by her Super Series streak.

"I know I wouldn't be able to beat Marin easily, so I was very patient when playing with her. I felt that I played

quite well today," she told reporters.

"I think everyone around me is more concerned about these five titles. But for me, I just want to play well in

every tournament."

It was Tai's first title in the city-state and she did not drop a game all tournament.

In the men's singles title, India's B. Sai Praneeth beat compatriot Srikanth Kidambi 17-21, 21-17, 21-12 for the

first Super Series title of his career.

Praneeth, the world number 30, said he was pegged back by a slow start but refused to give up. "When I got my

strokes going good and I got some rhythm, I thought 'OK, the game is still on.'"

"This is the best feeling: I had been waiting for a long, long time," he added.

In the opening mixed doubles match, China's Lu Kai and Huang Yaqiong beat Thailand's Dechapol Puavaranukroh

and Sapsiree Taerattanachai 19-21, 21-16, 21-11.

There was double joy for Denmark as they claimed both the men's and women's doubles.

Christinna Pedersen and Kamilla Rytter Juhl beat Misaki Matsutomo and Ayaka Takahashi of Japan 21-18, 14-21,

21-15, while Mathias Boe and Carsten Mogensen beat Li Junhui and Liu Yuchen of China 21-13, 21-14.

The tournament saw its fair share of upsets early on, with defending men's and

women's singles champions Sony

Dwi Kuncoro of Indonesia and Ratchanok Intanon of Thailand dumped out on Wednesday.

Kuncoro succumbed to South Korea's Lee Dong-Keun while world number eight Ratchanok was beaten by Japan's

Sayaka Sato.

Olympic bronze medallist Viktor Axelsen of Denmark was shown the door on the same day, falling in three sets to

Hong Kong's Vincent Wong.

TestFile21:

It was Tai's fifth consecutive Super Series title and her second victory over Marin in less than two weeks, having already triumphed at the Malaysian Open final.

TestFile22:

game game game game game game game game game game game game game game game world world world world world

world world world world world world world world world world world world world world world world world

TestFile23:

Saina Nehwal lost in straight games to world no. 1 Tai Tzu Ying in the French Open 2018 women's singles quarter-finals on Friday. Saina Nehwal, who has been in fine form for the last couple of weeks, was looking to avenge her Denmark Open final loss against Tai Tzu Ying. The Chinese Taipei now has an overwhelming 14-5 head-to-head record against the Indian. In the men's singles quarter-finals match, Kidambi Srikanth lost to world no.1 Kento Momota in a closely-contested match. In a match that lasted 52 minutes, Srikanth lost 16-21, 19-21.

2. Input Code Format

Three of examples for input use are in below....

Select No. of TestFile.txt to be tested (1: TestFile1.txt, 2: TestFile2.txt, others: leave) >
(1) 1

Select a method to Test (0: txt, 1: manual, others: leave) >
(2) 0

Enter No. of TestFile.txt to test(1, 2, 3, others to leave)>
(3) 3

3. Output Code Format

Three of examples for output use are in below....

(1)

Try to find "dialogue" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Accuracy of BST is 83.5616%

Accuracy of SPT is 83.5616%

Accuracy of Treap is 83.5616%

The Average Searching Time of BST is 8

The Average Searching Time of SPT is 8.45205

The Average Searching Time of Treap is 8.05479

(2)

Try to manipulate "the"

BST: Insert successfully

SPT: Insert successfully

Treap: Insert successfully

Try to manipulate "ai"

BST: Insert successfully

SPT: Insert successfully

Treap: Insert successfully

(3)

Try to manipulate "the"

BST: Delete successfully

SPT: Delete successfully

Treap: Delete successfully

Try to manipulate "ai"

BST: Delete unsuccessfully

SPT: Delete unsuccessfully

Treap: Delete unsuccessfully

(六) 執行結果、討論與心得

執行結果與討論 (執行時間、problem n 的大小等問題討論)等...

1. 執行結果

i. TestFile1.txt tested by TestFile11.txt :Try to find "in" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 30 microseconds. Treap: successful

Try to find "one" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "of" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 18 microseconds. SPT: successful

Running time of search is 18 microseconds. Treap: successful

Try to find "most" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "dramatic" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 19 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "moments" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "hou" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 11 microseconds. Treap: successful

Try to find "read" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 17 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "out" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "a" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "private" in three ways

Running time of search is 11 microseconds. BST: successful

Running time of search is 18 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "text" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "message" in three ways

Running time of search is 18 microseconds. BST: successful

Running time of search is 23 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "from" in three ways

Running time of search is 19 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "ko" in three ways

Running time of search is 15 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 19 microseconds. Treap: successful

Try to find "which" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 21 microseconds. Treap: successful

Try to find "ko" in three ways

Running time of search is 16 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 16 microseconds. Treap: successful

Try to find "said" in three ways

Running time of search is 16 microseconds. BST: successful

Running time of search is 17 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "gou" in three ways

Running time of search is 15 microseconds. BST: successful

Running time of search is 21 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "needed" in three ways

Running time of search is 15 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "to" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 28 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "find" in three ways

Running time of search is 19 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "a" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "reason" in three ways

Running time of search is 19 microseconds. BST: successful

Running time of search is 17 microseconds. SPT: successful

Running time of search is 16 microseconds. Treap: successful

Try to find "to" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "drop" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "out" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "of" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "race" in three ways

Running time of search is 20 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 19 microseconds. Treap: successful

Accuracy of BST is 100%

Accuracy of SPT is 100%

Accuracy of Treap is 100%

The Average Searching Time of BST is 10.8182

The Average Searching Time of SPT is 12.5152

The Average Searching Time of Treap is 12.4545

Enter No. of TestFile.txt to test(1, 2, 3, others to leave)> 2

TestFile1.txt tested by TestFile12.txt :

Try to find "opposition" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 26 microseconds. Treap: successful

Try to find "opposition" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Accuracy of BST is 100%

Accuracy of SPT is 100%

Accuracy of Treap is 100%

The Average Searching Time of BST is 5.16667

The Average Searching Time of SPT is 2.5

The Average Searching Time of Treap is 11.5

Enter No. of TestFile.txt to test(1, 2, 3, others to leave)> 3

TestFile1.txt tested by TestFile13.txt :

Try to find "the" in three ways

Running time of search is 11 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "dpp" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "meanwhile" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "has" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 17 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "been" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "powering" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "ahead" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 20 microseconds. Treap: successful

Try to find "its" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "campaign" in three ways

Running time of search is 16 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "having" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "registered" in three ways

Running time of search is 15 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "its" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "presidential" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "ticket" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "on" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "tuesday" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "currentt" in three ways

Running time of search is 15 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 12 microseconds. Treap: unsuccessful

Try to find "vicet" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 12 microseconds. SPT: unsuccessful

Running time of search is 21 microseconds. Treap: unsuccessful

Try to find "president" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "lai" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "chingte" in three ways

Running time of search is 15 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "who" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "is" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 17 microseconds. Treap: successful

Try to find "leading" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "polls" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 3 microseconds. Treap: successful

Try to find "and" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "hist" in three ways

Running time of search is 200 microseconds. BST: unsuccessful

Running time of search is 17 microseconds. SPT: unsuccessful

Running time of search is 18 microseconds. Treap: unsuccessful

Try to find "running" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "mate" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "hsiao" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "bikhimt" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 13 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "previously" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "taiwans" in three ways

Running time of search is 3 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "highprofilet" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 13 microseconds. SPT: unsuccessful

Running time of search is 14 microseconds. Treap: unsuccessful

Try to find "de" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "factot" in three ways

Running time of search is 16 microseconds. BST: unsuccessful

Running time of search is 13 microseconds. SPT: unsuccessful

Running time of search is 16 microseconds. Treap: unsuccessful

Try to find "ambassador" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "to" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "unitedt" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 16 microseconds. Treap: unsuccessful

Try to find "states" in three ways

Running time of search is 15 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 18 microseconds. Treap: successful

Try to find "hsiaot" in three ways

Running time of search is 17 microseconds. BST: unsuccessful

Running time of search is 16 microseconds. SPT: unsuccessful

Running time of search is 16 microseconds. Treap: unsuccessful

Try to find "speaking" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "to" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "international" in three ways

Running time of search is 17 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 19 microseconds. Treap: successful

Try to find "media" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "earliert" in three ways

Running time of search is 13 microseconds. BST: unsuccessful

Running time of search is 16 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "on" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "thursday" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "discussedt" in three ways

Running time of search is 16 microseconds. BST: unsuccessful

Running time of search is 15 microseconds. SPT: unsuccessful

Running time of search is 15 microseconds. Treap: unsuccessful

Try to find "the" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 17 microseconds. Treap: successful

Try to find "sanctions" in three ways

Running time of search is 22 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "china" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "has" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "placed" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "on" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "her" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "beijingt" in three ways

Running time of search is 20 microseconds. BST: unsuccessful

Running time of search is 29 microseconds. SPT: unsuccessful

Running time of search is 13 microseconds. Treap: unsuccessful

Try to find "believes" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "both" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "she" in three ways

Running time of search is 11 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "and" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "lai" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "are" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 2 microseconds. Treap: successful

Try to find "dangerous" in three ways

Running time of search is 13 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "separatists" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "and" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 17 microseconds. Treap: successful

Try to find "importance" in three ways

Running time of search is 17 microseconds. BST: successful

Running time of search is 17 microseconds. SPT: successful

Running time of search is 18 microseconds. Treap: successful

Try to find "of" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "dialogue" in three ways

Running time of search is 16 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 16 microseconds. Treap: successful

Accuracy of BST is 83.5616%

Accuracy of SPT is 83.5616%

Accuracy of Treap is 83.5616%

The Average Searching Time of BST is 13.2877

The Average Searching Time of SPT is 10.7808

The Average Searching Time of Treap is 11.0274

ii. map2.txt

TestFile2.txt tested by TestFile21.txt :

Try to find "it" in three ways

Running time of search is 17 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "was" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "tais" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 11 microseconds. Treap: successful

Try to find "fifth" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "consecutive" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "super" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "series" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 11 microseconds. Treap: successful

Try to find "title" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "and" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "her" in three ways

Running time of search is 3 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "second" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "victory" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "over" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 15 microseconds. SPT: successful

Running time of search is 2 microseconds. Treap: successful

Try to find "marin" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "less" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 2 microseconds. Treap: successful

Try to find "than" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "two" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "weeks" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "having" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "already" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "triumphed" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "at" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "malaysian" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "open" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "final" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Accuracy of BST is 100%

Accuracy of SPT is 100%

Accuracy of Treap is 100%

The Average Searching Time of BST is 6.55556

The Average Searching Time of SPT is 9.33333

The Average Searching Time of Treap is 7.44444

Enter No. of TestFile.txt to test(1, 2, 3, others to leave)> 2

ii. TestFile2.txt tested by TestFile22.txt :

Try to find "game" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 11 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "game" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 16 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Accuracy of BST is 100%

Accuracy of SPT is 100%

Accuracy of Treap is 100%

The Average Searching Time of BST is 6.34286

The Average Searching Time of SPT is 2.77143

The Average Searching Time of Treap is 6.71429

iii. TestFile2.txt tested by TestFile23.txt :

Try to find "saina" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "nehwal" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 10 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "lost" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "straight" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 19 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "games" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "to" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "no" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "tai" in three ways

Running time of search is 2 microseconds. BST: successful

Running time of search is 10 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "tzu" in three ways

Running time of search is 3 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "ying" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 14 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "french" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 7 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "open" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "womens" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "singles" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "quarterfinals" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 12 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "on" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "friday" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 6 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "saina" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "nehwal" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 7 microseconds. SPT: unsuccessful

Running time of search is 6 microseconds. Treap: unsuccessful

Try to find "who" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 7 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "has" in three ways

Running time of search is 7 microseconds. BST: unsuccessful

Running time of search is 7 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "been" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "fine" in three ways

Running time of search is 8 microseconds. BST: unsuccessful

Running time of search is 7 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "form" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 6 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "for" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 15 microseconds. Treap: successful

Try to find "last" in three ways

Running time of search is 20 microseconds. BST: unsuccessful

Running time of search is 12 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "couple" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 10 microseconds. Treap: unsuccessful

Try to find "of" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "weeks" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 12 microseconds. Treap: successful

Try to find "was" in three ways

Running time of search is 12 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "looking" in three ways

Running time of search is 17 microseconds. BST: unsuccessful

Running time of search is 12 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "to" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "avenge" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 13 microseconds. Treap: unsuccessful

Try to find "her" in three ways

Running time of search is 3 microseconds. BST: successful

Running time of search is 13 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "denmark" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 14 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "open" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "final" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 10 microseconds. Treap: successful

Try to find "loss" in three ways

Running time of search is 14 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "against" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 11 microseconds. Treap: unsuccessful

Try to find "tai" in three ways

Running time of search is 2 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "tzu" in three ways

Running time of search is 3 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 13 microseconds. Treap: successful

Try to find "ying" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "chinese" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 10 microseconds. Treap: unsuccessful

Try to find "taipei" in three ways

Running time of search is 5 microseconds. BST: unsuccessful

Running time of search is 4 microseconds. SPT: unsuccessful

Running time of search is 11 microseconds. Treap: unsuccessful

Try to find "now" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 6 microseconds. Treap: unsuccessful

Try to find "has" in three ways

Running time of search is 7 microseconds. BST: unsuccessful

Running time of search is 17 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "an" in three ways

Running time of search is 6 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "overwhelming" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 12 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "headtohead" in three ways

Running time of search is 7 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "record" in three ways

Running time of search is 10 microseconds. BST: unsuccessful

Running time of search is 10 microseconds. SPT: unsuccessful

Running time of search is 10 microseconds. Treap: unsuccessful

Try to find "against" in three ways

Running time of search is 9 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "the" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "indian" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 14 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "in" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 7 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "the" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "mens" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 4 microseconds. Treap: successful

Try to find "singles" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 6 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "quarterfinals" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 11 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Try to find "match" in three ways

Running time of search is 11 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "kidambi" in three ways

Running time of search is 20 microseconds. BST: successful

Running time of search is 12 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "srikanth" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "lost" in three ways

Running time of search is 16 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 9 microseconds. Treap: unsuccessful

Try to find "to" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "world" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "no" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "kento" in three ways

Running time of search is 15 microseconds. BST: unsuccessful

Running time of search is 8 microseconds. SPT: unsuccessful

Running time of search is 7 microseconds. Treap: unsuccessful

Try to find "momota" in three ways

Running time of search is 11 microseconds. BST: unsuccessful

Running time of search is 6 microseconds. SPT: unsuccessful

Running time of search is 6 microseconds. Treap: unsuccessful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "a" in three ways

Running time of search is 5 microseconds. BST: successful

Running time of search is 11 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "closelycontested" in three ways

Running time of search is 13 microseconds. BST: unsuccessful

Running time of search is 18 microseconds. SPT: unsuccessful

Running time of search is 13 microseconds. Treap: unsuccessful

Try to find "match" in three ways

Running time of search is 10 microseconds. BST: successful

Running time of search is 5 microseconds. SPT: successful

Running time of search is 7 microseconds. Treap: successful

Try to find "in" in three ways

Running time of search is 8 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "a" in three ways

Running time of search is 4 microseconds. BST: successful

Running time of search is 2 microseconds. SPT: successful

Running time of search is 6 microseconds. Treap: successful

Try to find "match" in three ways

Running time of search is 9 microseconds. BST: successful

Running time of search is 3 microseconds. SPT: successful

Running time of search is 5 microseconds. Treap: successful

Try to find "that" in three ways

Running time of search is 6 microseconds. BST: successful

Running time of search is 9 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "lasted" in three ways

Running time of search is 12 microseconds. BST: unsuccessful

Running time of search is 9 microseconds. SPT: unsuccessful

Running time of search is 13 microseconds. Treap: unsuccessful

Try to find "minutes" in three ways

Running time of search is 14 microseconds. BST: successful

Running time of search is 8 microseconds. SPT: successful

Running time of search is 9 microseconds. Treap: successful

Try to find "srikanth" in three ways

Running time of search is 7 microseconds. BST: successful

Running time of search is 4 microseconds. SPT: successful

Running time of search is 8 microseconds. Treap: successful

Try to find "lost" in three ways

Running time of search is 13 microseconds. BST: unsuccessful

Running time of search is 10 microseconds. SPT: unsuccessful

Running time of search is 8 microseconds. Treap: unsuccessful

Accuracy of BST is 59.3023%

Accuracy of SPT is 59.3023%

Accuracy of Treap is 59.3023%

The Average Searching Time of BST is 8.61628

The Average Searching Time of SPT is 8.05814

The Average Searching Time of Treap is 8.36047

2. 討論

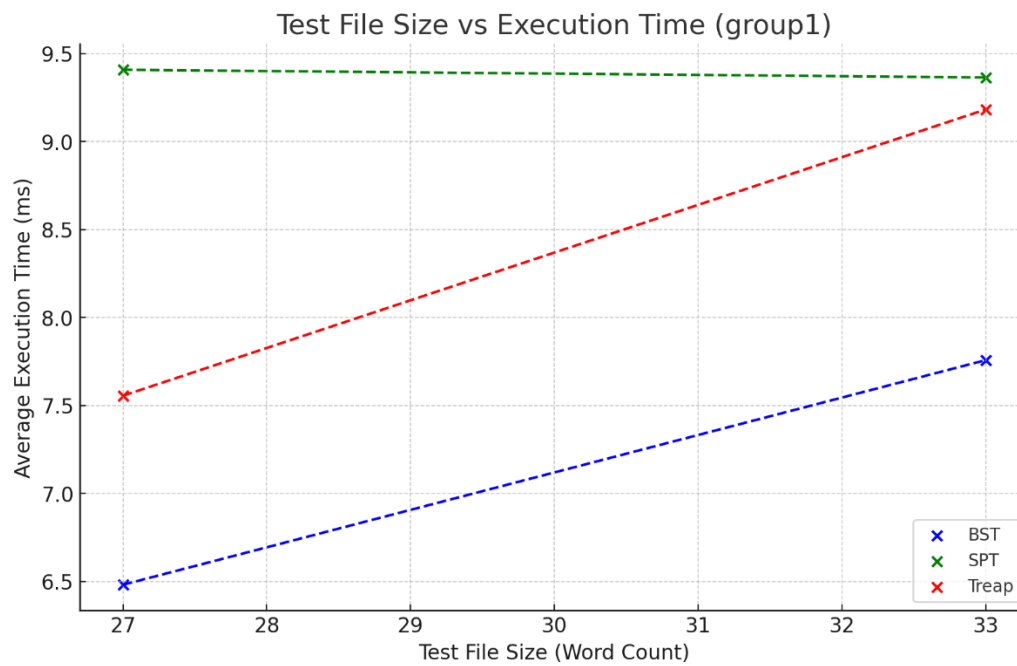
執行時間、問題大小等問題討論! 利用 MS Excel 畫出問題大小與執行時間的關係!

Running Time, Problem size n 關係圖

Test File	Word Count	Tested By	Search Method	Accuracy	Execution Time
TestFile1	574	TestFile11	BST	100%	7.75758
TestFile1	574	TestFile11	SPT	100%	9.36364
TestFile1	574	TestFile11	Treap	100%	9.18182
TestFile1	574	TestFile12	BST	100%	4.38889
TestFile1	574	TestFile12	SPT	100%	2.77778
TestFile1	574	TestFile12	Treap	100%	8.55556
TestFile1	574	TestFile13	BST	83.56%	8.71233
TestFile1	574	TestFile13	SPT	83.56%	8.76712
TestFile1	574	TestFile13	Treap	83.56%	8.56164
TestFile2	428	TestFile21	BST	100%	6.48148
TestFile2	428	TestFile21	SPT	100%	9.40741
TestFile2	428	TestFile21	Treap	100%	7.55556
TestFile2	428	TestFile22	BST	100%	6.91429
TestFile2	428	TestFile22	SPT	100%	3.14286

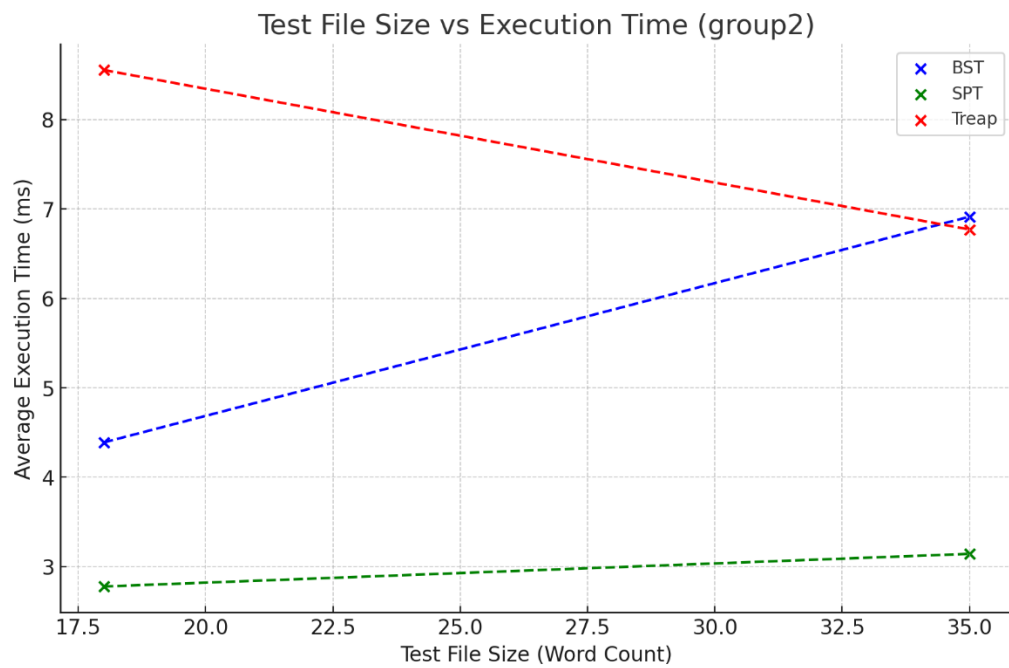
TestFile2	428 TestFile22	Treap	100%	6.77143
TestFile2	428 TestFile23	BST	59.30%	8.11628
TestFile2	428 TestFile23	SPT	59.30%	7.90698
TestFile2	428 TestFile23	Treap	59.30%	7.90698

i.



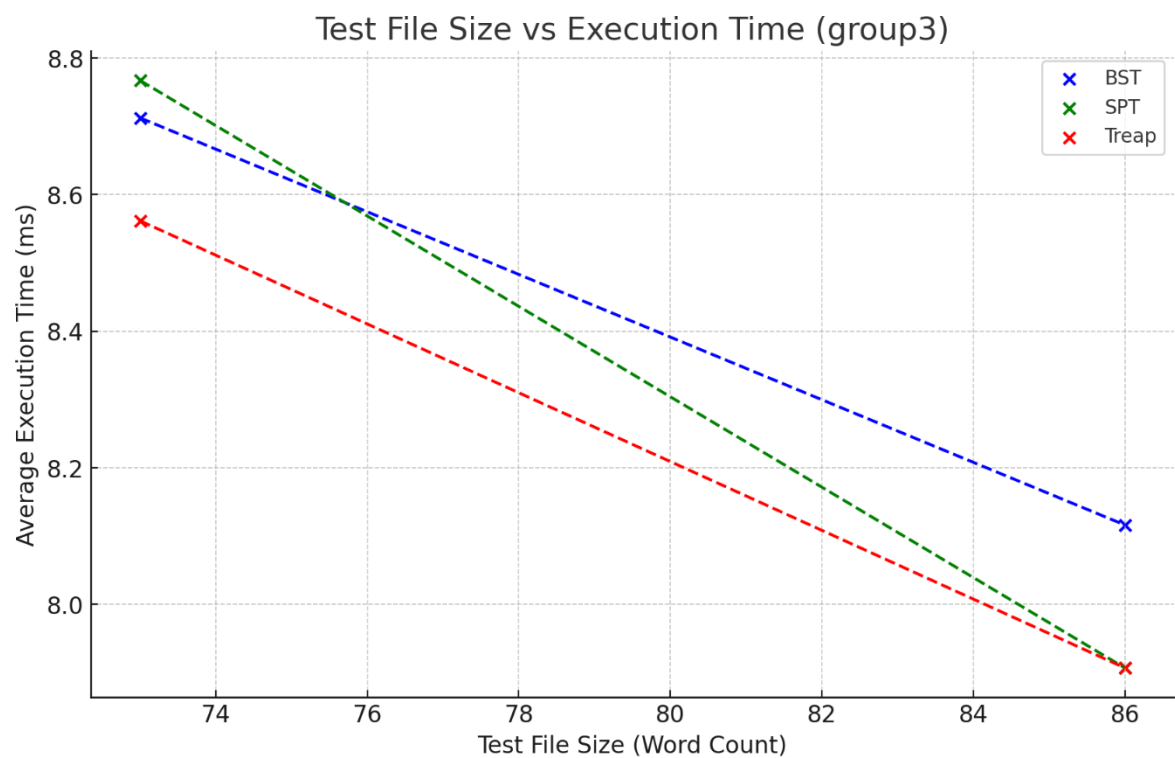
上圖為 testfile11 和 testfile21(accuracy 皆為 100%)的 size 對 execution time 的圖
由圖可知，正常搜索下，BST 較合適。

ii.



上圖為 testfile12 和 testfile22(資料重複性高)的 size 對 execution time 的圖
由圖可知，在 Searching file 重複性高搜索下，SPT 較合適。

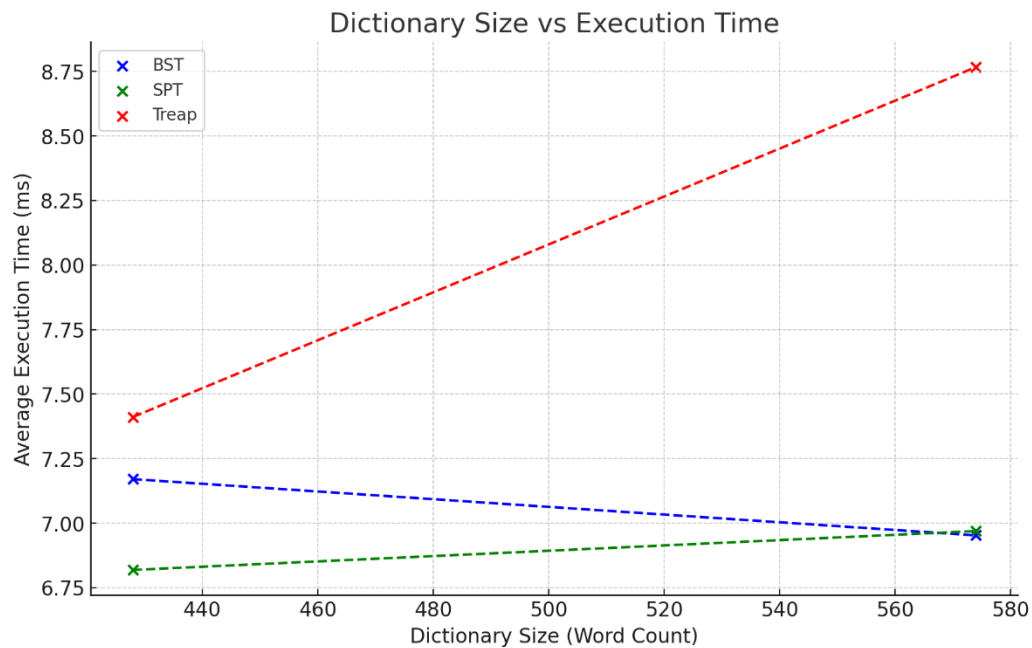
iii.



上圖為 testfile12 和 testfile22(accuracy < 80%)的 size 對 execution time 的圖

由圖可知，在資料高機率不再 Dictionary 的搜索下，Treap 較合適。

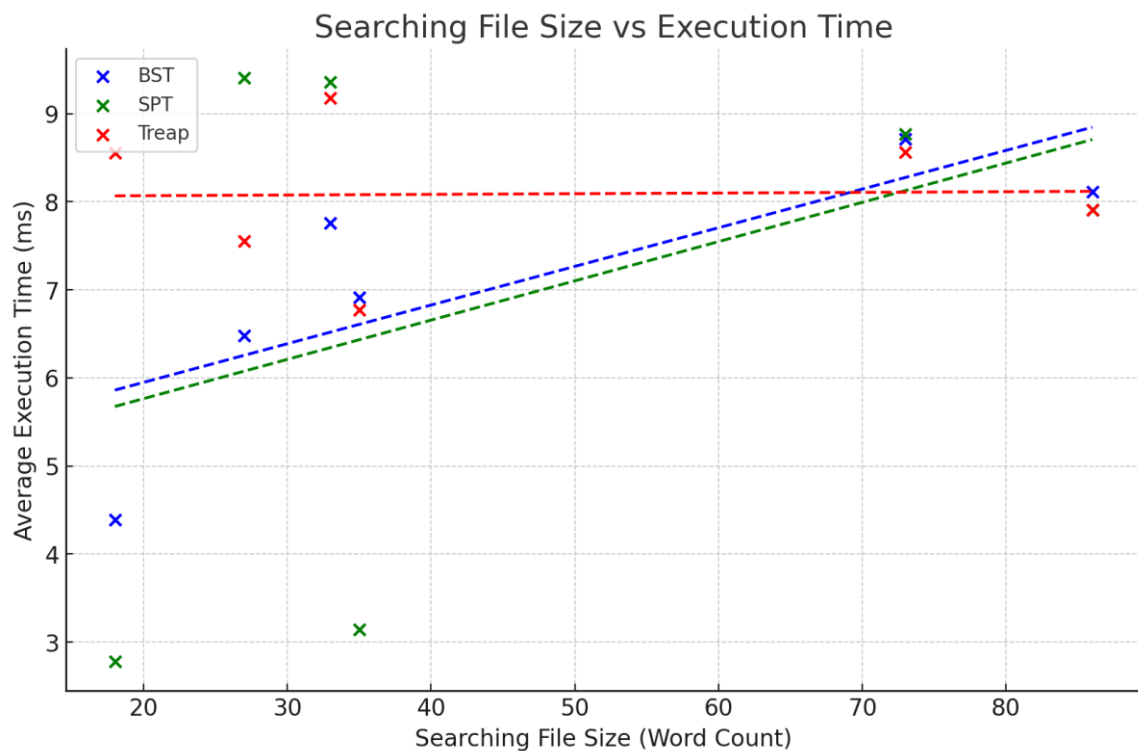
iv.



上圖為隨 Dictionary size 變化對應 execution time 的圖(Different Dictionaries tested by one Searching file)

可見 Treap 的 searching time 和 Dictionary size 成正相關，Treap 較不適合 Dictionary 經常新增的情況，應用另外二者。

v.



上圖為隨 Searching file size 變化對應 execution time 的圖(one Dictionary tested by different

Searching files)

可見 Treap 的 searching time 和 Searching file size 無關係，因為 heap 的特性，較適合用於 Searching file 較大的情況，應避免用另外二者。

這三種資料結構各有其特點和適用情景。BST 適合於數據皆包含在 Dictionary 中的情況，Splay Tree 適合於有一些頻繁訪問的元素的情況，而 Treap 則因為 heap 的平衡性，適合錯誤性高需要搜索到 leaf 或是 Searching file 較大的情況，且 Treap 應避免 Dictionary 經常新增的情況。選擇合適的結構取決於具體應用的需求和特點。

3. 心得

我通過實作 Binary Search Tree (BST)、Splay Tree (SPT) 和 Treap 這三種不同的資料結構，深入理解了它們在時間複雜度和空間複雜度方面的特點。這次實作體驗使我更加熟悉這些資料結構的操作原理和效率特性，並且讓我意識到理論分析和實際應用之間的差異。特別是在分析 Dictionary size 和 Searching file size 對執行時間與效率的影響時，我學會了如何根據不同情境選擇最合適的資料結構。此外，我還學習了如何利用 MS Excel 和 Word 等工具來整理數據和分析結果，這對於我的學習和研究非常有幫助。整體來說，這次作業不僅鞏固了我對於資料結構的理解，也提高了我解決實際問題的能力。

(七)參考文獻

- [1] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms," Third Edition, The MIT Press, 2009.
- [2] R.C.T. Lee, S.S. Tseng, R.C. Chang, and Y.T.Tsai, "Introduction to the Design and Analysis of Algorithms," McGraw-Hill, 2005.
- [3] Anany V. Levitin, "Introduction to the Design and Analysis of Algorithms," 3rd Edition, Addison Wesley, 2012.
- [4] Richard Neapolitan and Kumarss Naimipour, "Foundations of Algorithms," Fourth Edition, Jones and Bartlett Publishers, 2010.
- [5] <https://www.channelnewsasia.com/asia/taiwan-opposition-talks-presidential-bid-teeter-after-bitter-live-tv-showdown-3942111>
- [6] <https://www.channelnewsasia.com/news/sport/badminton-taiwan-s-tai-beats-marin-to-win-singapore-open-8727786>