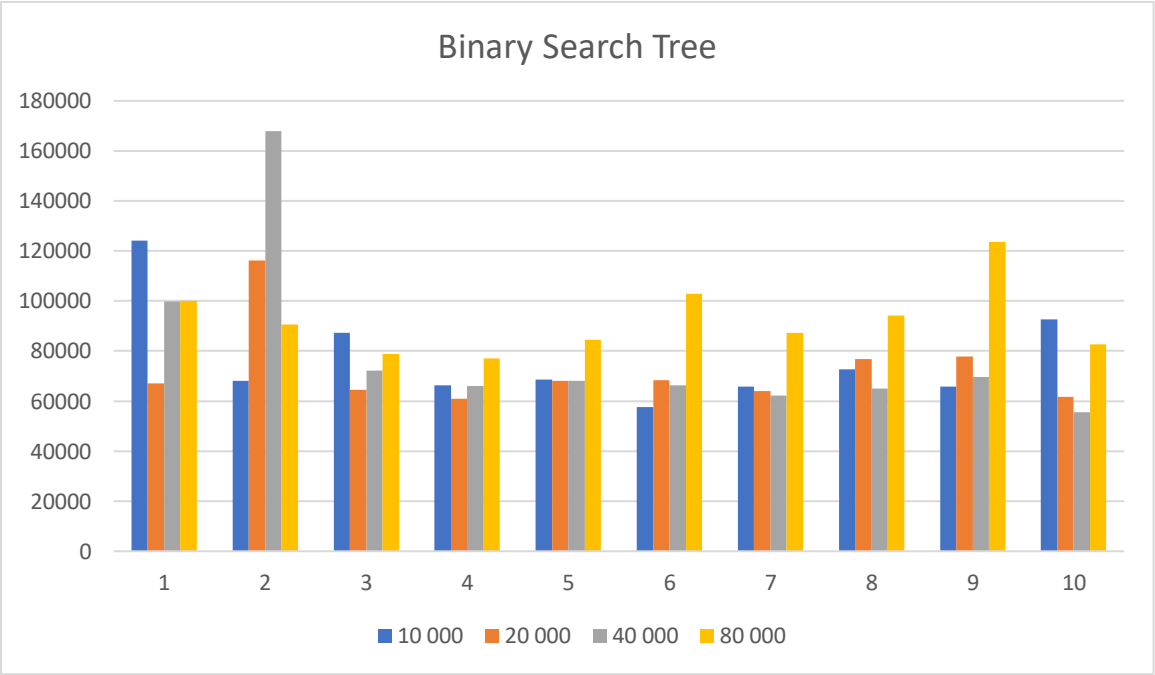
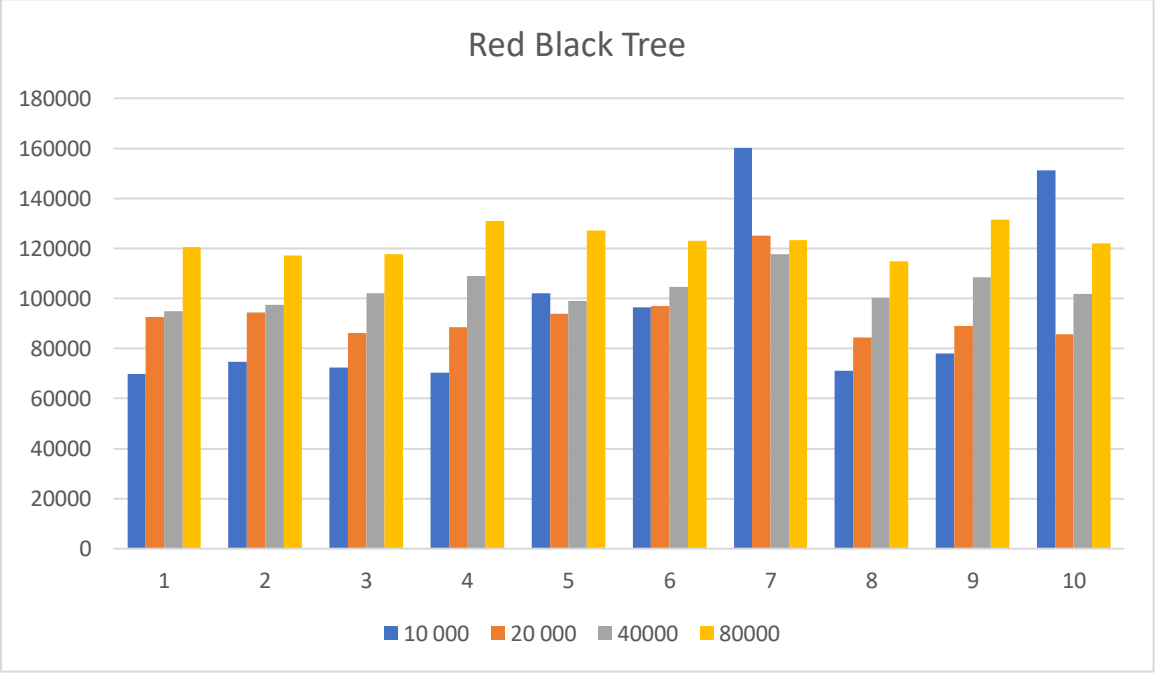
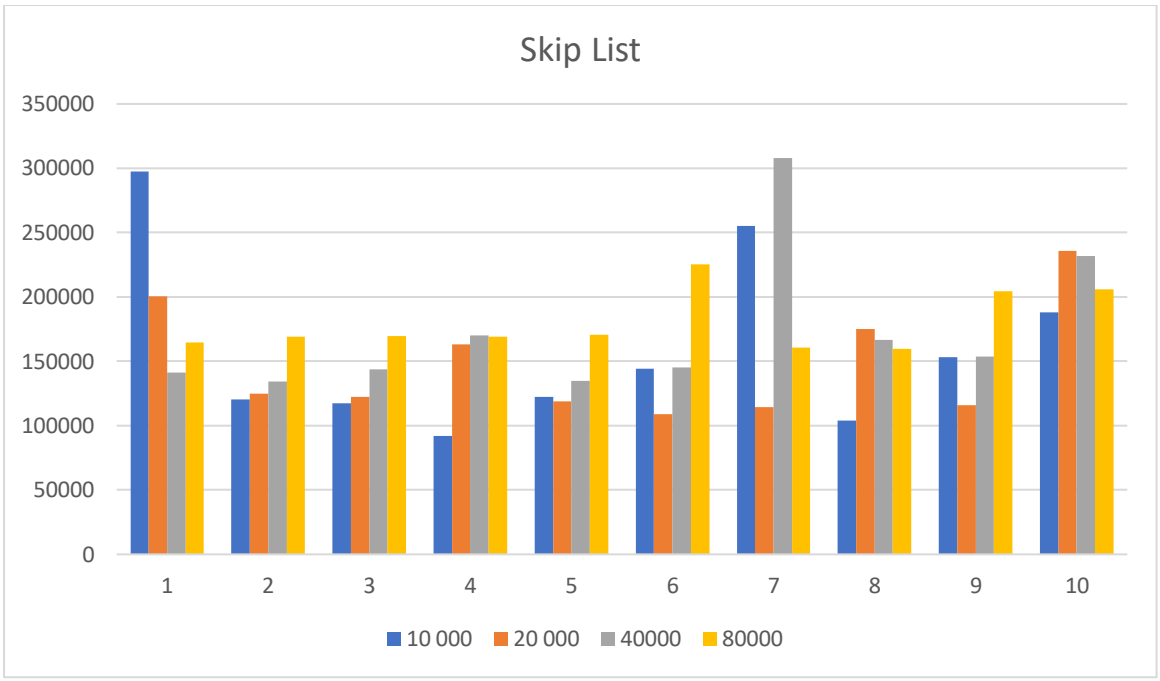
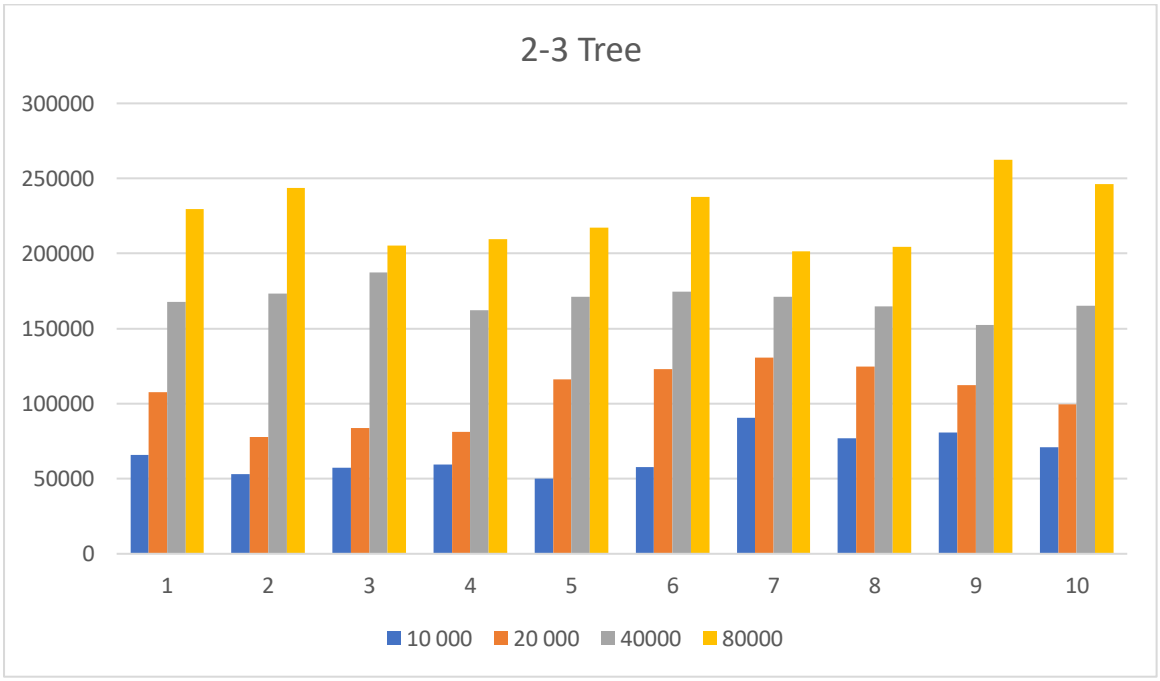
AVERAGE RUNNING TIME (ns)	10 000	20 000	40 000	80 000
BST	124 200	67 000	99 900	100 200
BST	68 000	116 200	167 900	90 600
BST	87 300	64 600	72 300	78 900
BST	66 200	61 000	66 000	77 100
BST	68 600	68 200	68 100	84 400
BST	57 600	68 400	66 300	102 800
BST	65 800	64 000	62 200	87 300
BST	72 600	76 900	65 100	94 300
BST	65 900	77 700	69 600	123 600
BST	92 600	61 800	55 600	82 600
AVERAGE	**76 880**	**72 590**	**79 300**	**92 180**
Red Black Tree	69 800	92 500	94 900	120 600
Red Black Tree	74 700	94 300	97 400	117 200
Red Black Tree	72 400	86 100	102 100	117 700
Red Black Tree	70 400	88 500	109 100	131 100
Red Black Tree	102 000	94 000	99 100	127 200
Red Black Tree	96 500	96 900	104 700	123 100
Red Black Tree	160 100	125 100	117 600	123 400
Red Black Tree	71 100	84 500	100 300	114 800
Red Black Tree	78 000	88 900	108 500	131 600
Red Black Tree	151 100	85 600	101 700	122 100
AVERAGE	**94 610**	**93 640**	**103 540**	**122 100**
Skip List	297 400	200 700	141 100	164 800
Skip List	120 200	124 900	134 300	169 300
Skip List	117 600	122 500	143 800	169 500
Skip List	91 900	163 400	170 200	169 200
Skip List	122 500	118 900	134 700	170 500
Skip List	144 100	108 700	145 400	225 500
Skip List	255 300	114 200	308 100	160 800
Skip List	103 800	175 000	166 800	159 900
Skip List	153 200	115 900	153 700	204 700
Skip List	187 800	235 800	231 800	205 900
AVERAGE	**159 380**	**148 000**	**172 990**	**180 010**
2-3 Tree	65 700	107 700	167 700	229 800
2-3 Tree	53 200	77 600	173 200	243 700
2-3 Tree	57 200	83 700	187 600	205 300
2-3 Tree	59 400	81 300	162 400	209 600
2-3 Tree	50 200	116 200	171 000	217 300
2-3 Tree	57 700	123 100	174 700	237 600
2-3 Tree	90 500	130 600	171 200	201 300
2-3 Tree	76 900	124 900	164 600	204 500
2-3 Tree	80 700	112 200	152 400	262 500
2-3 Tree	70 800	99 500	165 300	246 300
AVERAGE	**66 230**	**105 680**	**165 310**	**225 790**

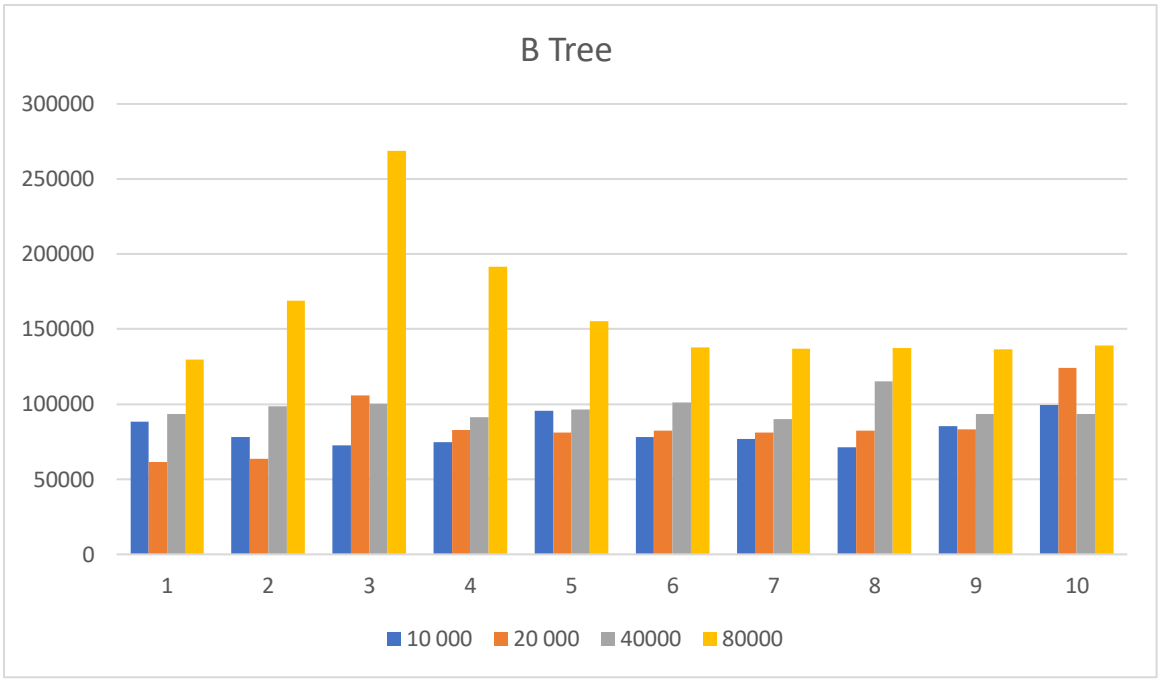
B Tree	88 300	61 400	93 300	129 600
B Tree	78 000	63 800	98 800	168 800
B Tree	72 400	105 700	100 400	268 800
B Tree	74 700	82 800	91 500	191 700
B Tree	95 800	81 000	96 300	155 400
B Tree	78 200	82 400	101 000	138 000
B Tree	76 700	81 000	90 200	137 200
B Tree	71 200	82 400	115 400	137 300
B Tree	85 300	83 300	93 500	136 600
B Tree	99 500	124 300	93 500	139 300
AVERAGE	**82 010**	**84 810**	**97 390**	**160 270**

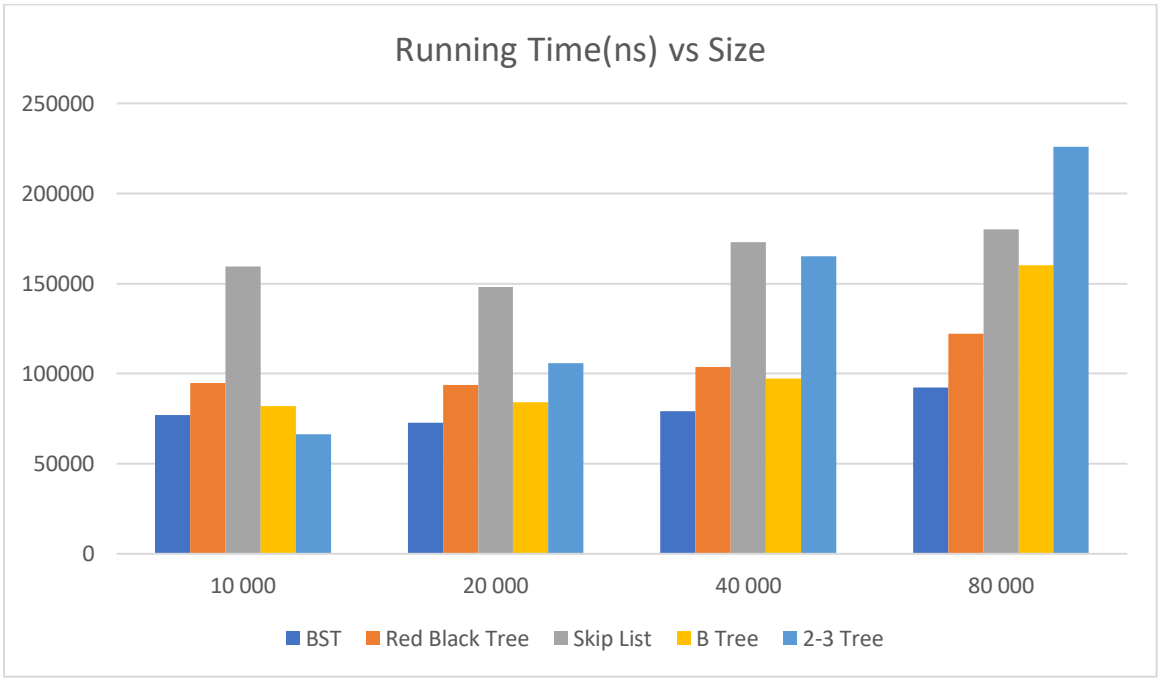





Skip List
350000
300000
250000
200000
150000
100000
50000
0
1
2
3
4
5
6
7
8
9
10
10 000
20 000
40000
80000


2-3 Tree
300000
250000
200000
150000
100000
50000
0
1
2
3
4
5
6
7
8
9
10
10 000
20 000
40000
80000

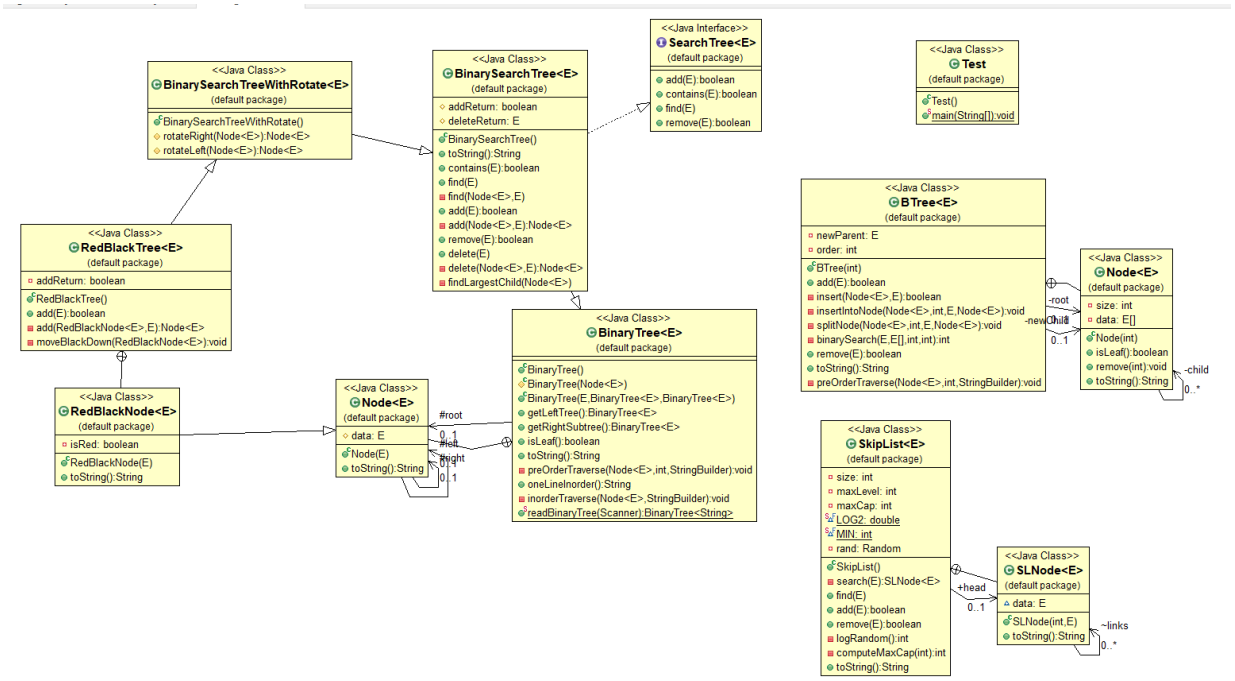




Initially I added a certain number of different elements to each tree. Then I added 100 more elements to each and measured the run times. Looking at the average values, binarySeachTree, RedBlackTree and SkipList values are more consistent despite increasing sizes. There isn't an extreme difference in running time as the size changes. B Tree and 2-3 Tree, on the other hand, increased their running time more than the others as their size increased. SkipList has the worst running speed among them. B Tree is more suitable when processing with 2-3 Tree less elements. It is more appropriate to use BinarySearchTree, RedBackTree and SkipList when processing with a large number of elements. Because

runtime is better. (Red black tree O(log n), Binary search tree worst O(n) and Skip List O(log n)) Insertion process is faster because RedBlackTree is balanced. If the elements are sorted in BinarySearchTree, the insertion process takes O(log n).

1. CLASS DIAGRAM



2. RUNNING COMMAND AND RESULT

```
***Length is 10 100***
Binary Search Tree adding times are:
110601 ns
59900 ns
87501 ns
56301 ns
53800 ns
80999 ns
53801 ns
51201 ns
57801 ns
77000 ns

Red Black Tree adding times are:
72201 ns
63500 ns
69000 ns
75500 ns
68900 ns
70700 ns
61799 ns
65500 ns
77900 ns
99000 ns

Skip List adding times are:
94600 ns
105700 ns
90600 ns
103700 ns
87601 ns
99201 ns
91700 ns
88400 ns
95901 ns
175300 ns
```

```
B Tree adding times are:
77700 ns
77300 ns
78199 ns
96499 ns
73999 ns
72900 ns
72900 ns
71800 ns
67199 ns
121300 ns

2-3 Tree adding times are:
121100 ns
139900 ns
105201 ns
1839300 ns
102100 ns
86400 ns
74800 ns
109901 ns
105300 ns
123000 ns

***Length is 20 100***
Binary Search Tree adding times are:
171699 ns
78100 ns
1271800 ns
70101 ns
65600 ns
80600 ns
86299 ns
80100 ns
944400 ns
75400 ns
```

```
Red Black Tree adding times are:
96199 ns
82600 ns
83300 ns
95799 ns
83099 ns
86800 ns
84801 ns
82701 ns
77600 ns
86199 ns

Skip List adding times are:
112501 ns
108800 ns
112400 ns
137600 ns
111301 ns
147800 ns
108600 ns
99500 ns
107400 ns
107400 ns

B Tree adding times are:
99700 ns
86799 ns
90300 ns
89400 ns
98199 ns
90900 ns
95199 ns
97901 ns
94999 ns
97600 ns
```

```
2-3 Tree adding times are:
127000 ns
143700 ns
145500 ns
130900 ns
181500 ns
123200 ns
139400 ns
121800 ns
271300 ns
119500 ns

***Length is 40 100***
Binary Search Tree adding times are:
131701 ns
100101 ns
99100 ns
86700 ns
79300 ns
78201 ns
77900 ns
97399 ns
98000 ns
76500 ns

Red Black Tree adding times are:
117100 ns
104499 ns
123600 ns
118601 ns
116899 ns
113900 ns
273500 ns
122400 ns
114000 ns
121800 ns
```

```
Skip List adding times are:
142901 ns
164500 ns
146101 ns
160701 ns
188000 ns
161299 ns
178899 ns
207199 ns
207600 ns
202400 ns

B Tree adding times are:
126200 ns
125099 ns
102901 ns
110300 ns
129400 ns
107000 ns
168700 ns
149801 ns
151300 ns
166800 ns

2-3 Tree adding times are:
158200 ns
158000 ns
183800 ns
178000 ns
175500 ns
216499 ns
201200 ns
200300 ns
214600 ns
223700 ns
```

```
***Length is 80 100***
Binary Search Tree adding times are:
90199 ns
99800 ns
118400 ns
94100 ns
90600 ns
84101 ns
94100 ns
84299 ns
84999 ns
82000 ns

Red Black Tree adding times are:
129400 ns
115499 ns
128000 ns
149301 ns
160101 ns
120599 ns
119400 ns
114399 ns
113400 ns
122100 ns

Skip List adding times are:
191000 ns
167600 ns
174800 ns
175901 ns
163099 ns
157000 ns
173801 ns
161300 ns
158599 ns
182500 ns
```

```
B Tree adding times are:
165300 ns
136300 ns
126999 ns
144200 ns
159000 ns
148100 ns
142300 ns
129901 ns
119700 ns
186100 ns

2-3 Tree adding times are:
182400 ns
139200 ns
134701 ns
136600 ns
123000 ns
131299 ns
137500 ns
142000 ns
139501 ns
168100 ns
```