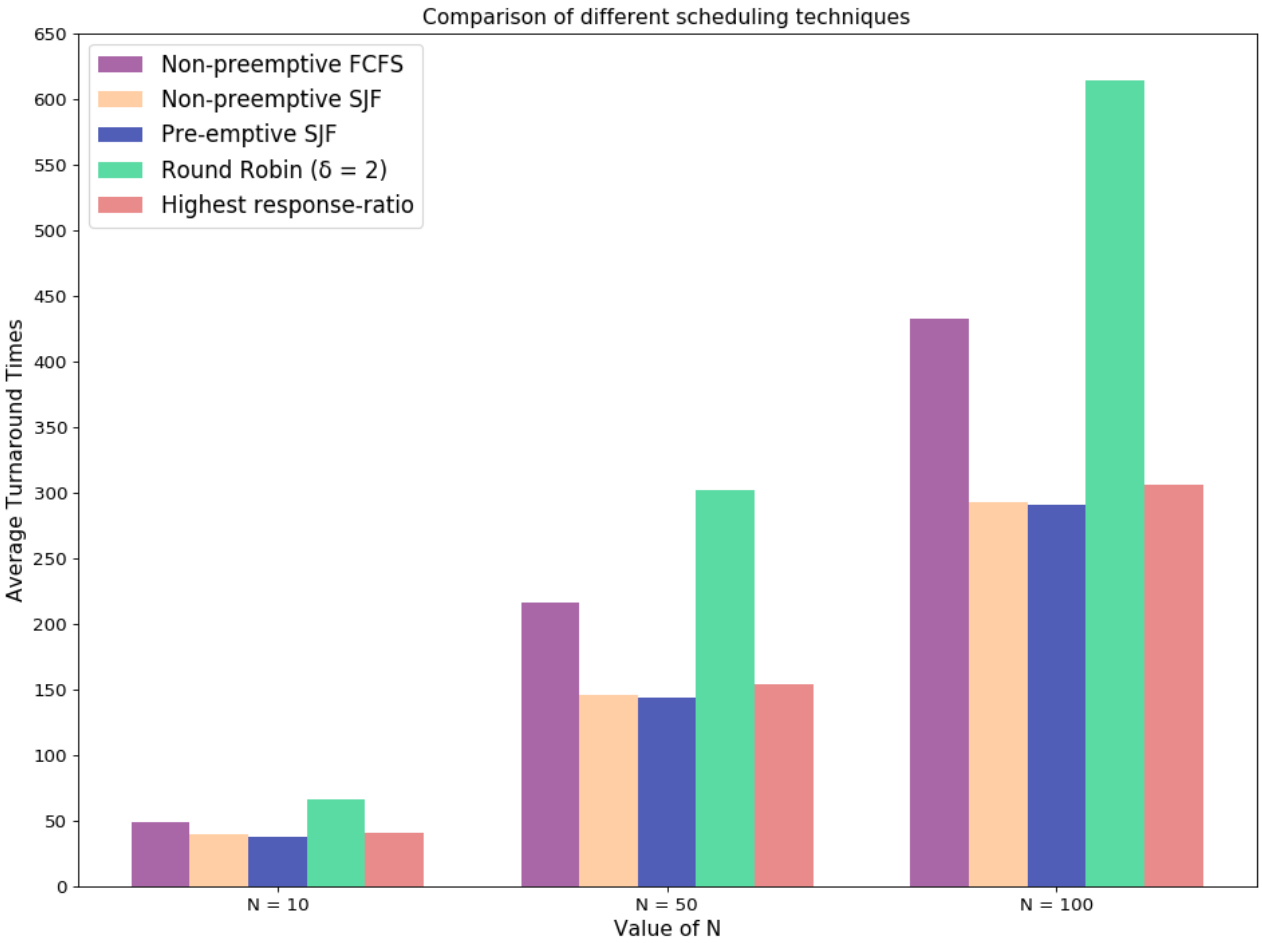

Generated Plot

The above plot is generated by the following python script:

```python
import matplotlib.pyplot as plt
import os
import numpy as np

#run for 10 times
times = 10

#values of N
NValues = [10, 50, 100]

#input filename
inputFile = "buffer.txt"

#output filename
outputFile = "output.txt"

#compile the file at the beginning
a = os.system("g++ a3_6.cpp")

Vals = []
```

```
21
22 for q in NValues:
23     #opening the input file
24     fout = open(inputFile, "w")
25
26     #writing value of N to it
27     fout.write(str(q)+"\n")
28
29     #closing the file
30     fout.close()
31
32     #defining Y
33     Y = [[],[],[],[],[]]
34
35     for i in range(times):
36         #running the executable and getting output in output.txt
37         a = os.system("./a.out < "+ inputFile + " > " + outputFile)
38
39         #reading from output.txt
40         fin = open(outputFile, "r")
41
42         #list of strings from fin
43         L = list(filter(None, fin.read().split('\n')))
44
45         for i in range(5):
46             L[i] = float(L[i])
47             Y[i].append(L[i])
48
```

```
49     for i in range(5):
50         Y[i] = sum(Y[i])/len(Y[i])
51
52     Vals.append(np.array(Y))
53 Vals = np.array(Vals)
54 Vals = np.transpose(Vals)
55
56 # data to plot
57 n_groups = 3
58 means = Vals
59
60 # create plot
61 plt.figure(num=None, figsize=(12, 9), dpi=80, facecolor='w', edgecolor='k')
62 index = np.arange(n_groups)
63 bar_width = 0.15
64 opacity = 0.9
65
66 labels=['Non-preemptive FCFS',
67             'Non-preemptive SJF',
68             'Pre-emptive SJF',
69             'Round Robin (δ = 2)',
70             'Highest response-ratio']
71 colors=['#A0569E','#FFC99B','#3D4CAF','#49D89A','#E87F7F']
72
```

```
for i in range(5):
    plt.bar(index + bar_width*i, means[i], bar_width, alpha = opacity, color=colors[i],label=labels[i])

plt.xlabel('Value of N', fontsize=14)
plt.ylabel('Average Turnaround Times',fontsize=14)
plt.title('Comparison of different scheduling techniques',fontsize=14)
plt.xticks(index + 2*bar_width, ('N = 10', 'N = 50', 'N = 100'), fontsize=12)
temp = int(max(means.flatten()))+50
plt.yticks(ticks=range(0,temp,50),fontsize=12)
plt.legend(prop={'size': 15})

plt.tight_layout()
plt.savefig("barChart.png")
```

Theoretical Analysis of Non-preemptive FCFS scheduling algorithm:
(Determination of Theoretically expected lower bound on the turn-around time)

Turn Around Time for some Process
= Process's Completion Time – Process' Arrival Time
= Process's Waiting Time + Process's CPU Burst

To get a theoretical lower bound, we consider the best case in which the waiting time for each process will be zero and hence turn around time for each process will be its CPU burst. Let Y_i be the CPU Burst of the i-th process

Hence, Expected value of lower bound

$$= E((\Sigma_{i=1 \text{ to } N} (Y_i)) / N)$$

$$= (\Sigma_{i=1 \text{ to } N} E(Y_i)) / N$$

$$= E(Y)$$

$$= 10.5$$ [as Y is a uniform random variable between 1 and 20]

And we checked, that, this lower bound is satisfied by our simulation.