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COMP SCI 5401 FS2015 Assignment 1c

Self-Adaptive EA Strategy Parameter

The adaptive strategy parameter used in this experiment was set over the recombination method used for creating children in each generation. Upon creation of the initial population, the program assigns half of the children uniform crossover recombination and the other half one point crossover recombination. When two individuals in the population are to be recombined, their loci for which combination to use are compared. If the individuals agree on the same method of recombination, the recombination they are assigned is what will be used. If the individuals are assigned different recombination types, the method of recombination will be randomized between uniform and one point crossover. The resulting child is assigned the method of recombination which was used.

The Experiment

The experiment conducted was meant to show the efficiency of the self-adaptive EA strategy parameter, as well as the usefulness of using r-elitism restarts while SAT solving. Four CNF files were used, ranging in difficulty to solve. On each file, the evolutionary algorithm was used normally, with the self-adapting parameter, with r-restarts, and with both the self-adapting parameter AND r-restarts. With each use of the program, 30 runs consisting of 10,000 evaluations each were carried out on the data. The results were then compiled into a set of graphs, and the author ran a statistical analysis on each set of data. The mentioned graphs can be seen in Appendix A.

Results

(a) The first objective of the experiment was to analyze whether the self-adaptive EA strategy parameter that was implemented helped the algorithm to become more efficient. The results from running the algorithm with and without the self-adaptive parameter were compared. For the simplest CNF file, CNF file 1, the results for either version of the algorithm were identical, both obtaining the maximum answer in every run. In CNF files 2-4, the results began to vary, so the author conducted f-tests and t-tests on each corresponding data set. The results of these tests can be seen in Table 1. For each of these three tests, the null hypothesis was rejected, so it became safe to assume the algorithm with the highest mean value was the better of the two. In each statistical test, the algorithm without the self-adaptive parameter produced a higher mean best value for each CNF file. It can be concluded that the self-adaptive EA strategy parameter used in this experiment was not effective at making the algorithm more efficient.

    In each run of the experiment, the one point crossover recombination type dominated the population early on, but ended up prematurely converging. The author hypothesizes that one point crossover has a much higher selective pressure than uniform crossover recombination. Because of this, the individuals using one point cross over ended up taking over. Because the selective pressure of this recombination type was so high, it caused premature convergence where uniform crossover recombination would not have. This caused the self-adaptive parameter to hamper the algorithm rather than help it.

CNF File 2			CNF File 3			CNF File 4		
	Norm.	Adapt.		Norm.	Adapt.		Norm.	Adapt.
Mean	70	69.733	Mean	200	198.567	Mean	1048.5	1000.8
Variance	0	0.2022	Variance	0	1.8402	Variance	9.4264	38.051
Observ.	30	30	Observ.	30	30	Observ.	30	30
F	0		F	0		F	0.2477	
F Critical	0.5374		F Critical	0.5374		F Critical	0.5374	
t Stat	3.2474		t Stat	5.7872		t Stat	37.9173	
t Crit.	2.0017		t Crit.	2.0017		t Crit.	2.0017	

Table 1: Shown is the information on the statistical analysis for each of the CNF files, comparing the normal evolutionary algorithm to the one using the self-adaptive EA strategy paramenter. For each, the t Stat was higher than the t Critical Two-Tail value. This means for each, the null hypothesis was rejected.

(b) The second objective of the experiment was to determine if using r-elitist restarts would improve the quality of the algorithm. For these tests, if the average value or best value of the population did not improve for 15 generations, half of the population would be eliminated, and new individuals would be generated to take their place. For CNF files 1-3, the best solution found was the best possible solution in every single run for both the algorithm alone and the algorithm with r-elitist restarts. Comparing these statistically would not yield any new information. The fourth and most complex CNF file, however, did yield different results for the algorithm with or without restarts. The statistical analysis, seen in Table 2, was unfortunately still inconclusive. The null hypothesis was accepted, meaning the variation for both versions of the algorithm were too high to say conclusively if one algorithm was better than another.

CNF File 4		
	Norm.	Restarts.
Mean	1048.5667	1049.367
Variance	9.4264	12.1713
Observ.	30	30
F	0.7745	
F Critical	0.5374	
t Stat	-0.9429	
t Crit.	2.0017	

Table 2: Shown above is the statistical analysis of the normal EA versus the EA with r-elitist restarts enabled. Since the t Stat was not larger than the Two-Tailed t Crit value, the null hypothesis was accepted. This means the information is not conclusive, and it cannot be said that one algorithm is more efficient than another.

(c) The third objective was to compare how use of both the self-adapting parameter and the r-elitist restarts affected the performance of the algorithm. The statistical analysis for this question was performed only on the data collected from experiments on the most complex of the CNF files, CNF file 4. Because the solution was more complex to find, analysis on this data would be the most representative of the algorithm's performance. Table 3 shows the statistical analysis comparing the use of the self-adaptive parameter and r-elitist restarts in combination with one another.

When comparing the use of just the adaptive parameter to the use of just r-restarts, it was found that the r-restarts were more efficient at finding the best solution. It can be hypothesized that this is for the same reasons given in part (a) of this conclusion.

When comparing using both r-restarts and the self-adaptive parameter to using just the self-adaptive parameter, it was shown that using both was more efficient. The author hypothesizes that this may be because each time the population was r-restarted, new individuals assigned with uniform crossover recombination would be created. This would allow some individuals with this type of recombination to be present while the population was near convergence, raising the overall efficiency of the algorithm.

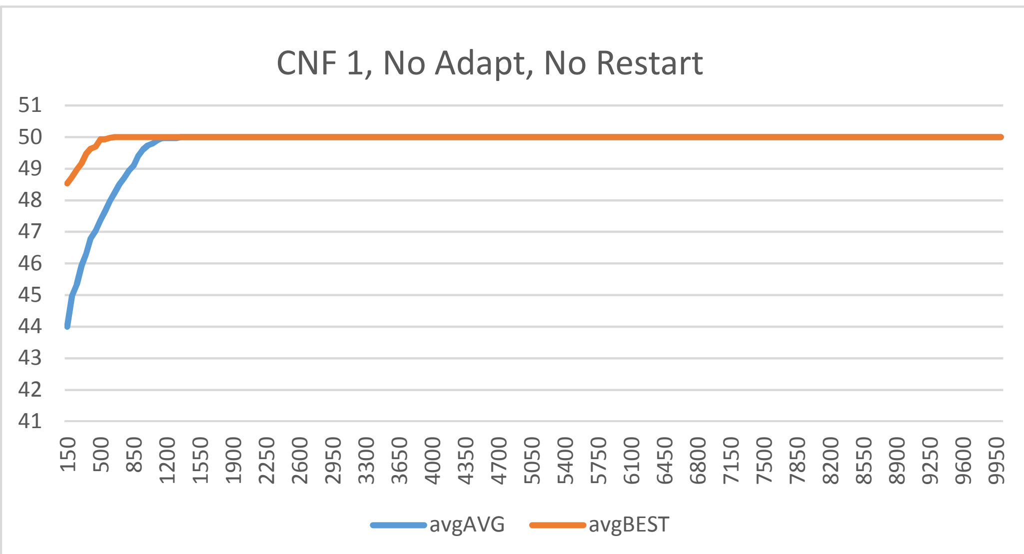
When comparing use of r-restarts to using both r-restarts and the self-adaptive parameter, it was shown that the algorithm performed better when only the r-restarts were used. The author hypothesizes this is for the same reason as described in part (a) of this conclusion.

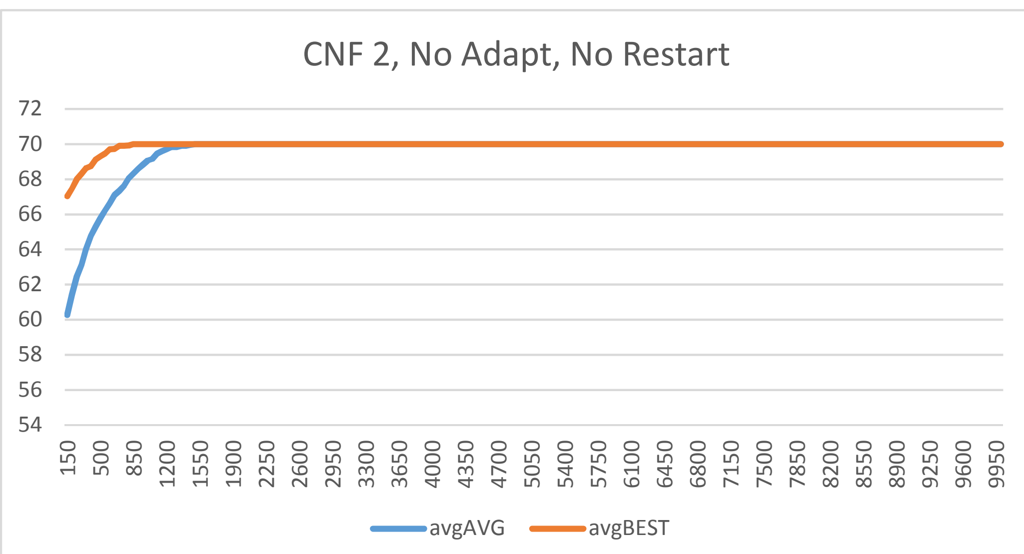
Adapting vs Restarting			Adapting vs Both			Restarting vs Both		
	Adapt.	Restart		Adapt.	Both		Restart	Both
Mean	1000.9	1049.4	Mean	1000.9	1005.8	Mean	1049.4	1005.8
Variance	38.051	12.171	Variance	38.051	52.557	Variance	12.171	52.557
Observ.	30	30	Observ.	30	30	Observ.	30	30
F	3.1263		F	0.7250		F	0.2316	
F Critical	1.8608		F Critical	0.5374		F Critical	0.5374	
t Stat	-37.4849		t Stat	-2.8579		t Stat	29.6370	
t Crit.	2.0017		t Crit.	2.0017		t Crit.	2.0017	

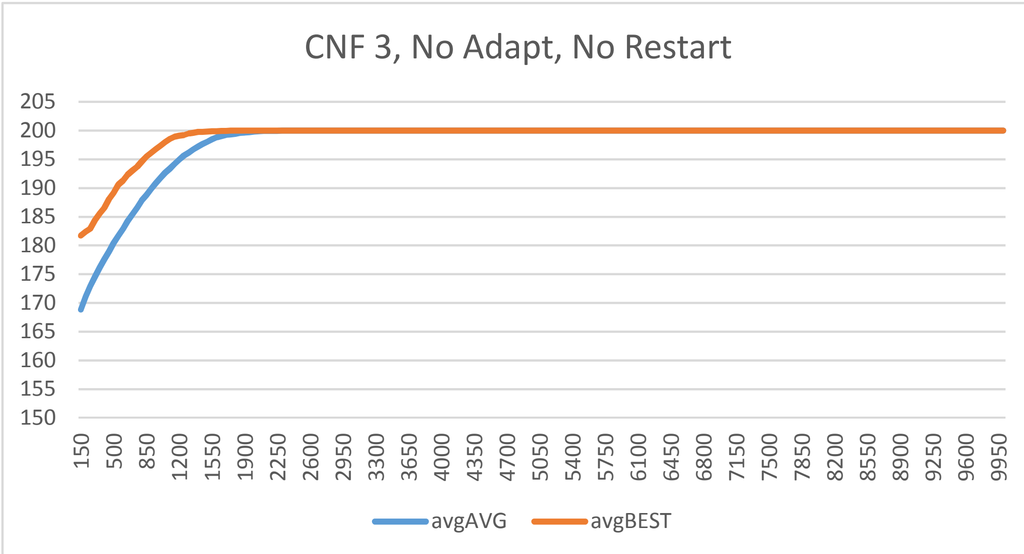
Table 3: Shown in this table is the statistical comparison between the use of self-adaptation, r-elitist restarts, and combinations of the two.

APPENDIX A: Data Graphs

In this appendix is each graph for each of the 16 experiments. The title of each graph shows which CNF file was tested on, and whether self-adaptation, r-restarts, or both was used in the experiment. The horizontal axis of each graph refers to the number of evaluations that have been exicuted, and the veritcal axis refers to the fitness. The orange line indicates the average best individual's fitness, and the blue line indicates the average average individual's fitness.






CNF 3, No Adapt, No Restart
205
200
195
190
185
180
175
170
165
160
155
150
150
500
850
1200
1550
1900
2250
2600
2950
3300
3650
4000
4350
4700
5050
5400
5750
6100
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6800
7150
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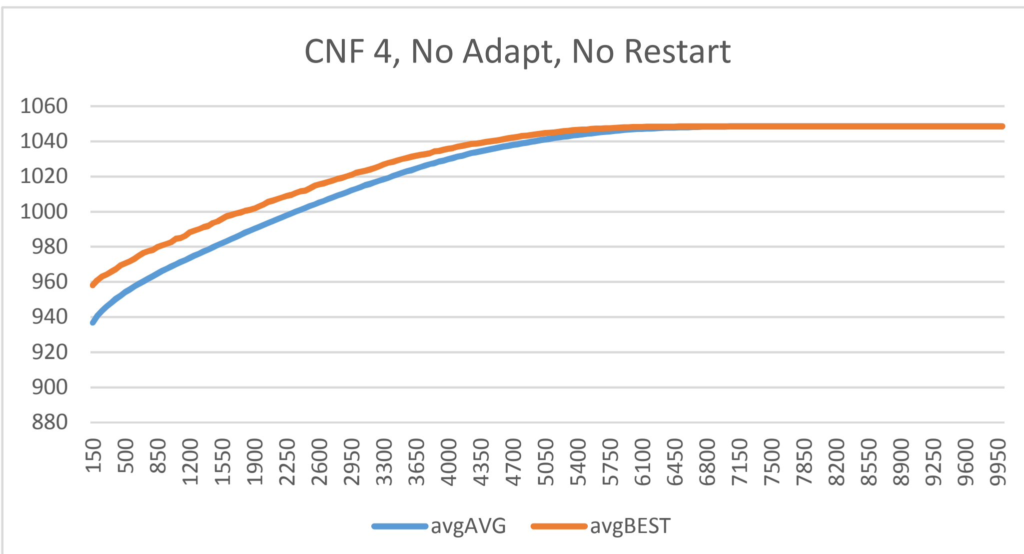
7850
8200
8550
8900
9250
9600
9950
avgAVG
avgBEST


CNF 4, No Adapt, No Restart
1060
1040
1020
1000
980
960
940
920
900
880
150
500
850
1200
1550
1900
2250
2600
2950
3300
3650
4000
4350
4700
5050
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9250
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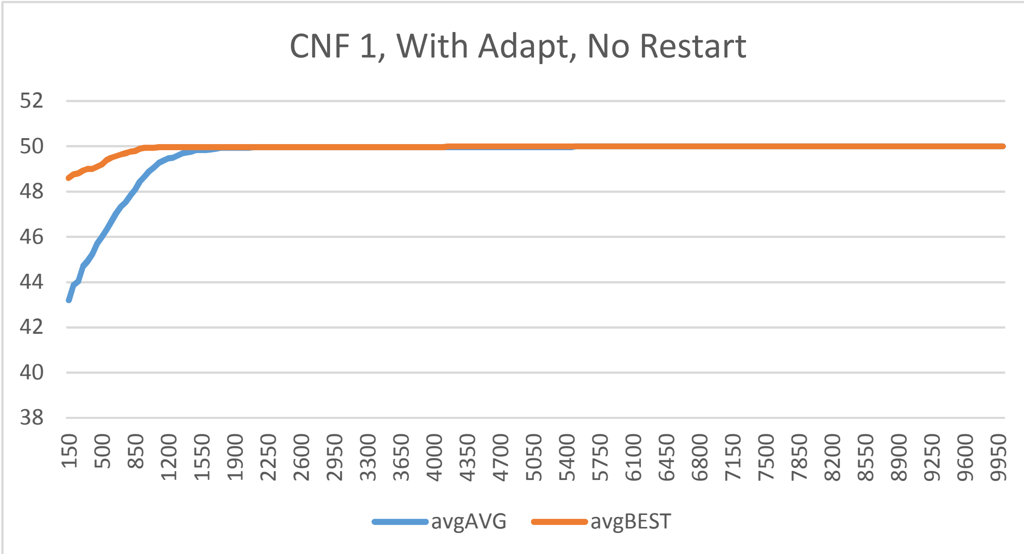
9950
avgAVG
avgBEST


CNF 1, With Adapt, No Restart
52
50
48
46
44
42
40
38
150
500
850
1200
1550
1900
2250
2600
2950
3300
3650
4000
4350
4700
5050
5400
5750
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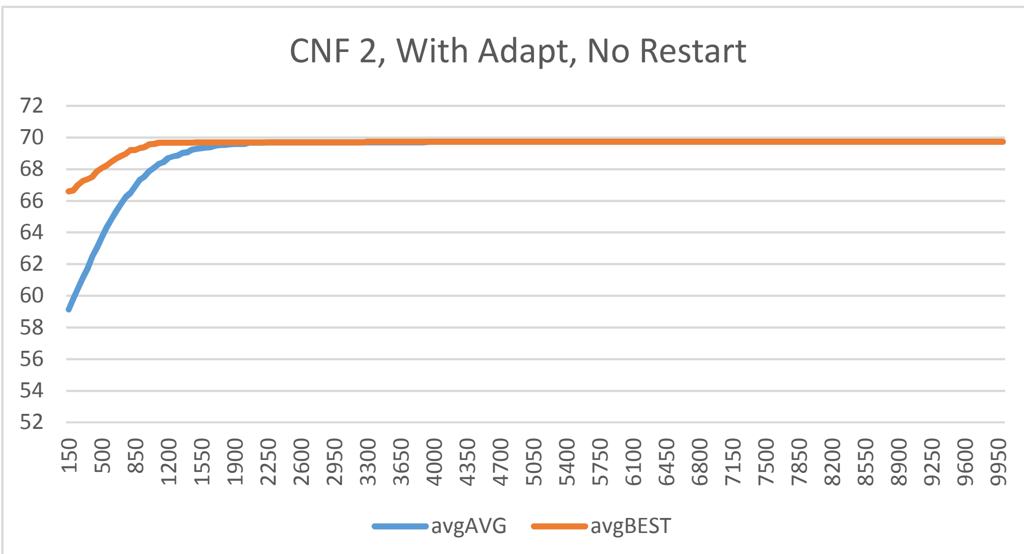
9250
9600
9950
avgAVG
avgBEST


CNF 2, With Adapt, No Restart
72
70
68
66
64
62
60
58
56
54
52
150
500
850
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1900
2250
2600
2950
3300
3650
4000
4350
4700
5050
5400
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9250
9600
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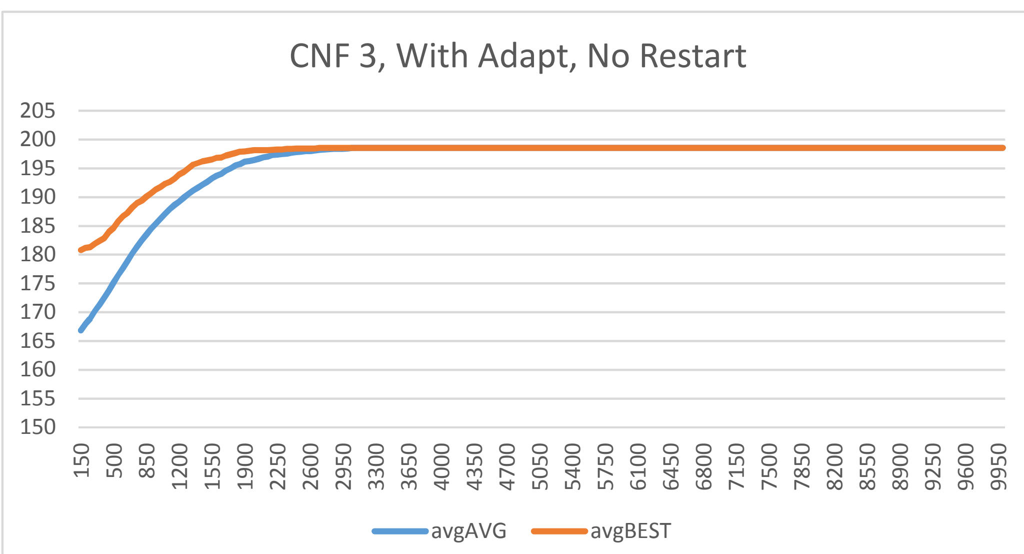
avgAVG
avgBEST


CNF 3, With Adapt, No Restart
205
200
195
190
185
180
175
170
165
160
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1550
1900
2250
2600
2950
3300
3650
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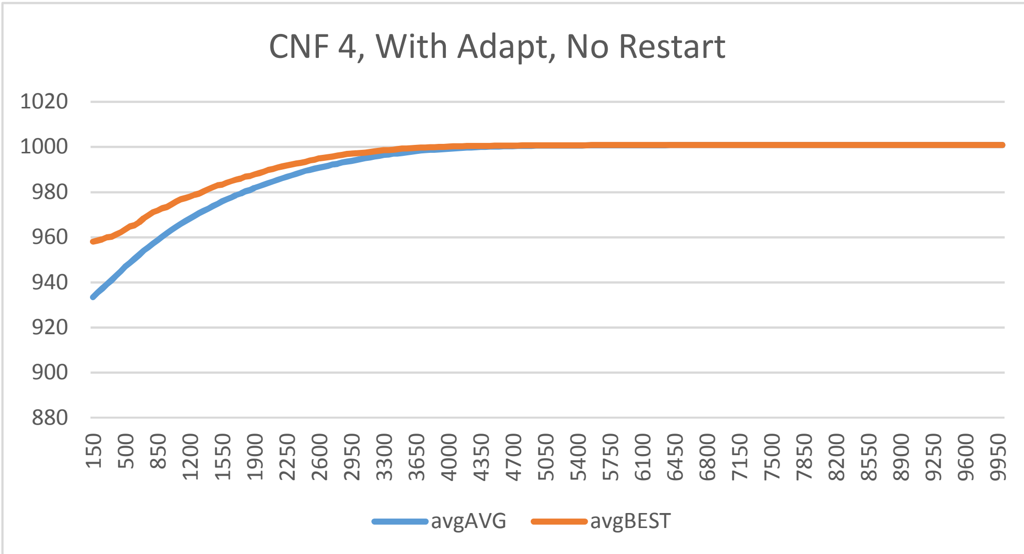
avgAVG
avgBEST



CNF 4, With Adapt, No Restart
1020
1000
980
960
940
920
900
880
150
500
850
1200
1550
1900
2250
2600
2950
3300
3650
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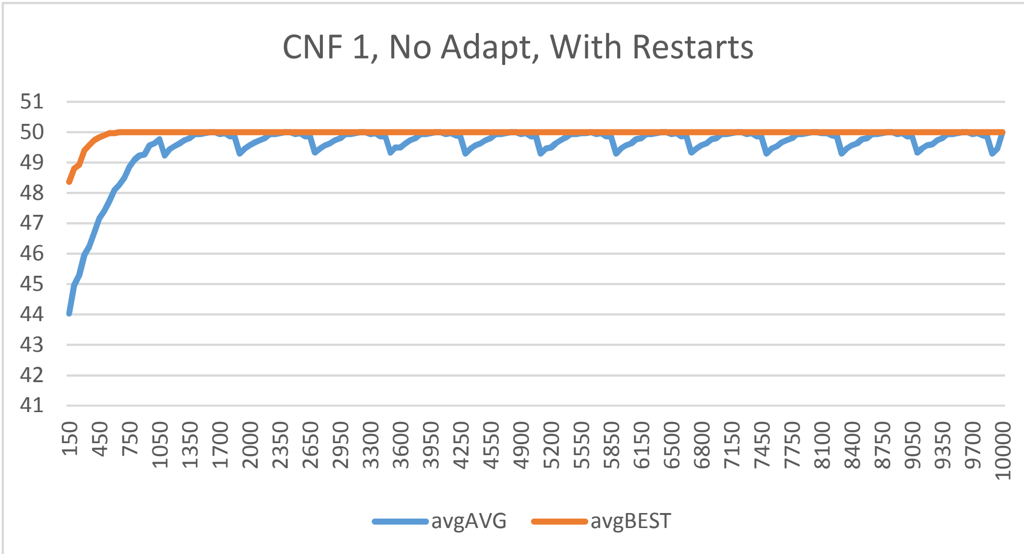
avgAVG
avgBEST


CNF 1, No Adapt, With Restarts
51
50
49
48
47
46
45
44
43
42
41
150
450
750
1050
1350
1700
2000
2350
2650
2950
3300
3600
3950
4250
4550
4900
5200
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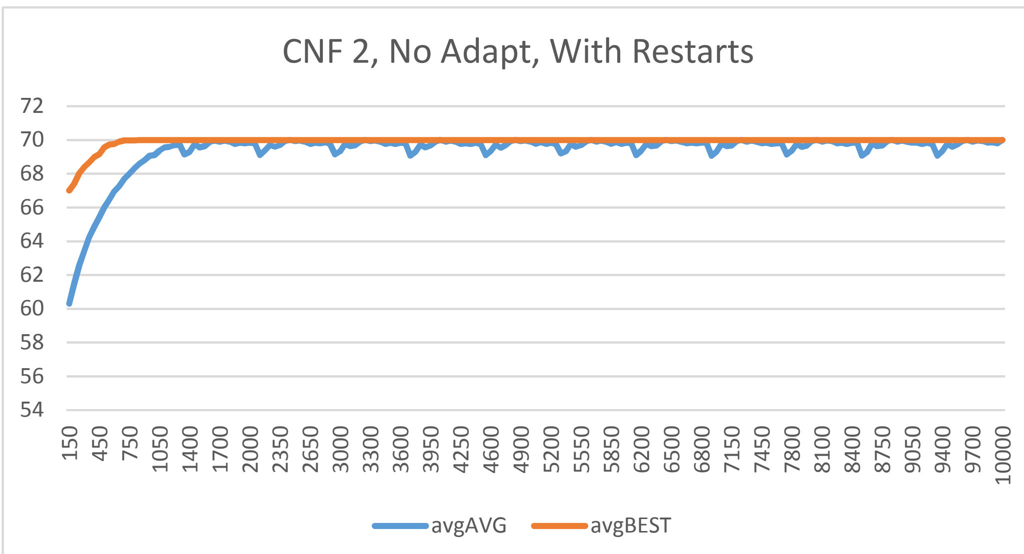
10000
avgAVG
avgBEST


CNF 2, No Adapt, With Restarts
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70
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62
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2000
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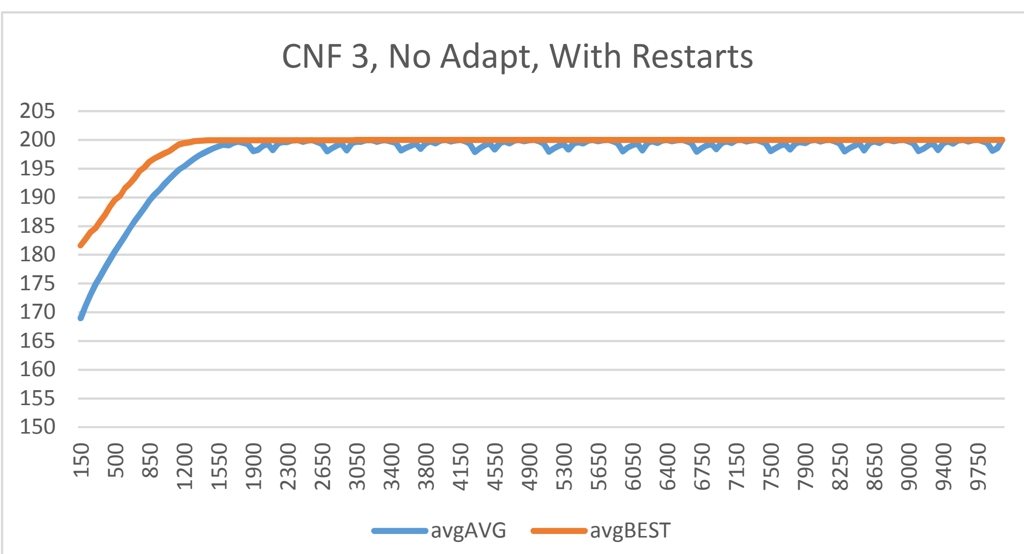
avgAVG
avgBEST


CNF 3, No Adapt, With Restarts
205
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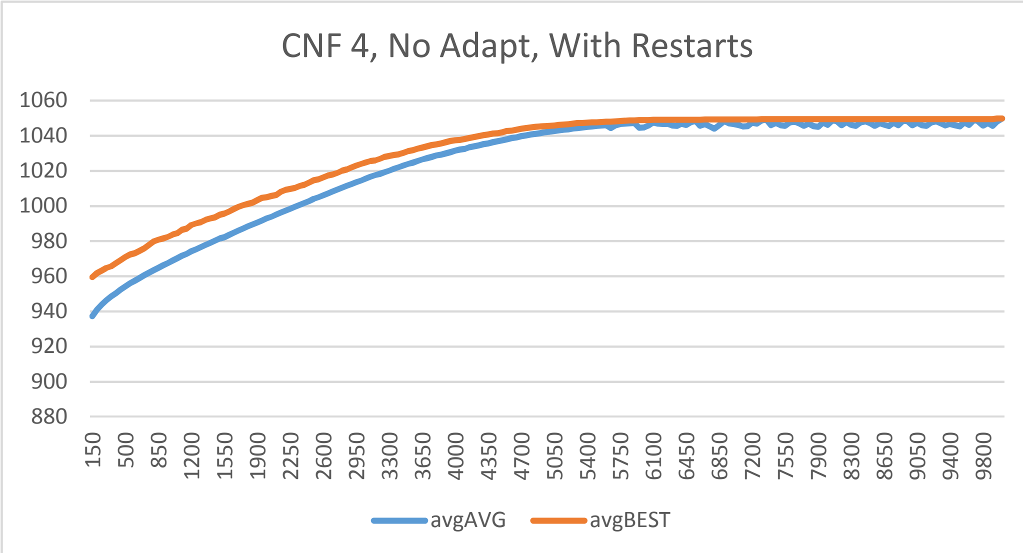
CNF 4, No Adapt, With Restarts
1060
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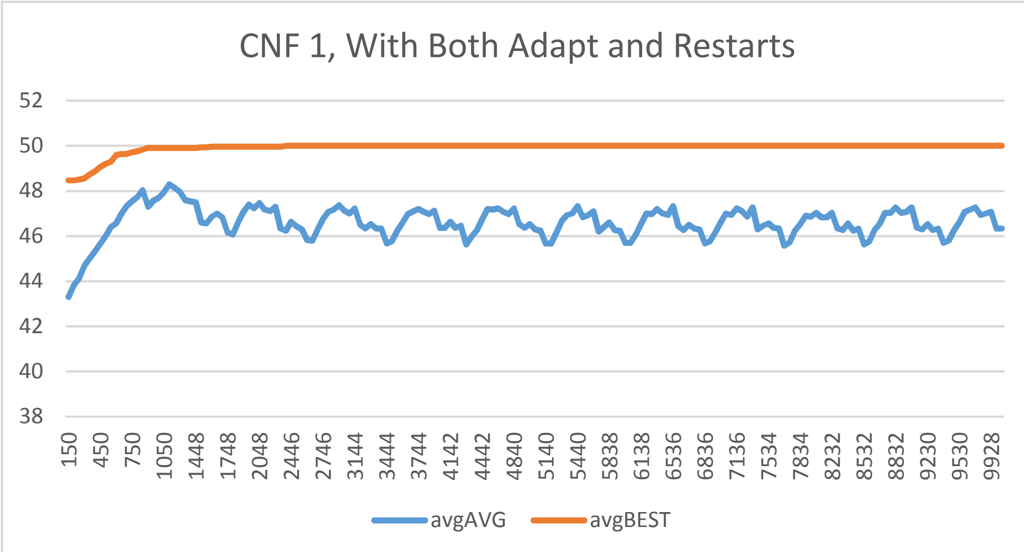
avgAVG
avgBEST


CNF 1, With Both Adapt and Restarts
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2446
2746
3144
3444
3744
4142
4442
4840
5140
5440
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9230
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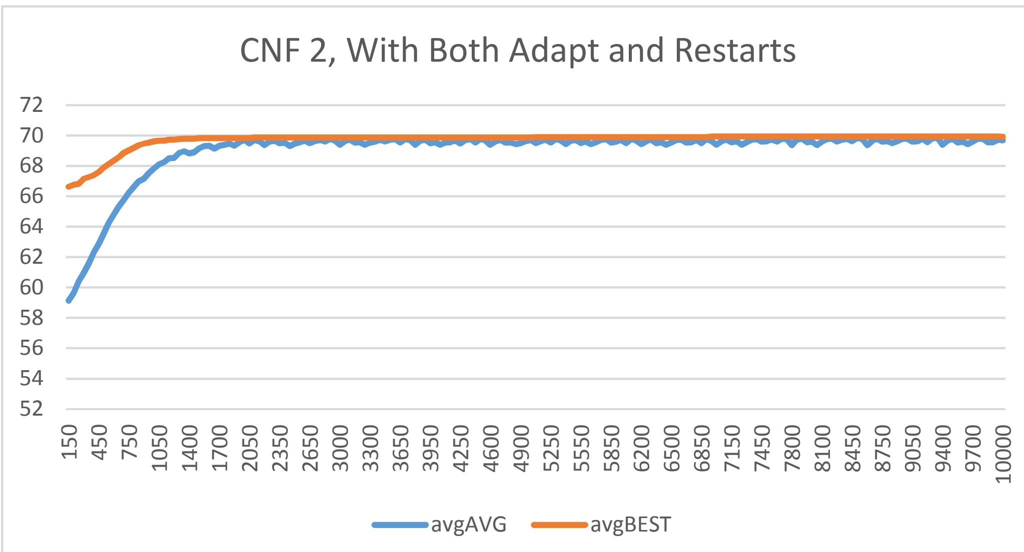
avgAVG
avgBEST


CNF 2, With Both Adapt and Restarts
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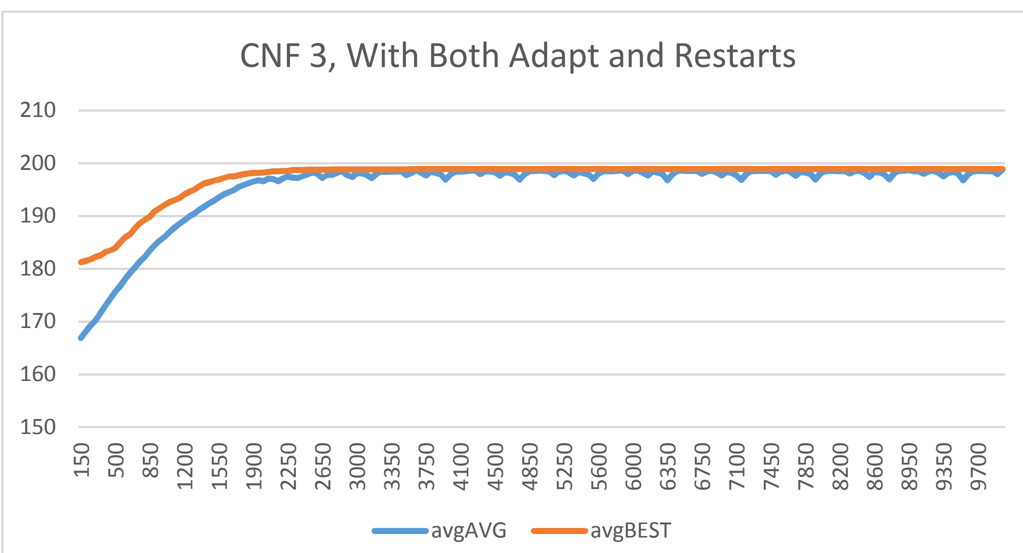
avgBEST


CNF 3, With Both Adapt and Restarts
210
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190
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170
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1550
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3350
3750
4100
4500
4850
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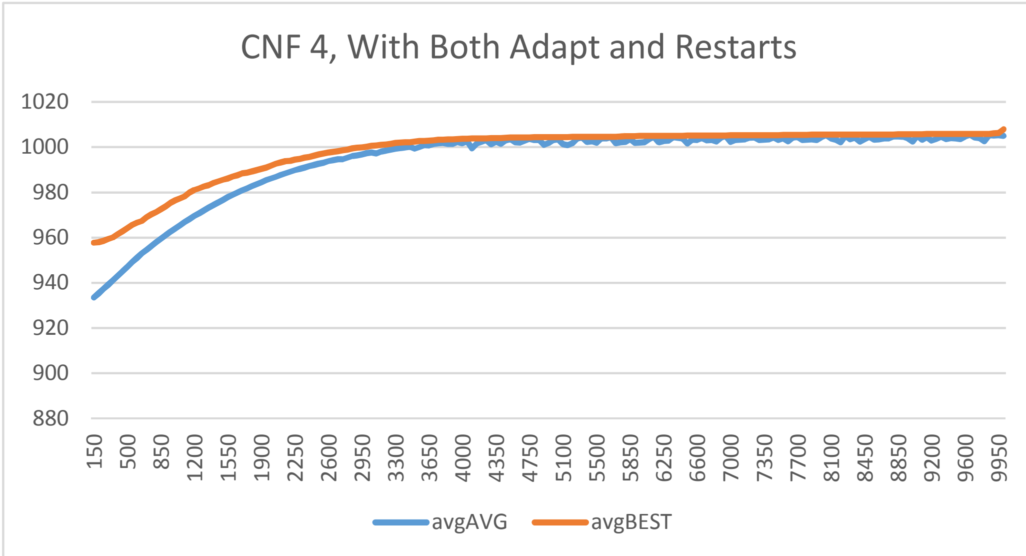
avgAVG
avgBEST


CNF 4, With Both Adapt and Restarts
1020
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2950
3300
3650
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5850
6250
6600
7000
7350
7700
8100
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8850
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9600
9950
avgAVG
avgBEST