The American University in Cairo

A Simple Simulated-Annealing Cell Placement Tool

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Digital Design II

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1. *Introduction*

Simulated Annealing is a stochastic global search optimization algorithm, used for resolving both bound, and unconstrained optimization issues. The technique mimics the physical procedure of raising a material's temperature and then gradually decreasing it to reduce flaws while conserving as little energy as possible in the process. The simulated annealing process generates a new point at random points, after each repetition. Based on a probability distribution scale, proportional to the temperature, the new point's separation from the present point, or the

scope of the search is determined. All new points that reduce the target are accepted by the algorithm, but the points that raise the objective are also accepted, but with a fixed probability. Accepting points that raise the objective allows the algorithm to search globally for a higher potential of finding solutions that do not keep the algorithm stuck in a local minima. To gradually lower the temperature while the algorithm runs, an annealing schedule is used. The said algorithm is used to narrow down the scope of its search as the temperature drops. The main aim of doing this is in order to converge towards the minimum.

2. *Problem Definition*

The aim of the optimization is to reduce the half-perimeter of the smallest bounding box that contains all of the pins for each net, added together for all nets. Each cell in a circuit is given a specific position by the device. Create a straightforward placer based on simulated annealing that reduces the overall wirelength. There was also a need to research the effect of different cooling rates. This is a version of a tool for placing standard cells during simulated annealing.

3. *Algorithm*

The coming lines are to explain the overall algorithm used, and our logic behind illustrated implementations, which performs a number of steps. Starting with, the algorithm begins to generate a random point of trial. A probability distribution with a scale dependent on the current temperature is used by the algorithm to select the trial point's separation from the present point. The algorithm generates the trial point, and if necessary, moves it to stay inside boundaries. Each infeasible element of the trial point is shifted by the algorithm to a value that is uniformly selected at random between the bound that was broken and the value that was - feasible - in the previous iteration. Whether the new point is superior to or inferior to the existing point is determined by the algorithm. Becomes the next point if the new point is superior to the one that comes before it. Even though the new point is inferior to the existing point, the algorithm may nevertheless choose it as the next point. Based on an acceptance function, the algorithm accepts a poorer point. The probability of acceptance algorithm is then used, where delta, and T are kept positive; between the values 0, and half, the smaller temperature results in a lower likelihood of acceptance, while greater temperature results in a lower acceptance probability. The algorithm, then, gradually reduces the temperature while storing the current optimal point, and hence, updating the temperature.

4. *Code*

Our code performs a number of functions; parsing, random placement, wire length calculation, swapping, and updating, based on calculating, and comparing. We also have a number of assumptions;

1) HPWL (half-perimeter of the smallest bounding box containing all pins for a net) is used to estimate the wirelength of any net
2) The core area is an 2D array of empty squares (sites)
3) Each cell is a square and matches the site size.
4) The site size is 1x1.
5) No site is assigned more than one cell.
6) The distance between two cells is measured from the center of one cell to the center of the other.

Used functions are a) initial_random_placement, b) swap_cells, c) simulated_annealing_placer, and d) allocating class, and e) HPWL f) dispplay_result

a) initial_random_placement:

This function is used to apply the random placement needed, using the greedy algorithm, to assign cells random grid locations. It picks a random cell, and applies random iterative improvement. First, picks two random cells, swaps their locations and evaluate the change in total wirelength. If total wirelength got smaller, then swap is accepted, else, swap is undone. This is repeated until the wirelength stops improving.

b) swap_cells:

The swap_cells performs the actual swapping function that was mentioned, and explained above in initial_random_placement.

c) simulated_annealing_placer:

The main idea behind this function is to create an initial random placement of the initial temperature; very high temp, where while T is more than Tfinal, the code picks 2 random cells, and swaps them, and calculates the change in the wire length (ΔL). Due to the swap, if the change in the wire length is less than 0, then this is accepted, else, reject. Used probability is (1 - e-ΔL/T). Used initial temperature is 500 * initial cost, and final temperature is 5 * 10^-6. The rate of cooling is 0.95 * temperature.

d) allocating class:

This class initializers the cells, the connected wires, the rows, and columns on our tracks, or the grid. It also contains the vector 'cell', which took the datatype int, and its mapping.

e) HPWL:

This function is used using HPWL as an estimating factor, put a bounding box then add, representing the width and the height. The code then loops among the wires, and from within, loops onto the size of all wires in order to finally return the half-perimeter wire length. This is done using the minimum, and maximum values calculated of x, and y.

f) display_result

We displayed the results of the grid.

5. Implementation, and Results

D0:

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

Total Wire Length vs Cooling rates:

*graphs in excel sheet

0.7

```
the initial random placement
13 1 -1 9 -1 5 6 0
16 22 19 18 15 14 -1 -1
-1 -1 12 23 17 3 8 7
4 2 -1 11 20 10 -1 21
the inital total wire length is: 84
the new TWL 39
the display in 0's and 1's
1 0 0 0 0 0 1 1
1 0 0 0 0 0 1 1
0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 1
annealing done
```

0.75

```
the initial random placement
20 12 0 3 14 5 9 2
11 -1 19 18 -1 15 21 13
23 16 6 17 1 -1 -1 22
8 -1 4 10 7 -1 -1 -1
the inital total wire length is: 86
the new TWL 39
the display in 0's and 1's
1 1 0 0 0 0 1 1
1 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0
annealing done
```

0.8

```
the initial random placement
9 6 15 19 -1 17 4 -1
-1 13 7 18 21 -1 -1 16
23 10 5 -1 11 12 0 22
14 2 3 -1 20 8 -1 1
the inital total wire length is: 91
the new TWL 36
the display in 0's and 1's
1 0 1 0 0 0 1 1
0 0 0 0 0 0 1 1
0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 1
annealing done
```

0.85

```
the initial random placement
-1 21 -1 10 7 8 2 -1
4 9 15 -1 19 -1 -1 5
11 -1 1 13 3 14 20 22
18 0 -1 16 17 12 6 23
the inital total wire length is: 86
the new TWL 40
the display in 0's and 1's
1 1 1 0 0 0 0 0
1 1 0 0 0 0 0 0
1 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0
annealing done
```

0.9

```
the initial random placement
10 17 20 16 15 3 2 8
13 7 1 -1 -1 -1 -1 0
21 -1 -1 4 -1 11 23 9
12 14 6 5 18 19 22 -1
the inital total wire length is: 93
the new TWL 39
the display in 0's and 1's
1 0 1 0 1 0 0 1
1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 0 1 0 0 1 0 0
annealing done
```

0.95

```
the initial random placement
16 9 23 7 17 14 -1 8
-1 22 3 18 21 5 13 -1
-1 6 1 10 -1 20 4 -1
12 19 -1 -1 15 2 0 11
the inital total wire length is: 97
the new TWL 37
the display in 0's and 1's
1 0 1 0 0 0 1 1
1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 1 0 1 1
annealing done
```

0.97

```
the initial random placement
21 11 15 12 18 1 -1 -1
9 -1 -1 7 17 4 -1 8
10 22 14 3 19 -1 -1 0
-1 23 5 13 16 20 6 2
the inital total wire length is: 92
the new TWL 38
the display in 0's and 1's
1 0 0 0 0 0 1 1
0 0 0 0 0 0 1 1
0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 1
annealing done
```

D1:

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

Total Wire Length vs Cooling rates:

*graphs in excel sheet

0.7

```
the initial random placement
21 -1 -1 0 5 20 6 17
32 14 26 15 7 23 -1 3
9 2 16 11 28 10 31 29
-1 33 35 1 27 34 12 24
8 30 22 13 19 18 25 4
the inital total wire length is: 170
the new TWL 76
the display in 0's and 1's
1 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0
annealing done
```

0.75

```
the initial random placement
10 18 35 30 23 31 13 -1
19 2 3 -1 28 22 29 24
8 14 25 27 34 4 -1 0
-1 21 12 5 1 26 20 17
9 32 6 16 7 11 15 33
the inital total wire length is: 158
the new TWL 71
the display in 0's and 1's
1 0 0 1 0 0 0 1
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
annealing done
```

0.8

```
the initial random placement
2 3 14 6 4 18 30 9
28 7 19 26 -1 20 23 13
24 25 -1 -1 -1 16 0 34
32 5 31 8 33 1 27 22
17 21 15 10 11 12 35 29
the inital total wire length is: 193
the new TWL 68
the display in 0's and 1's
1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0
annealing done
```

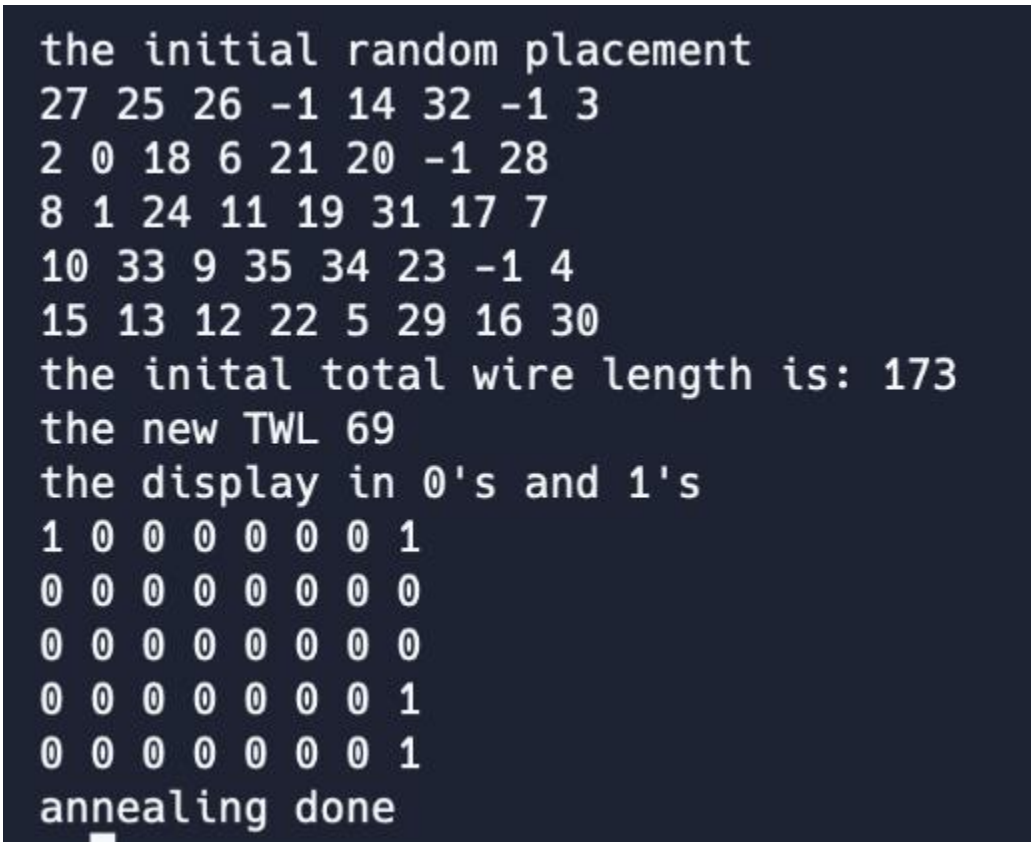
0.85

```
the initial random placement
20 7 23 14 9 -1 11 1
5 33 29 18 34 4 -1 28
2 -1 19 12 6 31 16 24
13 35 22 15 27 3 21 32
26 -1 10 17 25 8 0 30
the inital total wire length is: 155
the new TWL 67
the display in 0's and 1's
1 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 1
annealing done
```

0.9

```
the initial random placement
2 17 16 4 -1 24 -1 21
14 26 1 6 19 3 12 25
30 -1 29 33 11 -1 23 18
5 35 31 13 10 8 27 32
22 7 34 9 15 0 28 20
the inital total wire length is: 194
the new TWL 68
the display in 0's and 1's
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 1
annealing done
```

0.95


the initial random placement
27 25 26 -1 14 32 -1 3
2 0 18 6 21 20 -1 28
8 1 24 11 19 31 17 7
10 33 9 35 34 23 -1 4
15 13 12 22 5 29 16 30
the inital total wire length is: 173
the new TWL 69
the display in 0's and 1's
1 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 1
annealing done

0.97

```
the initial random placement
10 21 -1 29 35 34 25 9
31 13 27 0 5 14 4 -1
17 20 32 26 12 15 8 23
19 -1 3 18 16 22 7 24
33 30 11 -1 2 1 6 28
the inital total wire length is: 182
the new TWL 66
the display in 0's and 1's
1 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 1
annealing done
```

D2:

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

Total Wire Length vs Cooling rates:

*graphs in excel sheet

0.7

```
the initial random placement
164 224 79 152 18 74 130 85 9 90 251 243 80 170 67 16 155 -1 174 229
138 99 191 134 29 143 -1 252 24 -1 210 52 182 246 34 137 123 77 133 114
236 84 22 204 25 146 166 168 214 12 162 235 179 254 135 106 212 48 98 -1
240 223 119 35 239 91 209 100 109 94 50 193 82 142 42 40 -1 225 220 -1
-1 31 55 59 -1 -1 111 110 47 -1 78 60 101 127 -1 -1 49 92 258 30
190 202 222 -1 -1 66 176 180 112 120 192 -1 102 163 10 -1 172 161 249 140
36 139 27 -1 216 -1 195 160 184 144 -1 72 -1 208 200 0 145 96 198 108
46 215 73 211 17 171 175 136 169 15 226 241 186 148 232 63 244 248 4 6
103 11 23 257 199 56 51 151 234 68 -1 76 -1 201 53 37 159 93 203 206
187 157 62 121 -1 250 141 8 -1 118 189 -1 86 43 205 122 1 54 129 38
221 156 20 147 116 150 5 61 185 247 173 -1 14 227 230 253 71 81 32 117
95 178 39 245 -1 89 75 181 7 -1 64 107 57 21 -1 41 256 45 196 153
132 131 -1 -1 158 125 115 183 237 87 238 -1 70 207 3 219 65 -1 213 259
-1 2 194 69 231 13 149 19 33 -1 44 -1 218 97 128 154 -1 126 197 242
233 26 177 -1 217 188 165 -1 113 255 105 228 83 88 -1 124 104 167 28 58
the inital total wire length is: 4053
the new TWL 1291
the display in 0's and 1's
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 1 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1
1 1 0 1 1 0 0 0 0 1 0 0 0 0 0 1 1 0 1 0
annealing done
```

0.75

```
the initial random placement
36 145 149 219 5 234 88 -1 237 255 32 49 156 50 -1 83 -1 47 93 121
8 142 248 257 40 -1 254 35 38 136 -1 97 183 139 124 133 -1 201 54 233
15 2 251 70 73 117 -1 57 115 173 7 243 217 214 211 250 100 200 -1 102
165 169 58 41 125 59 128 78 147 53 72 105 3 146 16 163 -1 177 116 220
106 -1 127 181 222 193 236 148 231 189 157 60 241 -1 158 23 29 224 167 86
122 130 75 10 12 227 150 212 207 46 123 34 69 171 198 87 66 190 180 209
-1 112 208 99 230 94 247 258 187 216 160 197 21 51 111 144 84 228 129 238
-1 64 137 27 56 67 14 -1 22 170 20 182 174 89 206 68 92 0 1 -1
-1 240 259 42 253 210 25 154 141 62 19 61 246 118 98 155 -1 132 -1 77
196 225 -1 235 65 -1 63 -1 252 185 172 249 85 -1 191 91 6 -1 52 11
-1 178 -1 204 -1 48 -1 45 166 71 114 96 4 175 192 119 17 179 81 109
-1 152 26 13 184 213 202 76 -1 244 226 39 205 -1 131 9 104 24 143 43
223 107 37 -1 176 -1 138 168 159 -1 126 232 -1 256 140 -1 135 80 90 218
18 -1 31 151 101 95 134 82 113 195 55 161 242 28 162 239 153 79 110 108
-1 215 164 186 120 74 199 229 -1 203 188 33 245 221 103 44 30 194 -1 -1
the inital total wire length is: 3792
the new TWL 1336
the display in 0's and 1's
1 1 1 1 0 1 0 0 0 1 1 0 0 0 0 1 0 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
annealing done
```

0.8

```
the initial random placement
183 64 38 -1 116 161 214 178 120 145 73 147 -1 207 203 119 133 129 -1 62
225 63 242 41 7 127 202 22 -1 74 148 6 247 78 35 256 -1 18 -1 99
230 12 60 24 65 -1 70 155 201 23 9 17 165 87 258 219 93 0 222 126
218 40 -1 -1 220 -1 236 16 3 197 8 159 52 67 185 96 226 -1 14 89
224 42 -1 26 143 94 20 241 51 -1 -1 103 59 -1 11 101 149 81 33 79
122 121 208 141 27 189 114 111 153 49 82 29 204 28 163 182 -1 108 48 92
109 -1 39 257 146 10 25 -1 112 168 -1 154 113 184 137 15 47 228 -1 -1
216 128 98 209 118 125 200 19 -1 210 124 198 132 192 170 88 246 -1 95 -1
100 227 68 45 110 217 -1 -1 181 13 131 174 54 57 254 243 144 31 221 2
205 152 157 212 53 166 251 206 231 -1 85 136 -1 232 167 171 34 234 -1 58
-1 151 253 102 91 139 239 138 213 160 237 215 66 259 71 235 -1 162 117 107
158 175 37 104 134 72 -1 187 169 250 196 164 190 150 43 177 32 223 238 211
188 55 115 56 83 -1 249 194 179 46 252 240 255 106 77 173 80 130 -1 180
-1 -1 176 30 195 -1 123 76 142 -1 199 50 140 229 -1 21 61 36 193 84
186 86 1 233 44 191 156 172 69 248 5 90 4 105 135 245 97 244 -1 75
the inital total wire length is: 3916
the new TWL 1257
the display in 0's and 1's
1 1 0 1 1 1 1 0 0 0 0 0 0 0 1 0 0 1 0 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 1 1
0 0 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 1 1
annealing done
```

0.85

```
the initial random placement
59 17 95 -1 141 61 163 212 8 123 114 220 46 -1 245 -1 170 47 171 18
152 144 225 85 91 16 64 194 199 214 201 31 191 187 69 185 155 13 148 81
222 51 196 249 128 -1 53 202 125 20 -1 50 165 239 228 115 247 193 246 34
156 223 -1 139 101 23 -1 119 238 174 200 103 251 4 213 132 82 215 186 54
134 241 146 -1 161 -1 -1 71 110 149 97 60 151 86 14 74 117 29 230 197
190 -1 173 168 157 99 150 259 -1 76 -1 235 -1 106 147 206 49 -1 107 -1
-1 94 62 83 135 -1 133 66 184 28 11 -1 -1 127 80 178 58 109 37 -1
219 166 254 -1 98 236 153 33 48 129 55 25 75 7 42 -1 154 224 162 209
57 159 88 217 1 130 67 10 -1 102 65 216 2 145 256 143 167 232 6 203
90 12 -1 84 137 175 122 179 118 15 182 -1 234 5 -1 -1 257 -1 227 116
36 237 0 19 89 63 77 124 244 105 169 32 183 218 160 27 -1 242 43 30
35 96 70 40 73 210 231 93 138 192 208 136 -1 104 100 68 108 180 -1 252
172 -1 181 250 72 44 188 22 258 221 207 140 198 226 126 3 111 255 211 113
253 131 -1 -1 56 39 205 -1 158 243 121 177 120 189 9 229 79 248 45 78
164 195 176 204 142 112 -1 -1 -1 26 240 24 41 52 21 38 87 233 92 -1
the inital total wire length is: 3888
the new TWL 1267
the display in 0's and 1's
0 1 0 1 0 0 0 0 0 1 1 0 1 0 1 0 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0
1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 1 1 0 0 0
annealing done
```

0.9

```
the initial random placement
117 189 66 -1 28 -1 29 106 170 24 -1 176 249 -1 247 178 47 48 128 119
179 130 140 197 39 20 143 -1 175 253 -1 51 216 233 0 125 79 224 254 74
60 177 57 19 113 188 193 25 223 98 70 73 258 231 109 199 112 243 230 190
82 135 93 185 220 -1 -1 -1 200 14 139 122 123 68 183 198 235 -1 250 5
126 182 232 147 201 236 37 136 211 43 218 213 245 -1 234 157 203 103 252 227
124 167 184 59 -1 -1 8 -1 145 52 16 94 148 186 166 55 92 -1 -1 155
153 207 214 41 240 90 -1 248 4 96 45 -1 194 225 83 71 146 27 62 187
158 78 241 118 142 164 13 196 31 191 -1 -1 159 3 239 173 221 -1 21 204
-1 210 22 174 50 65 89 257 -1 217 33 76 229 116 114 -1 17 -1 -1 7
212 54 244 226 91 -1 -1 163 180 195 238 100 127 181 108 80 102 104 -1 75
18 141 246 97 23 144 255 77 81 209 132 138 35 172 129 38 10 222 192 251
2 40 120 32 -1 64 137 160 99 149 110 26 151 95 215 -1 206 115 134 205
-1 131 85 228 219 208 165 259 86 49 44 61 -1 6 -1 242 56 -1 9 11
237 161 107 152 121 171 34 -1 58 105 -1 30 67 88 46 111 -1 87 202 72
156 15 42 69 12 154 168 133 53 63 -1 1 101 256 36 84 -1 150 162 169
the inital total wire length is: 3963
the new TWL 1189
the display in 0's and 1's
1 1 0 0 0 0 1 1 1 1 1 0 1 1 1 1 0 0 1 1
1 1 1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 1 0 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 1
annealing done
```

0.95

```
the initial random placement
90 43 58 149 29 121 244 89 249 -1 230 164 48 30 10 174 21 -1 87 101
255 117 -1 213 -1 100 245 194 -1 152 104 148 32 84 224 178 197 131 147 115
234 1 247 167 126 134 138 -1 50 113 26 182 14 183 191 203 221 46 20 211
232 246 154 -1 231 201 190 122 132 35 110 170 41 140 229 -1 -1 215 176 -1
-1 74 118 189 150 86 7 125 64 209 208 -1 238 226 44 4 -1 57 144 200
11 223 243 -1 5 75 253 258 81 175 -1 106 37 220 161 145 -1 70 61 -1
-1 155 257 233 240 102 9 59 65 129 66 -1 80 96 99 187 -1 -1 252 19
156 12 0 218 195 54 63 198 250 98 128 239 210 199 181 242 227 185 53 83
173 -1 207 143 68 188 22 -1 214 146 88 103 180 76 -1 79 124 139 28 69
2 168 114 13 77 228 27 -1 -1 24 123 141 192 73 17 137 94 47 8 71
45 15 40 256 -1 193 111 36 165 78 217 97 136 179 31 -1 109 157 196 92
-1 67 -1 -1 153 184 91 85 39 216 55 -1 -1 241 151 142 251 25 42 259
166 206 177 52 237 62 6 -1 212 119 135 254 23 -1 72 127 248 82 95 159
202 205 225 -1 169 49 120 16 -1 112 18 158 171 38 93 130 172 235 186 204
116 236 160 -1 133 108 33 34 -1 219 51 163 107 -1 3 105 56 222 60 162
the inital total wire length is: 3925
the new TWL 1139
the display in 0's and 1's
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 1 1 0 0 0 0 0 1 0 0 0 1 0 1 1 1 1 1
annealing done
```

0.97

```
the initial random placement
-1 104 108 256 57 -1 77 165 182 55 50 45 0 223 -1 169 134 85 178 61
193 -1 109 92 230 155 180 78 172 -1 177 -1 59 75 98 80 189 233 38 101
44 127 136 146 202 70 83 226 9 -1 -1 148 234 190 51 164 259 216 32 205
219 218 110 -1 231 154 -1 106 -1 -1 143 254 -1 -1 166 238 215 64 -1 26
179 13 197 168 129 74 131 18 1 -1 241 69 82 103 -1 100 125 228 220 114
240 149 243 224 66 84 198 -1 56 53 151 135 65 -1 93 -1 95 118 176 34
174 162 33 16 22 229 126 97 187 76 -1 138 20 232 153 251 -1 111 72 7
217 99 123 209 112 88 150 194 137 170 15 212 157 207 63 171 2 158 245 249
-1 237 46 130 -1 167 184 -1 -1 -1 145 113 181 40 -1 250 89 14 244 204
152 161 49 62 210 208 122 222 192 248 -1 213 199 185 255 160 116 239 -1 139
8 257 52 173 144 29 163 -1 186 48 258 252 214 140 247 242 90 105 35 200
94 227 203 23 12 236 235 71 128 124 28 73 60 253 54 119 121 221 132 102
-1 225 96 5 141 -1 183 142 67 246 206 211 24 36 41 107 3 81 -1 39
21 -1 10 17 147 -1 37 4 6 159 47 25 133 -1 58 87 27 195 188 156
196 91 201 42 117 31 115 -1 120 -1 175 86 79 30 191 43 11 68 -1 19
the inital total wire length is: 3854
the new TWL 1140
the display in 0's and 1's
0 1 0 1 0 1 0 0 0 1 1 0 0 1 1 0 0 1 1 1
0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 1 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1
0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1
annealing done
```

D3:

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

Total Wire Length vs Cooling rates:

*graphs in excel sheet

0.7

```
the initial random placement
-1 149 177 -1 101 174 -1 -1 23 58 91 -1 43 -1 53 130 156 166 207 -1 141 81 -1 90 -1
-1 79 -1 -1 -1 24 -1 119 -1 -1 -1 -1 -1 89 44 67 -1 153 68 93 4 48 -1 -1 -1
98 124 206 167 56 57 157 -1 126 -1 96 -1 -1 14 -1 179 -1 -1 132 -1 105 -1 -1 -1 95
145 -1 107 -1 -1 11 137 -1 -1 187 212 -1 32 196 -1 3 10 125 134 59 112 -1 26 76 -1
170 117 -1 92 -1 -1 135 -1 -1 33 116 75 -1 211 -1 -1 110 -1 71 111 -1 188 -1 189 35
28 205 123 -1 -1 -1 -1 82 -1 100 -1 -1 103 203 73 47 109 194 143 16 180 22 15 136 50
83 -1 129 127 -1 60 74 -1 6 -1 -1 121 115 178 66 162 200 86 7 -1 -1 146 42 -1 78
181 -1 30 -1 -1 8 2 150 202 -1 -1 38 -1 -1 -1 -1 192 158 -1 -1 -1 185 152 -1 208
-1 9 118 94 19 72 168 -1 -1 -1 17 154 -1 159 190 197 99 77 -1 -1 -1 52 -1 139 -1
-1 -1 39 -1 51 34 -1 31 113 164 161 -1 201 148 46 -1 106 21 183 20 -1 -1 45 -1 -1
-1 122 -1 -1 191 49 12 -1 88 -1 -1 -1 41 108 -1 80 -1 165 173 18 -1 -1 70 172 -1
147 -1 97 140 -1 -1 -1 -1 169 204 102 -1 -1 -1 -1 27 -1 13 63 -1 131 -1 120 -1 175
-1 142 0 29 37 -1 -1 176 -1 -1 -1 -1 186 -1 182 133 84 155 85 -1 -1 163 198 62 -1
-1 -1 25 87 -1 54 -1 -1 -1 138 64 -1 -1 104 -1 -1 199 -1 1 210 -1 -1 -1 -1 -1
55 184 61 69 36 195 -1 193 -1 128 171 40 -1 5 -1 160 151 -1 65 209 144 -1 -1 -1 114
the new TWL 1266
the display in 0's and 1's
1 1 1 1 1 1 1 1 1 1 0 1 0 1 0 1 1 1 1 0 0 0 0 1 1
1 1 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 1
1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1
1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 1
1 1 1 1 1 1 1 1 1 0 1 0 0 0 1 0 0 1 0 0 0 0 1 1 1
1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
annealing done
```

0.75

```
the initial random placement
112 176 -1 96 -1 71 -1 -1 22 66 121 146 78 75 125 114 -1 0 -1 57 50 -1 -1 184 -1
-1 155 -1 -1 162 154 59 -1 -1 136 34 -1 65 189 99 -1 93 35 -1 72 33 -1 38 -1 130
-1 -1 11 -1 8 -1 -1 -1 150 64 -1 -1 160 190 -1 -1 133 46 113 -1 181 -1 47 195 -1
70 -1 118 84 -1 -1 122 169 165 193 -1 157 28 -1 -1 -1 -1 90 211 -1 -1 -1 210 14 207
9 187 -1 58 27 -1 101 -1 63 111 208 -1 -1 87 204 177 183 -1 89 -1 -1 175 37 128 105
102 158 -1 -1 -1 -1 85 127 67 -1 167 -1 -1 -1 -1 -1 -1 -1 44 80 40 -1 62 180 191
91 -1 -1 -1 117 -1 17 -1 138 -1 -1 -1 123 197 168 41 156 142 135 -1 209 -1 -1 -1 98
-1 139 92 29 -1 172 -1 -1 -1 170 13 25 4 77 -1 -1 129 -1 -1 16 6 86 -1 -1 202
-1 51 -1 -1 45 -1 137 144 -1 -1 49 -1 95 141 186 -1 -1 -1 206 205 -1 -1 203 43 120
79 115 131 -1 -1 21 -1 -1 82 152 182 -1 -1 -1 -1 199 2 -1 151 159 -1 48 109 -1 179
-1 166 -1 18 -1 104 134 -1 36 -1 161 163 119 20 -1 74 -1 5 61 -1 60 174 23 -1 108
52 -1 69 140 -1 56 73 100 196 -1 200 -1 39 -1 19 116 149 94 -1 30 88 -1 -1 54 -1
83 24 -1 32 -1 173 -1 12 147 -1 7 -1 -1 -1 -1 143 148 -1 3 -1 76 153 188 -1 31
171 -1 10 -1 81 145 26 -1 53 -1 -1 103 55 -1 -1 194 -1 178 110 107 -1 -1 185 124 15
198 -1 -1 126 -1 -1 201 -1 192 -1 1 68 -1 97 164 -1 -1 -1 -1 42 106 212 132 -1 -1
the new TWL 1193
the display in 0's and 1's
1 1 1 1 0 0 0 1 1 1 0 0 0 1 0 1 0 0 0 0 1 1 1 1 1
1 1 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1
1 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 1 1 1 1
1 1 1 1 1 1 0 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
annealing done
```

0.8

```
the initial random placement
69 76 -1 166 -1 -1 -1 -1 -1 140 13 184 -1 126 -1 -1 -1 193 -1 29 52 33 98 176 206
-1 -1 31 -1 -1 -1 170 135 -1 -1 -1 39 -1 -1 144 186 119 177 -1 5 -1 151 -1 -1 136
-1 137 -1 191 145 99 -1 -1 -1 62 154 -1 -1 -1 74 12 -1 -1 -1 60 55 188 70 -1 -1
44 190 129 111 26 20 -1 153 75 127 -1 -1 203 147 51 110 -1 -1 171 -1 -1 182 -1 -1 165
91 -1 24 -1 159 67 35 105 -1 63 207 -1 -1 -1 -1 -1 178 -1 93 120 -1 19 56 32 -1
156 -1 -1 54 102 210 -1 -1 112 -1 175 78 37 -1 211 -1 168 47 -1 89 -1 -1 9 8 -1
-1 3 57 -1 212 195 -1 -1 18 130 172 169 2 -1 81 -1 149 -1 -1 -1 -1 -1 -1 53 -1
-1 162 21 122 -1 152 -1 25 108 94 -1 66 23 -1 -1 1 -1 116 -1 14 208 -1 -1 115 22
124 199 58 -1 167 -1 146 134 71 -1 -1 -1 -1 138 -1 -1 -1 64 187 34 113 -1 -1 27 82
-1 128 163 87 -1 -1 68 45 95 -1 121 -1 185 4 46 107 125 161 -1 -1 180 -1 106 131 -1
139 -1 103 204 -1 15 92 50 -1 16 -1 104 41 36 42 143 174 -1 133 -1 209 164 86 -1 7
97 -1 -1 61 -1 196 -1 158 -1 -1 148 205 117 100 -1 181 88 59 -1 -1 -1 28 -1 -1 83
132 194 179 -1 11 150 17 40 49 183 109 -1 123 198 0 30 72 -1 -1 141 201 160 200 -1 114
77 -1 -1 173 96 90 -1 -1 -1 10 197 189 79 202 157 43 -1 -1 -1 -1 -1 80 192 142 101
-1 48 6 -1 -1 -1 -1 155 -1 118 84 -1 -1 73 38 -1 -1 -1 -1 -1 -1 -1 65 -1 85
the new TWL 1171
the display in 0's and 1's
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 0 1 0 0 1 0 0 0 0 1 1 1 0 1 1 1 0 1 1 1 1
1 1 1 1 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 1
1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 0 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1 1
1 1 1 1 1 0 1 0 0 0 1 0 0 1 0 1 0 1 1 1 0 1 1 1 1
1 1 1 1 1 1 1 0 0 0 0 0 1 0 0 1 1 0 1 1 1 1 1 1 1
annealing done
```

0.85

```
the initial random placement
-1 -1 145 123 197 -1 129 -1 -1 152 199 -1 25 137 26 -1 -1 -1 149 166 -1 103 29 -1 198
118 -1 -1 -1 -1 7 164 143 -1 82 79 22 157 -1 -1 182 163 71 -1 -1 33 -1 -1 47 -1
61 96 106 105 -1 21 101 14 70 -1 153 -1 100 133 51 159 -1 -1 -1 180 -1 30 40 -1 111
-1 92 -1 -1 -1 73 -1 -1 -1 -1 136 -1 -1 203 114 124 104 132 -1 -1 43 156 200 191 93
-1 -1 -1 -1 102 -1 115 44 -1 172 38 94 85 -1 2 174 109 168 11 113 208 -1 -1 -1 -1
13 -1 -1 -1 184 -1 32 -1 -1 -1 80 -1 -1 162 46 -1 150 127 -1 23 -1 16 56 -1 -1
-1 -1 134 204 -1 78 -1 8 -1 -1 141 99 35 202 -1 72 -1 -1 -1 19 17 76 -1 -1 -1
-1 -1 -1 179 -1 -1 -1 178 -1 -1 15 171 -1 48 -1 116 -1 -1 63 -1 110 -1 154 -1 188
50 81 10 -1 161 185 0 -1 5 201 65 206 122 64 3 107 140 -1 -1 41 54 62 -1 60 66
131 207 169 -1 53 165 176 -1 -1 -1 -1 31 -1 142 211 -1 194 -1 -1 -1 58 -1 212 196 -1
57 20 -1 210 6 55 209 151 42 77 52 -1 155 175 -1 95 83 -1 90 12 -1 -1 -1 187 75
173 205 -1 -1 144 -1 -1 86 148 112 -1 39 192 181 68 -1 45 -1 -1 160 27 -1 87 -1 183
186 125 97 -1 139 -1 -1 177 130 -1 -1 18 190 89 193 34 74 -1 -1 -1 -1 4 135 28 -1
49 98 -1 59 -1 -1 69 -1 88 -1 -1 128 120 126 -1 108 158 -1 170 117 -1 167 24 1 -1
-1 -1 -1 -1 -1 -1 195 -1 67 -1 146 -1 121 -1 9 189 147 36 138 84 37 91 -1 119 -1
the new TWL 1100
the display in 0's and 1's
1 1 1 1 1 1 0 1 0 1 0 1 0 0 0 0 0 0 1 0 0 0 1 1 1
1 1 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1
1 1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1
1 1 1 1 1 1 1 1 1 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 1 1
1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 1 1 0 1 1 0 0 0 0 0 1 1 1 1 0 1 1 1 1
annealing done
```

0.9

```
the initial random placement
-1 -1 -1 -1 157 -1 206 62 -1 -1 147 34 -1 -1 133 -1 12 -1 -1 111 -1 123 -1 -1 145
199 42 167 90 -1 69 -1 198 -1 -1 59 -1 102 -1 71 -1 6 -1 184 -1 -1 -1 192 169 120
37 118 174 86 -1 185 87 116 132 175 138 -1 22 135 -1 -1 -1 -1 134 152 197 170 -1 -1 30
-1 97 172 -1 7 -1 92 130 14 -1 -1 165 -1 -1 53 106 -1 21 25 64 60 39 -1 -1 -1
151 150 -1 187 211 -1 -1 -1 3 -1 31 1 65 -1 47 178 -1 202 -1 99 81 -1 115 5 113
-1 109 72 180 -1 153 76 -1 -1 190 149 126 200 193 -1 208 73 4 161 -1 85 127 110 -1 139
75 -1 -1 176 18 195 43 201 -1 128 173 -1 -1 -1 196 82 -1 129 159 141 137 78 -1 114 -1
41 -1 183 94 -1 -1 -1 -1 -1 -1 -1 -1 20 164 166 -1 46 191 -1 -1 44 2 177 203 104
179 -1 -1 45 49 101 -1 35 -1 -1 38 74 48 158 -1 -1 -1 -1 142 -1 -1 -1 105 -1 89
19 212 162 40 10 -1 28 -1 29 11 24 -1 36 107 96 15 -1 119 77 -1 -1 186 160 -1 -1
112 122 -1 -1 -1 27 136 -1 207 204 66 16 -1 -1 -1 -1 -1 -1 146 68 -1 163 70 -1 100
-1 51 52 -1 140 156 50 -1 -1 -1 63 -1 -1 91 -1 17 -1 124 -1 -1 -1 209 154 103 26
210 125 55 181 79 8 -1 93 -1 155 117 -1 13 -1 188 -1 205 121 58 98 -1 -1 61 -1 80
143 144 148 -1 -1 -1 -1 194 -1 -1 168 -1 95 0 -1 -1 -1 182 33 -1 -1 -1 54 -1 131
-1 57 32 -1 56 -1 67 -1 -1 84 171 9 88 108 83 -1 -1 -1 -1 189 -1 -1 -1 23 -1
the new TWL 1165
the display in 0's and 1's
1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1
1 1 1 0 0 1 1 1 0 1 0 1 0 0 0 1 1 0 1 1 1 1 1 1 1
1 1 1 1 1 1 0 1 0 0 0 1 1 0 1 0 0 0 1 1 1 1 0 0 1
1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 1 1
1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 1
1 1 1 1 1 0 1 1 1 1 0 0 0 1 0 1 1 1 1 1 0 1 1 1 0
1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
annealing done
```

0.95

```
the initial random placement
104 197 -1 174 25 129 -1 124 -1 105 128 -1 116 149 1 -1 -1 153 210 -1 -1 -1 63 154 48
38 182 -1 -1 191 -1 -1 35 71 90 111 194 22 64 -1 91 -1 97 179 69 -1 168 -1 -1 46
81 -1 127 -1 -1 185 200 150 212 -1 9 -1 -1 193 -1 -1 -1 -1 173 -1 -1 143 159 -1 171
114 41 -1 186 79 161 -1 -1 73 192 -1 122 130 49 139 -1 -1 -1 123 -1 135 -1 74 -1 -1
-1 66 -1 -1 -1 178 -1 43 -1 65 95 -1 -1 -1 202 -1 163 -1 115 7 -1 -1 39 157 165
61 -1 -1 -1 45 -1 -1 -1 83 164 -1 21 -1 -1 70 92 141 52 94 55 86 209 -1 -1 211
-1 -1 180 160 -1 195 -1 -1 99 -1 23 -1 84 17 -1 201 125 189 -1 -1 15 28 110 29 96
-1 -1 -1 -1 206 33 82 -1 -1 -1 51 32 -1 207 89 -1 72 162 -1 -1 148 -1 -1 -1 -1
113 133 -1 14 -1 77 131 -1 108 4 175 80 -1 75 27 -1 54 -1 -1 -1 31 -1 -1 -1 -1
6 140 -1 170 145 56 151 -1 112 -1 142 -1 136 134 -1 -1 -1 -1 -1 57 87 -1 12 26 76
205 147 59 16 -1 -1 -1 5 -1 -1 78 47 183 204 208 -1 -1 181 -1 -1 11 8 196 37 13
98 42 93 187 117 -1 144 -1 -1 68 176 137 126 190 -1 36 -1 -1 3 18 -1 88 34 -1 30
102 132 85 -1 -1 -1 184 203 -1 120 -1 146 -1 -1 -1 0 121 -1 188 169 -1 -1 10 106 -1
199 -1 62 67 -1 166 -1 40 53 101 50 198 44 -1 -1 60 2 -1 20 -1 103 100 152 -1 -1
158 119 -1 19 -1 -1 -1 -1 -1 156 177 109 167 138 118 -1 24 172 -1 155 58 -1 -1 -1 107
the new TWL 1068
the display in 0's and 1's
1 1 1 1 0 0 1 0 0 0 0 1 1 0 0 1 1 0 0 0 1 1 1 1 1
1 1 1 1 1 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 1 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1
1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 0 1 1 1 1
annealing done
```

0.97

```
the initial random placement
-1 -1 -1 -1 -1 196 81 -1 184 -1 55 -1 -1 65 112 -1 201 115 -1 -1 -1 -1 -1 -1 -1
195 99 -1 54 -1 74 31 -1 -1 151 -1 106 52 129 50 177 66 6 -1 13 142 -1 29 207 126
194 121 49 33 173 158 153 -1 -1 205 87 154 -1 -1 46 94 -1 -1 -1 103 75 -1 108 -1 96
160 -1 28 -1 93 22 11 10 -1 2 165 -1 -1 47 4 98 -1 36 34 -1 76 -1 143 -1 -1
123 157 -1 -1 56 209 -1 188 162 198 30 32 203 -1 -1 131 139 -1 -1 -1 127 -1 83 167 17
-1 -1 58 45 90 100 161 9 -1 147 -1 190 3 130 -1 124 -1 43 155 169 -1 -1 79 -1 109
-1 -1 182 -1 164 -1 68 -1 185 -1 42 51 134 174 37 -1 -1 18 175 -1 -1 64 102 -1 -1
166 -1 -1 -1 -1 -1 44 91 -1 -1 204 -1 -1 -1 25 -1 -1 -1 -1 82 -1 138 -1 163 78
-1 97 146 -1 5 63 -1 40 92 -1 -1 1 -1 -1 -1 -1 77 114 -1 19 -1 148 27 -1 181
141 200 24 136 -1 72 -1 179 187 -1 189 101 156 39 168 38 -1 206 80 118 21 135 -1 86 -1
140 26 -1 211 84 -1 69 -1 -1 71 183 -1 133 113 122 -1 132 170 0 199 -1 193 202 60 144
119 -1 110 117 178 53 -1 59 145 7 186 61 -1 67 -1 -1 89 105 41 -1 -1 -1 48 -1 -1
-1 125 85 -1 -1 -1 -1 197 -1 14 23 -1 -1 -1 16 -1 -1 12 150 192 107 -1 104 111 -1
-1 -1 -1 120 176 70 128 20 -1 -1 -1 35 62 -1 -1 -1 180 57 -1 -1 -1 -1 137 -1 -1
152 -1 -1 116 159 191 88 -1 -1 95 -1 210 212 171 172 15 208 149 73 -1 -1 -1 8 -1 -1
the new TWL 1001
the display in 0's and 1's
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 1 1
1 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1
1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1
1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 1 1
1 1 1 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 1 1 1 1
1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
annealing done
```

T1:

0.7

```
the initial random placement
265 191 115 120 250 141 28 -1 53 299 174 163 295 259 348 133 31 314 123 88 162 187 130 330 207 178
327 198 236 375 388 305 244 61 157 279 296 378 338 -1 203 72 117 376 132 60 320 362 151 193 231 93
344 398 135 127 74 131 14 347 361 368 -1 342 400 359 70 308 230 307 105 221 144 112 66 278 150 75
42 334 180 208 19 240 152 234 20 86 363 311 267 134 3 8 385 27 322 217 260 91 272 54 34 85
179 391 13 177 -1 58 169 5 345 381 -1 119 167 65 116 325 309 148 126 109 29 -1 -1 51 256 371
215 97 209 22 41 83 387 40 84 110 357 233 125 43 288 350 35 379 122 382 373 274 204 226 332 168
243 270 394 199 372 212 211 258 121 228 16 32 26 183 286 78 269 205 140 196 188 124 206 73 384 156
201 317 241 397 171 11 396 114 360 316 200 139 252 225 82 63 229 319 80 292 355 113 315 2 118 365
50 0 137 154 176 136 401 257 255 101 253 245 287 195 175 48 52 395 261 1 263 335 -1 160 249 282
146 33 268 326 -1 143 4 266 45 57 7 213 370 281 353 337 164 49 23 15 324 358 21 318 280 94
283 44 354 377 159 294 331 302 298 291 276 46 165 238 219 185 254 343 55 90 271 220 235 277 202 64
173 95 264 223 87 12 290 323 147 224 251 155 77 328 106 37 210 170 69 197 247 -1 68 107 186 190
142 246 -1 17 30 374 304 366 303 321 62 273 153 102 181 356 352 301 92 18 297 103 6 329 340 89
10 158 289 285 59 232 161 149 108 386 380 364 300 172 310 47 189 184 138 349 333 399 38 402 79 341
145 104 389 100 392 128 383 81 -1 293 9 56 36 24 129 222 99 71 194 336 76 248 351 313 239 96
306 67 275 -1 262 346 390 237 369 284 214 339 227 98 192 367 393 216 182 312 111 242 166 25 218 39
the inital total wire length is: 6991
```

```
the inital total wire length is: 6991
the new TWL 2539
the display in 0's and 1's
1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0
annealing done
```

0.75

```
the initial random placement
103 387 344 131 290 311 249 200 -1 193 4 164 141 48 25 37 209 343 321 299 277 366 59 239 64 291
143 2 1 199 380 402 303 71 346 307 198 328 53 104 176 157 61 38 130 279 49 254 211 87 309 -1
326 99 81 329 356 18 137 105 129 154 147 235 266 -1 43 375 302 313 358 376 68 12 166 189 391 217
296 374 350 39 77 223 214 -1 398 355 22 288 26 124 202 338 94 289 368 109 330 386 20 258 278 224
359 300 140 90 192 14 65 15 204 317 145 151 269 267 116 268 273 36 270 171 297 294 332 97 73 156
348 379 336 385 -1 315 -1 70 146 75 191 226 92 3 170 240 310 91 0 206 392 395 203 230 333 283
175 19 8 323 180 394 384 222 318 245 174 363 13 314 292 96 11 334 367 183 194 50 82 244 107 173
121 149 167 178 371 372 134 320 127 85 31 33 138 284 41 400 362 349 153 184 190 155 118 -1 122 187
182 225 32 57 287 360 80 324 243 227 207 377 276 304 98 298 95 -1 213 285 139 331 76 128 93 119
181 382 389 108 312 28 133 280 301 342 88 195 23 79 101 261 218 84 246 381 132 -1 117 113 256 262
148 112 335 158 353 388 78 55 152 352 168 365 67 228 237 234 319 142 72 265 201 357 196 238 251 51
136 241 259 16 135 248 34 83 126 337 378 345 396 160 106 220 233 172 282 253 370 46 351 42 347 219
354 250 221 123 257 60 -1 208 399 47 74 263 216 165 231 169 52 295 205 162 316 260 340 306 120 369
7 163 89 21 10 390 159 197 286 339 236 161 40 322 179 66 -1 56 125 144 215 364 177 24 232 45
62 255 325 35 393 110 274 44 275 242 150 272 252 210 102 6 361 100 69 -1 115 264 327 -1 373 383
401 30 5 17 271 281 212 29 305 63 111 247 58 308 9 86 54 341 188 27 186 114 185 293 397 229
the inital total wire length is: 6786
the new TWL 2435
the display in 0's and 1's
1 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1
annealing done
```

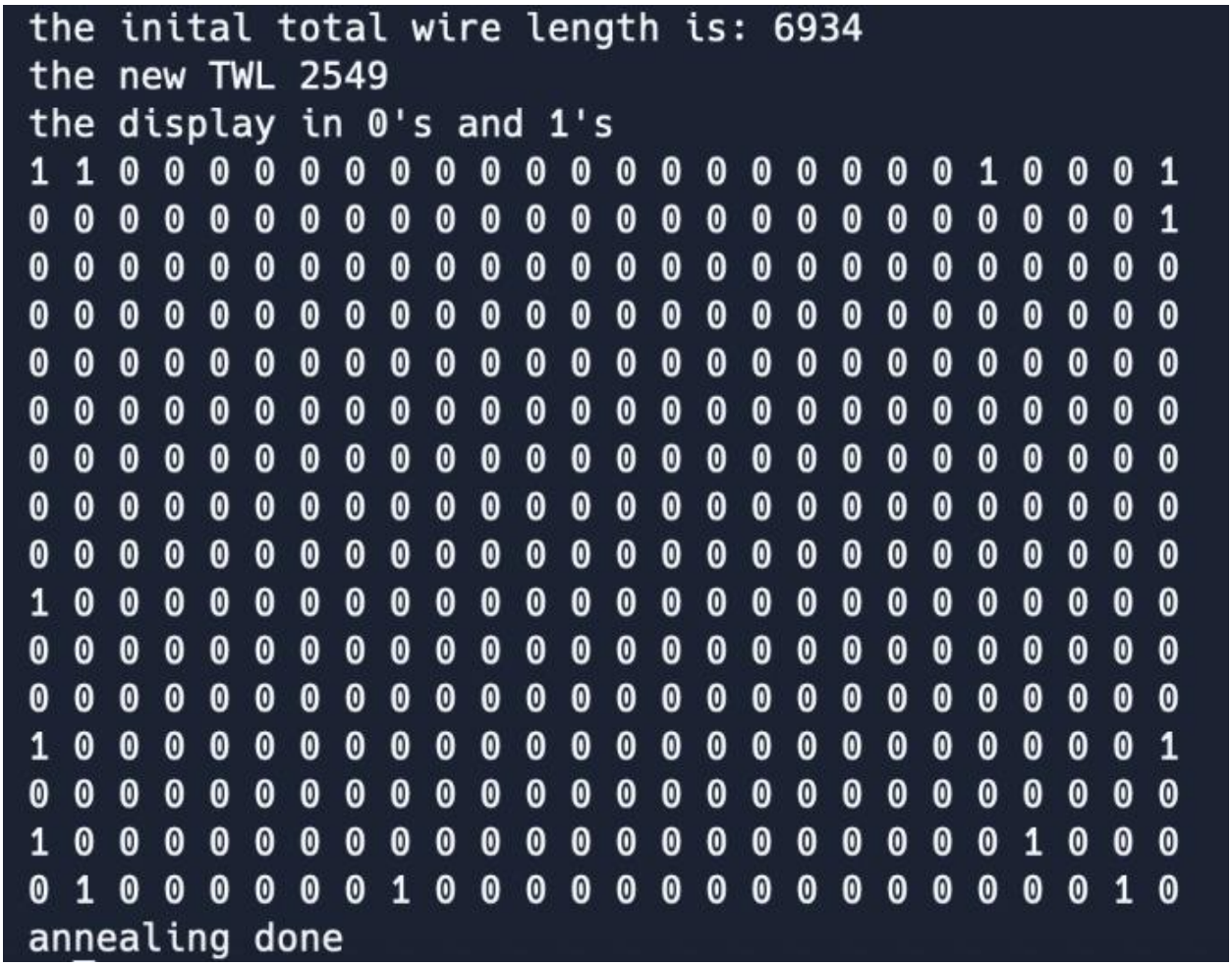
0.8

```
the initial random placement
379 115 -1 385 67 243 57 390 133 264 304 270 129 312 234 193 18 215 377 237 96 330 89 65 311 100
188 108 165 239 35 51 -1 27 -1 295 346 398 12 171 76 354 94 253 281 166 293 8 272 314 134 10
191 116 397 71 120 74 49 228 102 135 339 204 69 251 33 336 306 93 3 363 260 402 222 372 114 28
113 11 261 -1 83 132 333 70 271 155 152 380 87 77 324 122 179 66 355 180 48 266 357 392 186 187
-1 125 34 169 63 263 91 359 328 20 218 148 5 111 -1 302 75 365 236 294 310 192 142 383 95 335
276 219 268 248 401 217 124 194 221 265 203 123 139 196 389 97 352 183 24 364 280 382 226 303 360 308
297 143 286 162 358 366 356 52 173 399 145 53 158 200 130 257 110 274 388 231 205 317 147 207 19 373
-1 31 121 316 172 381 262 371 400 206 159 325 43 277 -1 301 39 154 104 161 101 326 -1 29 16 223
249 282 112 362 184 107 233 240 182 351 13 151 185 82 393 146 81 160 163 153 323 273 201 278 340 199
298 -1 214 117 44 345 232 361 370 368 329 299 103 322 41 238 320 195 56 309 137 296 2 313 26 62
256 391 241 331 269 -1 244 141 98 149 118 140 25 78 300 275 227 242 17 46 288 85 341 168 -1 36
224 230 376 50 245 386 342 105 167 30 229 349 315 84 247 128 190 119 343 353 348 174 15 38 375 156
127 319 177 136 164 189 72 58 64 284 216 321 211 318 -1 367 73 384 4 332 176 395 47 21 175 212
279 283 42 40 106 157 213 7 79 225 210 307 250 334 252 144 337 150 255 338 86 54 80 246 45 92
327 0 60 99 170 350 68 209 259 287 197 37 131 9 344 138 59 202 378 394 208 258 291 347 14 369
22 396 55 289 235 1 181 23 254 387 61 198 285 178 220 6 126 290 109 32 267 90 88 292 305 374
the inital total wire length is: 6861
```

```
the inital total wire length is: 6861
the new TWL 2344
the display in 0's and 1's
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
annealing done
```

0.85

```
the initial random placement
194 79 6 213 141 244 123 124 393 30 14 385 316 329 229 292 324 264 197 90 84 400 392 231 161 344
170 -1 307 153 88 366 72 274 36 295 9 165 96 44 219 357 1 386 345 185 19 81 -1 227 64 137
283 10 298 190 320 -1 228 198 175 178 331 383 270 119 171 391 375 210 226 257 382 149 282 105 -1 220
-1 269 187 248 279 398 308 311 125 396 367 322 121 89 183 140 28 -1 277 106 169 245 -1 289 296 328
15 200 313 267 388 16 157 13 54 8 361 130 201 246 23 180 55 110 294 332 107 195 179 17 239 199
209 374 247 330 181 347 2 163 100 92 339 25 291 148 306 117 188 46 -1 152 60 65 114 69 224 293
280 101 208 342 266 70 128 242 51 160 75 118 48 127 325 356 346 21 343 272 184 196 20 52 191 278
99 91 285 369 379 0 358 275 98 174 164 150 18 241 83 218 145 12 212 93 113 265 355 234 159 251
143 373 363 86 102 202 38 67 390 27 287 146 168 364 108 377 348 76 37 215 158 238 3 154 57 176
271 312 284 142 162 314 372 262 222 173 193 40 -1 167 43 33 73 77 387 401 95 338 254 309 11 259
34 56 323 255 327 301 82 395 310 166 352 335 203 216 155 151 58 109 111 359 134 41 172 261 112 59
402 281 290 370 223 192 126 276 243 7 138 326 206 232 5 133 260 365 104 362 24 315 389 144 147 273
80 250 63 319 136 -1 318 53 -1 297 31 253 233 204 115 39 85 317 341 32 139 214 47 240 371 256
333 381 300 360 353 252 380 207 132 177 376 97 78 -1 230 225 74 22 -1 286 350 236 334 351 103 302
299 87 116 122 384 304 340 42 45 182 349 221 131 61 49 249 50 397 186 129 135 156 205 268 189 35
303 378 4 235 26 94 337 237 336 394 354 258 120 66 68 305 217 288 368 321 62 399 211 71 263 29
the inital total wire length is: 6934
```



```
the inital total wire length is: 6934
the new TWL 2549
the display in 0's and 1's
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
annealing done
```

0.9

```
the initial random placement
133 398 175 295 393 26 233 241 129 37 274 184 32 -1 99 188 305 339 313 304 79 95 394 140 172 45
221 377 309 171 276 392 367 319 109 123 251 -1 277 98 381 80 121 124 268 355 286 131 35 245 378 69
66 176 222 60 3 6 28 308 193 152 103 102 220 260 108 190 270 126 24 -1 363 9 340 50 127 -1
78 261 149 331 48 8 390 351 90 -1 275 262 67 207 391 18 361 232 157 311 10 112 16 356 348 84
107 168 205 314 267 120 25 125 46 338 194 290 324 94 30 164 360 344 357 113 36 93 -1 136 389 91
323 257 216 97 83 322 128 372 58 301 0 31 7 386 401 375 269 72 327 246 155 148 70 165 132 352
68 41 376 382 242 383 248 373 252 49 143 285 27 227 368 341 77 278 271 34 342 139 154 87 53 272
4 335 202 343 160 259 81 332 135 73 255 399 374 214 333 347 158 208 111 64 166 400 153 228 186 40
315 258 134 15 101 231 236 -1 212 71 300 366 144 -1 237 230 289 316 244 287 337 181 296 229 119 249
359 173 38 387 349 225 297 115 88 138 75 310 281 266 117 307 402 223 51 243 235 354 54 178 86 325
169 312 137 17 59 145 395 397 122 170 110 234 182 256 240 114 -1 273 369 -1 247 146 42 47 217 22
76 370 321 89 282 353 224 203 206 180 11 162 183 55 74 56 57 147 317 151 130 326 263 291 200 294
330 345 187 14 62 318 43 1 238 23 159 204 33 2 302 329 283 211 201 209 -1 156 385 163 118 -1
365 141 85 189 371 265 346 39 362 213 44 293 396 13 19 303 215 5 226 218 279 63 -1 379 350 334
52 198 161 106 254 179 253 199 116 197 250 185 219 264 177 167 196 210 65 320 306 174 280 21 96 29
82 358 12 336 92 388 299 298 150 105 61 191 288 239 100 284 192 384 380 195 104 328 292 142 364 20
the inital total wire length is: 6878
the new TWL 2227
the display in 0's and 1's
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0
annealing done
```

0.95

```
the initial random placement
43 7 170 191 72 71 269 347 312 134 190 62 12 18 385 220 54 272 151 9 119 210 53 202 260 31
391 217 152 174 2 247 345 270 380 329 310 359 121 315 242 371 14 249 241 36 13 165 221 127 150 199
19 353 94 89 158 358 122 282 349 66 259 387 320 348 130 330 337 188 372 154 318 79 87 384 169 296
340 299 131 189 20 327 45 113 207 51 -1 346 111 333 50 -1 325 364 397 224 22 284 305 102 -1 381
175 379 261 289 248 148 234 235 -1 59 117 99 25 354 244 401 201 187 172 266 100 57 38 98 39 351
286 363 378 157 323 1 350 331 26 166 352 336 145 29 342 167 205 112 254 230 357 93 216 335 370 198
388 237 313 74 -1 159 297 37 324 196 17 219 383 182 362 374 49 263 239 386 155 192 368 73 361 262
171 301 223 285 292 304 101 126 96 227 177 193 238 63 123 341 273 365 114 267 398 69 276 176 91 343
233 321 288 250 275 195 184 132 373 149 81 97 -1 291 136 86 -1 103 -1 400 15 246 163 300 107 178
68 142 3 228 -1 88 164 105 116 108 161 375 306 390 77 186 83 56 95 16 27 82 61 194 75 316
355 24 55 389 5 245 356 395 143 294 382 92 32 144 295 109 118 120 206 277 139 156 -1 40 252 231
393 -1 240 84 214 279 222 33 264 10 78 65 64 225 70 369 317 322 180 256 278 307 104 213 133 218
377 153 293 90 328 28 200 211 257 52 303 212 162 4 271 268 141 392 367 147 332 185 226 287 236 396
197 394 47 60 344 11 399 179 183 311 140 85 35 204 314 -1 283 290 129 326 110 0 229 209 280 308
146 58 8 23 106 203 67 168 281 232 173 124 6 160 402 366 255 258 253 41 215 137 338 181 309 243
208 298 128 46 34 274 42 -1 76 302 339 138 48 319 376 265 125 30 360 135 44 334 251 80 115 21
the inital total wire length is: 6694
the new TWL 2090
the display in 0's and 1's
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
annealing done
```

0.97

```
the initial random placement
88 89 304 348 294 155 350 114 245 148 33 263 39 328 57 220 85 371 158 270 162 378 337 128 178 100
78 165 293 150 301 262 84 53 97 94 312 -1 205 239 283 25 69 157 199 364 130 48 395 272 -1 32
87 215 16 233 21 386 345 58 203 339 238 246 209 179 66 90 261 50 164 400 226 187 315 91 86 349
276 138 132 55 19 193 36 230 43 142 10 306 2 42 346 61 330 255 210 139 -1 325 275 143 287 342
190 389 361 363 113 372 394 133 22 54 269 31 322 250 56 365 368 116 376 3 286 75 82 124 397 258
12 136 373 266 167 0 176 208 173 206 224 144 59 260 305 223 401 375 343 254 369 231 191 92 129 34
26 189 166 329 292 7 163 103 367 62 207 379 119 30 341 134 398 253 249 140 278 126 149 214 289 125
186 243 122 335 67 217 9 188 277 192 303 170 326 27 101 -1 308 288 44 309 244 171 13 120 327 98
380 64 384 153 14 314 236 212 137 63 282 106 390 181 377 370 121 28 198 183 235 169 359 195 45 37
396 18 29 332 154 -1 310 320 232 -1 51 298 151 273 11 93 356 104 307 47 145 -1 177 242 74 381
160 374 311 267 251 -1 385 338 107 257 95 80 -1 23 213 333 274 393 172 355 300 353 299 83 284 17
218 241 117 73 127 168 182 360 141 323 156 96 41 46 399 65 221 324 194 15 109 248 118 60 200 271
8 -1 216 256 317 279 259 225 316 35 175 6 351 180 319 161 295 285 334 290 38 265 24 227 76 135
108 357 219 184 40 347 99 72 52 240 321 79 388 352 5 358 237 70 211 297 147 159 204 331 302 383
296 71 115 111 362 313 105 201 77 131 264 197 174 49 -1 196 247 387 234 -1 336 20 68 402 354 268
281 392 366 123 382 110 -1 185 4 102 81 391 146 291 318 344 1 340 280 202 228 229 112 222 252 152
the inital total wire length is: 6945
the new TWL 2009
the display in 0's and 1's
1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1
annealing done
```

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

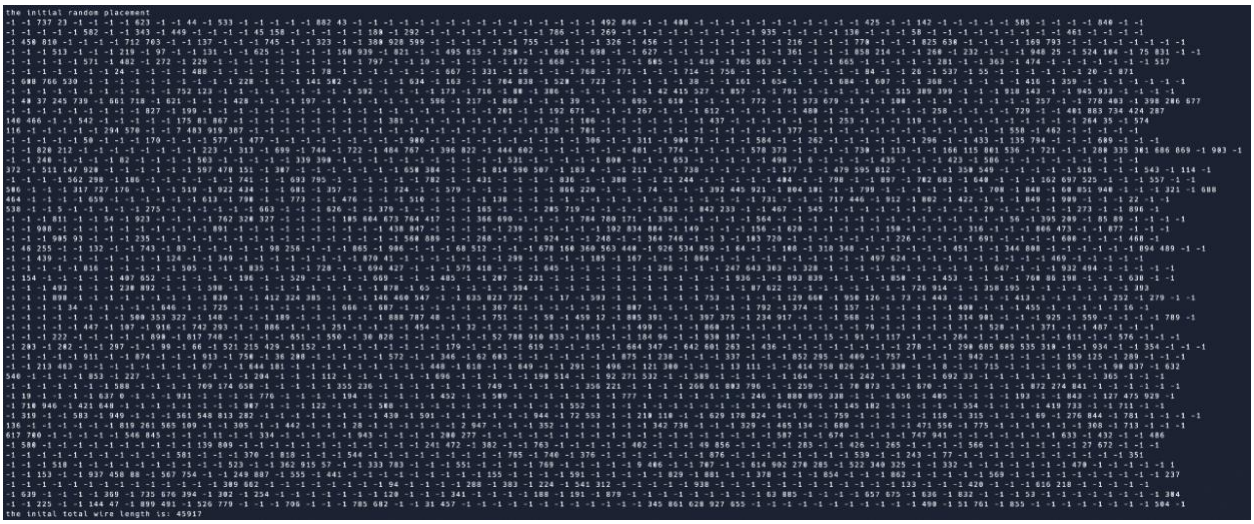
Total Wire Length vs Cooling rates:

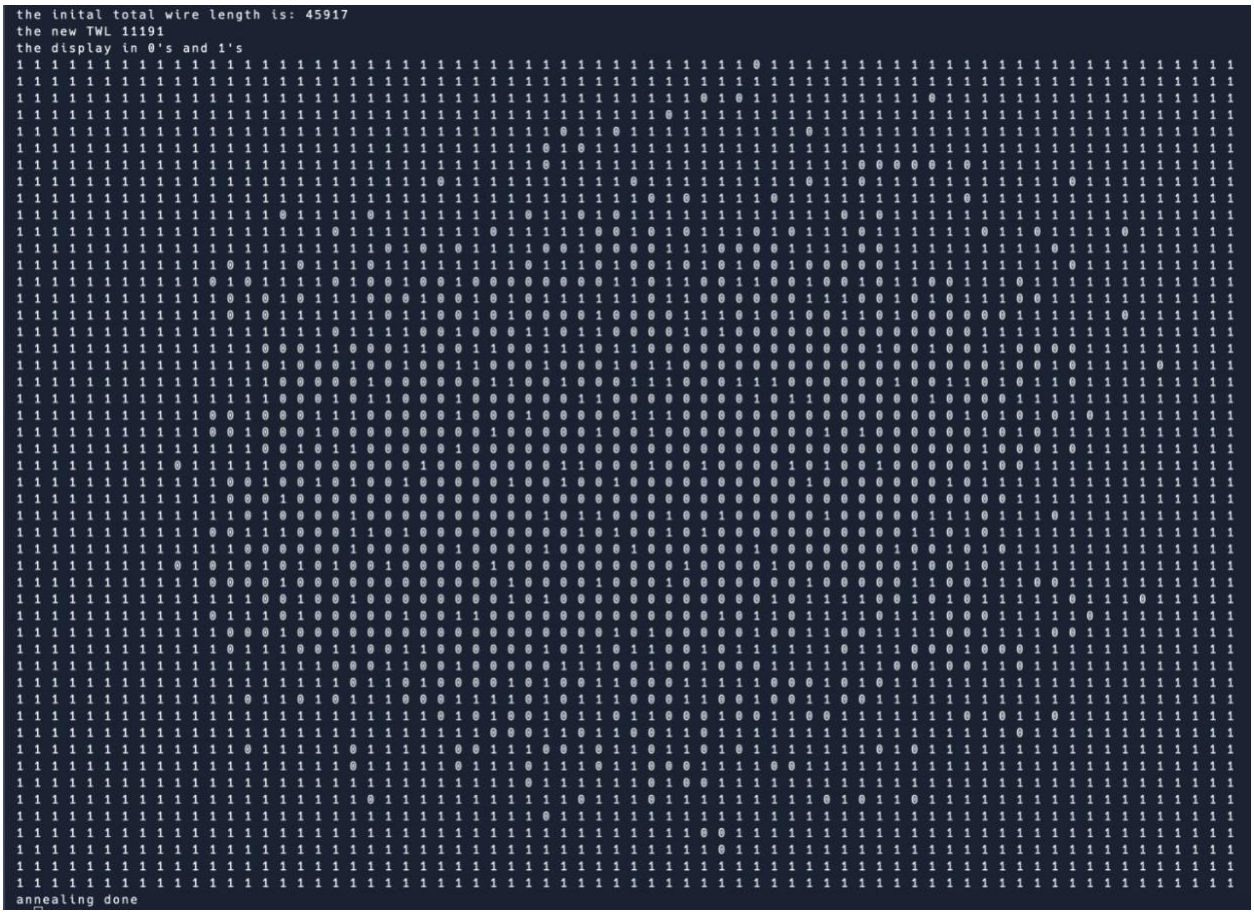
*graphs in excel sheet

0.7, 0.75,0.8,0.85,0.9,0.95,0.97

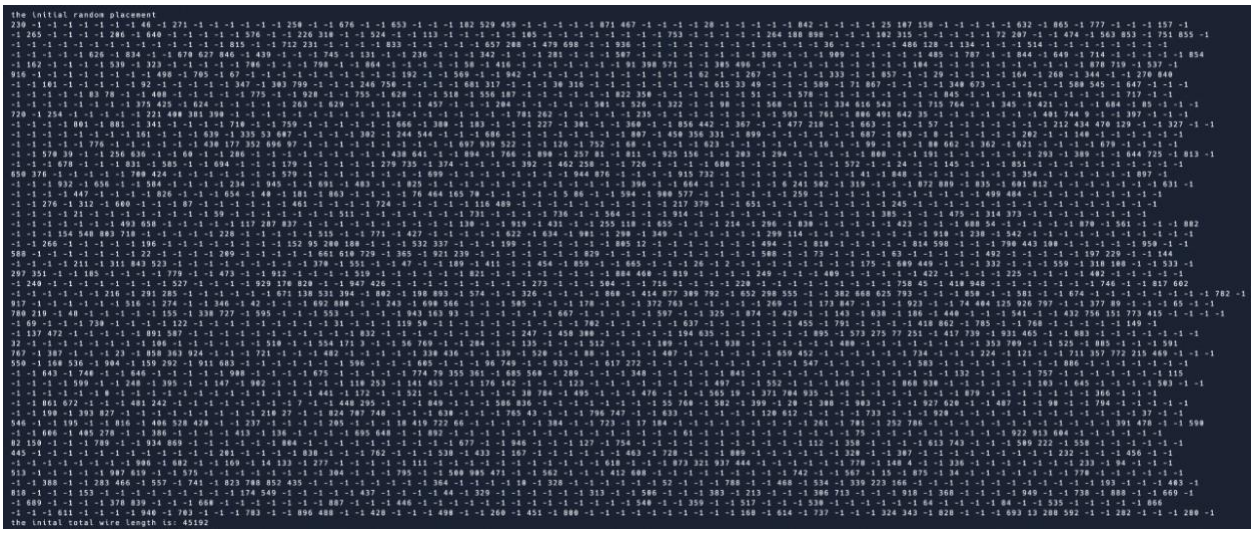
T2:

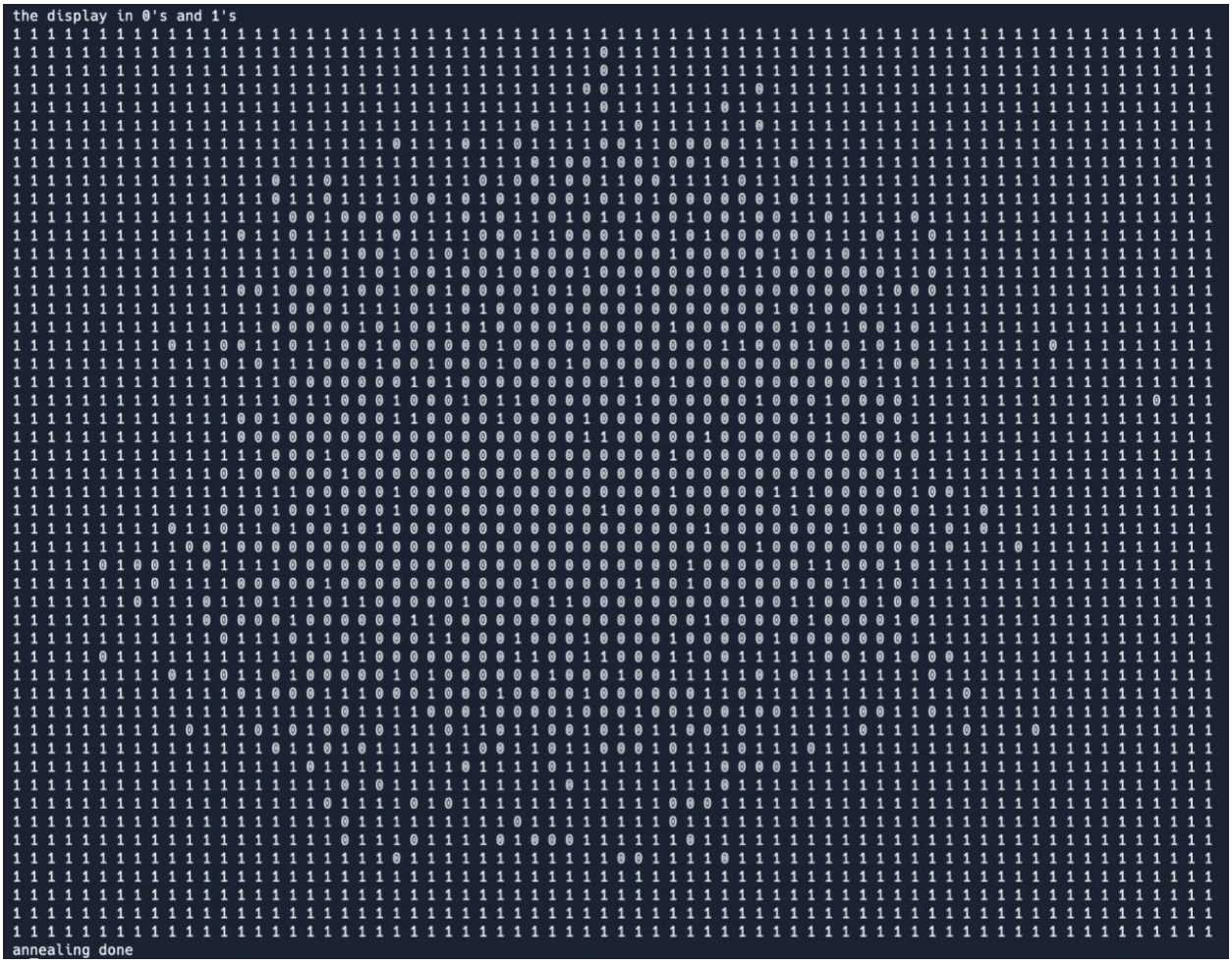
0.7


the initial random placement
the inital total wire length is: 45917

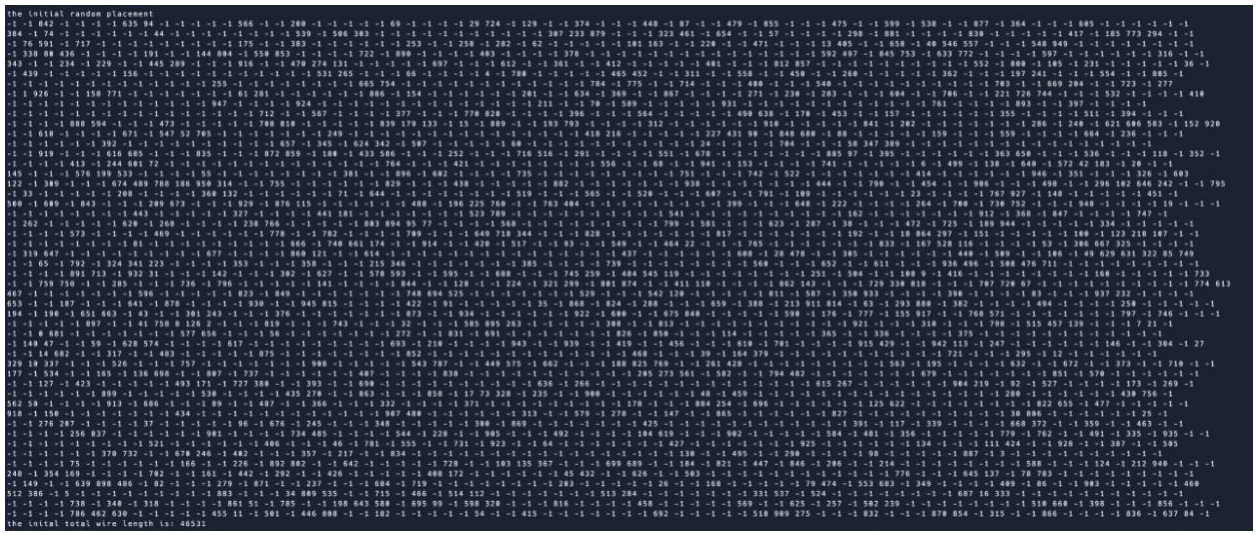

the inital total wire length is: 45917
the new TWL 11191
the display in 0's and 1's
annealing done

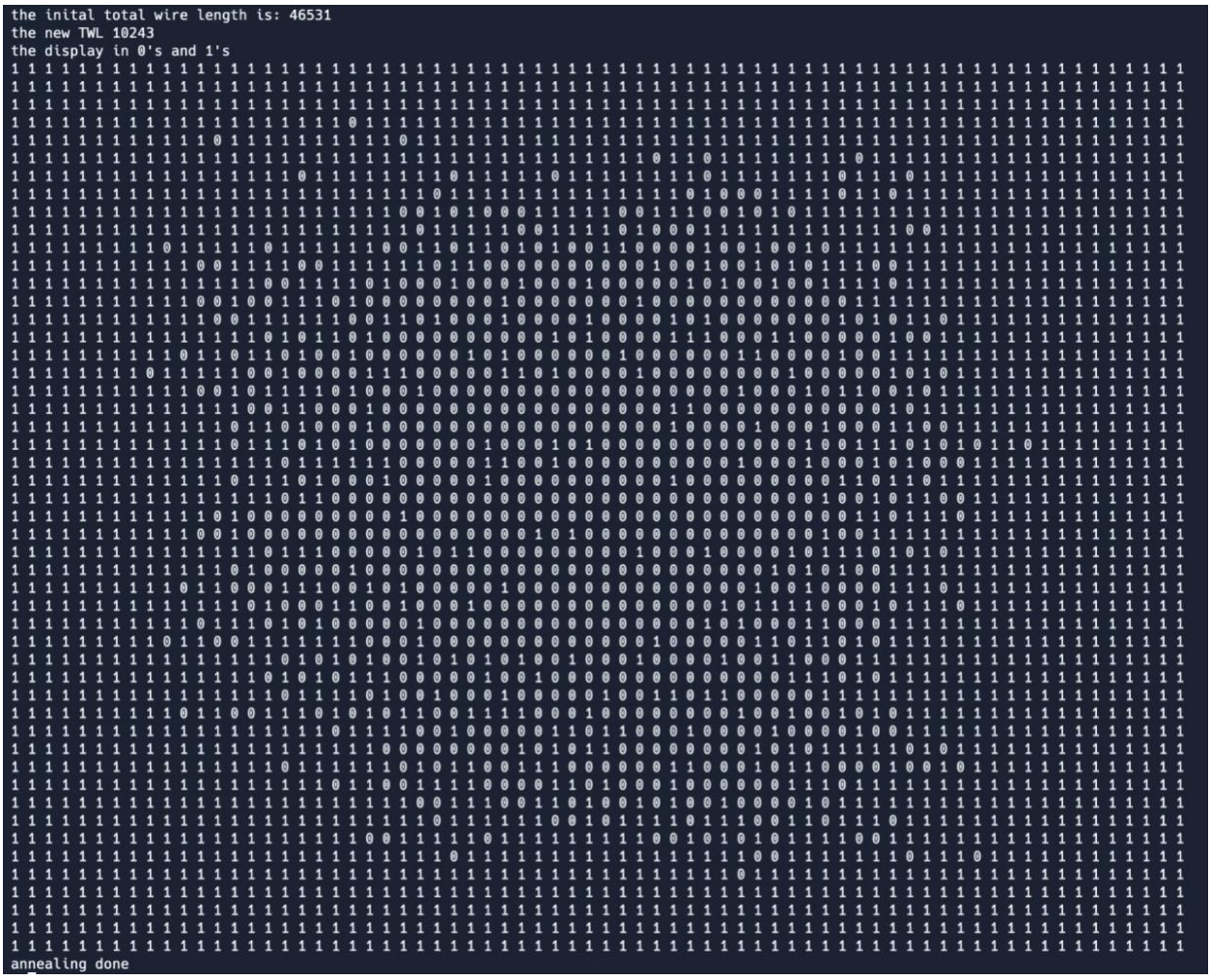
0.75


the initial random placement
the inital total wire length is: 45192

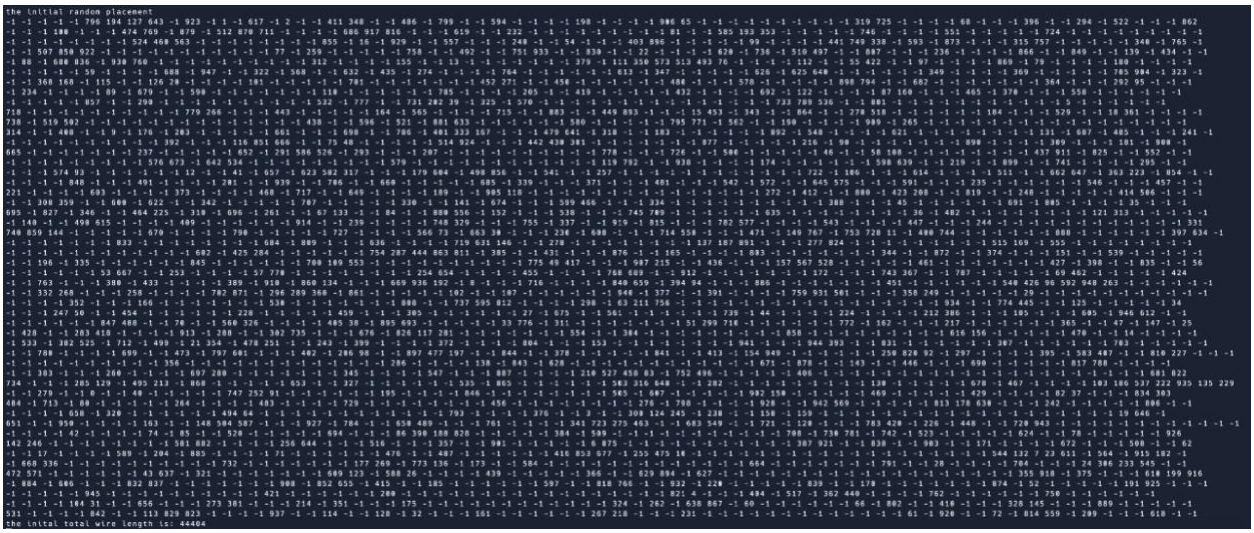

the display in 0's and 1's
annealing done

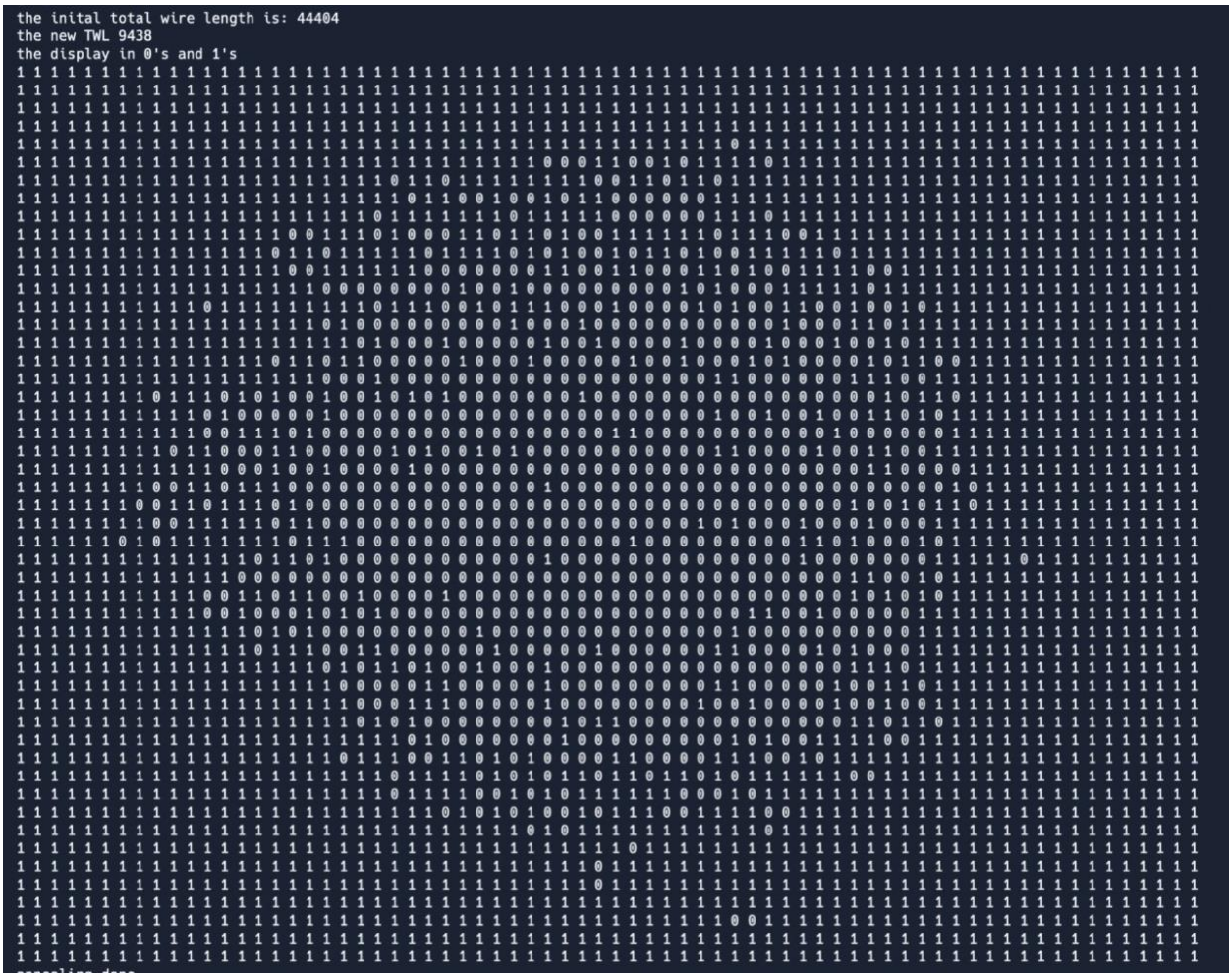
0.8


the initial random placement
the initial total wire length is: 46531

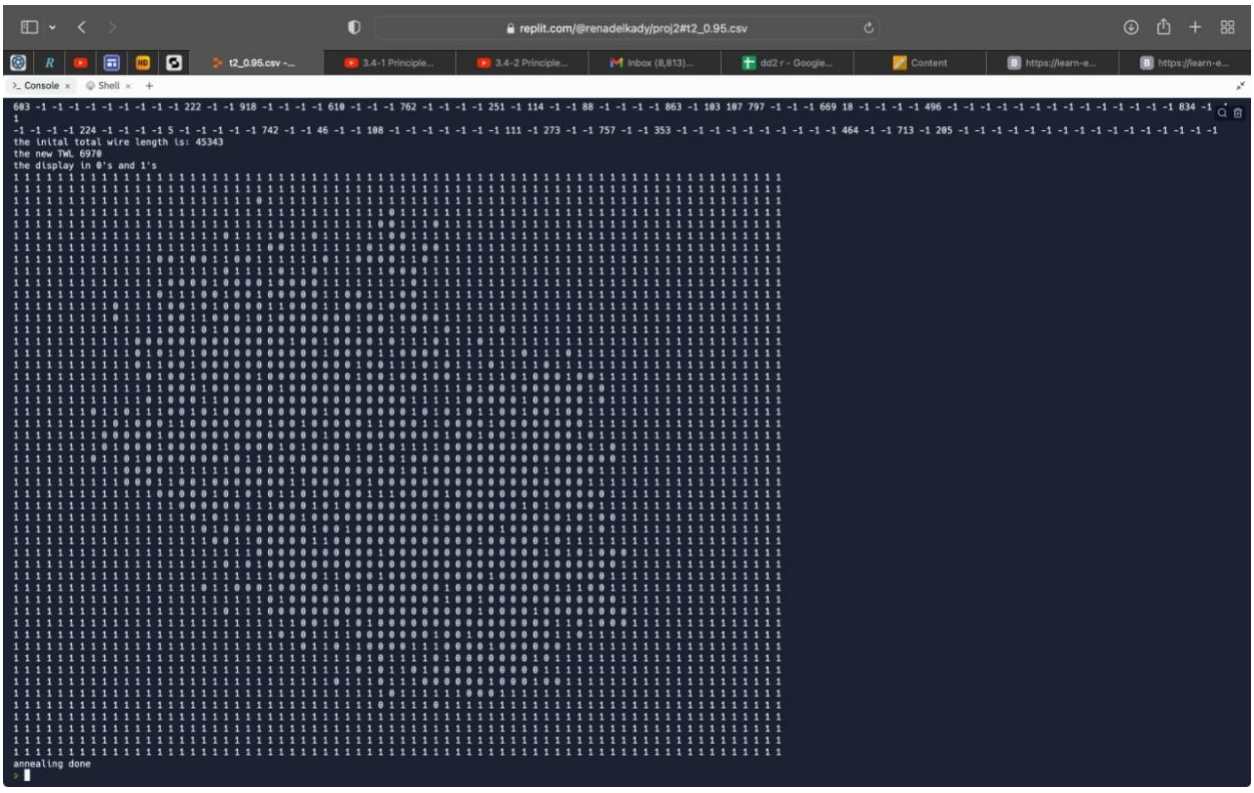

the inital total wire length is: 46531
the new TWL 10243
the display in 0's and 1's
annealing done

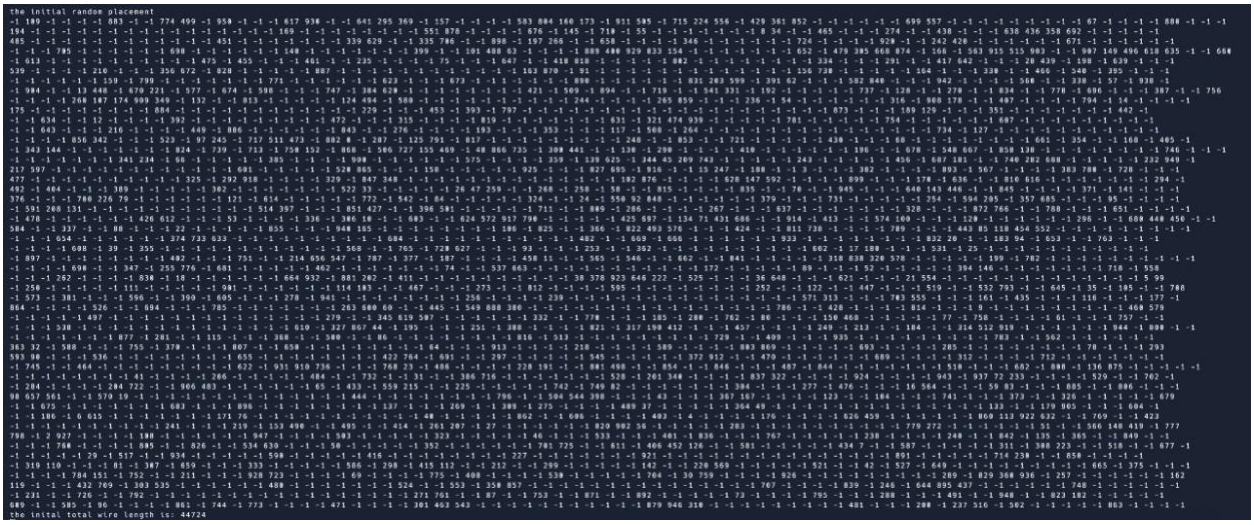
0.85


the initial random placement
the inital total wire length is: 44404

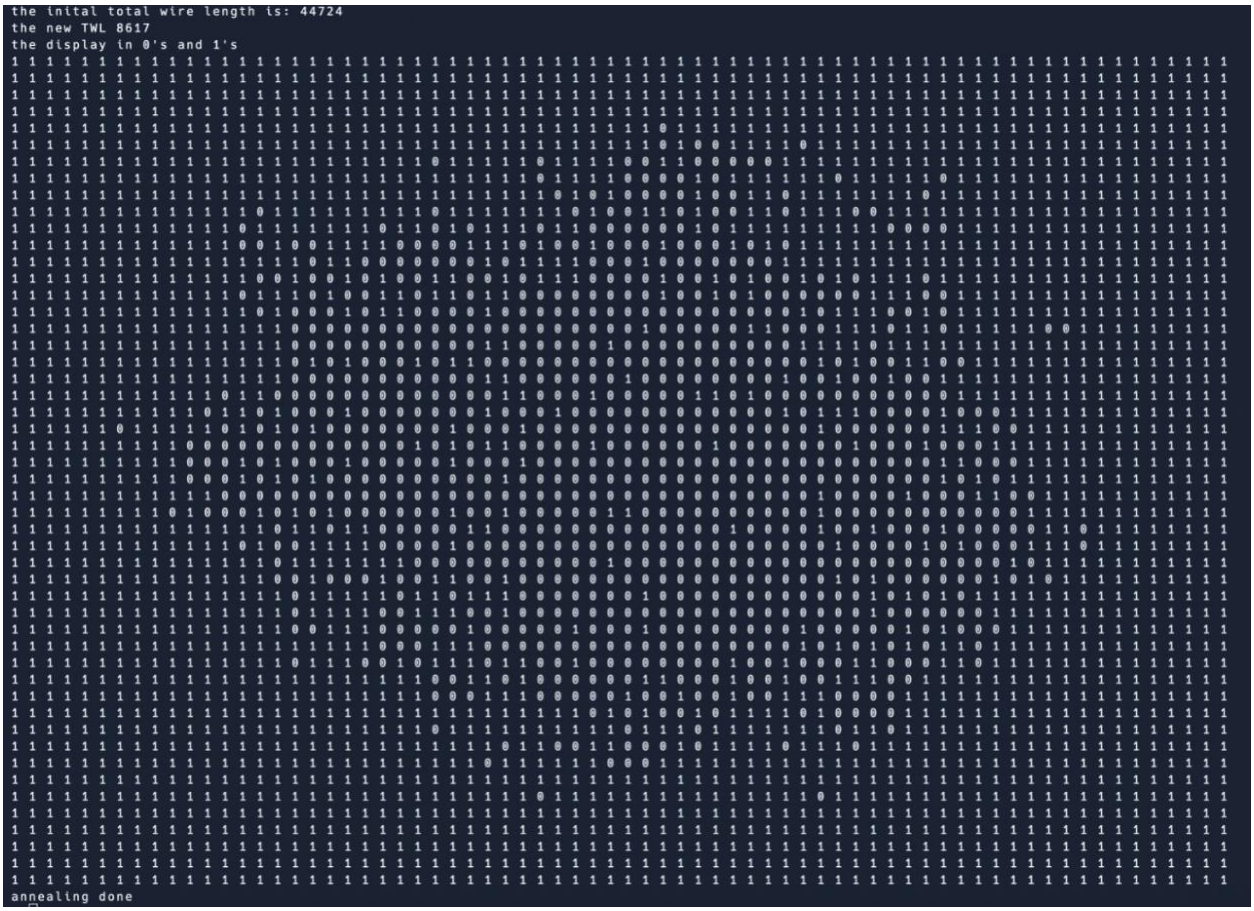

the inital total wire length is: 44404
the new TWL 9438
the display in 0's and 1's

0.9

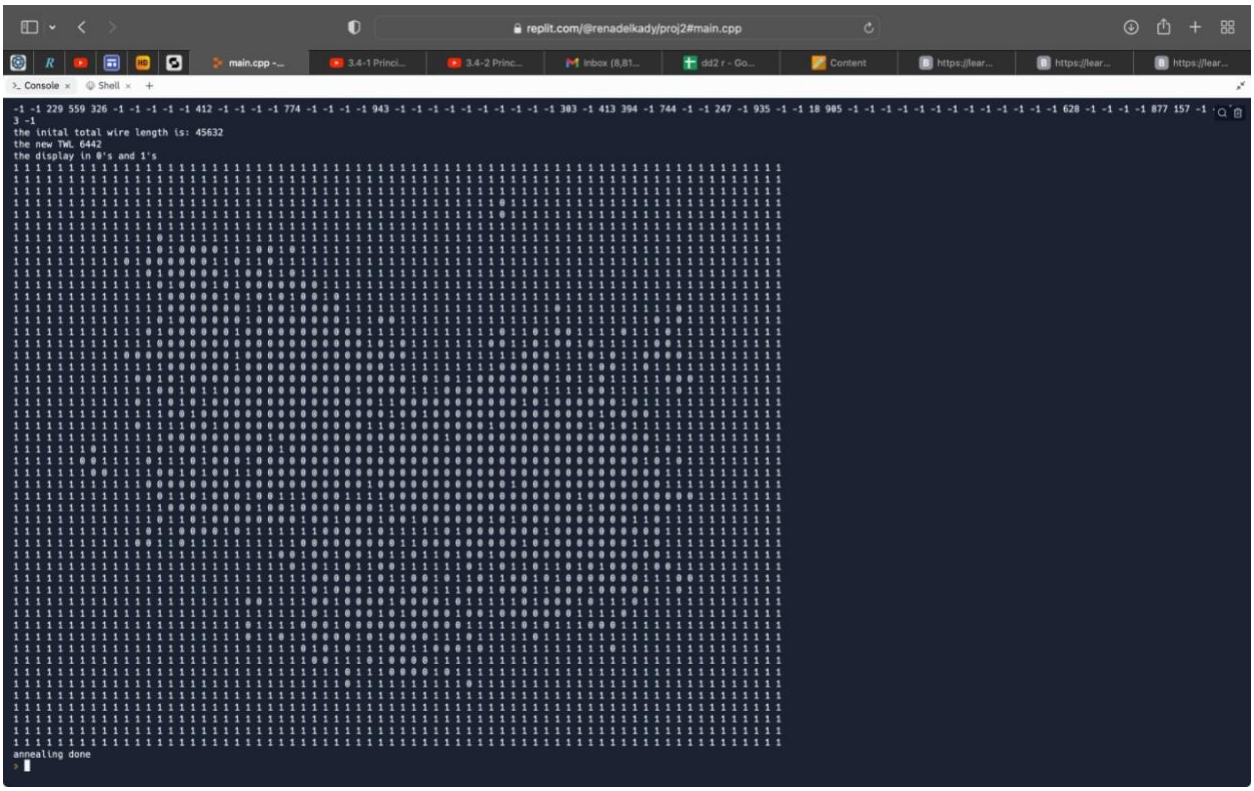

replit.com/@renadelkady/proj2#t2_0.95.csv
Console
Shell
the inital total wire length is: 45343
the new TWL 6978
the display in 0's and 1's
annealing done

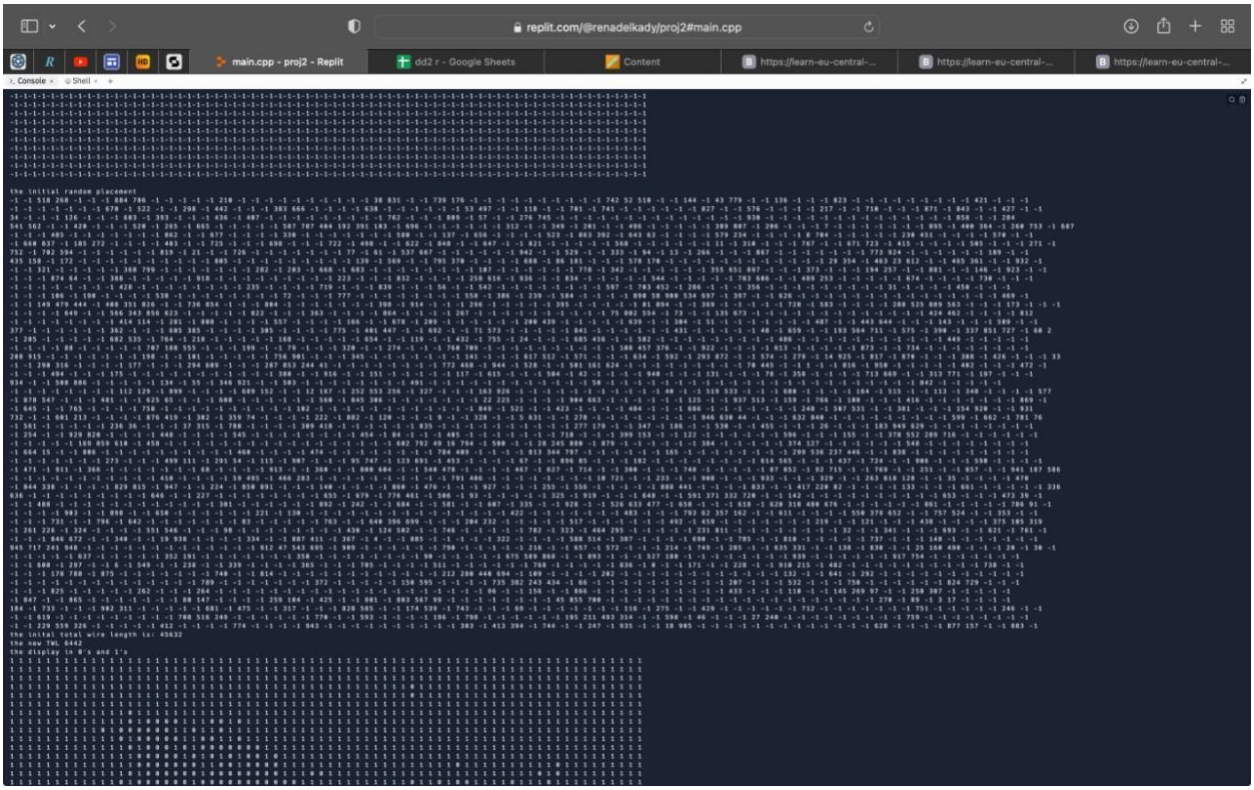

the initial random placement
the inital total wire length is: 44724

0.95


the inital total wire length is: 44724
the new TWL 8617
the display in 0's and 1's
annealing done

0.97


replit.com/@renadelkady/proj2#main.cpp
Console
Shell
the inital total wire length is: 45632
the new TWL 6442
the display in 0's and 1's
annealing done


replit.com/@renadelkady/proj2#main.cpp
main.cpp - proj2 - Replit
Console
Shell
the initial random placement
the inital total wire length is: 45632
the new TWL 6442
the display in 0's and 1's

Grid and Final outputs:

Temperature vs Total Wire Length:

*graphs in excel sheet

Total Wire Length vs Cooling rates:

*graphs in excel sheet

T3:

Grid and Final outputs:

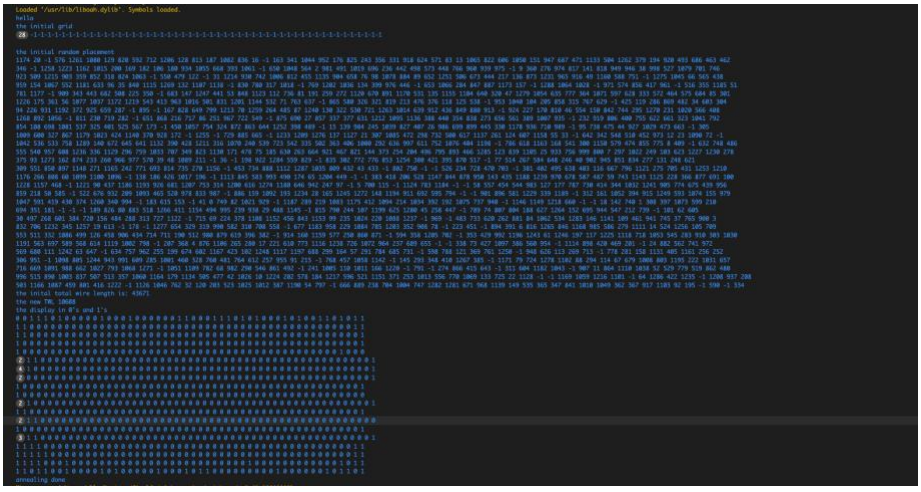
Temperature vs Total Wire Length:

*graphs in excel sheet

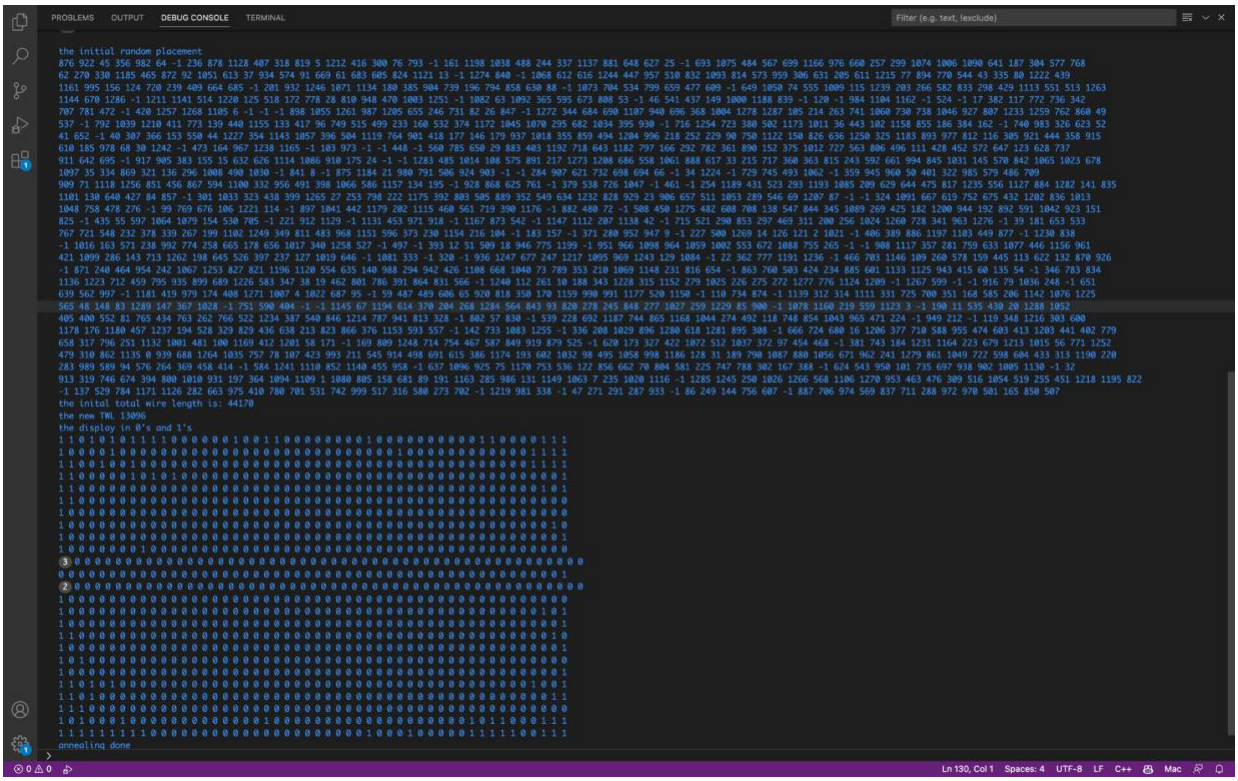
Total Wire Length vs Cooling rates:

*graphs in excel sheet

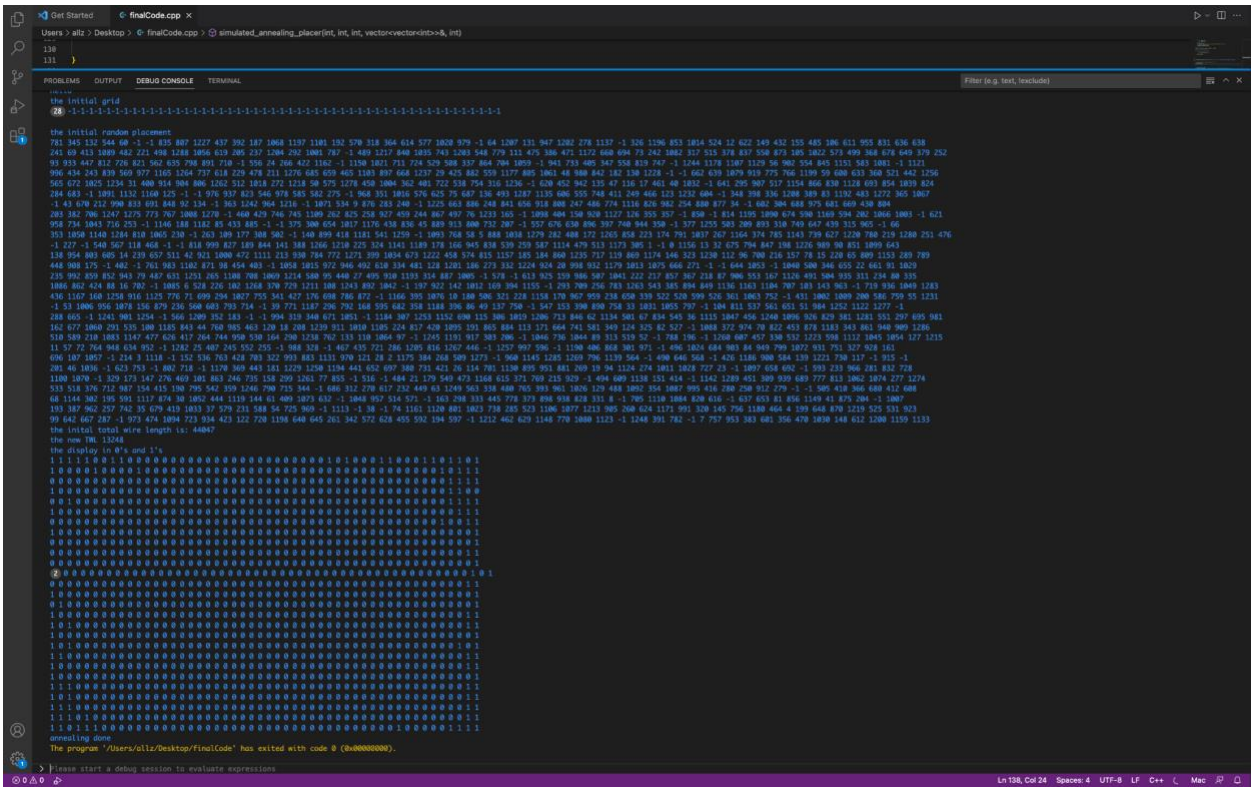
0.7:



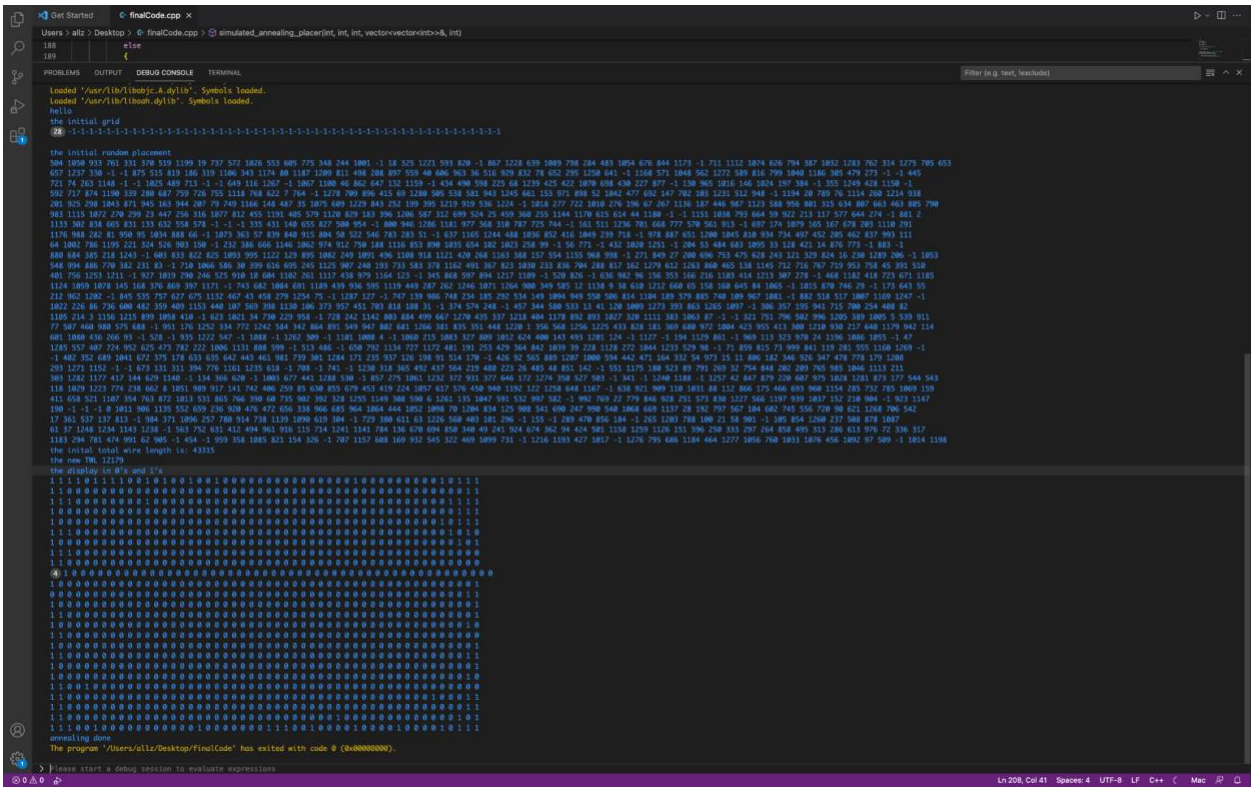
0.75:


PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
Filter (e.g. text, !exclude)
the initial random placement
the initial total wire length is: 44170
the new TWL 13096
the display in 0's and 1's
annealing done
Ln 130, Col 1
Spaces: 4
UTF-8
LF
C++
Mac

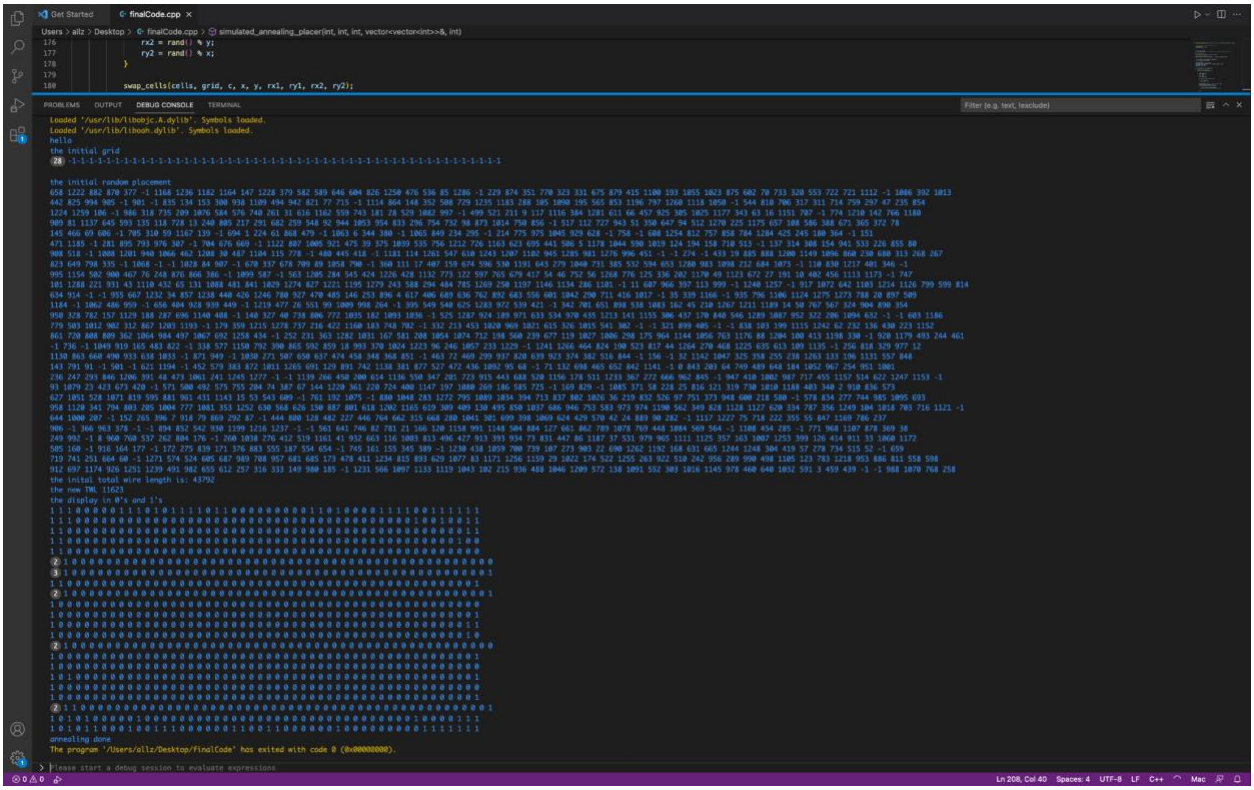
0.8:


Get Started
finalCode.cpp
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
the initial grid
the initial random placement
the inital total wire length is: 44047
the new TWL 13248
the display in 0's and 1's
annealing done
The program '/Users/allz/Desktop/finalCode' has exited with code 0 (0x00000000).
Please start a debug session to evaluate expressions

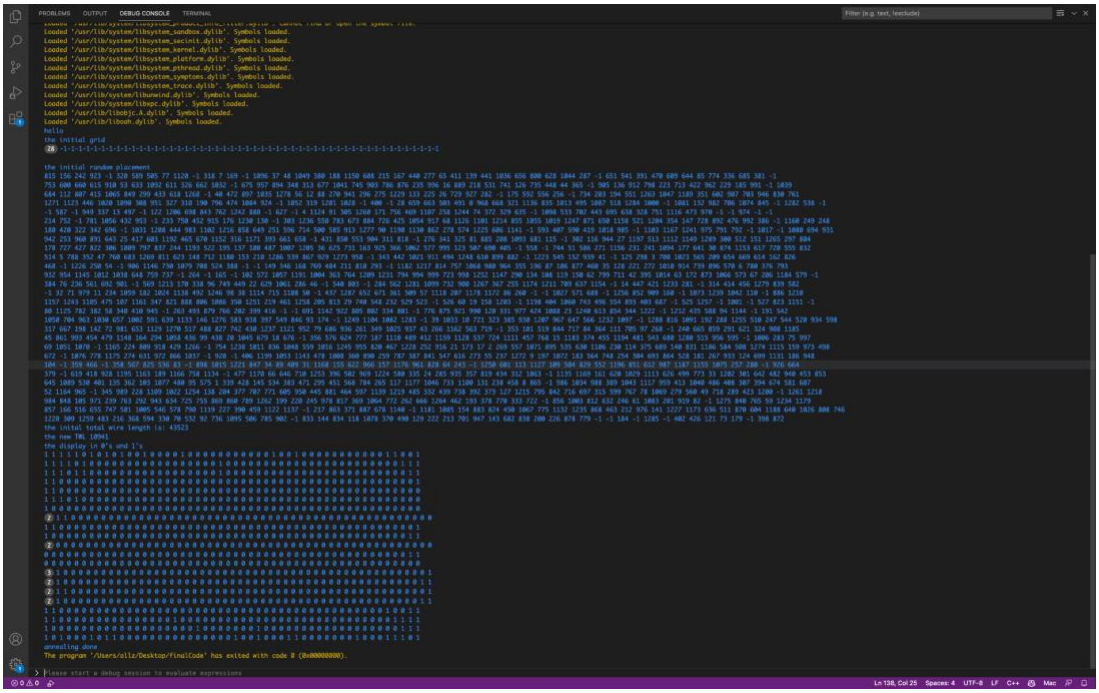
0.85:



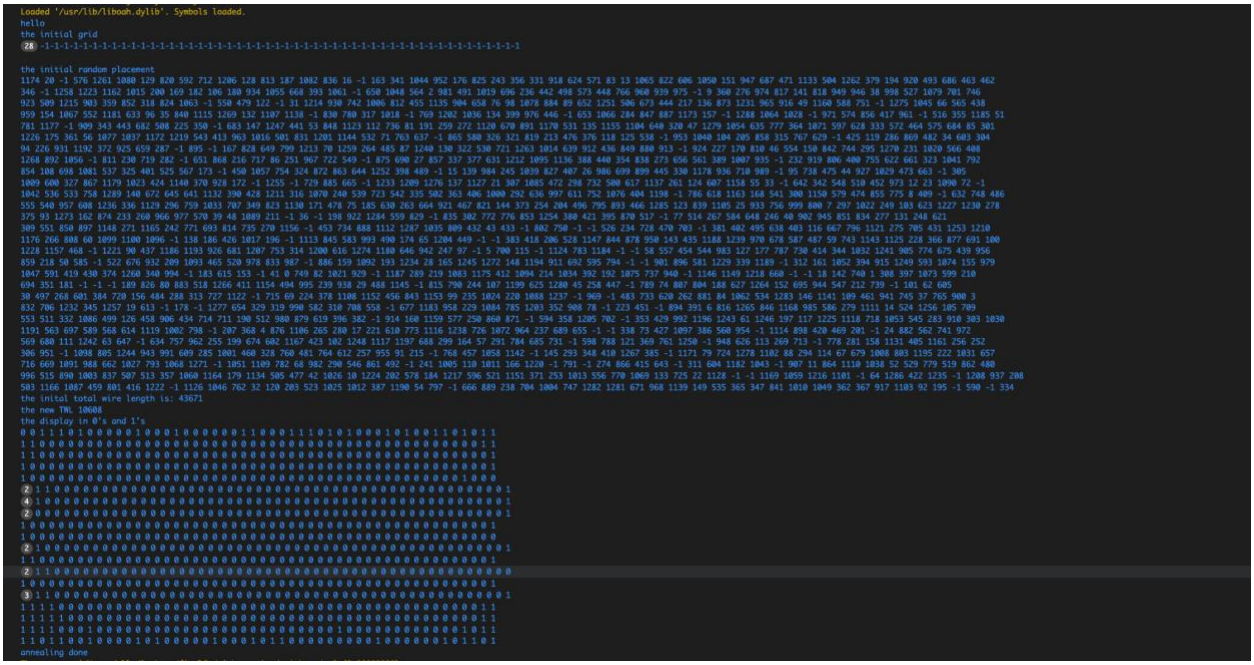
0.9:



0.95:



0.97:


Loaded '/usr/lib/libooh.dylib'. Symbols loaded.
hello
the initial grid
the initial random placement
the initol total wire length is: 43671
the new TWL 10604
the display in 0's and 1's
annealing done