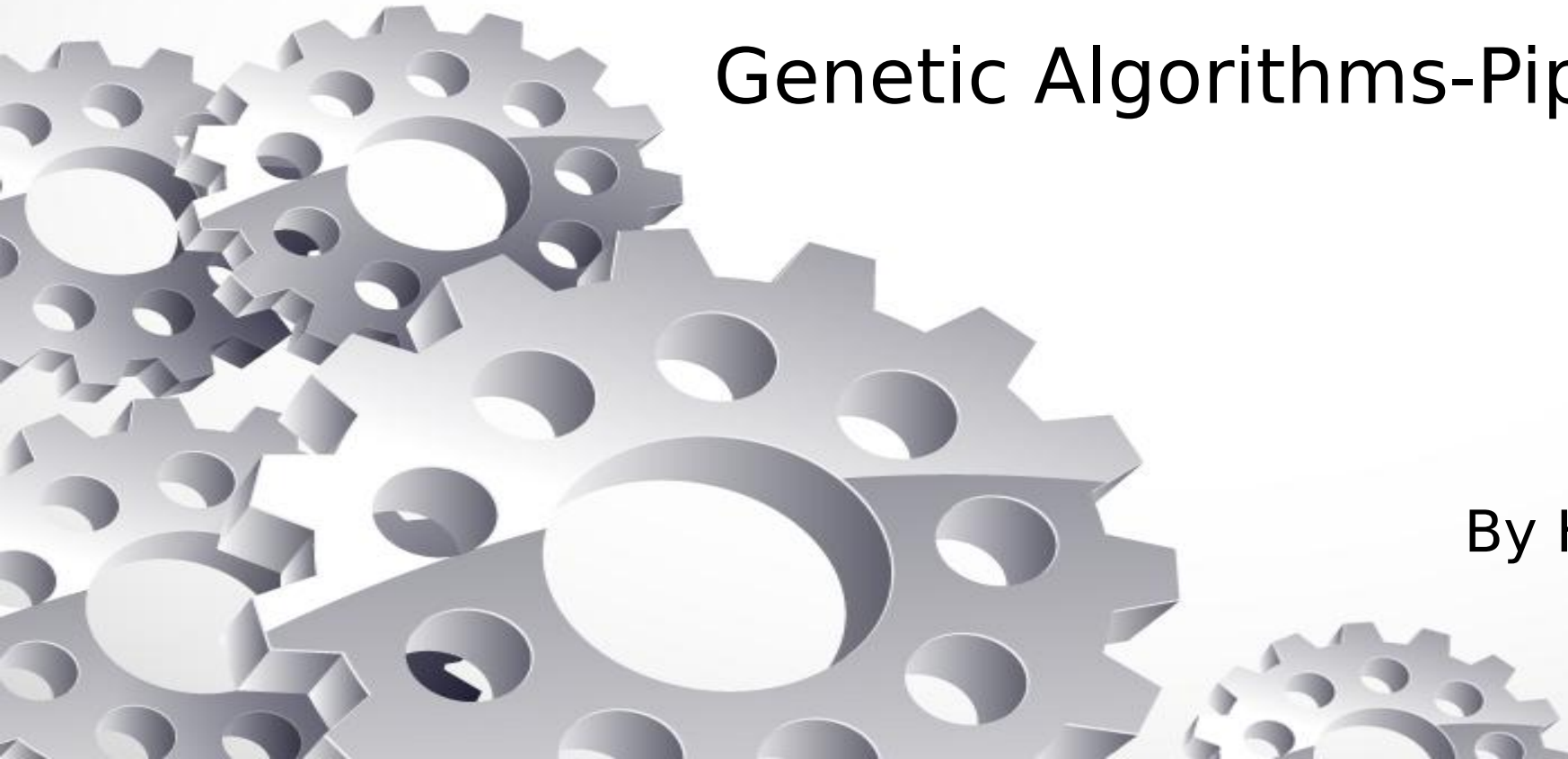


# CS465-Midterm

## Genetic Algorithms-Pipeline

By Hermann Yepdjio



# Introduction

The project was about optimizing the operations of a crude oil extraction plant. As requirements the program should be able to find a solution that would

- maintain each one of the 16 tanks of the pipeline to about 45% of their capacity,
- maintain a constant delivery flow of about 160 gallons per hour for the whole plant,
- maximize the lifespan of the plant,
- minimize the electricity consumption.



# Tools we used



To solve this problem, we considered implementing a genetic algorithm from scratch following some examples seen in class and some others found on the internet

# Steps

1. Create a station class
2. Create an initial population of 16 stations
3. Initialize the population with random values
4. Simulate the functioning of the plant for 48 hours
5. Use the Roulette-Wheel to pick 2 parents
6. Apply Cross-Over to obtain new children
7. Replace old individuals with new children



# Steps

8. Simulate again

9. Repeat the last 4 steps until the solution does not improve anymore

10. Apply mutation and go back to step 4



# Results

```
hermann@hrm-GL72M-7RDX: /media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution
File Edit View Search Terminal Help
16 || 1 || 1 || 44.39 || 11.17 || 11.17 || 160R || 0.986
Plant fitness: 0.877
Plant total dispatch: 179.75812734491865 gallons

Cross-over applied between station #3 and station #8
The new child will replace station #6 which has the lowest fitness in the whole plant
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
=====
1 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20L || 0.986
2 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20R || 0.986
3 || 1 || 1 || 45.20 || 11.09 || 11.09 || 40L || 0.996
4 || 1 || 1 || 44.39 || 11.17 || 11.17 || 40R || 0.986
5 || 1 || 1 || 44.39 || 11.17 || 11.17 || 60L || 0.986
6 || 1 || 1 || 44.79 || 11.13 || 11.13 || 60R || 0.995
7 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80L || 0.986
8 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80R || 0.986
9 || 1 || 1 || 44.39 || 11.17 || 11.17 || 100L || 0.986
10 || 1 || 1 || 41.70 || 10.59 || 10.59 || 100R || 0.927
11 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120L || 0.986
12 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120R || 0.986
13 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140L || 0.986
14 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140R || 0.986
15 || 1 || 1 || 39.00 || 10.00 || 10.00 || 160L || 0.867
16 || 1 || 1 || 44.39 || 11.17 || 11.17 || 160R || 0.986
Plant fitness: 0.894
Plant total dispatch: 176.88841274000453 gallons
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
=====
1 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20L || 0.986
2 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20R || 0.986
3 || 1 || 1 || 45.20 || 11.09 || 11.09 || 40L || 0.996
4 || 1 || 1 || 44.39 || 11.17 || 11.17 || 40R || 0.986
5 || 1 || 1 || 44.39 || 11.17 || 11.17 || 60L || 0.986
6 || 1 || 1 || 44.79 || 11.13 || 11.13 || 60R || 0.995
7 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80L || 0.986
8 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80R || 0.986
9 || 1 || 1 || 44.39 || 11.17 || 11.17 || 100L || 0.986
10 || 1 || 1 || 41.70 || 10.59 || 10.59 || 100R || 0.927
11 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120L || 0.986
12 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120R || 0.986
13 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140L || 0.986
14 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140R || 0.986
15 || 1 || 1 || 39.00 || 10.00 || 10.00 || 160L || 0.867
16 || 1 || 1 || 44.39 || 11.17 || 11.17 || 160R || 0.986
Plant fitness: 0.894
Plant total dispatch: 176.88841274000453 gallons
```

```
Hour: 1
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
=====
```



# Results

```
hermann@hrm-GL72M-7RDX: /media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution
File Edit View Search Terminal Help
```

Hour: 1

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
1	1	1	44.39	11.17	11.17	20L	0.986
2	1	1	44.39	11.17	11.17	20R	0.986
3	1	1	45.20	11.09	11.09	40L	0.996
4	1	1	44.39	11.17	11.17	40R	0.986
5	1	1	44.39	11.17	11.17	60L	0.986
6	1	1	44.79	11.13	11.13	60R	0.995
7	1	1	44.39	11.17	11.17	80L	0.986
8	1	1	44.39	11.17	11.17	80R	0.986
9	1	1	44.39	11.17	11.17	100L	0.986
10	1	1	41.70	10.59	10.59	100R	0.927
11	1	1	44.39	11.17	11.17	120L	0.986
12	1	1	44.39	11.17	11.17	120R	0.986
13	1	1	44.39	11.17	11.17	140L	0.986
14	1	1	44.39	11.17	11.17	140R	0.986
15	1	1	39.00	10.00	10.00	160L	0.867
16	1	1	44.39	11.17	11.17	160R	0.986

Plant fitness: 0.894

Plant total dispatch: 176.88841274000453 gallons

Hour: 2

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
1	1	1	44.39	11.17	11.17	20L	0.986
2	1	1	44.39	11.17	11.17	20R	0.986
3	1	1	45.20	11.09	11.09	40L	0.996
4	1	1	44.39	11.17	11.17	40R	0.986
5	1	1	44.39	11.17	11.17	60L	0.986
6	1	1	44.79	11.13	11.13	60R	0.995
7	1	1	44.39	11.17	11.17	80L	0.986
8	1	1	44.39	11.17	11.17	80R	0.986
9	1	1	44.39	11.17	11.17	100L	0.986
10	1	1	41.70	10.59	10.59	100R	0.927
11	1	1	44.39	11.17	11.17	120L	0.986
12	1	1	44.39	11.17	11.17	120R	0.986
13	1	1	44.39	11.17	11.17	140L	0.986
14	1	1	44.39	11.17	11.17	140R	0.986
15	1	1	39.00	10.00	10.00	160L	0.867
16	1	1	44.39	11.17	11.17	160R	0.986

Plant fitness: 0.894

Plant total dispatch: 176.88841274000453 gallons

Hour: 3

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
1	1	1	44.39	11.17	11.17	20L	0.986
2	1	1	44.39	11.17	11.17	20R	0.986

# Results

hermann@hrm-GL72M-7RDX: /media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution

File Edit View Search Terminal Help

Plant fitness: 0.964

Plant total dispatch: 165.75812734491868 gallons

Hour: 29

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
1	1	1	44.39	11.17	11.17	20L	0.986
2	1	1	44.39	11.17	11.17	20R	0.986
3	1	1	45.20	11.09	11.09	40L	0.996
4	1	1	44.39	11.17	11.17	40R	0.986
5	1	1	44.39	11.17	11.17	60L	0.986
6	1	1	11.00	8.00	14.00	60R	0.244
7	1	1	44.39	11.17	11.17	80L	0.986
8	1	1	44.39	11.17	11.17	80R	0.986
9	1	1	44.39	11.17	11.17	100L	0.986
10	1	1	41.70	10.59	10.59	100R	0.927
11	1	1	44.39	11.17	11.17	120L	0.986
12	1	1	44.39	11.17	11.17	120R	0.986
13	1	1	44.39	11.17	11.17	140L	0.986
14	1	1	44.39	11.17	11.17	140R	0.986
15	1	1	39.00	10.00	10.00	160L	0.867
16	1	1	44.39	11.17	11.17	160R	0.986

Plant fitness: 0.877

Plant total dispatch: 179.75812734491865 gallons

Hour: 30

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
1	1	1	44.39	11.17	11.17	20L	0.986
2	1	1	44.39	11.17	11.17	20R	0.986
3	1	1	45.20	11.09	11.09	40L	0.996
4	1	1	44.39	11.17	11.17	40R	0.986
5	1	1	44.39	11.17	11.17	60L	0.986
6	1	0	5.00	8.00	14.00	60R	0.111
7	1	1	44.39	11.17	11.17	80L	0.986
8	1	1	44.39	11.17	11.17	80R	0.986
9	1	1	44.39	11.17	11.17	100L	0.986
10	1	1	41.70	10.59	10.59	100R	0.927
11	1	1	44.39	11.17	11.17	120L	0.986
12	1	1	44.39	11.17	11.17	120R	0.986
13	1	1	44.39	11.17	11.17	140L	0.986
14	1	1	44.39	11.17	11.17	140R	0.986
15	1	1	39.00	10.00	10.00	160L	0.867
16	1	1	44.39	11.17	11.17	160R	0.986

Plant fitness: 0.964

Plant total dispatch: 165.75812734491868 gallons

Hour: 31

Station #	pump_in switch	pump_out switch	tank_level	pump_in	pump_out	Position_from_center	fitness
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# Results

```
hermann@hrm-GL72M-7RDX: /media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution
File Edit View Search Terminal Help
16 || 1 || 1 || 44.39 || 11.17 || 11.17 || 160R || 0.986
Plant fitness: 0.894
Plant total dispatch: 176.88841274000453 gallons

Hour: 48
Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
=====
1 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20L || 0.986
2 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20R || 0.986
3 || 1 || 1 || 45.20 || 11.09 || 11.09 || 40L || 0.996
4 || 1 || 1 || 44.39 || 11.17 || 11.17 || 40R || 0.986
5 || 1 || 1 || 44.39 || 11.17 || 11.17 || 60L || 0.986
6 || 1 || 1 || 44.79 || 11.13 || 11.13 || 60R || 0.995
7 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80L || 0.986
8 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80R || 0.986
9 || 1 || 1 || 44.39 || 11.17 || 11.17 || 100L || 0.986
10 || 1 || 1 || 41.70 || 10.59 || 10.59 || 100R || 0.927
11 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120L || 0.986
12 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120R || 0.986
13 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140L || 0.986
14 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140R || 0.986
15 || 1 || 1 || 39.00 || 10.00 || 10.00 || 160L || 0.867
16 || 1 || 1 || 44.39 || 11.17 || 11.17 || 160R || 0.986
Plant fitness: 0.894
Plant total dispatch: 176.88841274000453 gallons

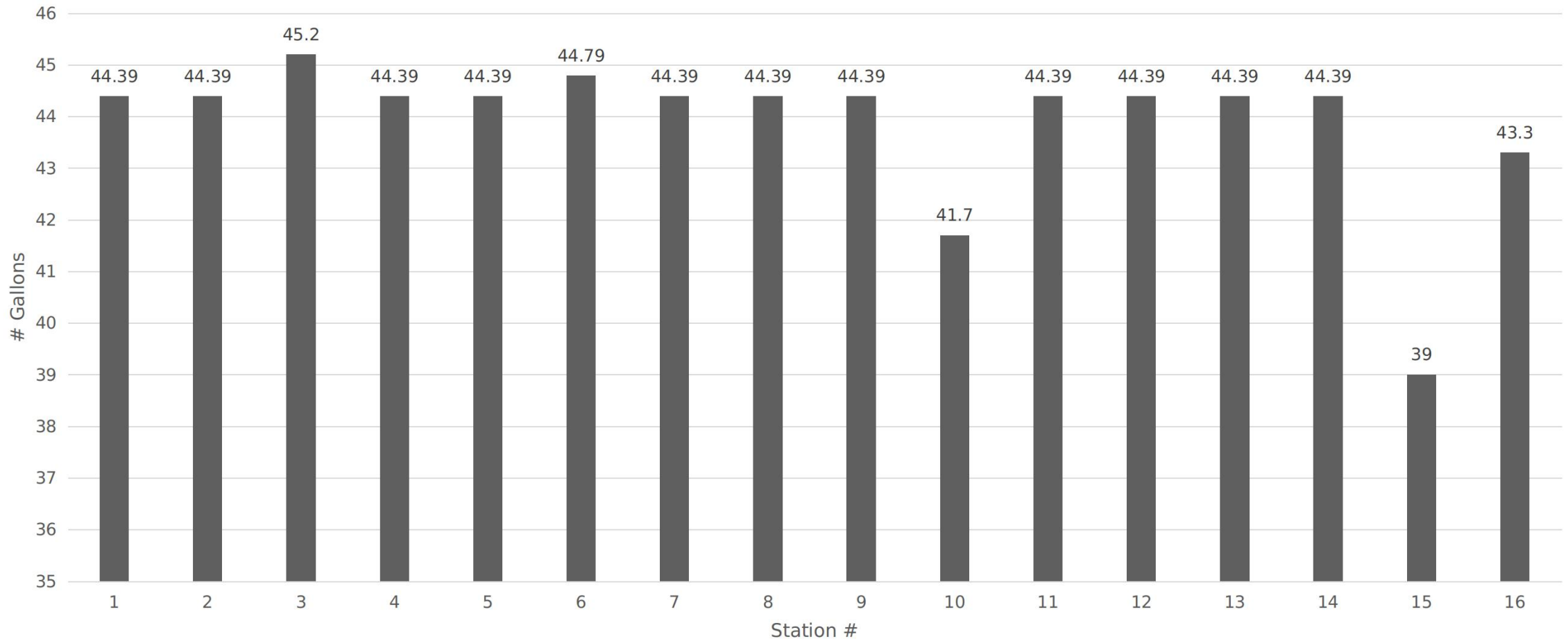
Mutation was just applied on station #16

Station # || pump_in switch || pump_out switch || tank_level || pump_in || pump_out || Position_from_center || fitness
=====
1 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20L || 0.986
2 || 1 || 1 || 44.39 || 11.17 || 11.17 || 20R || 0.986
3 || 1 || 1 || 45.20 || 11.09 || 11.09 || 40L || 0.996
4 || 1 || 1 || 44.39 || 11.17 || 11.17 || 40R || 0.986
5 || 1 || 1 || 44.39 || 11.17 || 11.17 || 60L || 0.986
6 || 1 || 1 || 44.79 || 11.13 || 11.13 || 60R || 0.995
7 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80L || 0.986
8 || 1 || 1 || 44.39 || 11.17 || 11.17 || 80R || 0.986
9 || 1 || 1 || 44.39 || 11.17 || 11.17 || 100L || 0.986
10 || 1 || 1 || 41.70 || 10.59 || 10.59 || 100R || 0.927
11 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120L || 0.986
12 || 1 || 1 || 44.39 || 11.17 || 11.17 || 120R || 0.986
13 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140L || 0.986
14 || 1 || 1 || 44.39 || 11.17 || 11.17 || 140R || 0.986
15 || 1 || 1 || 39.00 || 10.00 || 10.00 || 160L || 0.867
16 || 1 || 1 || 26.00 || 15.00 || 10.00 || 160R || 0.578
Plant fitness: 0.902
Plant total dispatch: 175.71476346772897 gallons
hermann@hrm-GL72M-7RDX:/media/hermann/Tonpi/tonpi/Collegecourses/CWU/Graduate School/Fall 2018/CS 565/Exams/Midterm/solution$
```

# Results



Average Tanks' levels over the last 48 hours



# Conclusion



To prevent the program to run for ever trying to find the perfect solution, I set it to stop whenever it finds a solution that has a plant fitness of 0.9 and above and an average station fitness of 0.95 and above