AI-Project 03

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<u>How to run the project</u>:
Run: python csp.py “instances folder link”
write the instance name you want to test , space, algorithm name you want to run. The script will print for you the results and ask you for the next instance you want to try.

(Also, if you like to run all the instances with all the algorithms for five iterations all together, there are some commented lines in red (somewhere between lines 556 to 564) you can uncomment, and also a script called test.txt with the proper commands. In this case when the program asks you to give “instance name and algorithm” you have to give the scripts path.)

<u>How to read results:</u>
Each given instance runs five times for each given algorithm. If an iteration takes more than 10 minutes the process is aborted and a corresponding message is printed(if the iteration was successful no message is shown). After five iterations a table with all the metrics for each instance is printed, followed by calculations for average metrics.

On the project I have included utils.py and search.py from aima. Script csp.py is a mixed version of aima csp.py and other functions I implemented to adapt to the rlfap problem.
Specifically, csp.py reads the link of the folder that contains instances from the command line and then asks for input as described above. Then opens the folder, reads data from the files of the given instance and creates data structures.
Creates an instance of class rlfap(that just creates a csp instance for the problem,(also shuffles the variables on structures,so as every time that the program start to run and the weight of the constraints are all equal to one a different variable will be chosen each time) then calls the corresponding algorithm five times and calculates the average results and prints them.

Data structures:
ctr_dict: Is a dictionary that stores the constraints. Each key is variable and has as value a list that contains the other variable included on the constraint, the operator and k value and an integer that represents the eight of the constraint. The weight is incremented by the revise function as described on the paper(every time a variable domain wipes out due to that constraint). Every time a constraint is read from the file it is added on the ctr_cict “both ways”. Tha means, if we read constraint (x operator y k) we create two dictionary items, one that has x as key and one that has y as key.

var_list: is a list of tuples. Each tuple stores a variable and the name of the variable domain.

dom_dict: is a dictionary that has as key a variable and each variable has as value a list of values of its domain.

Neighbors: is a dictionary that has as key a variable and as value a list of other variables that participate in a constraint with the key variable.
There are some utility functions that help on building these structures.

Heuristic:
Is implemented as described on the paper.

From aima:

CSP class, not modified significantly.
AC-3() (+dom_j_up**):**
revise(): modified to increase constraint weight as mentioned on the paper.
value ordering functions: not modified (using function unorder_domains_Value())
Inference functions:

- **mac()**: not modified
- **foward_checking():** not modified

min_conflicts(): modified to call dom_wdeg
backtracking_seearch(): not modified significantly

*There may be some changes on the aima code that I haven't mentioned here, cause they are insignificant changes I have done just to adapt the code to my functions and data structures.

Conclusions:
What I have observed from running different instances multiple times, using different algorithms,MAC,FC,(way more than the 5 iterations per algorithm as it was mentioned on Piazza) is that the problem is “unstable.” Running an instance with a specific algorithm can take from less than 0.20 seconds to more than 2-3 minutes. There are also some cases that some instances (like 2-f25, 14-f28, 3-f11) will take longer than 10 minutes. As mentioned before there is no certainty about the amount of time an instance could take to run and I think this is caused due to random choice of values on a variable domain(cause I do not use any value ordering heuristic), and also due to the fact that, when the algorithm start and all the constraints weight are equal to 1 the first variable is been chosen randomly.

On the tables below are presented the average (of five iterations) per instance for each algorithm. For more detailed results at the end of the document are shown some screenshots from the output of csp.py.

(I have not represented all the instances, because on my final result testing, some instances took too much time to run and I did not have much time left until the deadline so I tried only the ones I knew(from previous testings) that will run “fast”.)

<u>*when there are <5 iterations it means some iteration was dismissed because it took more than 10min so the results are calculated for the rest.</u>

MAC	Time(sec)	Checks	Assignments	Results	Iterations
11	1044.8(~17)	186961005	99352	SAT	1
2-f24	1.728	364632.2	433.6	SAT	5
2-f25	>10min				5
3-f10	4.2	1002359.75	546.5	SAT	4
3-f11	>10min				
6-w2	0.598	108734.0	0.0	UNSUT	5
7-w1-f4	48.07	14545378.0	19300.5	SAT	4
8-f10	>10min				
8-f11	1.138	2648.8	0.0	UNSAT	5
14-f27	>10min				
14-f28	0.244	379.2	0.0	UNSAT	5

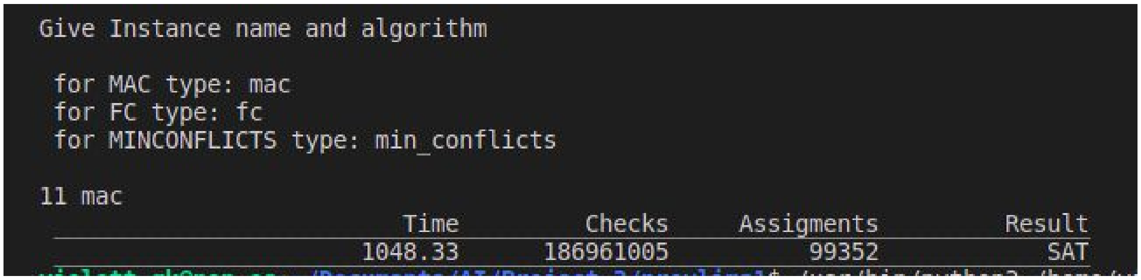
FC	Time(sec)	Checks	Assignments	Results	Iterations
11	>10min				
2-f24	1.207	144277.6	1033.0	SAT	5

2-f25	1.328	378684.2	421.6	SAT	5
3-f10	37.65	3242129.4	30717.2	SAT	5
3-f11	>10min				
6-w2	>10min				
7-w1-f4	182.7425	43605801.75	1219347.25	SAT	4
8-f10	>10min				
8-f11	8.204	5531.0	7.0	UNSAT	5
14-f27	>10min				
14-f28	2.59	3088.0	8.0	UNSAT	5

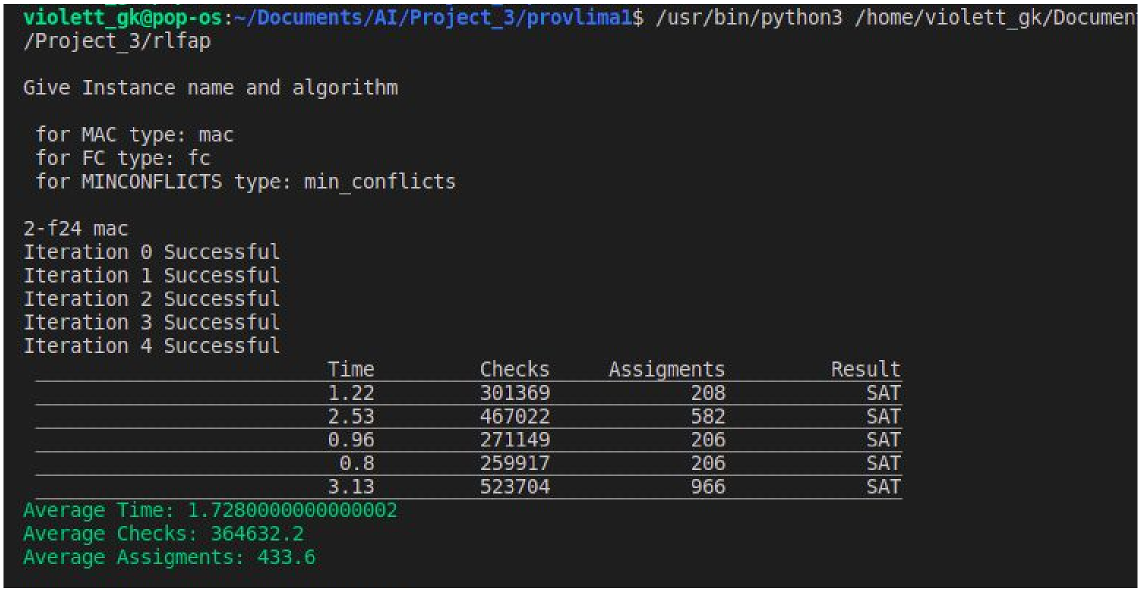
Min Conflict generally runs faster (never surpassed 4 minutes) but the biggest part of its results are wrong.
(On the screenshots none of the result is SUT, but on my previous testing runs a few results were SAT, and this is a good example that shows how much randomness affects the results.)

Min Conflicts	**Time(sec)**	**Checks**	**Assignments**	**Results**	**Iterations**
11					
2-f24	10.324	3015708.0	1200.0	UNSAT	5
2-f25	12.83	2959151.2	1200.0	UNSAT	5
3-f10	180.698	37920643.8	2000.0	UNSAT	5
3-f11	334.342	72524498.6	2400.0	UNSAT	5
6-w2	3.2239	1636558.8	1200.0	UNSAT	5
7-w1-f4	10.209	4968038.2	1600.0	UNSAT	5
8-f10	66.178	22392707.4	2156.0	UNSAT	5
8-f11	77.588	31484478.8	2360.0	UNSAT	5
14-f27					
14-f28					

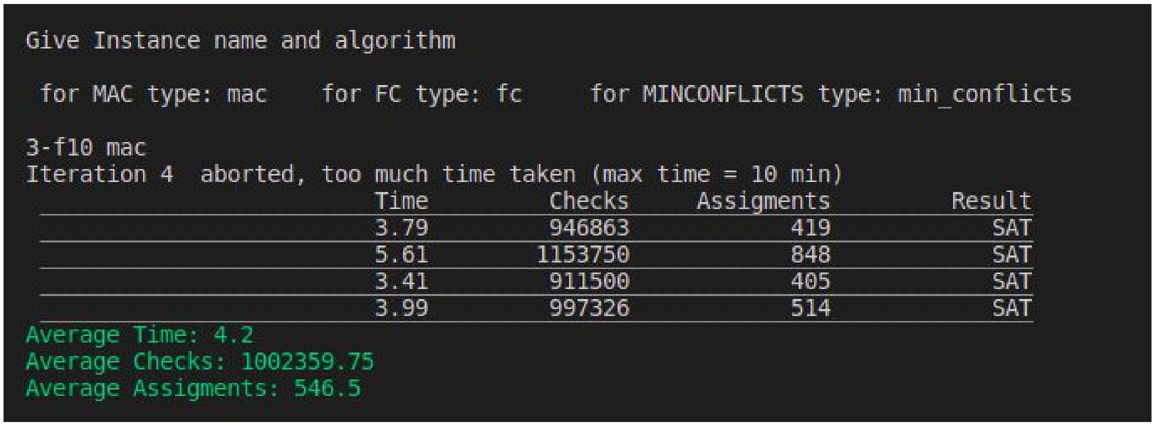
*screenshots graphics may differ because some are runned from terminal and some from vs code terminal



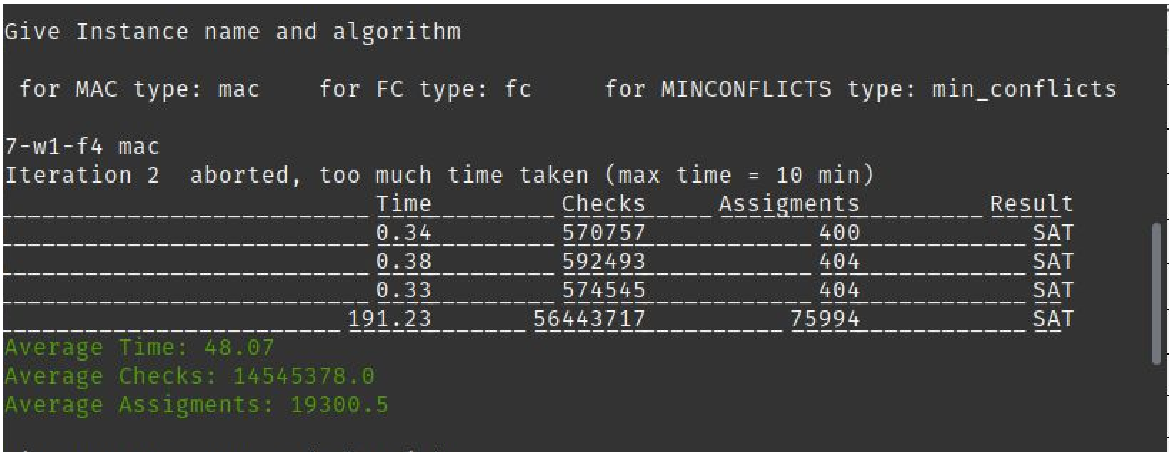
```
Give Instance name and algorithm

 for MAC type: mac
 for FC type: fc
 for MINCONFLICTS type: min_conflicts

11 mac
                          Time          Checks      Assigments          Result
 ______________________________________________________________________________
                        1048.33      186961005         99352               SAT
```



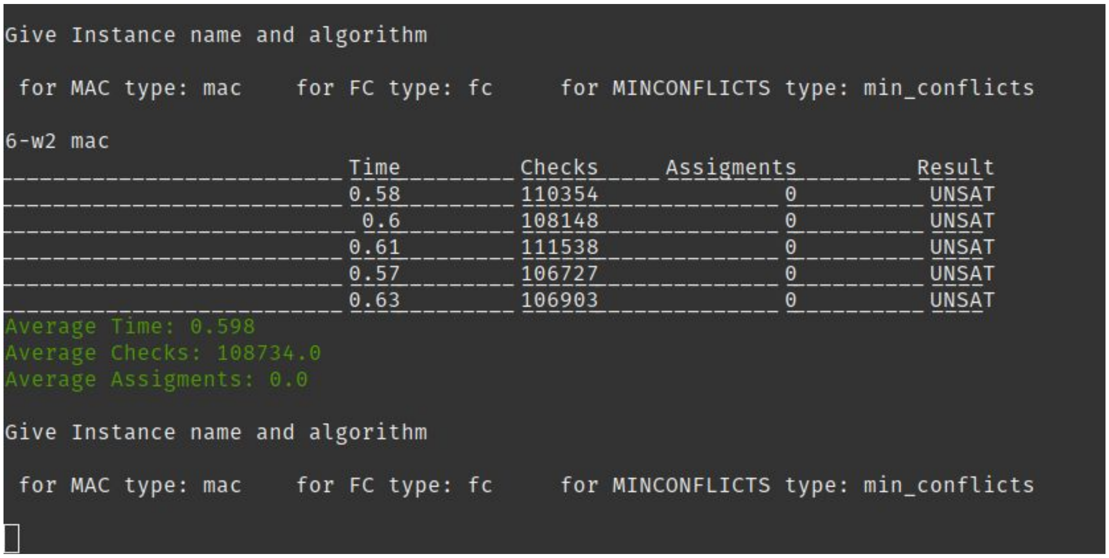
```
violett_gk@pop-os:~/Documents/AI/Project_3/provlima1$ /usr/bin/python3 /home/violett_gk/Documen
/Project_3/rlfap

Give Instance name and algorithm

 for MAC type: mac
 for FC type: fc
 for MINCONFLICTS type: min_conflicts

2-f24 mac
Iteration 0 Successful
Iteration 1 Successful
Iteration 2 Successful
Iteration 3 Successful
Iteration 4 Successful
 _________________________Time_________Checks_____Assigments_________Result
 _________________________1.22_________301369___________208____________SAT
 _________________________2.53_________467022___________582____________SAT
 _________________________0.96_________271149___________206____________SAT
 __________________________0.8_________259917___________206____________SAT
 _________________________3.13_________523704___________966____________SAT
Average Time: 1.7280000000000002
Average Checks: 364632.2
Average Assigments: 433.6
```



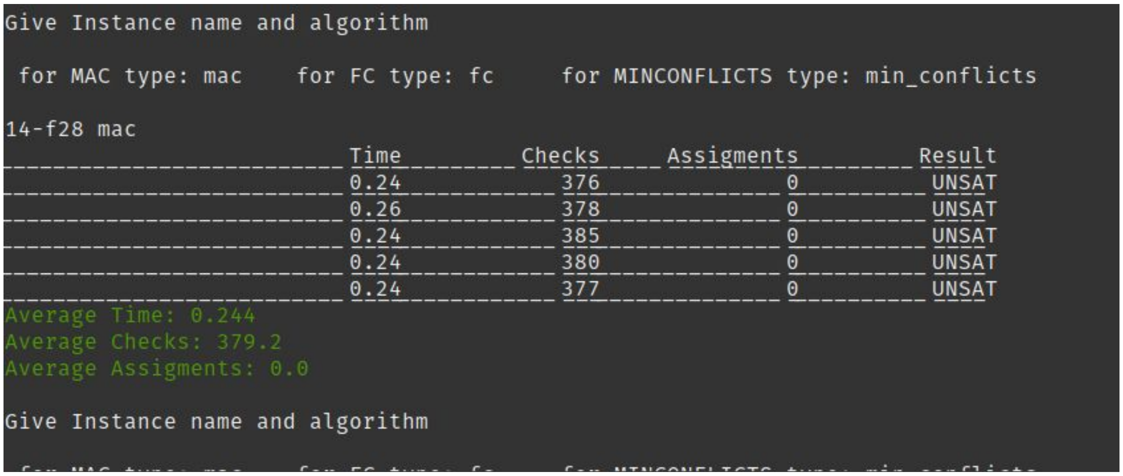
```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

3-f10 mac
Iteration 4  aborted, too much time taken (max time = 10 min)
 _________________________Time_________Checks_____Assigments___________Result
 _________________________3.79_________946863___________419______________SAT
 _________________________5.61________1153750___________848______________SAT
 _________________________3.41_________911500___________405______________SAT
 _________________________3.99_________997326___________514______________SAT
Average Time: 4.2
Average Checks: 1002359.75
Average Assigments: 546.5
```



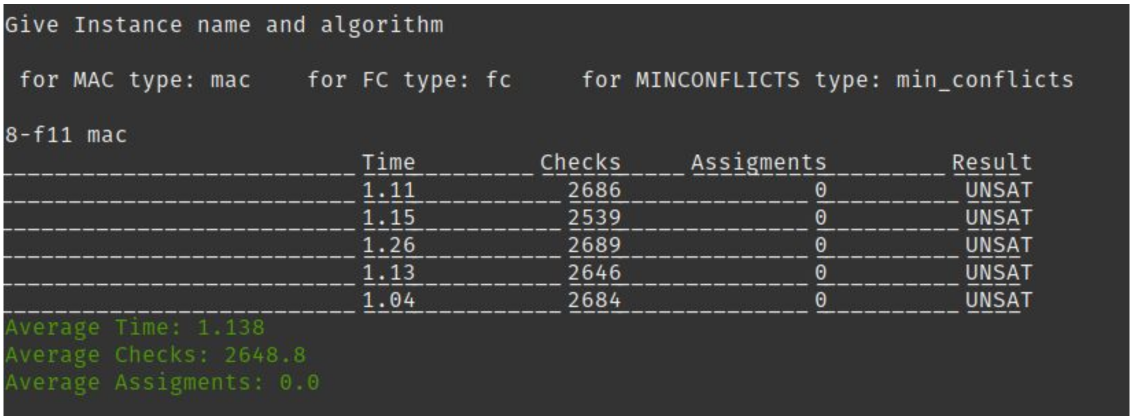
```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

7-w1-f4 mac
Iteration 2  aborted, too much time taken (max time = 10 min)
_________________________Time________Checks____Assigments________Result
_________________________0.34________570757_____________400___________SAT
_________________________0.38________592493_____________404___________SAT
_________________________0.33________574545_____________404___________SAT
_______________________191.23______56443717___________75994___________SAT
Average Time: 48.07
Average Checks: 14545378.0
Average Assigments: 19300.5
```



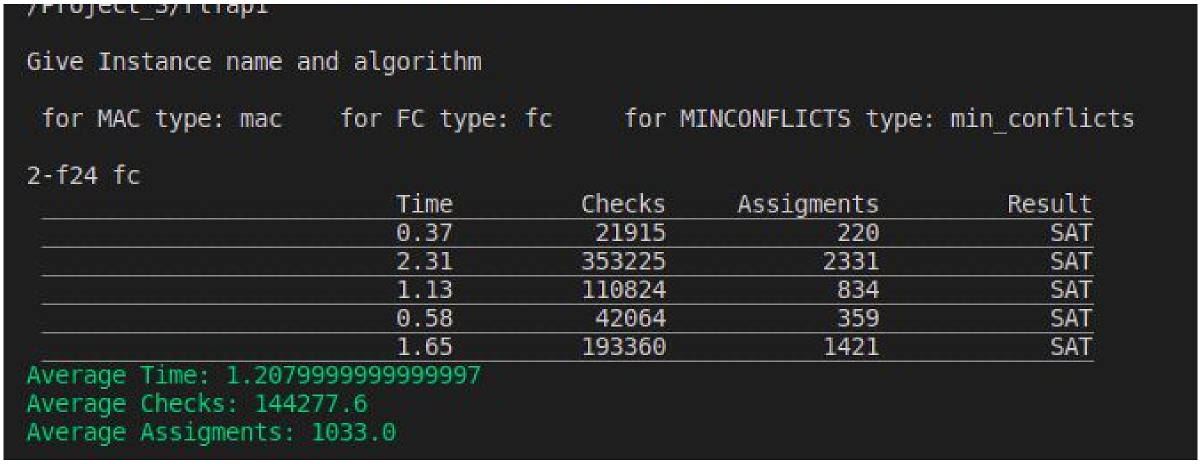
```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

6-w2 mac
__________________________Time_________Checks_____Assigments_________Result
__________________________0.58_________110354______________0__________UNSAT
__________________________ 0.6_________108148______________0__________UNSAT
__________________________0.61_________111538______________0__________UNSAT
__________________________0.57_________106727______________0__________UNSAT
__________________________0.63_________106903______________0__________UNSAT
Average Time: 0.598
Average Checks: 108734.0
Average Assigments: 0.0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

```



```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

14-f28 mac
__________________________Time_________Checks_____Assigments_________Result
__________________________0.24____________376______________0__________UNSAT
__________________________0.26____________378______________0__________UNSAT
__________________________0.24____________385______________0__________UNSAT
__________________________0.24____________380______________0__________UNSAT
__________________________0.24____________377______________0__________UNSAT
Average Time: 0.244
Average Checks: 379.2
Average Assigments: 0.0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts
```



```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

8-f11 mac
__________________________Time_________Checks_____Assigments_________Result
__________________________1.11___________2686______________0__________UNSAT
__________________________1.15___________2539______________0__________UNSAT
__________________________1.26___________2689______________0__________UNSAT
__________________________1.13___________2646______________0__________UNSAT
__________________________1.04___________2684______________0__________UNSAT
Average Time: 1.138
Average Checks: 2648.8
Average Assigments: 0.0
```



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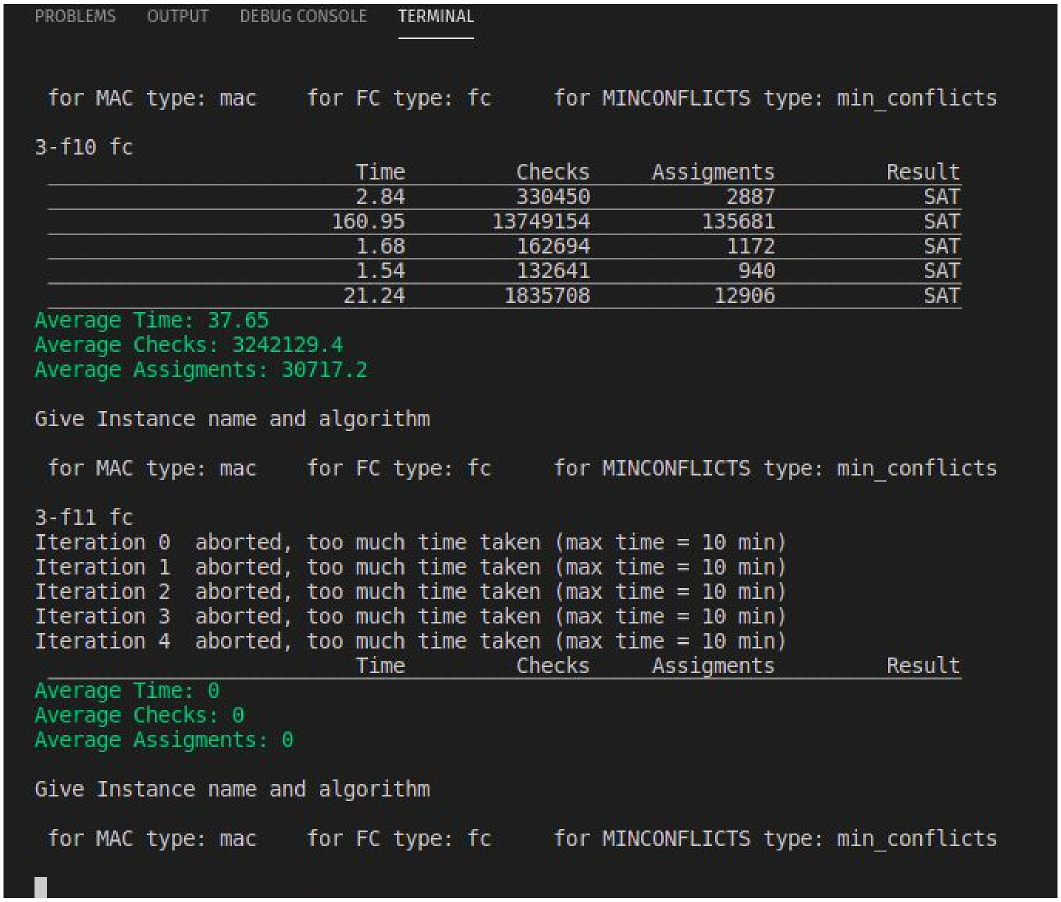
/Project_3/rltapi

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

2-f24 fc
                              Time           Checks     Assigments          Result
 ______________________________________________________________________________________
                              0.37            21915            220             SAT
                              2.31           353225           2331             SAT
                              1.13           110824            834             SAT
                              0.58            42064            359             SAT
                              1.65           193360           1421             SAT
Average Time: 1.2079999999999997
Average Checks: 144277.6
Average Assigments: 1033.0
```



```
 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

3-f10 fc
                              Time           Checks     Assigments          Result
                              2.84           330450           2887             SAT
                            160.95         13749154         135681             SAT
                              1.68           162694           1172             SAT
                              1.54           132641            940             SAT
                             21.24          1835708          12906             SAT
Average Time: 37.65
Average Checks: 3242129.4
Average Assigments: 30717.2

Give Instance name and algorithm

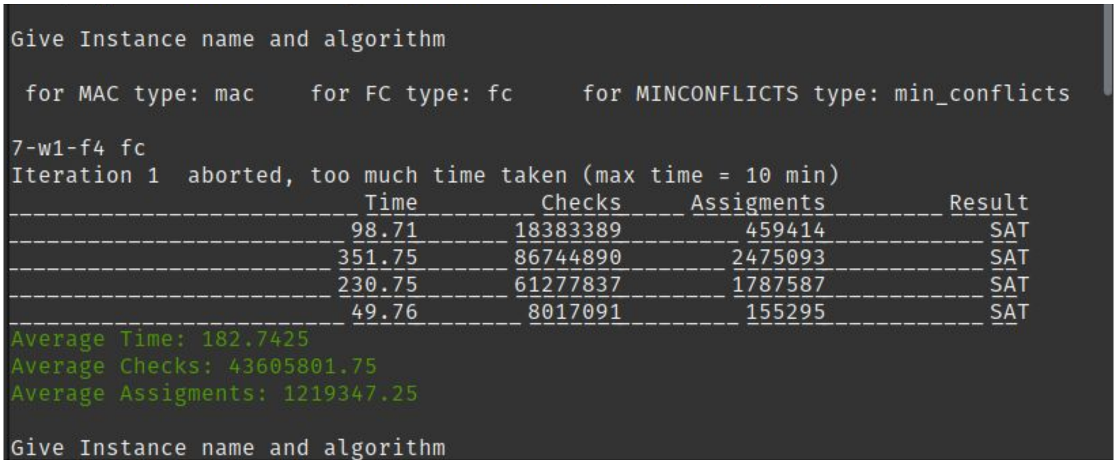
 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

3-f11 fc
Iteration 0  aborted, too much time taken (max time = 10 min)
Iteration 1  aborted, too much time taken (max time = 10 min)
Iteration 2  aborted, too much time taken (max time = 10 min)
Iteration 3  aborted, too much time taken (max time = 10 min)
Iteration 4  aborted, too much time taken (max time = 10 min)
                              Time           Checks     Assigments          Result
Average Time: 0
Average Checks: 0
Average Assigments: 0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

```

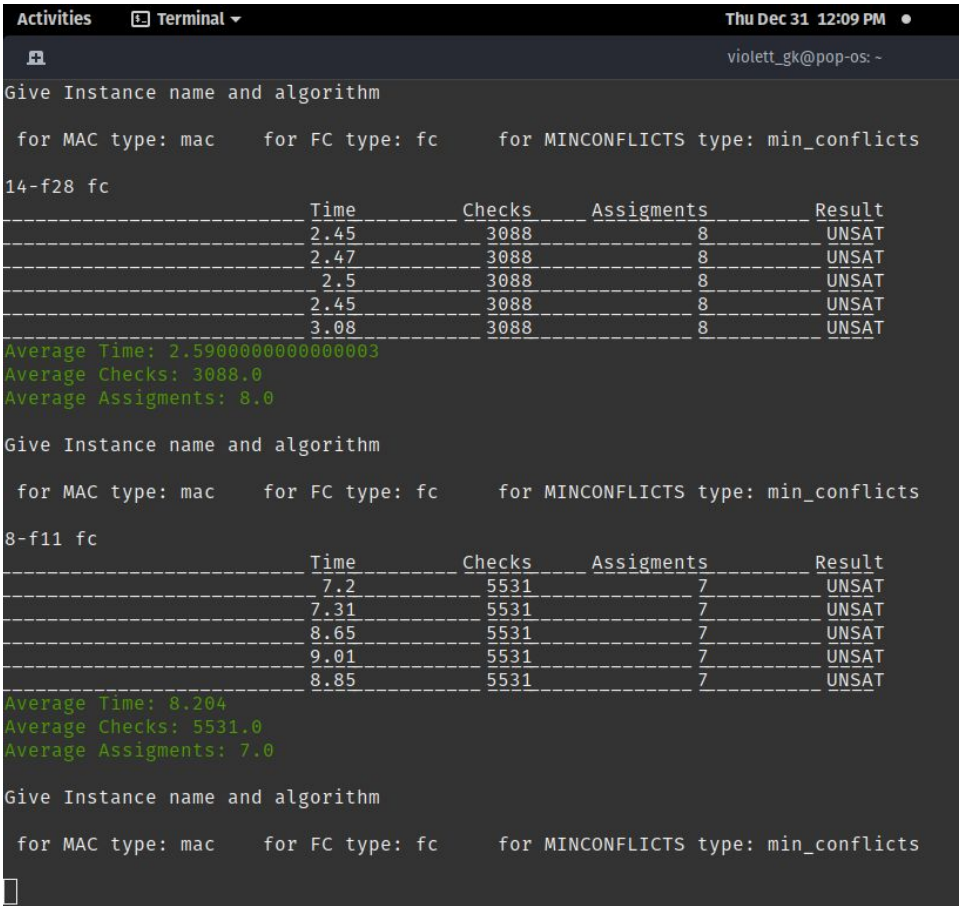


```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

7-w1-f4 fc
Iteration 1  aborted, too much time taken (max time = 10 min)
_________________________Time_________Checks____Assigments_________Result
________________________98.71______18383389_______459414___________SAT
_______________________351.75______86744890______2475093___________SAT
_______________________230.75______61277837______1787587___________SAT
________________________49.76_______8017091_______155295___________SAT
Average Time: 182.7425
Average Checks: 43605801.75
Average Assigments: 1219347.25

Give Instance name and algorithm
```



```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

14-f28 fc
__________________________Time_________Checks____Assigments________Result
__________________________2.45___________3088______________8_________UNSAT
__________________________2.47___________3088______________8_________UNSAT
___________________________2.5___________3088______________8_________UNSAT
__________________________2.45___________3088______________8_________UNSAT
__________________________3.08___________3088______________8_________UNSAT
Average Time: 2.5900000000000003
Average Checks: 3088.0
Average Assigments: 8.0

Give Instance name and algorithm

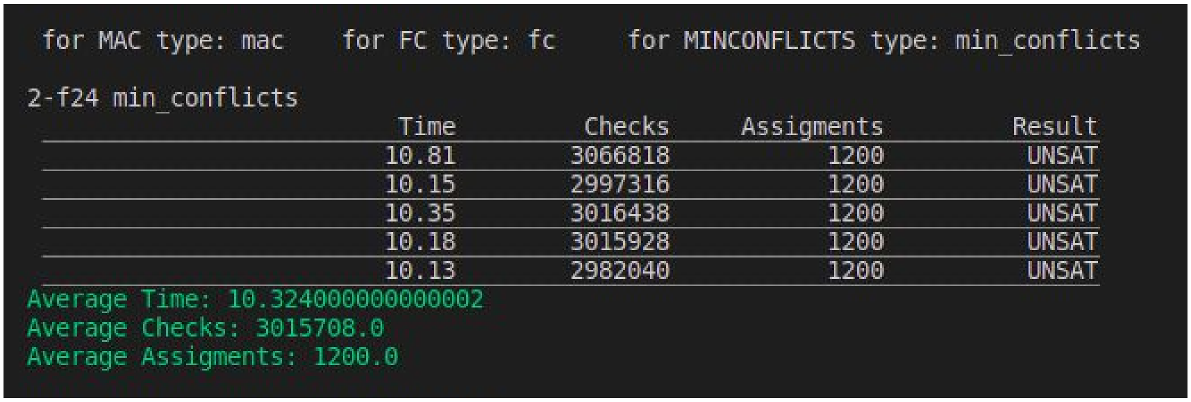
 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

8-f11 fc
__________________________Time_________Checks____Assigments________Result
___________________________7.2___________5531______________7_________UNSAT
__________________________7.31___________5531______________7_________UNSAT
__________________________8.65___________5531______________7_________UNSAT
__________________________9.01___________5531______________7_________UNSAT
__________________________8.85___________5531______________7_________UNSAT
Average Time: 8.204
Average Checks: 5531.0
Average Assigments: 7.0

Give Instance name and algorithm

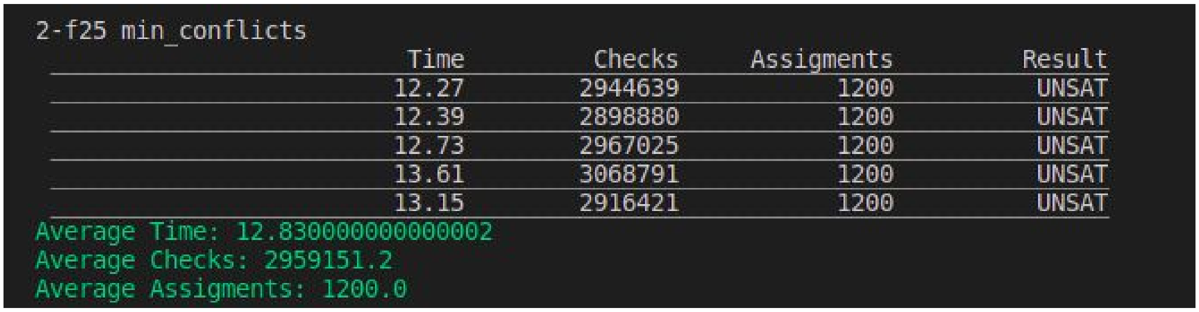
 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

```



```
 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

2-f24 min_conflicts
                                   Time           Checks      Assigments            Result
                                  10.81          3066818            1200             UNSAT
                                  10.15          2997316            1200             UNSAT
                                  10.35          3016438            1200             UNSAT
                                  10.18          3015928            1200             UNSAT
                                  10.13          2982040            1200             UNSAT
Average Time: 10.324000000000002
Average Checks: 3015708.0
Average Assigments: 1200.0
```



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2-f25 min_conflicts
                                   Time           Checks      Assigments            Result
                                  12.27          2944639            1200             UNSAT
                                  12.39          2898880            1200             UNSAT
                                  12.73          2967025            1200             UNSAT
                                  13.61          3068791            1200             UNSAT
                                  13.15          2916421            1200             UNSAT
Average Time: 12.830000000000002
Average Checks: 2959151.2
Average Assigments: 1200.0
```
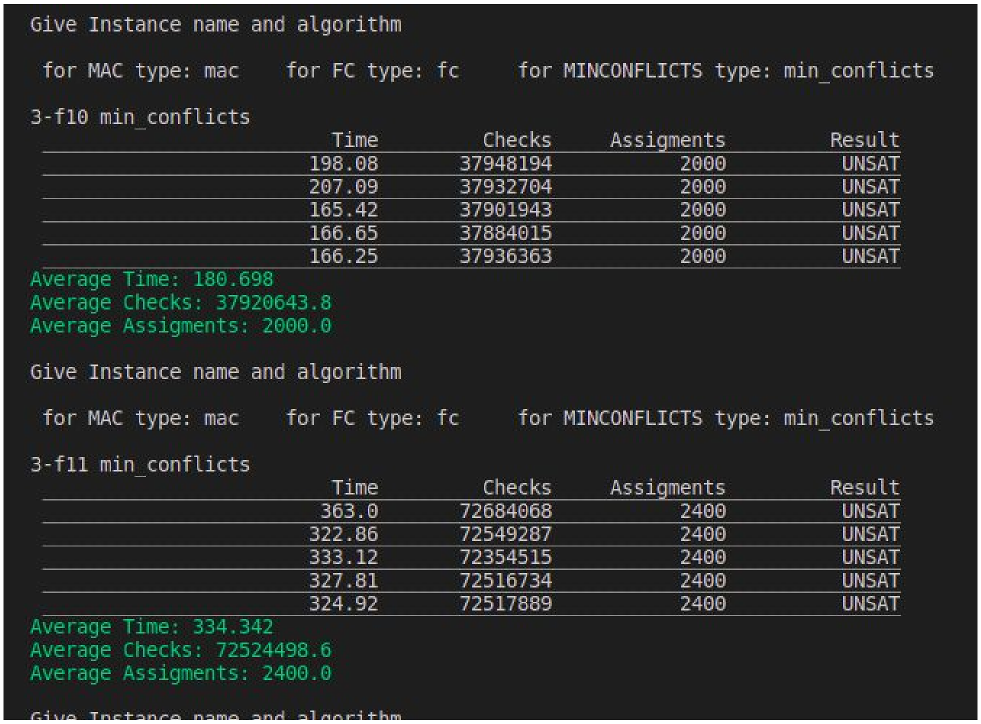
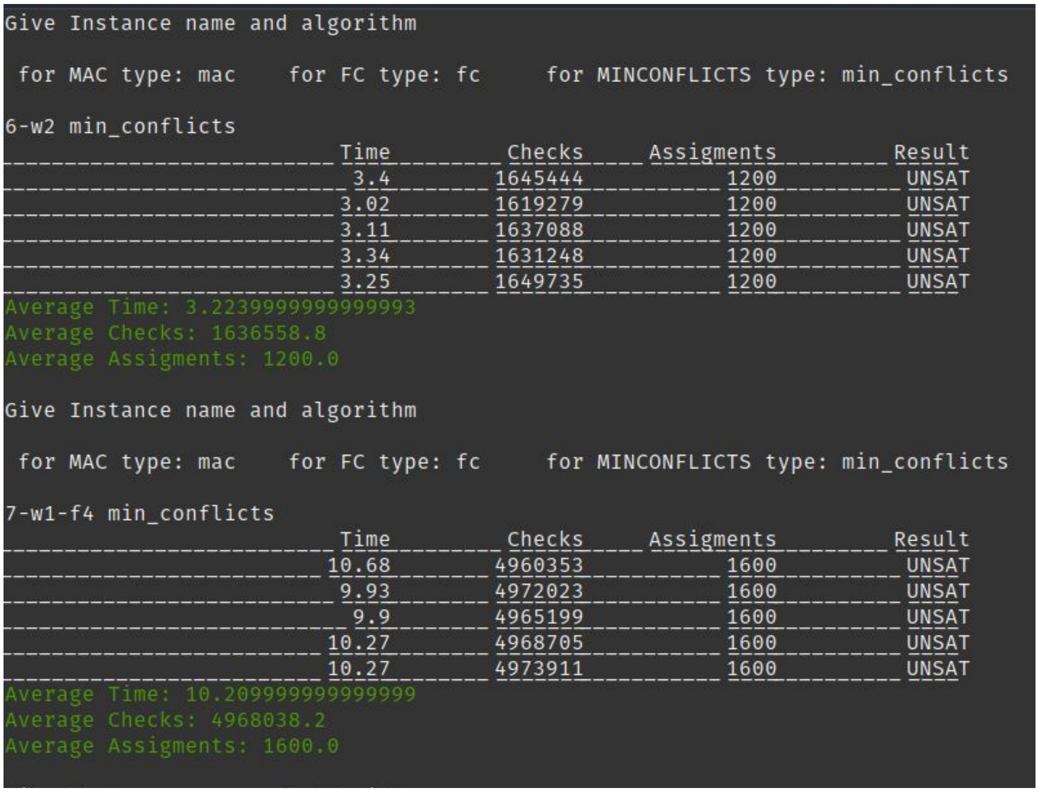
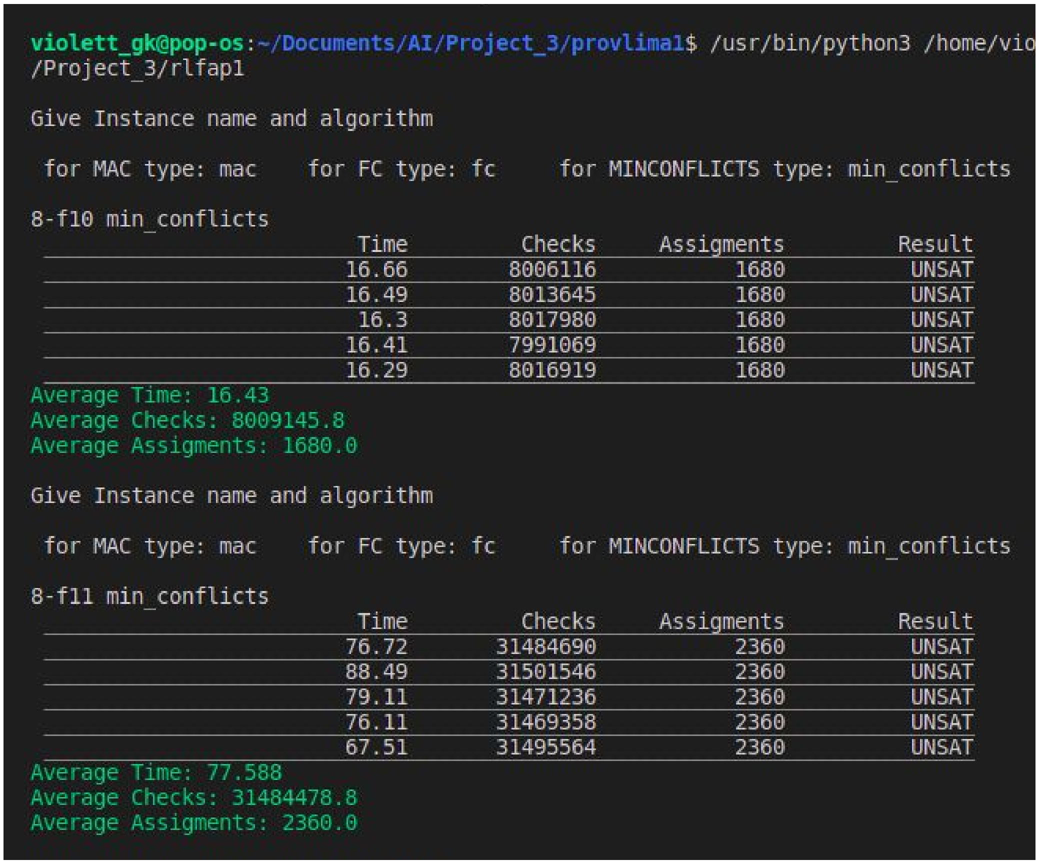



```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

3-f10 min_conflicts
                                   Time           Checks      Assigments            Result
                                 198.08         37948194            2000             UNSAT
                                 207.09         37932704            2000             UNSAT
                                 165.42         37901943            2000             UNSAT
                                 166.65         37884015            2000             UNSAT
                                 166.25         37936363            2000             UNSAT
Average Time: 180.698
Average Checks: 37920643.8
Average Assigments: 2000.0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

3-f11 min_conflicts
                                   Time           Checks      Assigments            Result
                                  363.0         72684068            2400             UNSAT
                                 322.86         72549287            2400             UNSAT
                                 333.12         72354515            2400             UNSAT
                                 327.81         72516734            2400             UNSAT
                                 324.92         72517889            2400             UNSAT
Average Time: 334.342
Average Checks: 72524498.6
Average Assigments: 2400.0

Give Instance name and algorithm
```



```
Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

6-w2 min_conflicts
__________________________Time_________Checks____Assigments_________Result
___________________________3.4_______1645444___________1200_________UNSAT
__________________________3.02_______1619279___________1200_________UNSAT
__________________________3.11_______1637088___________1200_________UNSAT
__________________________3.34_______1631248___________1200_________UNSAT
__________________________3.25_______1649735___________1200_________UNSAT
Average Time: 3.2239999999999993
Average Checks: 1636558.8
Average Assigments: 1200.0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

7-w1-f4 min_conflicts
__________________________Time_________Checks____Assigments_________Result
_________________________10.68_______4960353___________1600_________UNSAT
__________________________9.93_______4972023___________1600_________UNSAT
___________________________9.9_______4965199___________1600_________UNSAT
_________________________10.27_______4968705___________1600_________UNSAT
_________________________10.27_______4973911___________1600_________UNSAT
Average Time: 10.209999999999999
Average Checks: 4968038.2
Average Assigments: 1600.0
```



```
violett_gk@pop-os:~/Documents/AI/Project_3/provlima1$ /usr/bin/python3 /home/vio
/Project_3/rlfap1

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

8-f10 min_conflicts
                          Time         Checks    Assigments         Result
                         16.66        8006116          1680          UNSAT
                         16.49        8013645          1680          UNSAT
                          16.3        8017980          1680          UNSAT
                         16.41        7991069          1680          UNSAT
                         16.29        8016919          1680          UNSAT
Average Time: 16.43
Average Checks: 8009145.8
Average Assigments: 1680.0

Give Instance name and algorithm

 for MAC type: mac    for FC type: fc     for MINCONFLICTS type: min_conflicts

8-f11 min_conflicts
                          Time         Checks    Assigments         Result
                         76.72       31484690          2360          UNSAT
                         88.49       31501546          2360          UNSAT
                         79.11       31471236          2360          UNSAT
                         76.11       31469358          2360          UNSAT
                         67.51       31495564          2360          UNSAT
Average Time: 77.588
Average Checks: 31484478.8
Average Assigments: 2360.0
```