UNIVERSITÀ
DI TRENTO

Formal Method Mod. 1 (Automated Reasoning)

Laboratory 6

Giuseppe Spallitta
giuseppe.spallitta@unitn.it

Università degli studi di Trento

April 12, 2023

Outline

UNIVERSITÀ DEGLI STUDI
DI TRENTO

1. Advance OMT

Pareto VS lexicographic multi-optimization

OMT properties: minmax/maxmin

Multi-objective optimization

UNIVERSITÀ DEGLI STUDI DI TRENTO

Exercise 6.1: multiopt

A small business advertises through traditional media and personal appearances. Each ad campaign in traditional media costs about \$2000, generating 2 new customers and 1 positive rating per month. Each personal appearance costs \$500, generating 2 new customers and 5 positive ratings. Moreover, suppose each personal appearance takes 2 hours and each ad campaign takes 1 hour. The company wants at least 16 new customers and 28 positive ratings per month. Try to minimize BOTH costs and time.

Multi-objective optimization: problem

UNIVERSITÀ DEGLI STUDI DI TRENTO

- First, we distinguish amongs cost functions (our goals to minimize), constraints and variables:
- **Variables**: n. of ads and n. of personal appearance (we must set their values according to external conditions).
- **Constraints**: n. of minimum customers and positive ratings (these are mandatory to be satisfied)
- **Goal**: time and money.

We must encode time and money as functions depending on the variables!

Multi-objective optimization: optimizations

- If we expect the solver to return multiple optima (i.e. in the case of Pareto), we can call check-sat and get-objectives multiple times.
- Once no more solutions are found, the solver will return UNSAT.
- You can change the type of optimization from the option **:opt.priority**.

Not getting high penalties

UNIVERSITÀ DEGLI STUDI DI TRENTO

Exercise 6.2: penalty

Rose\Colin	A	B	C	D
A	4	3	2	5
B	-10	2	0	-1
C	7	5	2	3
D	0	8	-4	-5

Suppose you are Rose. You choose one character between A and D. After your turn also Collin chooses one character. Your goal is to get the lowest penalty, according to the joint choice between Collin and yourself. Assume also that Collin is your worst enemy, and since it is the second it will make his choice to maximize your penalty. Use OptiMathSAT to get the minimum penalty.

UNIVERSITÀ DEGLI STUDI
DI TRENTO

Not getting high penalties: hints

- Rose searches for the minimum, while Collins searches for the maximum among the possible choices... What is this minmax/maxmin in OptiMathSAT?

Not getting high penalties: variables

UNIVERSITÀ DEGLI STUDI DI TRENTO

As always, we first define the variables that efficiently describe the problem:

- For each cell in the grid we require a `Int` constant.
- We also add additional variables $\mathbf{r}i$ to store, for each choice made by Rose, the possible penalties she can get.

Not getting high penalties: properties

UNIVERSITÀ DEGLI STUDI DI TRENTO

- In each variable $\mathbf{r}i$ we store the possible output is Rose chooses character i. We can simulate it using `or` operators.
- We can minmax the problem: for each row, we minimize the penalty (we want to avoid any risk), and from these values, OptiMathSAT will retrieve the maximum (Collin's choice).