University of St Andrews

Towards Understanding Differences Between Modelling Pipelines: a Modelers Perspective

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What and why?

From a (single) users perspective:

- Investigate the capabilities of constraint programming pipelines
- Investigate the difference in languages
- Comparing MiniZinc and Savile Row

How?

- Create as close to equivalent models as possible
- Using MiniZinc and Essence' (not Essence)
- Compare over the same solver (Chuffed)
- Compare over equivalent(ish) optimisation levels
- 6 Models from different problem classes
  1. Quasigroup Completion, (no exciting differences)
  2. Wordpress Problem (no exciting differences)
  3. Rotating Rostering Problem (no exciting differences)
  4. Travelling Tournament Problem with Predefined Values
  5. Multi-Skilled Project Scheduling Problem
  6. Capacitated Vehicle Routing Problem with Time Windows
- Use pre-existing instances and some generated ones

`regular` (MZn) vs `forAll` (SR)

Traveling Tournament Problem with Predefined Venues

- at most three consecutive away or home games

MZn `regular` asserts that a sequence of variables take a value from a finite automaton

E' `forAll` checking that there are not four consecutive assignments

circuit (MZn)

Capacitated Vehicle Routing problem with Time Windows, Service Times and Pickup and Deliveries

- `circuit` is used to ensure the vehicle delivery routes do not take sub-tours in their route and visits each location uniquely for optimisation

MZn A `circuit` is such that the cell value of an array points to the index of the next number, and this forms a circuit that continues around

E' `https://github.com/MiniZinc/libminizinc/blob/master/share/minizinc/std/fzn_circuit.mzn`

Set Variables

Multi-Skilled Project Scheduling Problem

- Sets of skills, workers etc. (each assigned an integer)

MZn Variables which are a set

E' Occurrence representation of the integers/elements

letting (MZn)

Multi-Skilled Project Scheduling Problem

- letting creates variables within constraints

```
let { set of int: WTasks =
        { i | i in Tasks where exists(k in has_skills [j])(rr[k, i] > 0) }
} in ...
let { set of int: TWorkers =
        { j | j in Workers where exists(k in has_skills [j])(rr[k, i] > 0) }
} in ...
```

```
forAll i : Tasks . forAll j : Workers .
    TWorkers[j, i] = 1 <-> 
        exists k : Skills . has_skills [j, k] = 1 /\ rr[k,i] > 0,
```

`cumulative` (MZn)

Multi-Skilled Project Scheduling Problem

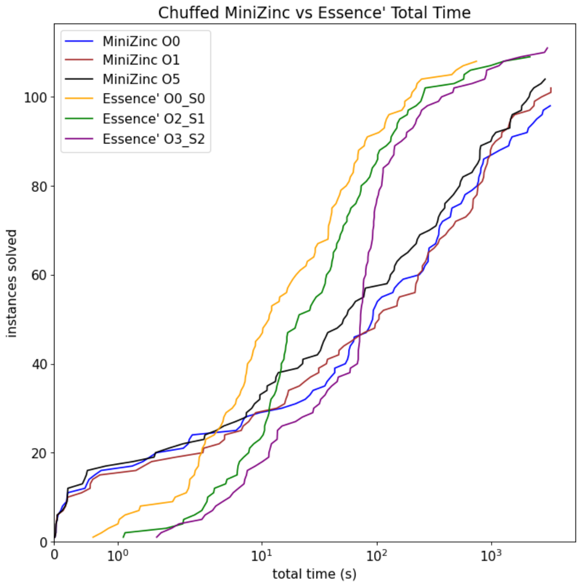
- Determines whether set of tasks with start times, durations, and resource requirements, never exceed the global resource bound at any time

MZn Determines if a cumulative resource usage is within bounds

E' `https://github.com/MiniZinc/libminizinc/blob/master/share/minizinc/std/fzn_cumulative.mzn`

Results

Problem	#	E' O0S0	E' O2S1	E' O3S2	MZn O0	MZn O1	MZn O5
Quasigroup	43	41	42	41	40	39	40
Quasigroup Occ.	43	41	41	42	32	37	38
Wordpress	9	6	6	6	6	6	6
Wordpress Symm.	9	4	4	6	4	4	4
TTPPV	20	3	3	3	3	3	3
MSPSP	6	6	6	6	6	6	6
CVRPTW	5	0	0	0	0	0	0
Rostering	7	7	7	7	7	7	7


Chuffed MiniZinc vs Essence' Total Time
MiniZinc O0
MiniZinc O1
MiniZinc O5
Essence' O0_S0
Essence' O2_S1
Essence' O3_S2
instances solved
0
20
40
60
80
100
total time (s)
0
10^0
10^1
10^2
10^3

Future/Ongoing Work

- Compare to other frameworks, such as CPMpy, picat
- Widen the field of users/do a more proper user study
- Analyse the different framework stages in more detail
- Compare over different solvers

Take Away

MZn	allows better (expert) modeler control
MZn	provides a slightly more expressive language due to the facilities for code organization and reusability
SR	provides a solid set of default settings
SR	has a more consistent performance profile

Thank you!

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