LUNDS UNIVERSITET
Lunds Tekniska Högskola

Institutionen för datavetenskap
Krzysztof Kuchcinski

Tentamen i kursen EDAN01: Constraint-Programmering (Constraint programming)

2017-01-10, kl. 8-13

Sal:

MA10F

Hjälpmedel:

Inga

Resultat anslås:

Senast 2017-01-24

Poänggränser:

Max 40 p., för 4 krävs ca 25 p, för 5 ca 30 p.

Jourhavande lärare:

Krzysztof Kuchcinski, tel. 22 23414

The answers to the questions can be written in Swedish or English.

Lycka till!

1 (3 p.)

Consistency methods for finite domain constraints are implemented using special techniques that are usually called *propagation rules* or *propagators*. Enumerate and discuss briefly basic properties that the propagation rules must fulfill.

2 (3 p.)

Constraint programming defines *node*, *arc* and *path* consistency methods for domain pruning based on constraints.

- Explain these methods shortly and give examples of their applications.
- Give example when arc consistency cannot determine inconsistency while path consistency can do it.
- How these methods are related to k-consistency and strong k-consistency.

3 (3 p.)

Use *bounds consistency* and *domain consistency* to prune the domains of FDVs involved in the constraint $y = 4 * x$, $x :: \{0..40\}, y :: \{0..5, 11..17\}$.

4 (4 p.)

In constraint programming over finite domain, depth-first-search algorithm is used to enumerate different solutions for a given problem. Discuss different strategies to control the search by selecting variable ordering and domain assignment.

What is the difference between the following two selection choices for finite domain variables.

- choice between $X = val$ and $X \neq val$
- multiple choice for X corresponding to the values in its domain (i.e., $X = val_1, X = val_2, \ldots, X = val_n$)

Illustrate this on an example of list `[X, Y]` with `X :: {1..2}, Y :: {1..3}` and *anti-first-fail* selection principle (a first variable with the largest domain size is selected). Draw a search tree and all values which are assigned to `X` and `Y` in the order specified by assigning values in ascending order (from min to max).

5 (3 p.)

Using reification constraints of finite domain solvers ($C \Leftrightarrow B$, where C is a constraint and B a 0/1 finite domain variable) write a program (using a pseudo-code) for user-defined constraint `AtLeast(List, El, N)` that constraints at least N of the elements of $List$ to be equal to value El. Both N and El are finite domain variables and $List$ is a list of finite domain variables.

6 (3 p.)

Explain why finite domain solvers use global constraints. As an example use `Alldifferent` constraints and illustrate the propagation "strength" with different implementations of the consistency methods, such as a method that is equivalent to imposing inequality constraints, bounds consistency and hyper-arc consistency.

7 (5 p.)

There are four students: Algy, Bertie, Charlie and Digby, who share a flat. Four newspapers are delivered to the house: the Financial Times, the Guardian, the Daily Express and the Sun. Each of the students reads all of the newspapers, in particular order and for a specified amount of time (see below).

Given that Algy gets up at 8:30, Bertie and Charlie at 8:45 and Digby at 9:30, what is the earliest that they can all set off for college?

	Algy		Bertie		Charlie		Digby	
1st	FT	60 min	Guardian	75 min	Express	5 min	Sun	90 min
2nd	Guardian	30 min	Express	3 min	Guardian	15 min	FT	1 min
3rd	Express	2 min	FT	25 min	FT	10 min	Guardian	1 min
4st	Sun	5 min	Sun	10 min	Sun	30 min	Express	1 min

8 (5 p.)

Figure 1 depicts a data-flow graph of a computation that uses two types of operations, additions and multiplications. Schedule this graph assuming that addition requires one and multiplications two clock cycles for their execution. Define time-constrained scheduling where you minimize the total number of used resources.

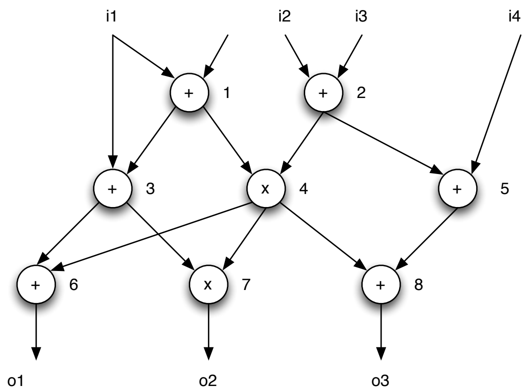

Figure 1: An example of data-flow graph

9 (5 p.)

A manufacturer makes wooden desks and tables. Each desk requires 2.5 hours to assemble, 3 hours for buffing, and 1 hour to crate. Each table requires 1 hour to assemble, 3 hours to buff, and 2 hours to crate. The firm can do only up to 20 hours of assembling, 30 hours of buffing, and 16 hours of crating per week. Profit is $3 per desk and $4 per table. Write the linear programming model that finds the maximal profit.

10 (6 p.)

The traveling salesperson needs to visit four cities, A, B, C, and D, to sell products. There is different distance between cities and the salesperson wants to optimize the route. The distance between cities is given in the table. Note, that it is non-symmetrical traveling salesperson problem, i.e. distances are different in different directions.

	A	B	C	D
A	-	3	6	41
B	4	-	40	5
C	8	42	-	4
D	37	6	2	-

- Write a program using FD solver which finds the minimal distance route which contains all cities.
- Assume that the salesperson distributes parcels in the cities as presented in the table below. Positive integer means that the specified number of parcels is loaded into the car and negative integer means that this number of parcels is unloaded. Find a shortest rout that fulfills car maximum capacity of 5 parcels, i.e., a route that one cannot unload from an empty car and load number of parcels that exceeds car capacity.

	Cities			
	A	B	C	D
Distribution	2	-3	4	-1

Write a pseudo-code or minizinc program that models and solves this problem.