Aalto University School of Science, Department of Information and Computer Science TJ

T-79.5105 Answer Set Programming

Examination, December 14, 2015

Assignment 1 (Max. 10p)

(a) Define/explain the following terms/mathematical concepts in detail (2p each):

a *Herbrand interpretation* (or Herbrand structure),
a *tight* normal logic program, and
resolution rule for nogoods.

(b) Which of the following claims are true and which false? Justify your answers precisely! (2p each)

Claim 1: For any normal programs P, Q, and R: if $\mathrm{SM}(P) \subseteq \mathrm{SM}(Q)$, then $\mathrm{SM}(P \cup R) \subseteq \mathrm{SM}(Q \cup R)$.
Claim 2: It holds that $\{\, a \leftarrow b.\ \ a \leftarrow {\sim}c. \,\} \equiv_s \{\, a \leftarrow b, c.\ \ a \leftarrow {\sim}c. \,\}$.

Assignment 2 (Max. 10p) Consider a normal logic program P consisting of the following rules:

$$a \leftarrow b, {\sim}g. \quad b \leftarrow a, {\sim}d. \quad \cancel{b} \leftarrow e, {\sim}f. \quad c \leftarrow f, {\sim}b.$$
$$\cancel{e} \leftarrow a, {\sim}c. \quad e \leftarrow {\sim}g. \quad f \leftarrow {\sim}d. \quad g \leftarrow a, c. \quad g \leftarrow c, {\sim}e.$$

Determine the following for the program P:

(a) WFM(P), (2p) {f,c}∪{~a,~b,~d}.
(b) the supported models of P, (2p) {{a,b,e,d} {c f g} {c e f} {a b e f}
(c) SM(P), (2p) {
(d) the set LF(P) of loop formulas, and (2p) {a∨b∨e, a∨b}
(e) the solutions for c-NG(P)$\cup$l-NG(P). (2p)

Assignment 3 (Max. 10p) Consider the following program P involving choice, cardinality, and weight rules in addition to normal rules:

$\{\mathsf{Bus}, \mathsf{Tram}, \mathsf{Walk}\}.$	$\mathsf{Bad} \leftarrow 4\,[\mathsf{Left}=2, \mathsf{Right}=2, \mathsf{Bus}=1, \mathsf{Tram}=1, \mathsf{Walk}=1].$
$\mathsf{Road} \leftarrow \mathsf{Bus}.$	$\mathsf{Bad} \leftarrow \mathsf{Left}, {\sim}\mathsf{Walk}.$
$\mathsf{Rail} \leftarrow \mathsf{Tram}.$	$\mathsf{Bad} \leftarrow {\sim}\mathsf{Left}, {\sim}\mathsf{Right}.$
$\{\mathsf{Road}, \mathsf{Rail}\} \leftarrow \mathsf{Walk}.$	$\mathsf{F} \leftarrow \mathsf{Bad}, {\sim}\mathsf{F}.$
$\{\mathsf{Left}, \mathsf{Right}\} \leftarrow \mathsf{Road}.$	
$\mathsf{Road} \leftarrow 1\,\{\mathsf{Left}, \mathsf{Right}\}.$	

Walk T
X

(a) Translate (the choice, cardinality, and weight rules in) P into a normal program P' such that the stable models of P and P' are in a one-to-one correspondence. (6p)

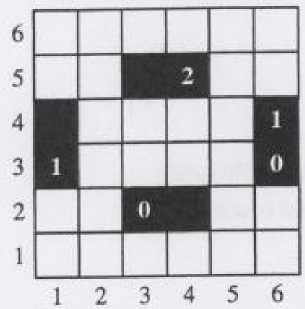
(b) Determine the stable models of P along with the corresponding stable models of P'. (4p)

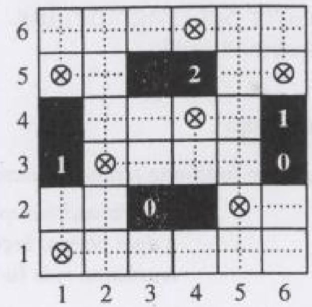
Assignments 4–5 are given on the reverse side of this sheet!!!

The name of the course, the course code, the date, your name, your student identifier, and your signature must appear on every sheet of your answers.

Please remember that one bonus point is awarded for filling in the **feedback form** on time!

Assignment 4 (Max. 12p) Consider a grid puzzle as shown below on the left hand side:





The idea is to place lights on white grid cells such that

1. every white cell contains a light or is visible, in horizontal or vertical direction, from a cell with a light via a straight path of white cells,
2. no distinct cells with lights are mutually visible via straight paths of white cells, and
3. black cells with numbers determine how many of their horizontally or vertically adjacent white cells must contain lights.

A solution for the example grid is displayed on the right hand side above. Observe that the lights in adjacent white cells match the numbers given in some black cells, e.g., the lights at (4,4) and (4,6) are adjacent to the black cell with a 2 at (4,5). Moreover, every white cell has a light or is visible from a light, as indicated by dotted straight lines, while no distinct lights are mutually visible. Also note that lights may be placed freely, i.e., not having an adjacent black cell with a number, as it is the case for the lights at (1,1), (1,5), and (5,2).

An instance like the example grid on the left hand side above is given by facts as follows:

White(1,6).	White(2,6).	White(3,6).	White(4,6).	White(5,6).	White(6,6).
White(1,5).	White(2,5).		Black(4,5,2).	White(5,5).	White(6,5).
	White(2,4).	White(3,4).	White(4,4).	White(5,4).	Black(6,4,1).
Black(1,3,1).	White(2,3).	White(3,3).	White(4,3).	White(5,3).	Black(6,3,0).
White(1,2).	White(2,2).	Black(3,2,0).		White(5,2).	White(6,2).
White(1,1).	White(2,1).	White(3,1).	White(4,1).	White(5,1).	White(6,1).

A solution shall be represented in terms of the output predicate Light(·,·), e.g., Light(1,1), Light(1,5), Light(2,3), Light(4,4), Light(4,6), Light(5,2), and Light(6,5) for the solution on the right hand side above.

Formalize the requirements for solutions by writing a uniform encoding in the syntax of `gringo`, possibly using integer arithmetic, auxiliary and built-in comparison predicates, as well as choice and cardinality rules.

Assignment 5 (Max. 8p) Consider the following `smodels` program modules:

$$\mathbb{P} = \begin{array}{|c|}\hline \{a,b\} \\ \hline a \leftarrow \sim b. \\ a \leftarrow \sim c. \\ b \leftarrow c, \sim a. \\ b \leftarrow a, \sim c. \\ \hline \{c\} \\ \hline \end{array} \qquad \mathbb{Q} = \begin{array}{|c|}\hline \{c\} \\ \hline c \leftarrow a, \sim d. \\ c \leftarrow d. \\ d \leftarrow c, \sim a. \\ d \leftarrow a, \sim c. \\ \hline \{a\} \\ \hline \end{array}$$

{a,b} {c,b} ∅

(a) Determine the sets $\mathrm{SM}(\mathbb{P})$ and $\mathrm{SM}(\mathbb{Q})$ of stable models. (4p)

(b) Provide the join $\mathbb{P} \sqcup \mathbb{Q}$ and apply the *module theorem* to determine $\mathrm{SM}(\mathbb{P} \sqcup \mathbb{Q})$ using $\mathrm{SM}(\mathbb{P}) \bowtie \mathrm{SM}(\mathbb{Q})$. (4p)