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

T-79.5105 Answer Set Programming

Examination, December 16, 2013

Assignment 1 (Max. 10p)

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

a *monotonic operator*, an *upper bound* of stable models, and a *modular* translation.

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

Claim 1: For any atoms a and b and the rule $r = a \leftarrow b, \sim b$, $\{r\} \equiv_s \emptyset$.
Claim 2: For any normal programs P, Q, and R: if $P \equiv Q$ and $Q \equiv R$, then $P \equiv R$.

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

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

Determine the following (sets of) models for P:

(a) WFM(P), (3p)

(b) SM(P) based on the `smodels` algorithm, and (4p)

(c) SuppM(P) using the completion Comp(P). (3p)

Note: For (b) it is sufficient to provide a **search tree** with justifications for each conclusion made.

Assignment 3 (Max. 8p) Consider the following primitive for answer set programming

Make c true if and only if at least one literal amongst $a_1, \ldots, a_n$ and $\sim b_1, \ldots, \sim b_m$ is true.

(a) How would you express this primitive using the rule types available in the `smodels` system? (Max. 1p)

(b) What if only basic/normal rules and no new atoms are allowed? (Max. 3p)

(c) Use SE-models to justify the strong equivalence for the (sets of) rule(s) devised for items (a) and (b), respectively. (Max. 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!

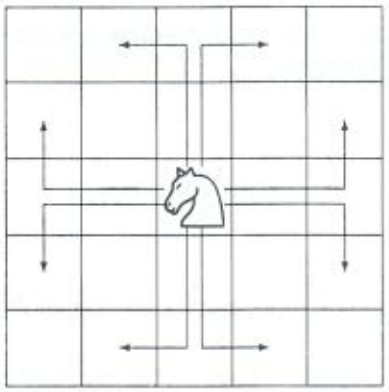

Figure 1: Valid Moves of a Knight

Assignment 4 (Max. 12p) Consider a chess board of size $n \times n$ (the case $n = 5$ is illustrated in Figure 1 where the colors of cells have been omitted for clarity). The valid moves of a *knight piece* in the middle cell are indicated by arrows. In general, the requirements for a *knight's tour* are:

1. The knight starts to move from a particular cell.
2. Only valid moves are allowed.
3. The knight is supposed to visit each cell exactly once.
4. The last move takes the knight back to the starting cell.

Formalize the requirements for a knight's tour by writing a logic program in the syntax of `gringo`. The parameter n should be a constant in your program, to be set when the grounder is called, and the predicate $\mathsf{Start}(\cdot,\cdot)$ should be used to specify the starting node. Moreover, use an output predicate $\mathsf{Move}(X_1,Y_1,X_2,Y_2)$ to represent individual moves of the knight (from coordinates $\langle X_1,Y_1\rangle$ to coordinates $\langle X_2,Y_2\rangle$).

Assignment 5 (Max. 10p) Consider the following normal program P:

$$\begin{array}{lllll} a \leftarrow b, c. & b \leftarrow d. & c \leftarrow d, e. & c \leftarrow \sim b. & c \leftarrow \sim d. \\ d \leftarrow b. & d \leftarrow \sim a. & e \leftarrow a. & & \end{array}$$

(a) Form the *positive* dependency graph $\mathrm{DG}^+(P)$ of P and determine strongly connected components. (2p)

(b) Split the program in two *non-trivial* modules $\mathbb{P}_1$ and $\mathbb{P}_2$ such that $\mathbb{P}_1 \sqcup \mathbb{P}_2$ is justifiably defined. Provide interface specifications for the modules $\mathbb{P}_1$ and $\mathbb{P}_2$, and calculate the composition $\mathbb{P}_1 \oplus \mathbb{P}_2$ (4p).

(c) Apply the *module theorem* in order to calculate $\mathrm{SM}(\mathbb{P}_1 \sqcup \mathbb{P}_2)$ using $\mathrm{SM}(\mathbb{P}_1)$ and $\mathrm{SM}(\mathbb{P}_2)$. (4p)

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