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

T-79.5105 Answer Set Programming

Examination, December 19, 2011

Assignment 1 (Max. 10p)

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

the *least fixed point* of an operator, a *strongly domain restricted program*, and a *faithful and 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 of the form $b \leftarrow a, {\sim}a$: $\{r\} \equiv_s \emptyset$.
Claim 2: For any normal programs P and Q: if $P \equiv \emptyset$, then $P \cup Q \equiv Q$.

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 primitives for answer set programming:

(a) Make an odd number of atoms amongst $a_1, \ldots, a_n$ true.

(b) Make c true if and only if the number of true atoms amongst $a_1, \ldots, a_n$ is greater than the number of true atoms amongst $b_1, \ldots, b_n$.

How would you express these primitives using

- rule types available in the `smodels` system and
- basic/normal rules only?

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.

Assignment 4 (Max. 12p) Consider the problem of deciding whether two graphs $G_1 = \langle V_1, E_1 \rangle$ and $G_2 = \langle V_2, E_2 \rangle$ given as input are *isomorphic*, i.e., there is a bijection $f : V_1 \to V_2$ such that for all nodes $u, v \in V_1$,

$$\langle u, v \rangle \in E_1 \iff \langle f(u), f(v) \rangle \in E_2.$$

Suppose that the respective sets of edges E_1 and E_2 are represented using relations $\mathsf{Edge}_1(\cdot,\cdot)$ and $\mathsf{Edge}_2(\cdot,\cdot)$.

Write a **normal** logic program $P(G_1, G_2)$ which uses variables and input predicates $\mathsf{Edge}_1(\cdot,\cdot)$ and $\mathsf{Edge}_2(\cdot,\cdot)$ representing the graphs G_1 and G_2 such that $\mathrm{SM}(P(G_1, G_2)) \neq \emptyset \iff G_1$ and G_2 are isomorphic.

Given this and the complexity results concerning normal logic programs, what can be stated about the computational time complexity of deciding graph isomorphism?

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)
