Aalto University School of Science, Department of Information and Computer Science
T-79.5105 Answer Set Programming
Examination, March 7, 2012

TJ

Assignment 1 (Max. 10p)

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

the *transitive closure* of a relation, *brave and cautious reasoning*, and a *loop formula*.

(b) Which of the following claim are true and which false? Justify your answers precisely! (2p each)
Claim 1: For any atom a, $\{a \leftarrow a\} \equiv_s \emptyset$.
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) $\mathrm{WFM}(P)$, (3p)

(b) $\mathrm{SM}(P)$ based on the `smodels` algorithm, and (4p)

(c) $\mathrm{SuppM}(P)$ using the completion $\mathrm{Comp}(P)$. (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 b true if and only if at most one atom of $a_1, \ldots, a_n$ is 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.

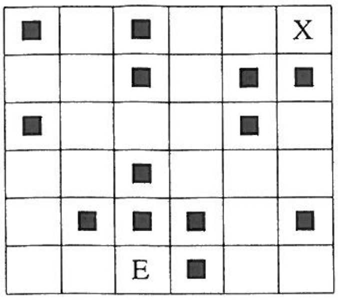

Figure 1: An Example of a valid maze of size 6

Assignment 4 (Max. 12p) Consider the problem of designing an $n \times n$ maze based on an $n \times n$ grid such as the one illustrated in Figure 1 when $n = 6$. In general, the requirements for a *valid* maze are:

1. Each cell in the grid can be either empty or contain a wall, denoted by "■" in the figure.
2. There are two special *empty* cells which are the entrance and the exit of the maze, respectively denoted by "E" and "X" in the figure.
3. The entrance and the exit of the maze must be along the *borders* of the grid, i.e., they are not supposed to be inner cells in the grid.
4. Each empty cell C must be *reachable* from the entrance E via empty cells, i.e., there is a sequence of empty cells $C_1, \ldots, C_n$ where $C_1 = \mathrm{E}$, $C_n = C$, and C_i is adjacent to C_{i-1} for every $1 < i \leq n$.
5. The exit must be similarly reachable from every empty cell via empty cells.
6. There should be at least k cells containing a wall.

Formalize the requirements for a valid maze by writing a logic program in the syntax of `lparse`. The parameters n and k should be constants in your program—to be specified when the grounder is called. Moreover, use output predicates $\mathsf{Wall}(\cdot,\cdot)$, $\mathsf{Enter}(\cdot,\cdot)$, and $\mathsf{Exit}(\cdot,\cdot)$ to represent valid solutions.

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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