Authors:

Erick Rosete Beas — er165@uni-freiburg.de

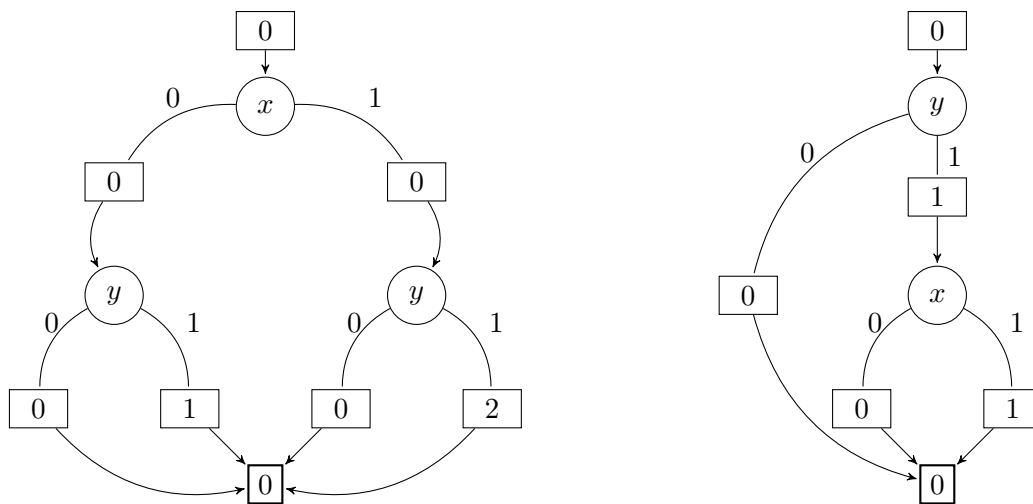Jessica Lizeth Borja Diaz — jb986@uni-freiburg.de

Principles of AI Planning
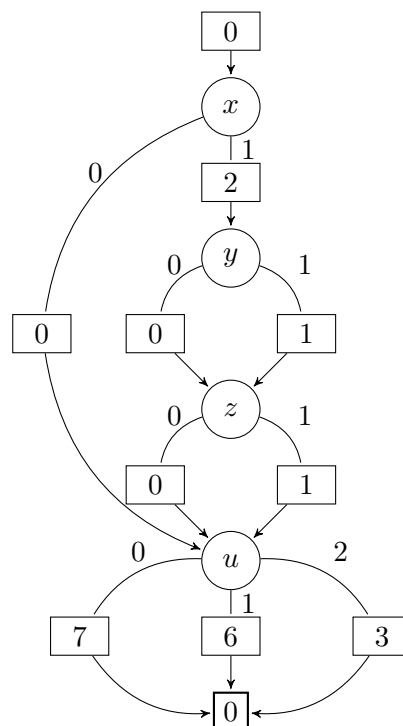## Exercise Sheet 13

07.02.2020

Exercise 13.1 - EVMDDs

(a)

(b)

Exercise 13.2 - EVMDD sizes and variable orders

Let $v_0, ..., v_{2n-1}$ be variables with domains $\mathcal{D}_{v_i} = \{0, ..., k-1\} \forall i = 0, ..., 2n-1$, let $\pi := \{0, ..., 2n-1\} \to \{0, ..., 2n-1\}$ be a permutation of the variables, let $k_j \in \mathbb{N}, j = 0, ..., n-1$, be natural numbers and let $c = \Sigma_{j=0}^{n-1} k_j v_{\pi(2j)} v_{\pi(2j+1)}$ be an arithmetic function over $v_0, ..., v_{2n-1}$. Intuitively, c is a weighted sum of products of two variables each, such that no variable occurs in more than one product subterm. Show that there exists a variable order for $v_0, ..., v_{2n-1}$ such that there exists an EVMDD with that order that represents the function c and that has a size (number of edges) in the order of nk^2.

Hint: Consider the example $c = 2v_0v_3 + 6v_1v_5 + 4v_2v_4$. How should the variables be ordered to minimize the size of the EVMDD.
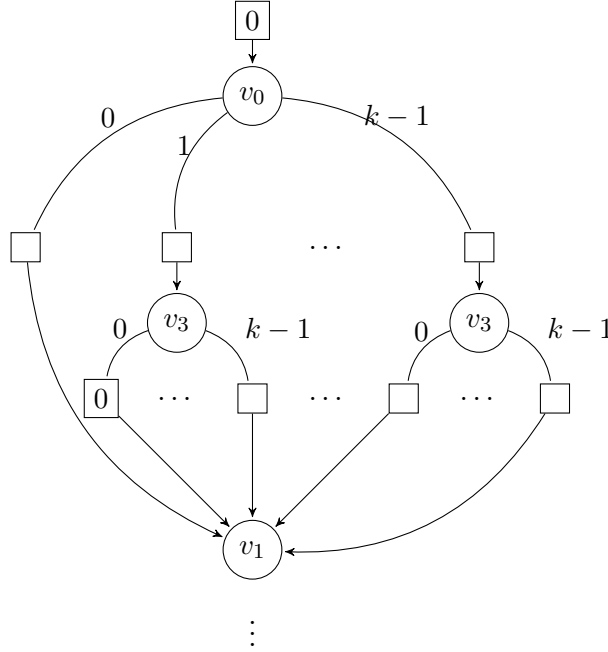
for $c = 2v_0v_3 + 6v_1v_5 + 4v_2v_4$ we consider the diagram above which is a EVMDD for c. v_0 can take values from 0 to $k-1$ hence that node has k outcoming edges. And for $k-1$ edges that branch out from v_0 there is a node v_3 with k more edges. Then for each pair $v_{\pi(2j)}v_{\pi(2j+1)}$ there exists $(k-1)k + 1$ edges which is in order $O(k^2)$, and we have n variable pairs which means the EVMDD has in total $O(n * k^2)$ edges.

Given arbitrary n and k, using as variable order the order on which the variables show in the cost function there exists an EVMDD with that order and represents the cost function with $O(n * k^2)$ edges using the same construction as in the previous example.
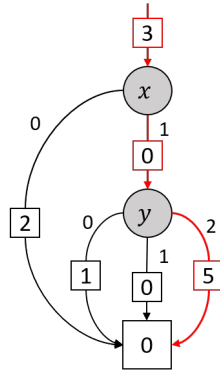
Exercise 13.3 - Evaluating states with EVMDDs

Consider a cost function represented by the EVMDD on the right.
Let s be a state with $s(x) = 1$ and $s(y) = 2$. To which value does the EVMDD evaluate for state s?
$cost(s) = 3 + 0 + 5 = 8$

Exercise 13.4 - EVMDD-based action compilation

Consider again the EVMDD from Exercise 13.3. Assume it encodes the cost c_{o_1} of operator $o_1 = \langle z = 1 \wedge u = 1, x := 0 \rangle$.

a) Give the EVMDD-based action compilation of o_1 using this EVMDD.

$$O_1^{z=1 \wedge u=1} = \langle z = 1 \wedge u = 1 \wedge \sigma = 0 \wedge \alpha_{o_1} = 0, \sigma := 1 \wedge \alpha_{o_1} = 1 \rangle \qquad cost = 3$$

$$O_1^{1,x=0} =$$