Exercise 10: Datalog Evaluation

Database Theory

2023-06-20

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Exercise 1

Exercise. Consider the program

$$P = \{\, T(x) \leftarrow e(x), T(x) \leftarrow a(x,y) \wedge T(y) \wedge b(x,z) \wedge T(z) \,\}.$$

1. Describe, in your own words, the kind of structures that the query $\langle T, P \rangle$ recognises.
2. Compute the semi-naive evaluation of P for the database D with the following facts:

   e(1)   e(2)   e(6)   a(3,1)   a(4,3)   a(5,3)   a(7,5)   b(3,2)   b(5,3)   b(7,6)

   Specify for each newly derived fact which of the rule(s) of P will produce it at the given point in the derivation.

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Solution.

1. $\langle T, P \rangle$ recognises binary forests with leaves labelled e and branches labelled a and b, and structures derived from those by merging vertices.

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1. $\langle \mathsf{T}, P \rangle$ recognises binary forests with leaves labelled e and branches labelled a and b, and structures derived from those by merging vertices.
2. Transformed program:

$$\hat{P} = \Big\{\, \underbrace{\mathsf{T}(x) \leftarrow \mathsf{e}(x)}_{\text{(R1)}}, \underbrace{\mathsf{T}(x) \leftarrow \mathsf{a}(x,y) \wedge \Delta_T^i(y) \wedge \mathsf{b}(x,z) \wedge \mathsf{T}^i(z)}_{\text{(R2.1)}}, \underbrace{\mathsf{T}(x) \leftarrow \mathsf{a}(x,y) \wedge \mathsf{T}^{i-1}(y) \wedge \mathsf{b}(x,z) \wedge \Delta_T^i(z)}_{\text{(R2.2)}} \,\Big\}$$

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$$T_{\hat{P}}^0 = \varnothing$$
$$T_{\hat{P}}^1 = D \cup \{ \, T(1), T(2), T(6) \, \} \qquad\qquad \text{(R1)}$$

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$$T_{\hat{P}}^1 = D \cup \{\, T(1), T(2), T(6) \,\} \qquad\qquad\qquad (R1)$$
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$$
\begin{aligned}
T^0_{\hat{P}} &= \varnothing \\
T^1_{\hat{P}} &= D \cup \{ \, \mathsf{T}(1), \mathsf{T}(2), \mathsf{T}(6) \, \} && \text{(R1)} \\
T^2_{\hat{P}} &= T^1_{\hat{P}} \cup \{ \, \mathsf{T}(3) \, \} && \text{(R2.1)} \\
T^3_{\hat{P}} &= T^2_{\hat{P}} \cup \{ \, \mathsf{T}(5) \, \} && \text{(R2.1)}
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T_{\hat{P}}^0 &= \varnothing \\
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T_{\hat{P}}^4 &= T_{\hat{P}}^3 \cup \{\, T(7) \,\} = T_{\hat{P}}^5 = T_{\hat{P}}^\infty && \text{(R2.1)}
\end{aligned}
$$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x, x) \leftarrow h(x) \qquad\qquad S(x, y) \leftarrow p(x, w) \wedge S(v, w) \wedge p(y, v)$$

and the adorned version for query $S(1, x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x) \qquad\qquad r_4 = S^{fb}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v) \qquad r_5 = S^{fb}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v)$$
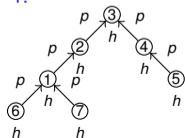
together with the database that contains the following facts for predicate p:

  h(1)   h(2)   h(3)   h(4)   h(5)   h(6)   h(7)   p(1,2)   p(2,3)   p(4,3)   p(5,4)   p(6,1)   p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?
2. Apply the QSQR algorithm to compute the answer to the query.

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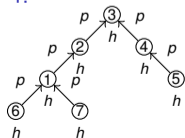$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \land S^{fb}(v, w) \land p(y, v) \qquad r_5 = S^{fb}(x, y) \leftarrow p(x, w) \land S^{fb}(v, w) \land p(y, v)$$

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together with the database that contains the following facts for predicate p:

| h(1) | h(2) | h(3) | h(4) | h(5) | h(6) | h(7) | | p(1, 2) | p(2, 3) | p(4, 3) | p(5, 4) | p(6, 1) | p(7, 1) |

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Expected answers:

$$\left\{ \text{Query}(1), \text{Query}(5) \right\}$$

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2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \varnothing$	$\text{input}^{bf}_S[x] = \varnothing$	$\text{input}^{fb}_S[x] = \varnothing$	$\text{input}^{fb}_S[y] = \varnothing$
$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_2}_0[x] = \varnothing$	$\sup^{r_3}_0[x] = \varnothing$	$\sup^{r_4}_0[x] = \varnothing$	$\sup^{r_5}_0[y] = \varnothing$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \varnothing$	$\sup^{r_3}_1[x, w] = \varnothing$	$\sup^{r_4}_1[x] = \varnothing$	$\sup^{r_5}_1[x, w, y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x, y] = \varnothing$	$\sup^{r_3}_2[x, v] = \varnothing$	$\text{output}^{fb}_S[x, y] = \varnothing$	$\sup^{r_5}_2[x, v, y] = \varnothing$
		$\sup^{r_3}_3[x, y] = \varnothing$		$\sup^{r_5}_3[x, y] = \varnothing$
		$\text{output}^{bf}_S[x, y] = \varnothing$		$\text{output}^{fb}_S[x, y] = \varnothing$

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Solution.

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$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_2}_0[x] = \varnothing$	$\sup^{r_3}_0[x] = \varnothing$	$\sup^{r_4}_0[x] = \varnothing$	$\sup^{r_5}_0[y] = \varnothing$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \varnothing$	$\sup^{r_3}_1[x, w] = \varnothing$	$\sup^{r_4}_1[x] = \varnothing$	$\sup^{r_5}_1[x, w, y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x, y] = \varnothing$	$\sup^{r_3}_2[x, v] = \varnothing$	$\text{output}^{fb}_S[x, y] = \varnothing$	$\sup^{r_5}_2[x, v, y] = \varnothing$
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$$S(x,x) \leftarrow h(x) \qquad\qquad S(x,y) \leftarrow p(x,w) \wedge S(v,w) \wedge p(y,v)$$

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$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_3}_1[x] = \varnothing$	$\sup^{r_3}_1[x,w] = \varnothing$	$\sup^{r_4}_1[x] = \varnothing$	$\sup^{r_5}_1[x,w,y] = \varnothing$
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together with the database that contains the following facts for predicate p:

h(1) h(2) h(3) h(4) h(5) h(6) h(7)   p(1, 2) p(2, 3) p(4, 3) p(5, 4) p(6, 1) p(7, 1)

1. Sketch the database as a tree. What are the expected answers to the query?
2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \varnothing$	$\text{input}^{fb}_S[y] = \varnothing$
$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_2}_0[x] = \{1\}$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_4}_0[x] = \varnothing$	$\sup^{r_5}_0[y] = \varnothing$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \{1\}$	$\sup^{r_3}_1[x, w] = \varnothing$	$\sup^{r_4}_1[x] = \varnothing$	$\sup^{r_5}_1[x, w, y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x, y] = \varnothing$	$\sup^{r_3}_2[x, v] = \varnothing$	$\text{output}^{fb}_S[x, y] = \varnothing$	$\sup^{r_5}_2[x, v, y] = \varnothing$
		$\sup^{r_3}_3[x, y] = \varnothing$		$\sup^{r_5}_3[x, y] = \varnothing$
		$\text{output}^{bf}_S[x, y] = \varnothing$		$\text{output}^{fb}_S[x, y] = \varnothing$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x,x) \leftarrow h(x) \qquad\qquad S(x,y) \leftarrow p(x,w) \wedge S(v,w) \wedge p(y,v)$$

and the adorned version for query $S(1,x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1,x)$$
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$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \{2\}$	$\text{input}^{fb}_S[y] = \{2\}$
$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_5}_0[x] = \varnothing$	$\sup^{r_5}_0[y] = \varnothing$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_3}_1[x] = \{1\}$	$\sup^{r_3}_1[x] = \{1\}$	$\sup^{r_5}_1[x] = \varnothing$	$\sup^{r_5}_1[x, w, y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x, y] = \{\langle 1, 1 \rangle\}$	$\sup^{r_3}_2[x, w] = \{\langle 1, 2 \rangle\}$	$\text{output}^{fb}_S[x, y] = \varnothing$	$\sup^{r_5}_2[x, v, y] = \varnothing$
		$\sup^{r_3}_2[x, v] = \varnothing$		$\sup^{r_5}_3[x, y] = \varnothing$
		$\sup^{r_3}_3[x, y] = \varnothing$		$\text{output}^{fb}_S[x, y] = \varnothing$
		$\text{output}^{bf}_S[x, y] = \varnothing$		

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\begin{array}{lllll}
\text{input}^f_{\text{Query}}[] = \varnothing & \text{input}^{bf}_S[x] = \{1\} & \text{input}^{bf}_S[x] = \{1\} & \text{input}^{fb}_S[x] = \{2\} & \text{input}^{fb}_S[y] = \{2\} \\
\text{sup}^{r_1}_0[] = \varnothing & \text{sup}^{r_2}_0[x] = \{1\} & \text{sup}^{r_3}_0[x] = \{1\} & \text{sup}^{r_4}_0[x] = \{2\} & \text{sup}^{r_5}_0[y] = \varnothing \\
\text{sup}^{r_1}_1[x] = \varnothing & \text{sup}^{r_2}_1[x] = \{1\} & \text{sup}^{r_3}_1[x, w] = \{\langle 1, 2\rangle\} & \text{sup}^{r_4}_1[x] = \varnothing & \text{sup}^{r_5}_1[x, w, y] = \varnothing \\
\text{output}^f_{\text{Query}}[x] = \varnothing & \text{output}^{bf}_S[x, y] = \{\langle 1, 1\rangle\} & \text{sup}^{r_3}_2[x, v] = \varnothing & \text{output}^{fb}_S[x, y] = \varnothing & \text{sup}^{r_5}_2[x, v, y] = \varnothing \\
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$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \{1\}$	$\sup^{r_3}_1[x,w] = \{\langle 1,2 \rangle\}$	$\sup^{r_4}_1[x] = \{2\}$	$\sup^{r_5}_1[x,w,y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1 \rangle\}$	$\sup^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \varnothing$	$\sup^{r_5}_2[x,v,y] = \varnothing$
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$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_3}_1[x] = \{1\}$	$\sup^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\sup^{r_4}_1[x] = \{2\}$	$\sup^{r_5}_1[x,w,y] = \varnothing$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\sup^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 2,2\rangle\}$	$\sup^{r_5}_2[x,v,y] = \varnothing$
		$\sup^{r_3}_3[x,y] = \varnothing$		$\sup^{r_5}_3[x,y] = \varnothing$
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$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_4}_0[x] = \{2\}$	$\sup^{r_5}_0[y] = \{2\}$
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$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\sup^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 2,2\rangle\}$	$\sup^{r_5}_2[x,v,y] = \varnothing$
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$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \{1\}$	$\sup^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\sup^{r_4}_1[x] = \{2\}$	$\sup^{r_5}_1[x,w,y] = \{\langle 1,2,2\rangle, \langle 2,3,2\rangle, \ldots, \langle 7,1,2\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\sup^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 2,2\rangle\}$	$\sup^{r_5}_2[x,v,y] = \varnothing$
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$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{2\}$	$\text{sup}^{r_5}_0[y] = \{2\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_2}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{2\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,2\rangle, \langle 2,3,2\rangle, \ldots, \langle 7,1,2\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 2,2\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \varnothing$
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together with the database that contains the following facts for predicate p:

h(1)   h(2)   h(3)   h(4)   h(5)   h(6)   h(7)   p(1,2)   p(2,3)   p(4,3)   p(5,4)   p(6,1)   p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?

2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x,x) \leftarrow h(x) \qquad\qquad S(x,y) \leftarrow p(x,w) \wedge S(v,w) \wedge p(y,v)$$

and the adorned version for query $S(1,x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1,x)$$
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h(1)	h(2)	h(3)	h(4)	h(5)	h(6)	h(7)		p(1,2)	p(2,3)	p(4,3)	p(5,4)	p(6,1)	p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?

2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \{1,2,3,4\}$	$\text{input}^{fb}_S[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{2\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_2}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,2\rangle, \langle 2,3,2\rangle, \ldots, \langle 7,1,2\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 2,2\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \varnothing$
		$\text{sup}^{r_3}_3[x,y] = \varnothing$		$\text{sup}^{r_5}_3[x,y] = \varnothing$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \varnothing$

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1. Sketch the database as a tree. What are the expected answers to the query?
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$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{2\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_2}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,2\rangle,\langle 2,3,2\rangle,\ldots,\langle 7,1,2\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 3,3\rangle,\langle 4,4\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \varnothing$
		$\text{sup}^{r_3}_3[x,y] = \varnothing$		$\text{sup}^{r_5}_3[x,y] = \varnothing$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \varnothing$

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1. Sketch the database as a tree. What are the expected answers to the query?
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Solution.

2.

$$\text{input}^f_{\text{Query}}[] = \varnothing$$
$$\text{sup}^{r_1}_0[] = \varnothing$$
$$\text{sup}^{r_1}_1[x] = \varnothing$$
$$\text{output}^f_{\text{Query}}[x] = \varnothing$$

$$\text{input}^{bf}_S[x] = \{1\}$$
$$\text{sup}^{r_2}_0[x] = \{1\}$$
$$\text{sup}^{r_2}_1[x] = \{1\}$$
$$\text{output}^{bf}_S[x, y] = \{\langle 1, 1\rangle\}$$

$$\text{input}^{bf}_S[x] = \{1\}$$
$$\text{sup}^{r_3}_0[x] = \{1\}$$
$$\text{sup}^{r_3}_1[x, w] = \{\langle 1, 2\rangle\}$$
$$\text{sup}^{r_3}_2[x, v] = \varnothing$$
$$\text{sup}^{r_3}_3[x, y] = \varnothing$$
$$\text{output}^{bf}_S[x, y] = \varnothing$$

$$\text{input}^{fb}_S[x] = \{1, 2, 3, 4\}$$
$$\text{sup}^{r_4}_0[x] = \{1, 2, 3, 4\}$$
$$\text{sup}^{r_4}_1[x] = \{1, 2, 3, 4\}$$
$$\text{output}^{fb}_S[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 3, 3\rangle, \langle 4, 4\rangle\}$$

$$\text{input}^{fb}_S[y] = \{1, 2, 3, 4\}$$
$$\text{sup}^{r_5}_0[y] = \{1, 2, 3, 4\}$$
$$\text{sup}^{r_5}_1[x, w, y] = \{\langle 1, 2, 2\rangle, \langle 2, 3, 3\rangle, \dots, \langle 7, 1, 2\rangle\}$$
$$\text{sup}^{r_5}_2[x, v, y] = \varnothing$$
$$\text{sup}^{r_5}_3[x, y] = \varnothing$$
$$\text{output}^{fb}_S[x, y] = \varnothing$$

Exercise 2

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Solution.

2.

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$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_2}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 3,3\rangle, \langle 4,4\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \varnothing$
		$\text{sup}^{r_3}_3[x,y] = \varnothing$		$\text{sup}^{r_5}_3[x,y] = \varnothing$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \varnothing$

Exercise 2

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$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_2}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 3,3\rangle, \langle 4,4\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$
		$\text{sup}^{r_3}_3[x,y] = \varnothing$		$\text{sup}^{r_5}_3[x,y] = \varnothing$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \varnothing$

Exercise 2

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1. Sketch the database as a tree. What are the expected answers to the query?
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Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$

$\sup^{r_1}_0[] = \varnothing$

$\sup^{r_1}_1[x] = \varnothing$

$\text{output}^f_{\text{Query}}[x] = \varnothing$

$\text{input}^{bf}_S[x] = \{1\}$

$\sup^{r_3}_0[x] = \{1\}$

$\sup^{r_3}_1[x] = \{1\}$

$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$

$\text{input}^{bf}_S[x] = \{1\}$

$\sup^{r_3}_0[x] = \{1\}$

$\sup^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$

$\sup^{r_3}_2[x,v] = \varnothing$

$\sup^{r_3}_3[x,y] = \varnothing$

$\text{output}^{bf}_S[x,y] = \varnothing$

$\text{input}^{fb}_S[x] = \{1,2,3,4\}$

$\sup^{r_4}_0[x] = \{1,2,3,4\}$

$\sup^{r_4}_0[x] = \{1,2,3,4\}$

$\sup^{r_4}_1[x] = \{1,2,3,4\}$

$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 3,3\rangle,\langle 4,4\rangle\}$

$\text{input}^{fb}_S[y] = \{1,2,3,4\}$

$\sup^{r_5}_0[y] = \{1,2,3,4\}$

$\sup^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\ldots,\langle 7,1,4\rangle\}$

$\sup^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\ldots,\langle 7,1,4\rangle\}$

$\sup^{r_5}_3[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 2,4\rangle,\langle 4,2\rangle,\langle 4,4\rangle\}$

$\text{output}^{fb}_S[x,y] = \varnothing$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

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$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_2}_0[x] = \{1\}$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_4}_0[x] = \{1,2,3,4\}$	$\sup^{r_5}_0[y] = \{1,2,3,4\}$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_1[x] = \{1\}$	$\sup^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\sup^{r_4}_1[x] = \{1,2,3,4\}$	$\sup^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\ldots,\langle 7,1,4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\sup^{r_3}_2[x,v] = \varnothing$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 3,3\rangle,\langle 4,4\rangle\}$	$\sup^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\ldots,\langle 7,1,4\rangle\}$
		$\sup^{r_3}_3[x,y] = \varnothing$		$\sup^{r_5}_3[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 2,4\rangle,\langle 4,2\rangle,\langle 4,4\rangle\}$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 2,4\rangle,\langle 4,2\rangle,\langle 4,4\rangle\}$

Exercise 2

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h(1)   h(2)   h(3)   h(4)   h(5)   h(6)   h(7)   p(1,2)   p(2,3)   p(4,3)   p(5,4)   p(6,1)   p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?

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$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_1[x] = \varnothing$	$\text{sup}^{r_3}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\dots,\langle 7,1,4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \{\langle 1,2\rangle,\langle 1,4\rangle\}$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 3,3\rangle,\langle 4,4\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle,\langle 2,3,1\rangle,\dots,\langle 7,1,4\rangle\}$
		$\text{sup}^{r_3}_3[x,y] = \varnothing$		$\text{sup}^{r_5}_3[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 2,4\rangle,\langle 4,2\rangle,\langle 4,4\rangle\}$
		$\text{output}^{bf}_S[x,y] = \varnothing$		$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle,\langle 2,2\rangle,\langle 2,4\rangle,\langle 4,2\rangle,\langle 4,4\rangle\}$

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$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x) \qquad\qquad r_4 = S^{fb}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v) \qquad r_5 = S^{fb}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v)$$

together with the database that contains the following facts for predicate p:

h(1) h(2) h(3) h(4) h(5) h(6) h(7)   p(1, 2) p(2, 3) p(4, 3) p(5, 4) p(6, 1) p(7, 1)

1. Sketch the database as a tree. What are the expected answers to the query?

2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^r_{\text{Query}}[] = \varnothing$	$\text{input}^{br}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \{1, 2, 3, 4\}$	$\text{input}^{fb}_S[y] = \{1, 2, 3, 4\}$
$\sup^{r_1}_0[] = \varnothing$	$\sup^{r_1}_S[x] = \{1\}$	$\sup^{r_3}_0[x] = \{1\}$	$\sup^{r_4}_0[x] = \{1, 2, 3, 4\}$	$\sup^{r_5}_0[y] = \{1, 2, 3, 4\}$
$\sup^{r_1}_1[x] = \varnothing$	$\sup^{r_2}_S[x] = \{1\}$	$\sup^{r_3}_1[x, w] = \{\langle 1, 2\rangle\}$	$\sup^{r_4}_1[x] = \{1, 2, 3, 4\}$	$\sup^{r_5}_1[x, w, y] = \{\langle 1, 2, 1\rangle, \langle 2, 3, 1\rangle, \ldots, \langle 7, 1, 4\rangle\}$
$\text{output}^r_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x, y] = \{\langle 1, 1\rangle\}$	$\sup^{r_3}_2[x, v] = \{\langle 1, 2\rangle, \langle 1, 4\rangle\}$	$\text{output}^{fb}_S[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 3, 3\rangle, \langle 4, 4\rangle\}$	$\sup^{r_5}_2[x, v, y] = \{\langle 1, 2, 1\rangle, \langle 2, 3, 1\rangle, \ldots, \langle 7, 1, 4\rangle\}$
		$\sup^{r_3}_3[x, y] = \{\langle 1, 1\rangle, \langle 1, 5\rangle\}$		$\sup^{r_5}_3[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 2, 4\rangle, \langle 4, 2\rangle, \langle 4, 4\rangle\}$
		$\text{output}^{bf}_S[x, y] = \varnothing$		$\text{output}^{fb}_S[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 2, 4\rangle, \langle 4, 2\rangle, \langle 4, 4\rangle\}$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x,x) \leftarrow h(x) \qquad\qquad S(x,y) \leftarrow p(x,w) \wedge S(v,w) \wedge p(y,v)$$

and the adorned version for query $S(1,x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1,x)$$
$$r_2 = S^{bf}(x,x) \leftarrow h(x) \qquad\qquad r_4 = S^{fb}(x,x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x,y) \leftarrow p(x,w) \wedge S^{fb}(v,w) \wedge p(y,v) \qquad r_5 = S^{fb}(x,y) \leftarrow p(x,w) \wedge S^{fb}(v,w) \wedge p(y,v)$$

together with the database that contains the following facts for predicate p:

h(1) h(2) h(3) h(4) h(5) h(6) h(7)   p(1,2) p(2,3) p(4,3) p(5,4) p(6,1) p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?
2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^{r_1}_{\text{Query}}[] = \varnothing$

$\text{sup}^{r_1}_0[] = \varnothing$

$\text{sup}^{r_1}_1[x] = \varnothing$

$\text{output}^{r_1}_{\text{Query}}[x] = \varnothing$

$\text{input}^{bf}_S[x] = \{1\}$

$\text{sup}^{r_2}_0[x] = \{1\}$

$\text{sup}^{r_2}_1[x] = \{1\}$

$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$

$\text{input}^{bf}_S[x] = \{1\}$

$\text{sup}^{r_3}_0[x] = \{1\}$

$\text{sup}^{r_3}_1[x,w] = \{\langle 1,2\rangle\}$

$\text{sup}^{r_3}_2[x,v] = \{\langle 1,2\rangle, \langle 1,4\rangle\}$

$\text{sup}^{r_3}_3[x,y] = \{\langle 1,1\rangle, \langle 1,5\rangle\}$

$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle, \langle 1,5\rangle\}$

$\text{input}^{fb}_S[x] = \{1,2,3,4\}$

$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$

$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$

$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 3,3\rangle, \langle 4,4\rangle\}$

$\text{input}^{fb}_S[y] = \{1,2,3,4\}$

$\text{sup}^{r_5}_0[y] = \{1,2,3,4\}$

$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$

$\text{sup}^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$

$\text{sup}^{r_5}_3[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 2,4\rangle, \langle 4,2\rangle, \langle 4,4\rangle\}$

$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 2,4\rangle, \langle 4,2\rangle, \langle 4,4\rangle\}$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x, x) \leftarrow h(x) \qquad\qquad S(x, y) \leftarrow p(x, w) \wedge S(v, w) \wedge p(y, v)$$

and the adorned version for query $S(1, x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x) \qquad\qquad r_4 = S^{fb}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v) \qquad r_5 = S^{fb}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v)$$

together with the database that contains the following facts for predicate p:

h(1)   h(2)   h(3)   h(4)   h(5)   h(6)   h(7)   p(1,2)   p(2,3)   p(4,3)   p(5,4)   p(6,1)   p(7,1)

1. Sketch the database as a tree. What are the expected answers to the query?
2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \{1,2,3,4\}$	$\text{input}^{fb}_S[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_2}_0[x] = \{1\}$	$\text{sup}^{r_4}_0[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_0[y] = \{1,2,3,4\}$
$\text{sup}^{r_1}_1[x] = \{1,5\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x,w] = \{\langle 1,2\rangle\}$	$\text{sup}^{r_4}_1[x] = \{1,2,3,4\}$	$\text{sup}^{r_5}_1[x,w,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \varnothing$	$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle\}$	$\text{sup}^{r_3}_2[x,v] = \{\langle 1,2\rangle, \langle 1,4\rangle\}$	$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 3,3\rangle, \langle 4,4\rangle\}$	$\text{sup}^{r_5}_2[x,v,y] = \{\langle 1,2,1\rangle, \langle 2,3,1\rangle, \ldots, \langle 7,1,4\rangle\}$
		$\text{sup}^{r_3}_3[x,y] = \{\langle 1,1\rangle, \langle 1,5\rangle\}$		$\text{sup}^{r_5}_3[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 2,4\rangle, \langle 4,2\rangle, \langle 4,4\rangle\}$
		$\text{output}^{bf}_S[x,y] = \{\langle 1,1\rangle, \langle 1,5\rangle\}$		$\text{output}^{fb}_S[x,y] = \{\langle 1,1\rangle, \langle 2,2\rangle, \langle 2,4\rangle, \langle 4,2\rangle, \langle 4,4\rangle\}$

Exercise 2

Exercise. Consider the "Same generation" Datalog program given in the lecture (Lecture 15, Slide 15):

$$S(x, x) \leftarrow h(x) \qquad\qquad S(x, y) \leftarrow p(x, w) \wedge S(v, w) \wedge p(y, v)$$

and the adorned version for query $S(1, x)$:

$$r_1 = \text{Query}^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x) \qquad\qquad r_4 = S^{fb}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v) \qquad r_5 = S^{fb}(x, y) \leftarrow p(x, w) \wedge S^{fb}(v, w) \wedge p(y, v)$$

together with the database that contains the following facts for predicate p:

h(1)   h(2)   h(3)   h(4)   h(5)   h(6)   h(7)   p(1, 2)   p(2, 3)   p(4, 3)   p(5, 4)   p(6, 1)   p(7, 1)

1. Sketch the database as a tree. What are the expected answers to the query?
2. Apply the QSQR algorithm to compute the answer to the query.

Solution.

2.

$\text{input}^f_{\text{Query}}[] = \varnothing$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{bf}_S[x] = \{1\}$	$\text{input}^{fb}_S[x] = \{1, 2, 3, 4\}$	$\text{input}^{fb}_S[y] = \{1, 2, 3, 4\}$
$\text{sup}^{r_1}_0[] = \varnothing$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_3}_0[x] = \{1\}$	$\text{sup}^{r_5}_0[x] = \{1, 2, 3, 4\}$	$\text{sup}^{r_5}_0[y] = \{1, 2, 3, 4\}$
$\text{sup}^{r_1}_1[x] = \{1, 5\}$	$\text{sup}^{r_3}_1[x] = \{1\}$	$\text{sup}^{r_3}_1[x, w] = \{\langle 1, 2\rangle\}$	$\text{sup}^{r_5}_1[x] = \{1, 2, 3, 4\}$	$\text{sup}^{r_5}_1[x, w, y] = \{\langle 1, 2, 1\rangle, \langle 2, 3, 1\rangle, \dots, \langle 7, 1, 4\rangle\}$
$\text{output}^f_{\text{Query}}[x] = \{1, 5\}$	$\text{output}^{bf}_S[x, y] = \{\langle 1, 1\rangle\}$	$\text{sup}^{r_3}_2[x, v] = \{\langle 1, 2\rangle, \langle 1, 4\rangle\}$	$\text{output}^{fb}_S[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 3, 3\rangle, \langle 4, 4\rangle\}$	$\text{sup}^{r_5}_2[x, v, y] = \{\langle 1, 2, 1\rangle, \langle 2, 3, 1\rangle, \dots, \langle 7, 1, 4\rangle\}$
		$\text{sup}^{r_3}_3[x, y] = \{\langle 1, 1\rangle, \langle 1, 5\rangle\}$		$\text{sup}^{r_5}_3[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 2, 4\rangle, \langle 4, 2\rangle, \langle 4, 4\rangle\}$
		$\text{output}^{bf}_S[x, y] = \{\langle 1, 1\rangle, \langle 1, 5\rangle\}$		$\text{output}^{fb}_S[x, y] = \{\langle 1, 1\rangle, \langle 2, 2\rangle, \langle 2, 4\rangle, \langle 4, 2\rangle, \langle 4, 4\rangle\}$

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the sup_0 relation of a rule during the execution of the QSQR algorithm.
Solution.

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the sup_0 relation of a rule during the execution of the QSQR algorithm.
Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the sup_0 relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.
Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$
$$r_4 = S^{bb}(x, x) \leftarrow h(x)$$

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$
$$r_4 = S^{bb}(x, x) \leftarrow h(x)$$
$$r_5 = S^{bb}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$
$$r_4 = S^{bb}(x, x) \leftarrow h(x)$$
$$r_5 = S^{bb}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$

- Consider the auxiliary relations for r_4: $\text{input}_S^{bb}[x, y]$ has arity two, since two variables are bound.

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$
$$r_4 = S^{bb}(x, x) \leftarrow h(x)$$
$$r_5 = S^{bb}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$

- Consider the auxiliary relations for r_4: $\text{input}_S^{bb}[x, y]$ has arity two, since two variables are bound.
- However, $\sup_0^{r_4}[x]$ has arity one, since r_4 forces $x = y$.

Exercise 3

Exercise. Consider the following modified version of the same generation program:

$$S(x, x) \leftarrow h(x)$$
$$S(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S(v, w)$$

What is the adorned version of this program for the query $S(1, x)$? Use this program to show that it is possible that some tuples in an input-relation are not copied to the $\sup_0$ relation of a rule during the execution of the QSQR algorithm.

Solution.

$$r_1 = Q^f(x) \leftarrow S^{bf}(1, x)$$
$$r_2 = S^{bf}(x, x) \leftarrow h(x)$$
$$r_3 = S^{bf}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$
$$r_4 = S^{bb}(x, x) \leftarrow h(x)$$
$$r_5 = S^{bb}(x, y) \leftarrow p(x, w) \wedge p(y, v) \wedge S^{bb}(v, w)$$

- Consider the auxiliary relations for r_4: $\text{input}_S^{bb}[x, y]$ has arity two, since two variables are bound.
- However, $\sup_0^{r_4}[x]$ has arity one, since r_4 forces $x = y$.
- Thus, only tuples $\langle x, y \rangle$ with $x = y$ are copied.

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = Query^f(y) \leftarrow Sv^{bf}(a, y)$$

Exercise 4

Exercise. Consider the following program:

$$\text{Sv}(x, y) \leftarrow \text{flat}(x, y)$$
$$\text{Sv}(x, y) \leftarrow \text{up}(x, z_1) \wedge \text{Sv}(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge \text{Sv}(z_3, z_4) \wedge \text{down}(z_4, y)$$

Give the magic set transformation for this program and the query $\text{Sv}(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = \text{Query}^f(y) \leftarrow \text{Sv}^{bf}(a, y)$$
$$r_1 = \text{Sv}^{bf}(x, y) \leftarrow \text{flat}(x, y)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow flat(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow up(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge down(z_4, y)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = Query^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow flat(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow up(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge down(z_4, y)$$

Magic Sets transformation:

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow \text{flat}(x, y)$$
$$Sv(x, y) \leftarrow \text{up}(x, z_1) \land Sv(z_1, z_2) \land \text{flat}(z_2, z_3) \land Sv(z_3, z_4) \land \text{down}(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.

Solution.

Adorned program:

$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow \text{flat}(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow \text{up}(x, z_1) \land Sv^{bf}(z_1, z_2) \land \text{flat}(z_2, z_3) \land Sv^{bf}(z_3, z_4) \land \text{down}(z_4, y)$$

Magic Sets transformation:

$$\text{input}_{Sv}^{bf}(a) \leftarrow$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = Query^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow flat(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow up(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge down(z_4, y)$$

Magic Sets transformation:

$$input_{Sv}^{bf}(a) \leftarrow \qquad\qquad\qquad\qquad output_{Sv}^{bf}(x, y) \leftarrow input_{Sv}^{bf}(x) \wedge flat(x, y)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
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$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
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Magic Sets transformation:

$$\text{input}_{Sv}^{bf}(a) \leftarrow$$

$$\text{output}_{Sv}^{bf}(x, y) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge flat(x, y)$$

$$\text{sup}_2^{r_2}(x, z_1) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge up(x, z_1)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow \text{flat}(x, y)$$
$$Sv(x, y) \leftarrow \text{up}(x, z_1) \wedge Sv(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge Sv(z_3, z_4) \wedge \text{down}(z_4, y)$$

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Solution.
Adorned program:

$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
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$$r_2 = Sv^{bf}(x, y) \leftarrow \text{up}(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge \text{down}(z_4, y)$$

Magic Sets transformation:

$$\text{input}_{Sv}^{bf}(a) \leftarrow \qquad\qquad \text{output}_{Sv}^{bf}(x, y) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge \text{flat}(x, y)$$
$$\text{sup}_2^{r_2}(x, z_1) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge \text{up}(x, z_1) \qquad\qquad \text{input}_{Sv}^{bf}(z_1) \leftarrow \text{sup}_2^{r_2}(x, z_1)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow \text{flat}(x, y)$$
$$Sv(x, y) \leftarrow \text{up}(x, z_1) \wedge Sv(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge Sv(z_3, z_4) \wedge \text{down}(z_4, y)$$

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$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
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$$r_2 = Sv^{bf}(x, y) \leftarrow \text{up}(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge \text{down}(z_4, y)$$

Magic Sets transformation:

$$\text{input}_{Sv}^{bf}(a) \leftarrow \qquad\qquad \text{output}_{Sv}^{bf}(x, y) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge \text{flat}(x, y)$$
$$\text{sup}_2^{r_2}(x, z_1) \leftarrow \text{input}_{Sv}^{bf}(x) \wedge \text{up}(x, z_1) \qquad\qquad \text{input}_{Sv}^{bf}(z_1) \leftarrow \text{sup}_2^{r_2}(x, z_1)$$
$$\text{sup}_3^{r_2}(x, z_2) \leftarrow \text{sup}_2^{r_2}(x, z_1) \wedge \text{output}_{Sv}^{bf}(z_1, z_2)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow \text{flat}(x, y)$$
$$Sv(x, y) \leftarrow \text{up}(x, z_1) \land Sv(z_1, z_2) \land \text{flat}(z_2, z_3) \land Sv(z_3, z_4) \land \text{down}(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
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$$r_0 = \text{Query}^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow \text{flat}(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow \text{up}(x, z_1) \land Sv^{bf}(z_1, z_2) \land \text{flat}(z_2, z_3) \land Sv^{bf}(z_3, z_4) \land \text{down}(z_4, y)$$

Magic Sets transformation:

$$\text{input}_{Sv}^{bf}(a) \leftarrow \qquad\qquad \text{output}_{Sv}^{bf}(x, y) \leftarrow \text{input}_{Sv}^{bf}(x) \land \text{flat}(x, y)$$
$$\text{sup}_2^{r_2}(x, z_1) \leftarrow \text{input}_{Sv}^{bf}(x) \land \text{up}(x, z_1) \qquad\qquad \text{input}_{Sv}^{bf}(z_1) \leftarrow \text{sup}_2^{r_2}(x, z_1)$$
$$\text{sup}_3^{r_2}(x, z_2) \leftarrow \text{sup}_2^{r_2}(x, z_1) \land \text{output}_{Sv}^{bf}(z_1, z_2) \qquad\qquad \text{sup}_4^{r_2}(x, z_3) \leftarrow \text{sup}_3^{r_2}(x, z_2) \land \text{flat}(z_2, z_3)$$

Exercise 4

Exercise. Consider the following program:

$$\text{Sv}(x, y) \leftarrow \text{flat}(x, y)$$
$$\text{Sv}(x, y) \leftarrow \text{up}(x, z_1) \wedge \text{Sv}(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge \text{Sv}(z_3, z_4) \wedge \text{down}(z_4, y)$$

Give the magic set transformation for this program and the query $\text{Sv}(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = \text{Query}^f(y) \leftarrow \text{Sv}^{bf}(a, y)$$
$$r_1 = \text{Sv}^{bf}(x, y) \leftarrow \text{flat}(x, y)$$
$$r_2 = \text{Sv}^{bf}(x, y) \leftarrow \text{up}(x, z_1) \wedge \text{Sv}^{bf}(z_1, z_2) \wedge \text{flat}(z_2, z_3) \wedge \text{Sv}^{bf}(z_3, z_4) \wedge \text{down}(z_4, y)$$

Magic Sets transformation:

$$\text{input}_{\text{Sv}}^{bf}(a) \leftarrow \qquad\qquad \text{output}_{\text{Sv}}^{bf}(x, y) \leftarrow \text{input}_{\text{Sv}}^{bf}(x) \wedge \text{flat}(x, y)$$
$$\text{sup}_2^{r_2}(x, z_1) \leftarrow \text{input}_{\text{Sv}}^{bf}(x) \wedge \text{up}(x, z_1) \qquad\qquad \text{input}_{\text{Sv}}^{bf}(z_1) \leftarrow \text{sup}_2^{r_2}(x, z_1)$$
$$\text{sup}_3^{r_2}(x, z_2) \leftarrow \text{sup}_2^{r_2}(x, z_1) \wedge \text{output}_{\text{Sv}}^{bf}(z_1, z_2) \qquad\qquad \text{sup}_4^{r_2}(x, z_3) \leftarrow \text{sup}_3^{r_2}(x, z_2) \wedge \text{flat}(z_2, z_3)$$
$$\text{input}_{\text{Sv}}^{bf}(z_3) \leftarrow \text{sup}_4^{r_2}(x, z_3)$$

Exercise 4

Exercise. Consider the following program:

$$Sv(x, y) \leftarrow flat(x, y)$$
$$Sv(x, y) \leftarrow up(x, z_1) \wedge Sv(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv(z_3, z_4) \wedge down(z_4, y)$$

Give the magic set transformation for this program and the query $Sv(a, y)$, where a is a constant.
Solution.
Adorned program:

$$r_0 = Query^f(y) \leftarrow Sv^{bf}(a, y)$$
$$r_1 = Sv^{bf}(x, y) \leftarrow flat(x, y)$$
$$r_2 = Sv^{bf}(x, y) \leftarrow up(x, z_1) \wedge Sv^{bf}(z_1, z_2) \wedge flat(z_2, z_3) \wedge Sv^{bf}(z_3, z_4) \wedge down(z_4, y)$$

Magic Sets transformation:

$$input_{Sv}^{bf}(a) \leftarrow \qquad\qquad output_{Sv}^{bf}(x, y) \leftarrow input_{Sv}^{bf}(x) \wedge flat(x, y)$$
$$sup_2^{r_2}(x, z_1) \leftarrow input_{Sv}^{bf}(x) \wedge up(x, z_1) \qquad input_{Sv}^{bf}(z_1) \leftarrow sup_2^{r_2}(x, z_1)$$
$$sup_3^{r_2}(x, z_2) \leftarrow sup_2^{r_2}(x, z_1) \wedge output_{Sv}^{bf}(z_1, z_2) \qquad sup_4^{r_2}(x, z_3) \leftarrow sup_3^{r_2}(x, z_2) \wedge flat(z_2, z_3)$$
$$input_{Sv}^{bf}(z_3) \leftarrow sup_4^{r_2}(x, z_3) \qquad output_{Sv}^{bf}(x, y) \leftarrow sup_4^{r_2}(x, z_3) \wedge output_{Sv}^{bf}(z_3, z_4) \wedge down(z_4, y)$$