Rytter for CFPQ

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1 Linear input

Let the input grammar is

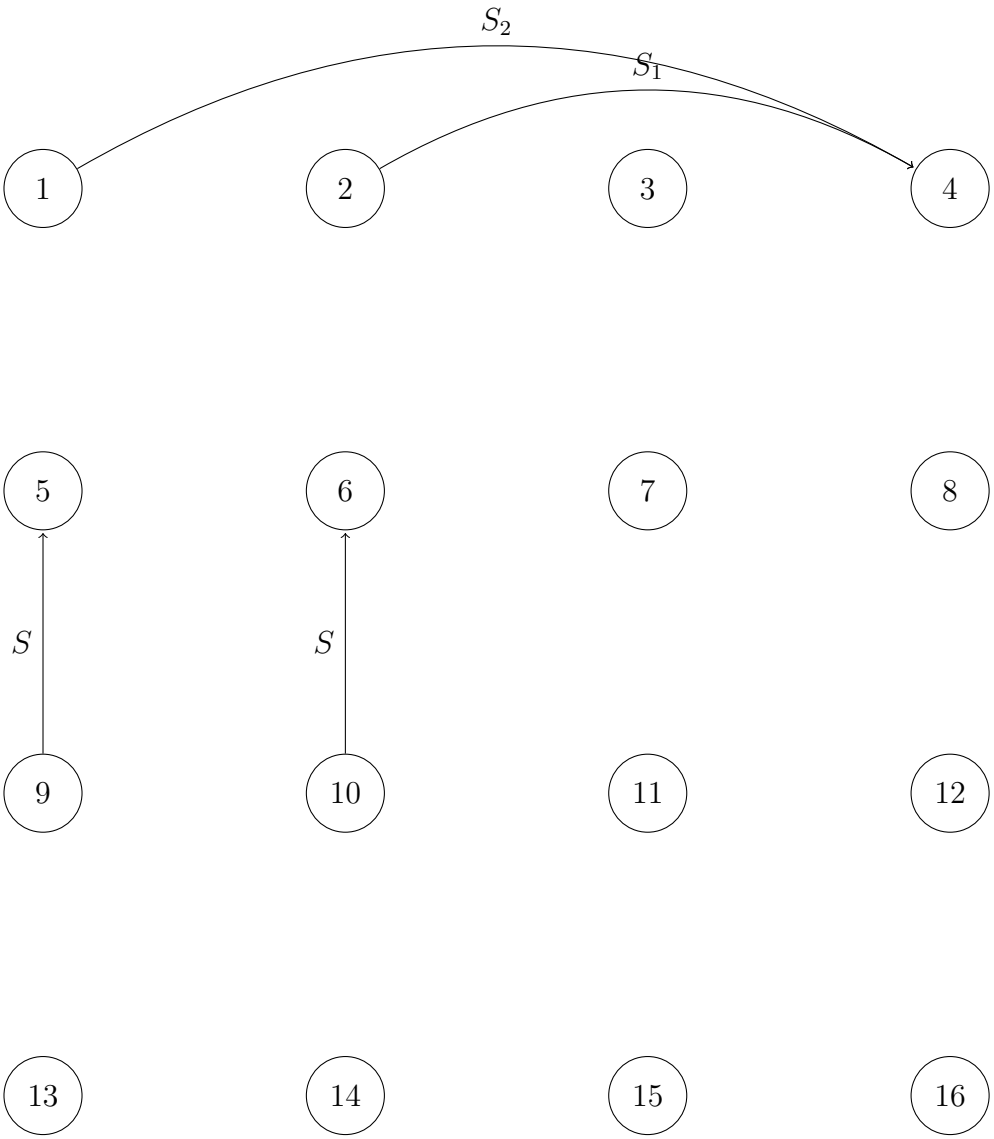
$$S \to a\ S\ b$$
$$S \to S\ S$$
$$S \to a\ b$$

The input grammar in CNF is

$$S \to A\ S_1$$
$$S_1 \to S\ B$$
$$S \to S\ S$$
$$S \to A\ B$$
$$A \to a$$
$$B \to b$$

Input: *abab*

Grid:



2 Graph input

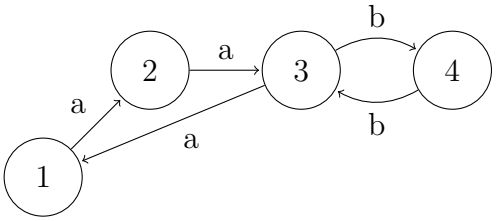
Let the input grammar is

$$S \to a\ S\ b$$
$$S \to a\ b$$

The input grammar in CNF is

$$S \to A\ S_1$$
$$S_1 \to S\ B$$
$$S \to A\ B$$
$$A \to a$$
$$B \to b$$

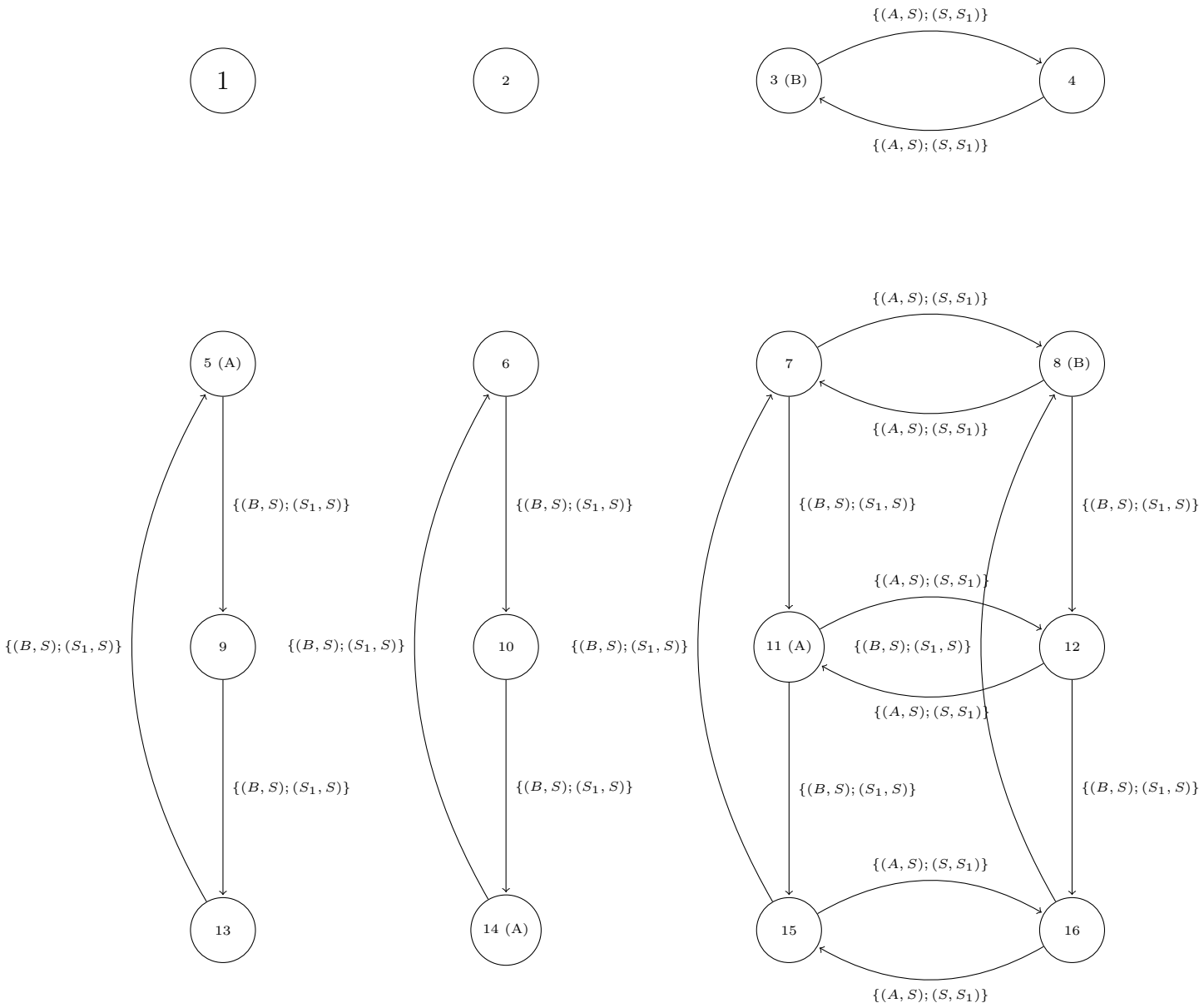
Let the input graph is



The *IMPLIED* relation:

$(B,2,3) \Rightarrow (S,1,3)$	$(B,2,4) \Rightarrow (S,1,4)$	$(B,2,2) \Rightarrow (S,1,2)$	$(B,2,1) \Rightarrow (S,1,1)$
$(B,3,4) \Rightarrow (S,2,4)$	$(B,3,3) \Rightarrow (S,2,3)$	$(B,3,2) \Rightarrow (S,2,2)$	$(B,3,1) \Rightarrow (S,2,1)$
$(B,1,2) \Rightarrow (S,3,2)$	$(B,1,3) \Rightarrow (S,3,3)$	$(B,1,4) \Rightarrow (S,3,4)$	$(B,1,1) \Rightarrow (S,3,1)$
$(S_1,2,3) \Rightarrow (S,1,3)$	$(S_1,2,4) \Rightarrow (S,1,4)$	$(S_1,2,2) \Rightarrow (S,1,2)$	$(S_1,2,1) \Rightarrow (S,1,1)$
$(S_1,3,4) \Rightarrow (S,2,4)$	$(S_1,3,3) \Rightarrow (S,2,3)$	$(S_1,3,2) \Rightarrow (S,2,2)$	$(S_1,3,1) \Rightarrow (S,2,1)$
$(S_1,1,2) \Rightarrow (S,3,2)$	$(S_1,1,3) \Rightarrow (S,3,3)$	$(S_1,1,4) \Rightarrow (S,3,4)$	$(S_1,1,1) \Rightarrow (S,3,1)$
$(A,2,3) \Rightarrow (S,2,4)$	$(A,1,3) \Rightarrow (S,1,4)$	$(A,3,3) \Rightarrow (S,3,4)$	$(A,4,3) \Rightarrow (S,4,4)$
$(A,3,4) \Rightarrow (S,3,3)$	$(A,4,4) \Rightarrow (S,4,3)$	$(A,2,4) \Rightarrow (S,2,3)$	$(A,1,4) \Rightarrow (S,1,3)$
$(S,2,3) \Rightarrow (S_1,2,4)$	$(S,1,3) \Rightarrow (S_1,1,4)$	$(S,3,3) \Rightarrow (S_1,3,4)$	$(S,4,3) \Rightarrow (S_1,4,4)$
$(S,3,4) \Rightarrow (S_1,3,3)$	$(S,4,4) \Rightarrow (S_1,4,3)$	$(S,2,4) \Rightarrow (S_1,2,3)$	$(S,1,4) \Rightarrow (S_1,1,3)$

Grid:



$H =$

$$\begin{pmatrix} \varnothing & \varnothing & \varnothing & \varnothing \\ \varnothing & \varnothing & \varnothing & \varnothing \\ \varnothing & \varnothing & \varnothing & \{(A,S);(S,S_1)\} \\ \varnothing & \varnothing & \{(A,S);(S,S_1)\} & \varnothing \end{pmatrix}$$

$V =$

$$\begin{pmatrix} \varnothing & \varnothing & \{(B,S);(S_1,S)\} & \varnothing \\ \{(B,S);(S_1,S)\} & \varnothing & \varnothing & \varnothing \\ \varnothing & \{(B,S);(S_1,S)\} & \varnothing & \varnothing \\ \varnothing & \varnothing & \varnothing & \varnothing \end{pmatrix}$$

D_1 is "from column to row" $D_1 =$

$$\begin{pmatrix} \varnothing & \varnothing & \varnothing & \varnothing \\ \varnothing & \varnothing & \varnothing & \varnothing \\ \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} \\ \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} & \{(A,S);(S,S_1)\} \end{pmatrix}$$

D_2 is "from row to column" $D_2 =$

$$\begin{pmatrix} \varnothing & \varnothing & \varnothing & \varnothing \\ \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} \\ \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} \\ \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} & \{(B,S_1);(S_1,S_1)\} \end{pmatrix}$$

References

[1] Krishnendu Chatterjee, Bhavya Choudhary, and Andreas Pavlogiannis. 2017. *Optimal Dyck reachability for data-dependence and alias analysis.* Proc. ACM Program. Lang. 2, POPL, Article 30 (December 2017), 30 pages. DOI: https://doi.org/10.1145/3158118