# Rytter for CFPQ

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## 1 Linear input

Let the input grammar is

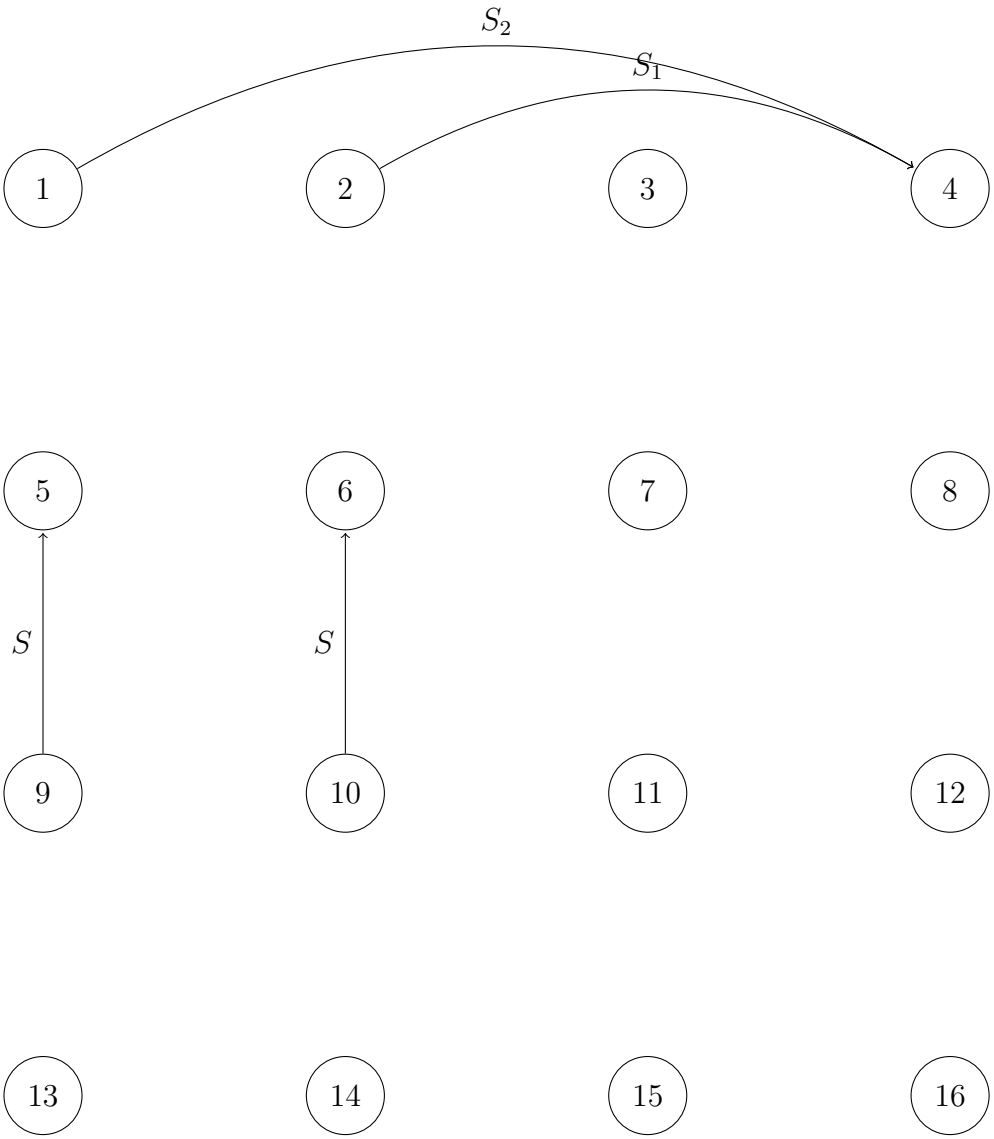
$$S \to a\ S\ b$$
$$S \to S\ S$$
$$S \to a\ b$$

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

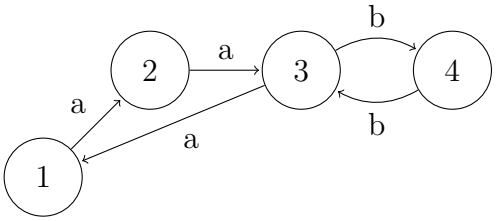
Let the input grammar is

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

The input grammar in CNF is

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

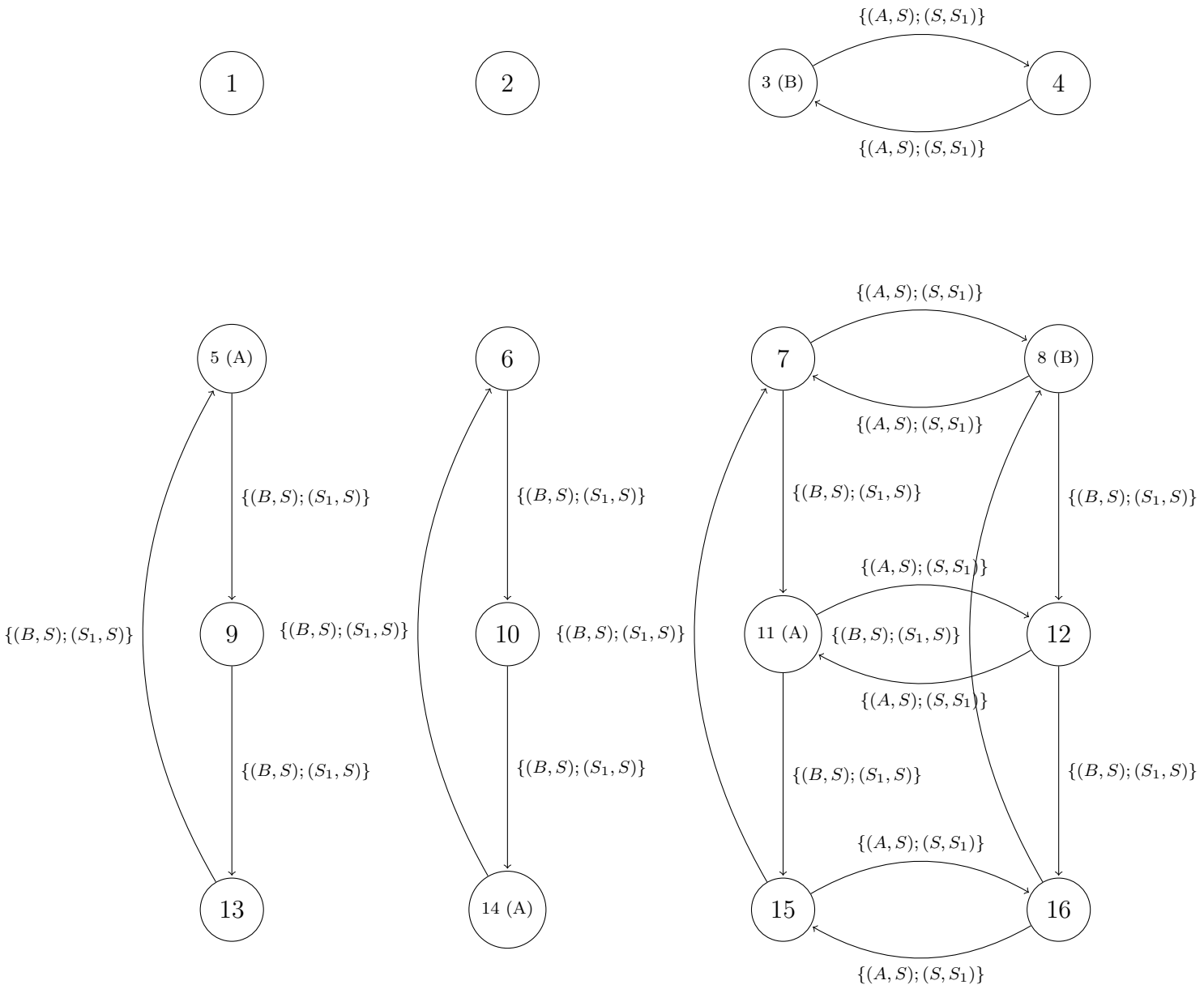
Let the input graph is




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:




# 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