

Rytter for CFPQ

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1 Linear input

Let the input grammar is

$$S \rightarrow a S b$$

$$S \rightarrow S S$$

$$S \rightarrow a b$$

The input grammar in CNF is

$$S \rightarrow A S_1$$

$$S_1 \rightarrow S B$$

$$S \rightarrow S S$$

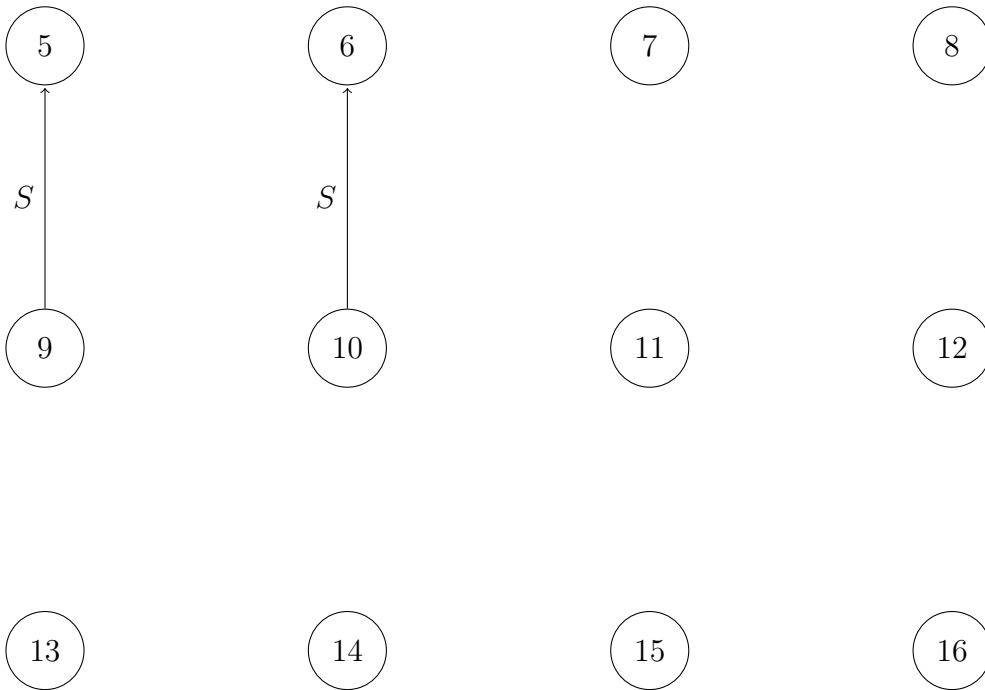
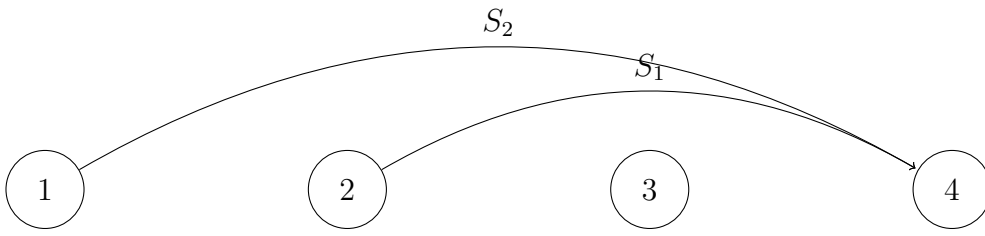
$$S \rightarrow A B$$

$$A \rightarrow a$$

$$B \rightarrow b$$

Input: *abab*

Grid:



2 Graph input

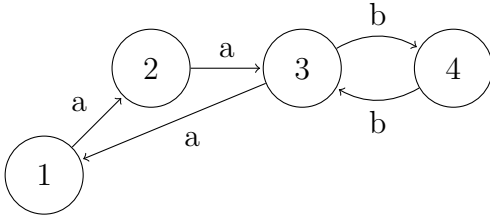
Let the input grammar is

$$\begin{aligned} S &\rightarrow a S b \\ S &\rightarrow a b \end{aligned}$$

The input grammar in CNF is

$$\begin{aligned} S &\rightarrow A S_1 \\ S_1 &\rightarrow S B \\ S &\rightarrow A B \\ A &\rightarrow a \\ B &\rightarrow b \end{aligned}$$

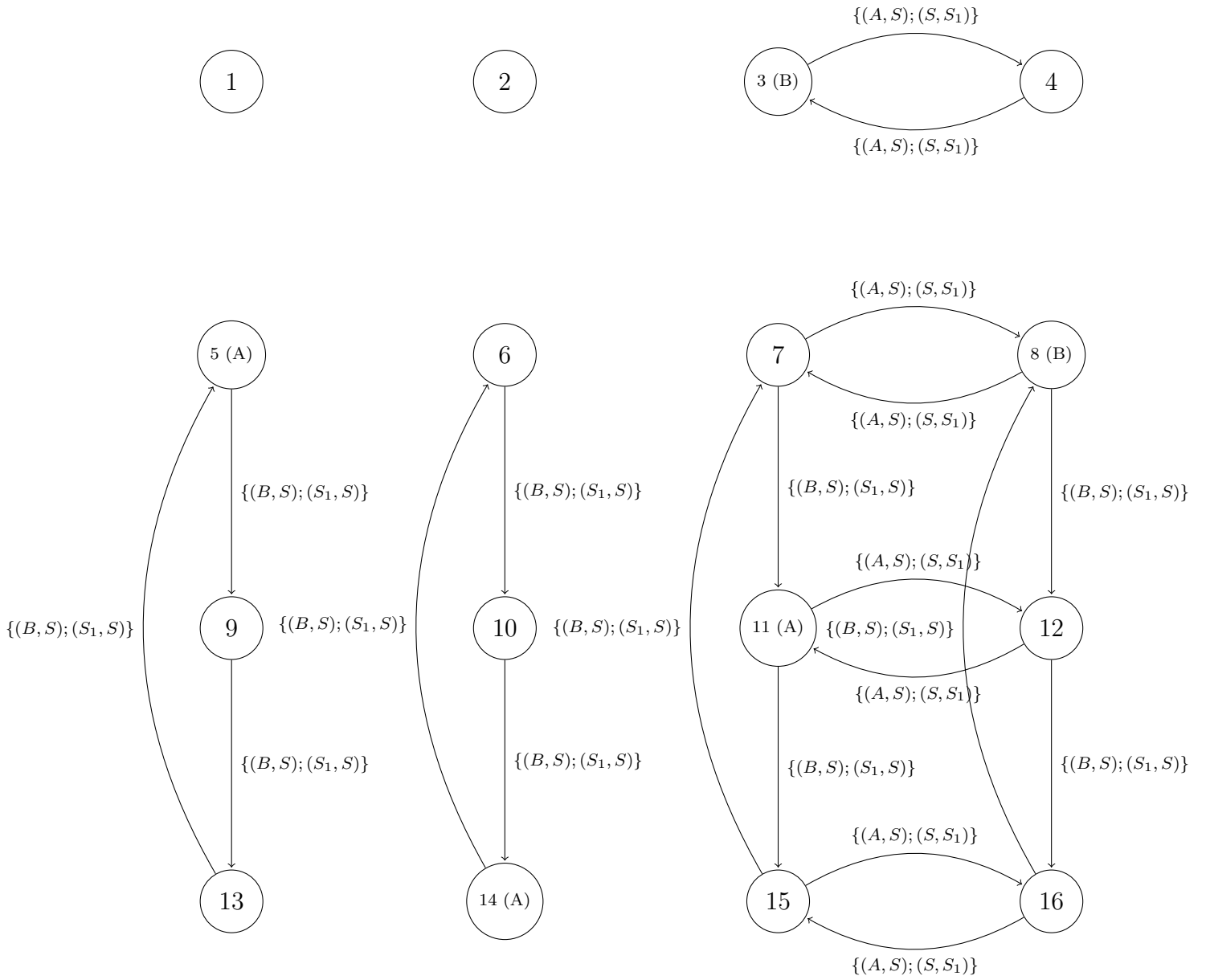
Let the input graph is



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>