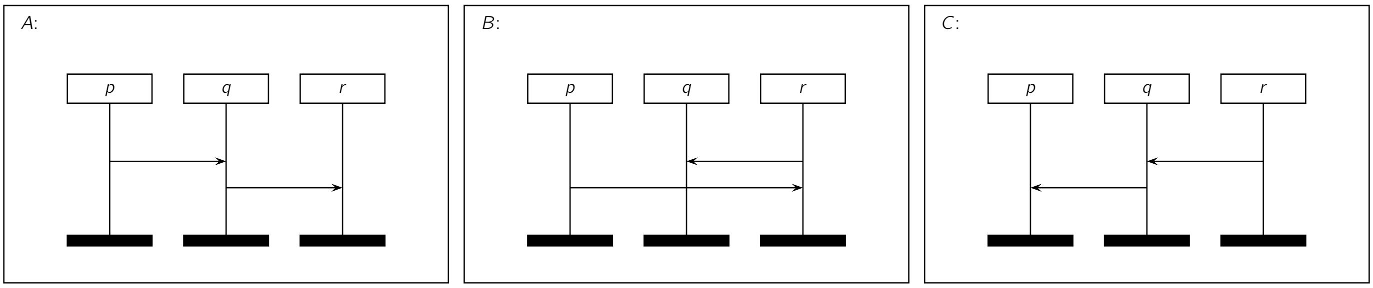
Exercise 1 (Regular Expressions and Realizability): (5 Points)



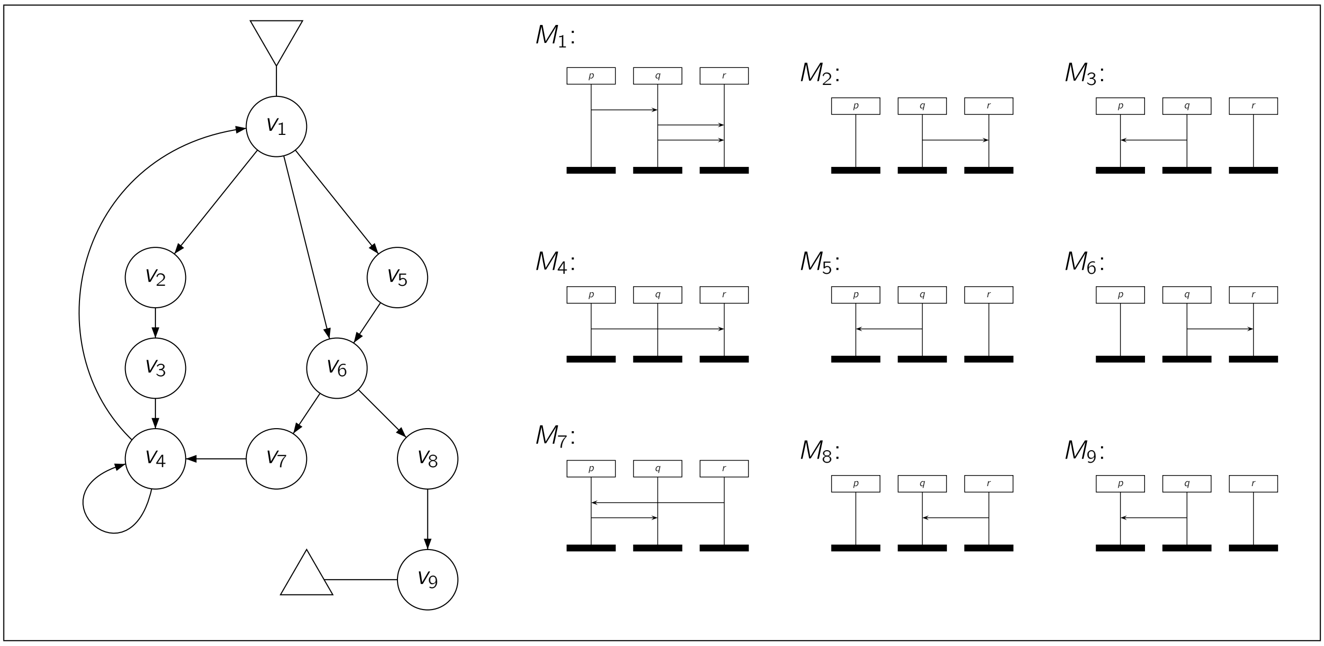
Check whether the following regular expressions are realisable or not:

- $\alpha_1 = A^* + B^* + C^*$,
- $\alpha_2 = A \cdot (B + C)^*$,
- $\alpha_3 = (A \cdot B \cdot C)^*$,
- $\alpha_4 = (A \cdot B)^*$,
- $\alpha_5 = (A \cdot C)^*$,

and if so, whether they can be realized by a universally bounded, deadlock-free CFM?

Exercise 2 (Realizability of MSGs): (8 Points)

Given the following local-choice MSG $\mathcal{G}$ over $\mathcal{P} = \{p, q, r\}$, where $\lambda(v_i) = M_i$ (for $i \in \{1, \ldots, 9\}$):



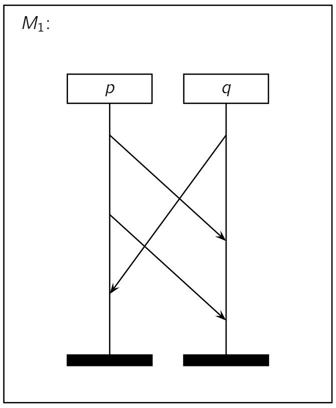
Construct a deadlock-free CFM $\mathcal{A}$ according to the algorithm presented in lecture 11. Determine, moreover, for every node $v \in V$ of $\mathcal{G}$ the maximal non-branching path $nbp(v)$.

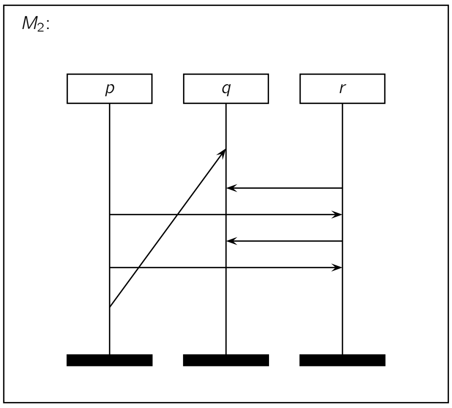
Exercise 3 (PDL): (5 Points)

Write down the PDL formulas according to the informal descriptions:

- The total number of messages sent and received at process 1 is odd.
- There does not exist a path from process 1 to process 2.
- If process 1 receives *req* from process 2, then process 1 will eventually send an *ack* to process 2 and in between these two events, process 1 cannot send any messages to other processes.

Exercise 4 (PDL): (5 Points)





Show whether the formulas:

- $\Phi_1 = \exists(\langle proc\rangle^{-1}\langle proc\rangle^{-1}\langle msg\rangle q!p \wedge \langle msg\rangle^{-1} p!q)$ and
- $\Phi_2 = \forall([proc]^{-1} false \wedge (\langle msg\rangle p!q \vee \langle proc\rangle q?p))$

hold for M_1 and the formulas

- $\Phi_3 = \exists\langle\{p!q\}; proc; proc; proc\rangle[proc] false\}$ and
- $\Phi_4 = \exists\phi$, where

$$\begin{array}{rcl} \phi & = & [proc]^{-1} false \to \langle\alpha\rangle[proc] false \\ \alpha & = & ((\{q!p \vee q!r\}; proc)^*; \{q?p \vee q?r\}; proc; \\ & & (\{q!p \vee q!r\}; proc)^*; \{q?p \vee q?r\}; proc; \\ & & (\{q!p \vee q!r\}; proc)^*; \{q?p \vee q?r\}; proc; \\ & & (\{q!p \vee q!r\}; proc)^*)^* \end{array}$$

hold for M_2.