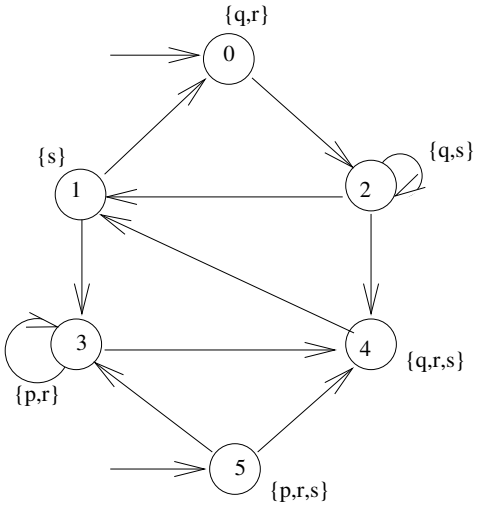
# Formal Models SS 2016: Assignment 9

Institute for Formal Models and Verification, JKU Linz

Due 02.06.2016

**Exercise 33**
Given the Kripke structure $K$ shown below.




Given trace $\pi$ and LTL formula $f$, decide if $f$ holds in $\pi$, i.e., $\pi \models f$.

| Trace $\pi$ | Formula $f$ | yes | no |
|---|---|---|---|
| $5,(3,4,1)^\omega$ | $\mathbf{FG}r$ | ☐ | ☐ |
| $5,4,1,(3)^\omega$ | $\mathbf{GF}s$ | ☐ | ☐ |
| $0,(2)^\omega$ | $\mathbf{FF}(\neg s)$ | ☐ | ☐ |
| $(0,2,1)^\omega$ | $\mathbf{G}(\neg r \rightarrow \mathbf{X}s)$ | ☐ | ☐ |
| $(0,2,1,2,4,1)^\omega$ | $\mathbf{F}(p\ \mathbf{U}\ s)$ | ☐ | ☐ |

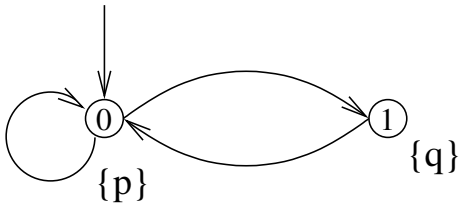
**Exercise 34**
For each of the following temporal formulae, check whether there is an equivalent formula in $LTL^{\text{det}}$. If so, then specify such an equivalent formula meeting the syntactic criteria for $LTL^{\text{det}}$ as given on lecture slide 69. Note that subformulae $p$ and $q$ are atomic propositions, i.e. $p, q \in \mathcal{A}$.

a) $\mathbf{EF}\ p \rightarrow \mathbf{AX}\ q$

b) $(\mathbf{AF}\ p) \wedge \mathbf{AX}\ \neg p$

c) $\neg((\mathbf{EX}\ \neg q) \vee (\mathbf{EF}\ \neg p))$

**Exercise 35**




Given Kripke structure $K$ as shown above. Justify your answers to the following questions.

a) Does $K \models f$ hold for ACTL formula $f := \mathbf{AX}\ p \vee \mathbf{AX}\ q$?

b) Let $g := f \setminus \mathbf{A}$. Does $K \models g$ hold?

c) Based on the results of a) und b): are $f$ and $g$ equivalent?

d) Based on the results of a), b) and c): is there an LTL formula which is equivalent to $f$?

**Exercise 36**
Given CTL formula $f := \mathbf{AF}\ (r \rightarrow \mathbf{AG}\ a)$, where $r$ and $a$ are atomic propositions, i.e. $r, a \in \mathcal{A}$. Draw a Kripke structure $K$ with exactly one initial state such that $K \not\models f$ but $K \models f \setminus \mathbf{A}$ (Hint: there is such $K$ with no more than 3 states). Is there an LTL formula which is equivalent to $f$? Justify your answers.