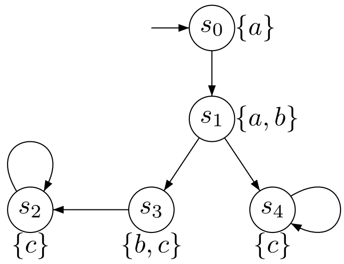
Exercise 1 (CTL Model Checking): (4 points)

Consider the following CTL-formulas

$$\Phi_1 = \exists\Diamond\forall\Box c \quad \text{and} \quad \Phi_2 = \forall(a \mathsf{U} \forall\Diamond c)$$

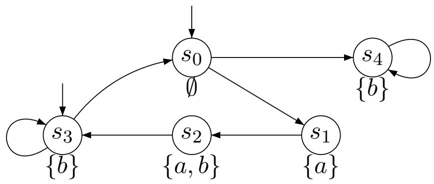
and the transition system outlined on the right. Decide whether $TS \models \Phi_i$ for $i = 1, 2$ using the CTL model checking algorithm from the lecture. Do not forget to translate to existential normal form and compute the satisfaction sets for subformulas.



Exercise 2 (CTL): (2 points)

Consider the following CTL formulas and the transition system TS outlined on the right:

$$\Phi_1 = \forall(a \mathsf{U} b) \vee \exists \bigcirc (\forall\Box b)$$
$$\Phi_2 = \forall\Box\forall(a \mathsf{U} b)$$
$$\Phi_3 = (a \wedge b) \rightarrow \exists\Box\exists \bigcirc \forall(b \mathsf{W} a)$$
$$\Phi_4 = (\forall\Box\exists\Diamond\Phi_3)$$



Give the satisfaction sets $Sat(\Phi_i)$ and decide whether $TS \models \Phi_i$ holds ($1 \leq i \leq 4$).

Exercise 3 (CTL and LTL expressiveness): (4 points)

We consider the incomparable expressiveness of CTL and LTL.

(a) Using a theorem from the lecture, prove that there does not exist an equivalent LTL-formula for the CTL-formula $\Phi_1 = \forall\Diamond(a \wedge \exists \bigcirc a)$.

(b) Now prove directly (i.e. without the above theorem), that there does not exist an equivalent LTL-formula for the CTL-formula $\Phi_2 = \forall\Diamond\exists \bigcirc \forall\Diamond\neg a$.
Hint: Argument by contraposition, think about trace inclusion vs. CTL-equivalence!