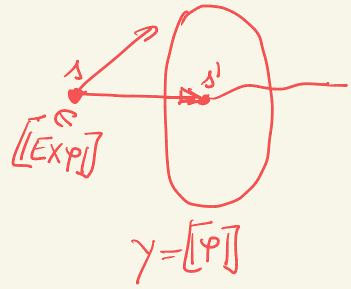
$A \subseteq A' \Rightarrow pre_\exists(A) \subseteq pre_\exists(A')$

(Solving Model Checking Problem)

- *Let define:*

$$pre_\exists(Y) = \{s \in S \mid \exists s' \in Y \text{ s.t. } (s, s') \in \mathcal{R}\}$$
$$pre_\forall(Y) = \{s \in S \mid \mathcal{R}(s) \subseteq Y\}$$



- *Compute* $[\![\varphi]\!] = \{s \in S \mid s \models \varphi\}$

$$[\![p]\!] = \{s \in S \mid p \in L(s)\}$$
$$[\![\neg\varphi]\!] = S \setminus [\![\varphi]\!]$$
$$[\![\varphi_1 \vee \varphi_2]\!] = [\![\varphi_1]\!] \cup [\![\varphi_2]\!]$$
$$[\![EX\varphi]\!] = pre_\exists([\![\varphi]\!])$$
$$[\![AF\varphi]\!] = MC^{AF}_{CTL}(\varphi)$$
$$[\![E(\varphi_1 \mathcal{U} \varphi_2)]\!] = MC^{EU}_{CTL}(\varphi_1, \varphi_2)$$

- *Test if the input state* $s \in [\![\varphi]\!]$

- $MC^{EU}_{CTL}(\varphi_1, \varphi_2)$ is computed as:
  - $Y := \emptyset$; $Z := [\![\varphi_2]\!]$
  - **while** $Z \not\subseteq Y$ **do**:

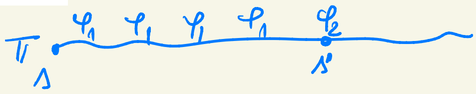
    $Y = Y \cup Z$;

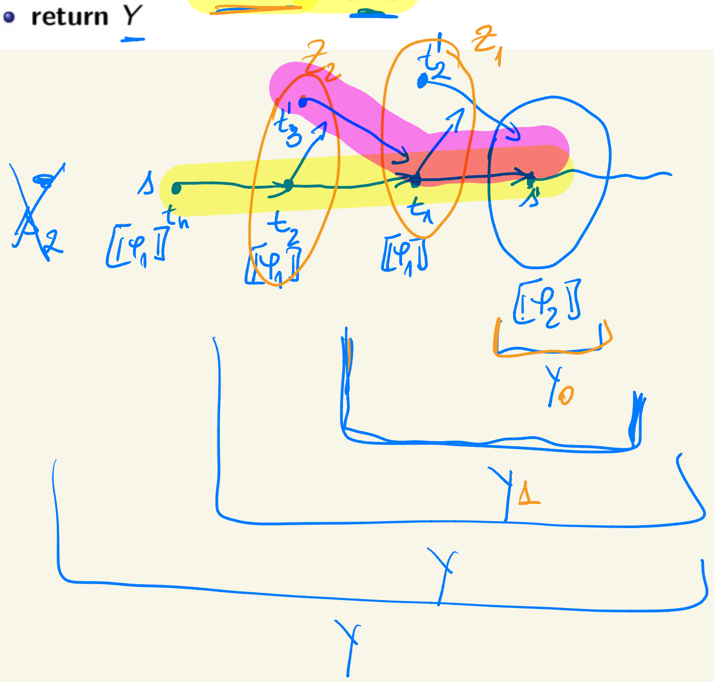
    $Z = pre_\exists(Y) \cap [\![\varphi_1]\!]$

  - **return** Y

Stop when cannot add nodes in Y!

$[\![E \varphi_1 \mathcal{U} \varphi_2]\!]$

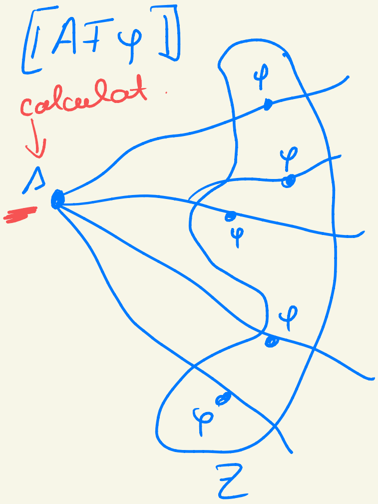


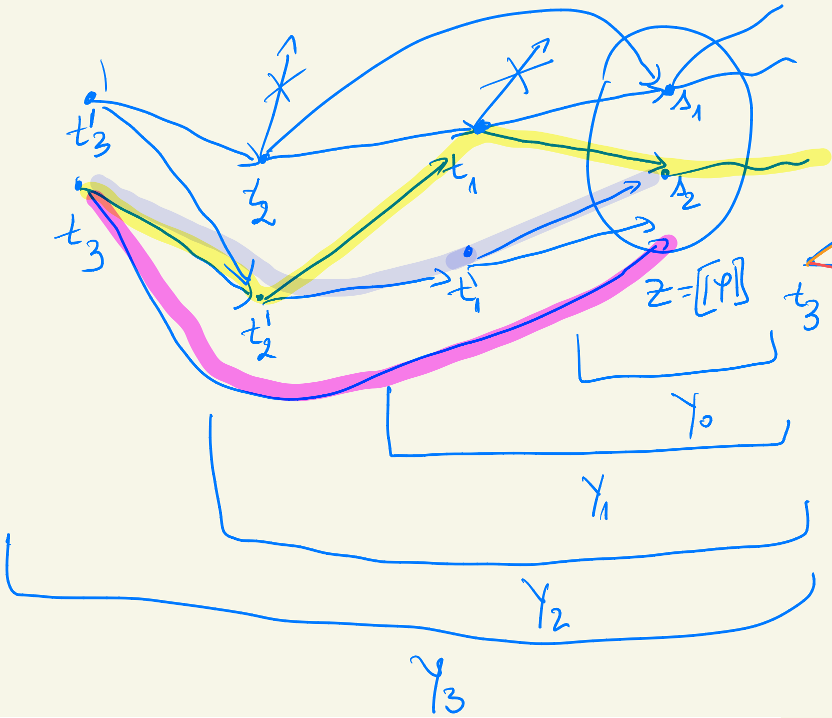


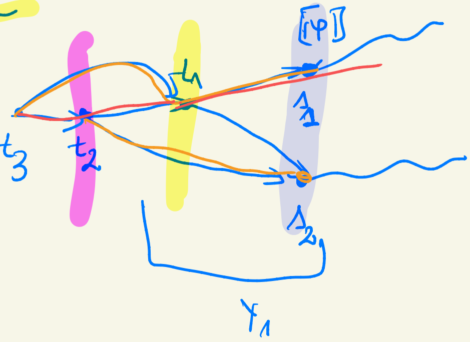
- $MC^{AF}_{CTL}(\varphi)$ is computed as:
  - $Y := S$; $Z := [\![\varphi]\!]$;
  - **while** $Y \neq Z$ **do**:

    $Y := Z$

    $Z = Z \cup pre_\forall(Y)$
  - return Y





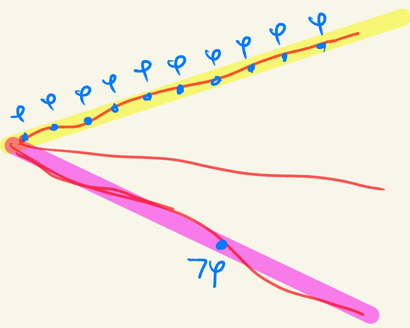


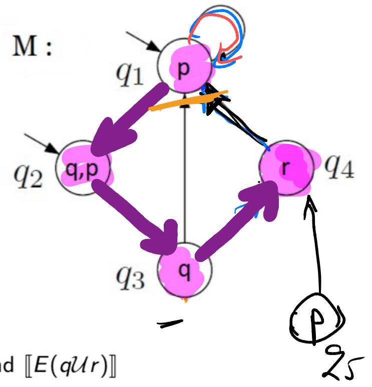
$$AX\varphi \equiv \neg EX\neg\varphi$$
$$A(\varphi_1 \mathcal{U} \varphi_2) \equiv \neg(E(\neg\varphi_2 \mathcal{U}(\neg\varphi_1 \wedge \neg\varphi_2)) \vee EG\neg\varphi_2)$$
$$EF\varphi \equiv E(\top \mathcal{U} \varphi)$$
$$EG\varphi \equiv \neg AF\neg\varphi$$
$$AG\varphi \equiv \neg EF\neg\varphi$$

definim alg. similar cu EU și AF

$G\varphi \equiv \neg F \neg \varphi$

$$[\![AX\varphi]\!] = [\![\neg \underbrace{EX\neg\varphi}_{\varphi_1}]\!] = S\setminus[\![EX\underbrace{\neg\varphi}_{\varphi_2}]\!] = S\setminus pre_\exists([\![\neg\varphi]\!])$$
$$= \underbrace{S\setminus pre_\exists(\underbrace{S\setminus[\![\varphi]\!]}_{Y})}_{}$$





Compute $[\![AXq]\!]$, $[\![EXp]\!]$ and $[\![E(q\,\mathcal{U}\,r)]\!]$

$[\![AXq]\!] = [\![\neg EX\neg q]\!] =$

$= S \setminus pre_\exists(\underline{S \setminus [\![q]\!]})$

$[\![q]\!] = \{q_2, q_3\}$

$S \setminus [\![q]\!] = \{q_1, q_4\}$

$pre_\exists(S \setminus [\![q]\!]) = \{q_3, q_1, q_4\}$

$[\![AXq]\!] = \{q_2\}$

$[\![EXp]\!] = pre_\exists([\![p]\!])$

$[\![p]\!] = \{q_1, q_2\}$

$[\![EXp]\!] = \{q_1, q_3, q_4\}$

$[\![E(q\,\mathcal{U}\,r)]\!]$

- $MC^{EU}_{CTL}(\varphi_1, \varphi_2)$ is computed as:
  - $Y := \emptyset$; $Z := [\![\varphi_2]\!]$
  - **while** $Z \not\subseteq Y$ **do**:
    - $Y = Y \cup Z$;
    - $Z = pre_\exists(Y) \cap [\![\varphi_1]\!]$
  - **return** Y

Stop when cannot add nodes in Y!

$Y = \emptyset \qquad Z = [\![r]\!] = \{q_4\}$

$[\![q]\!] = \{q_2, q_3\}$

- $Y = Y \cup Z = \{q_4\}$

  $Z = \{q_3\} \quad = \underbrace{pre_\exists(q_4)}_{\{q_3, q_5\}} \cap \underbrace{[\![q]\!]}_{\{q_2, q_3\}}$

- $Y = Y \cup Z = \{q_4, q_3\}$

  $Z = \{q_2, q_3\}$

- $Y = Y \cup Z = \{q_2, q_3, q_4\}$

  $Z = \{q_2, q_3, \cancel{q_4}\} = \underbrace{pre_\exists(Y)}_{\{q_2, q_3, q_1\}} \cap \underbrace{[\![q]\!]}_{\{q_2, q_3\}}$

- $Z \subseteq Y$ stop.