COL:750/7250

Foundations of Automatic Verification

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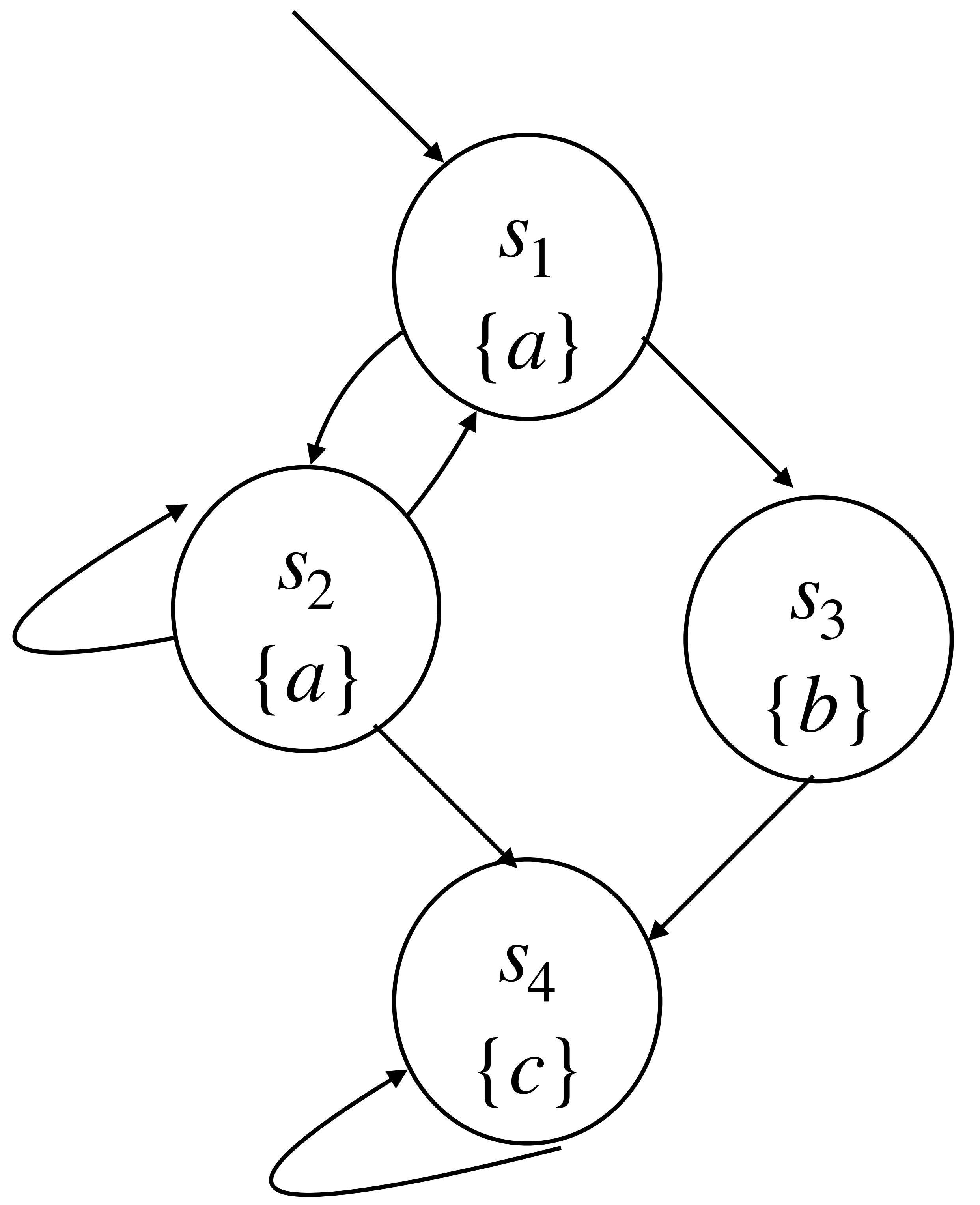
Course Webpage

https://priyanka-golia.github.io/teaching/COL-750-COL7250/index.html

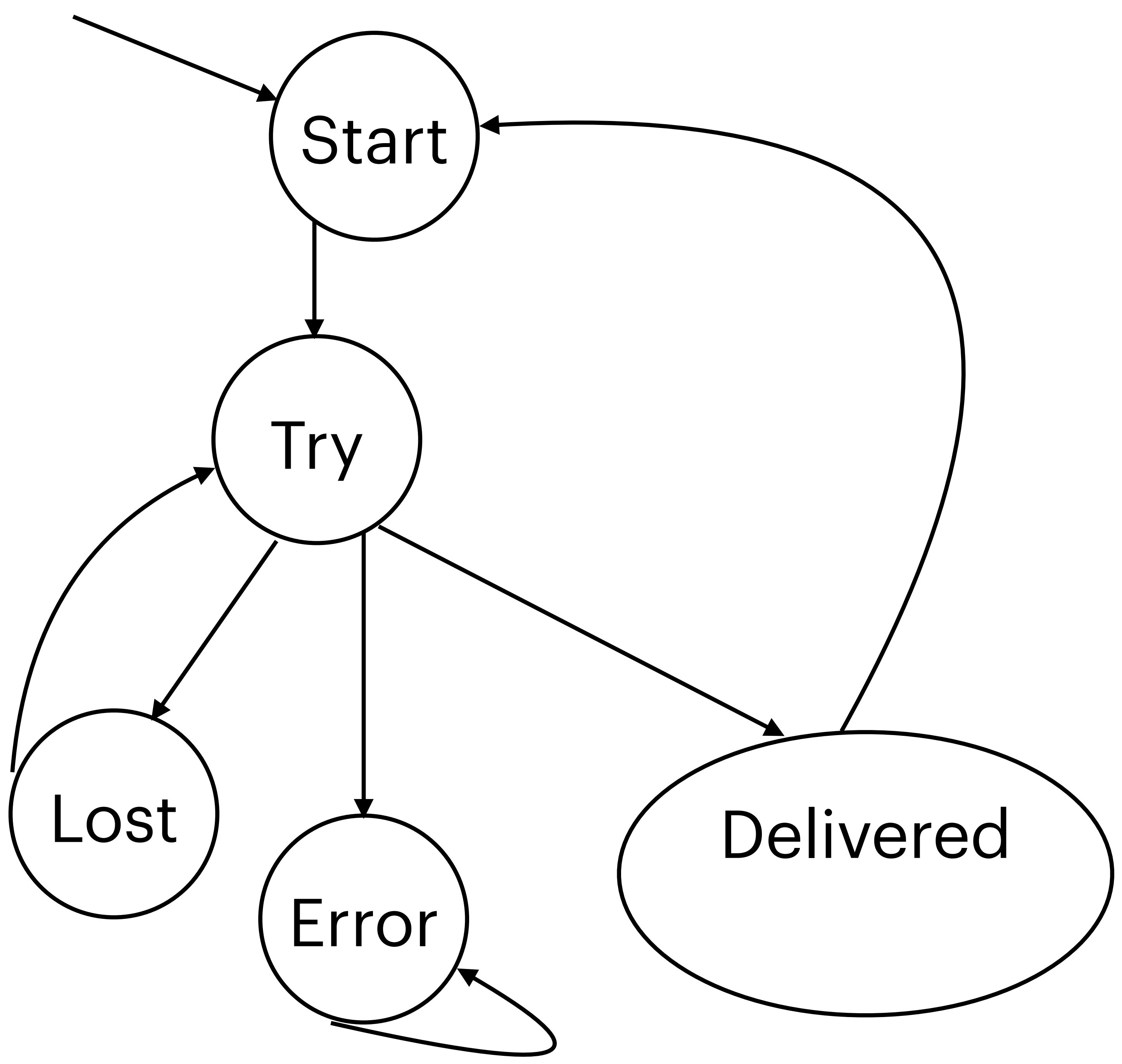
CTL

$$M \overset{?}{\models} \forall((\exists \mathbf{N}(b \vee c))\mathbf{W}\,(a \wedge b))$$

Yes!



CTL : Example



$M \overset{?}{\models} \forall \Box \forall \Diamond start$ No!

"Infinitely often start"

$M \overset{?}{\models} \exists \Diamond \forall \Box \neg start$ No!

After introducing "error" state.

$M \overset{?}{\models} \exists \Diamond \forall \Box \neg start$ Yes!

$M \overset{?}{\models} \forall \mathbf{N} \exists \mathbf{N} \forall \Box \neg start$ Yes!

CTL-LTL

Correlation: $\Diamond p \rightarrow \Diamond q$ What will be the equivalent CTL formula?

$\forall \Diamond p \rightarrow \forall \Diamond q$ If all the paths have p along them then all the paths have q along them!

CTL :Examples

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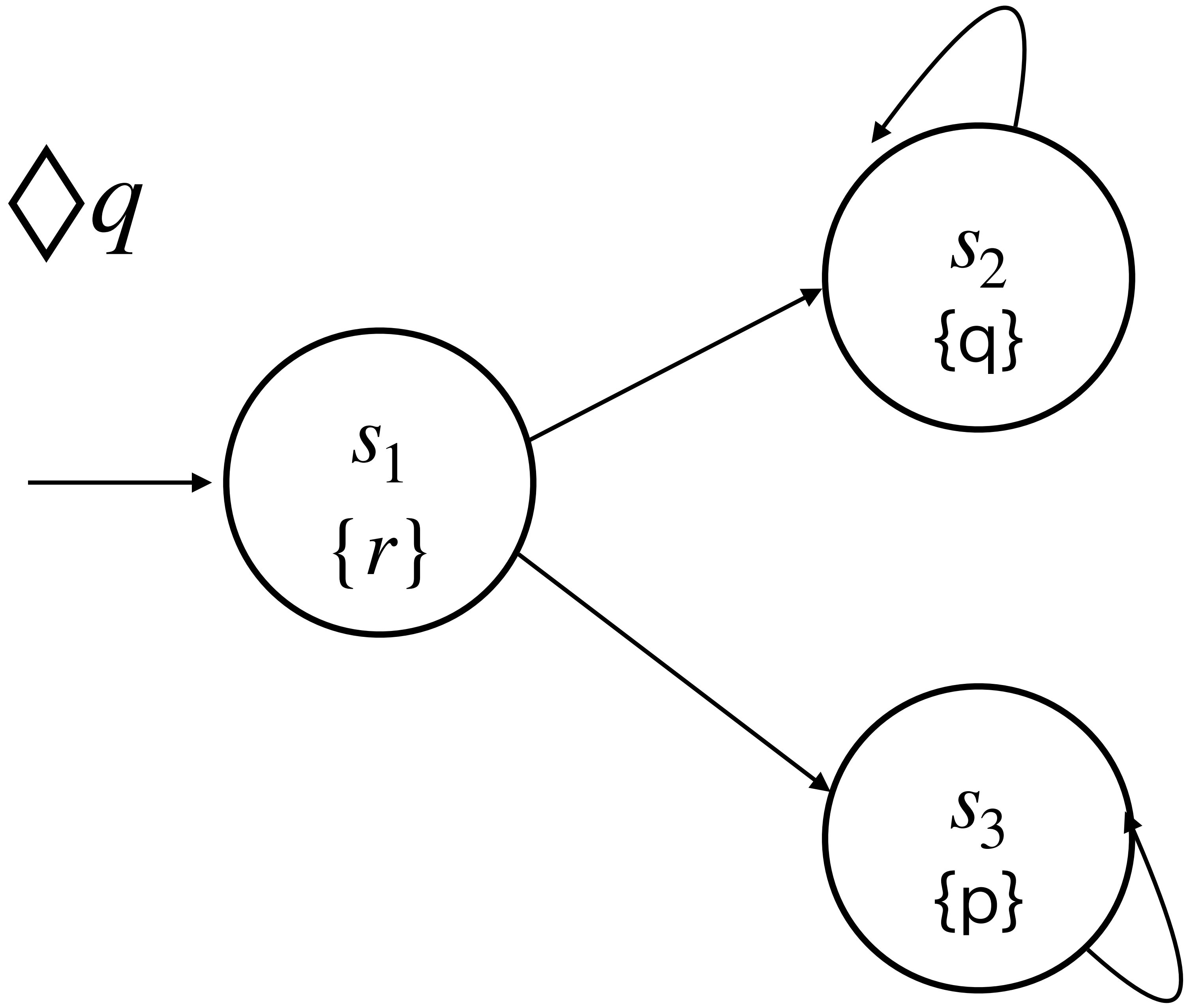
$F = \Diamond p \rightarrow \Diamond q$



$\pi_1 = rqqqq\ldots$

$\pi_2 = rpppp\ldots$

$< M, \pi_2 > \not\models F$

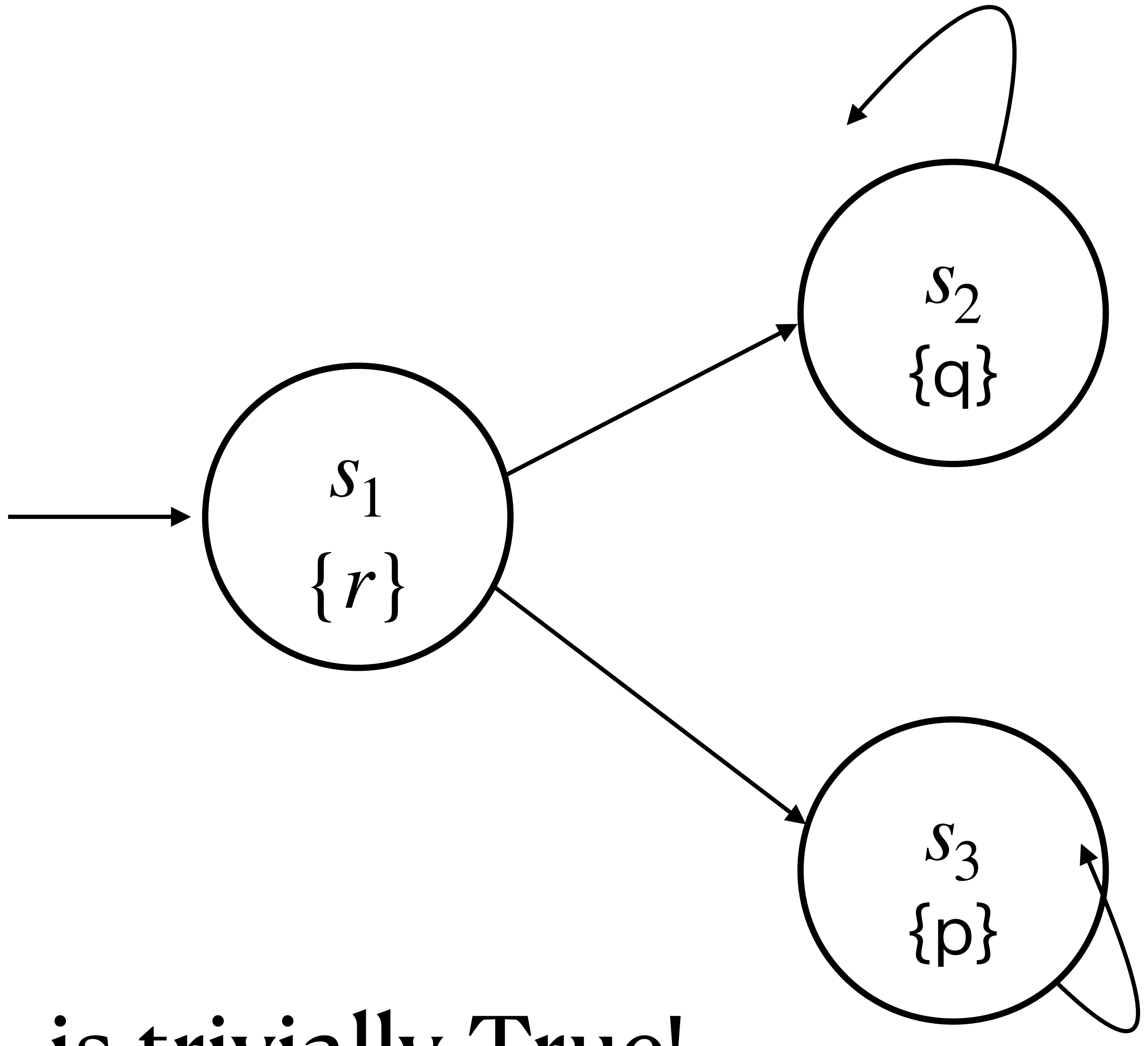
$< M > \not\models F$

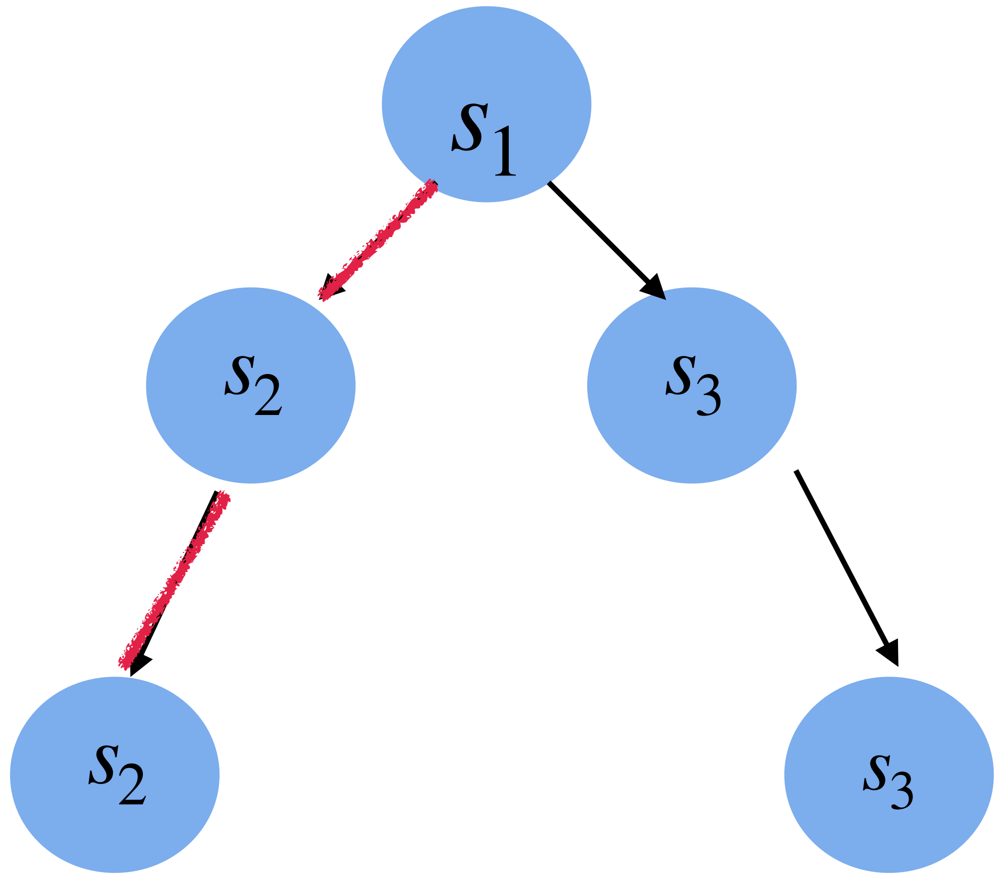
CTL :Examples

Correlation: $\Diamond p \rightarrow \Diamond q$ What will be the equivalent CTL formula?

$\forall \Diamond p \rightarrow \forall \Diamond q$ If all the paths have p along them then all the paths have q along them!

$F_1 = \forall \Diamond p \rightarrow \forall \Diamond q$





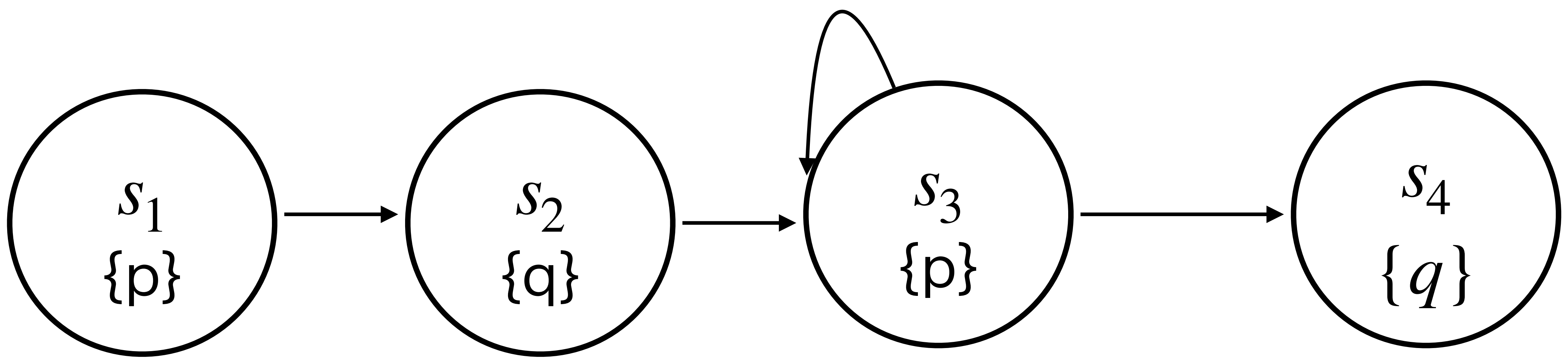
$\forall \Diamond p$ is False, hence F_1 is trivially True!

$$< M > \models F_1$$

CTL :Examples

Correlation: $\Diamond p \rightarrow \Diamond q$ What will be the equivalent CTL formula?

$$\forall \Box (p \rightarrow \forall \Diamond q)$$



$$F = \Diamond p \rightarrow \Diamond q$$

$$F_1 = \forall \Box (p \rightarrow \forall \Diamond q)$$

CTL :Examples

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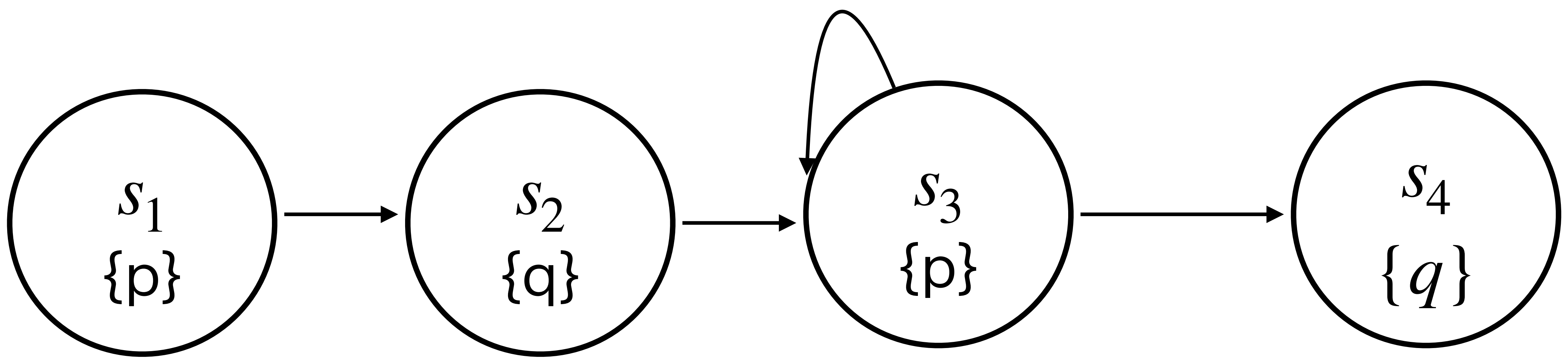


$$F = \Diamond p \rightarrow \Diamond q$$

$$F_1 = \forall \Box (p \rightarrow \forall \Diamond q)$$

$\pi_1 = p, q, p, p, p, \ldots$

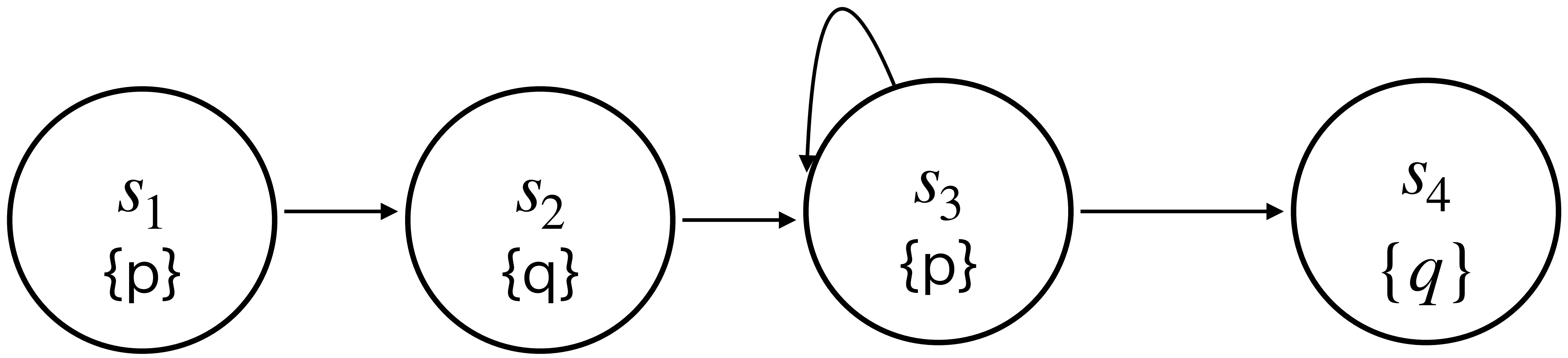
$\pi_2 = p, q, p, p, p, p$

$< M > \models F$

CTL :Examples

Correlation: $\Diamond p \rightarrow \Diamond q$ What will be the equivalent CTL formula?

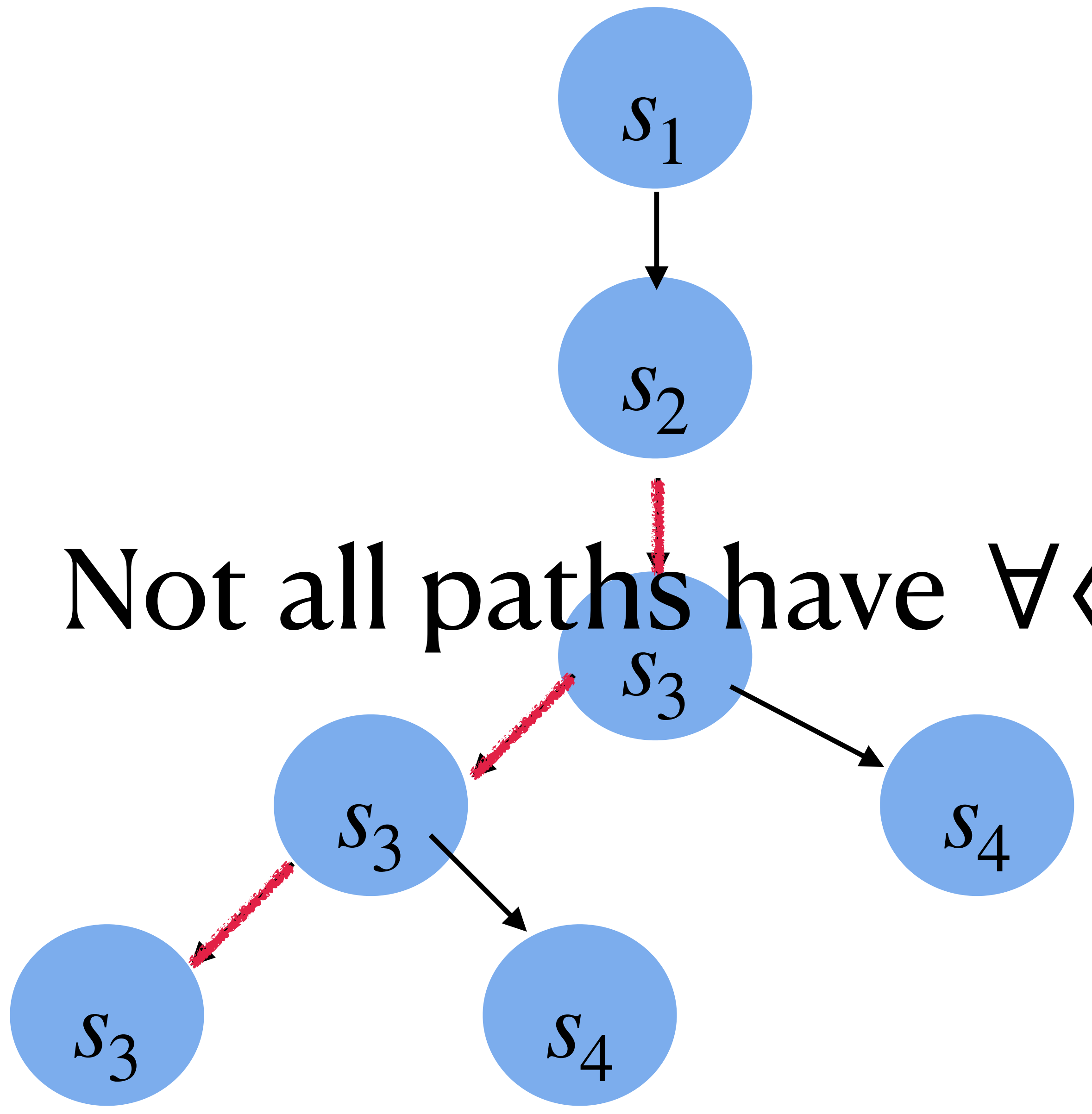
$$\forall \Box (p \rightarrow \forall \Diamond q)$$



$$F = \Diamond p \rightarrow \Diamond q$$

$$F_1 = \forall \Box (p \rightarrow \forall \Diamond q)$$

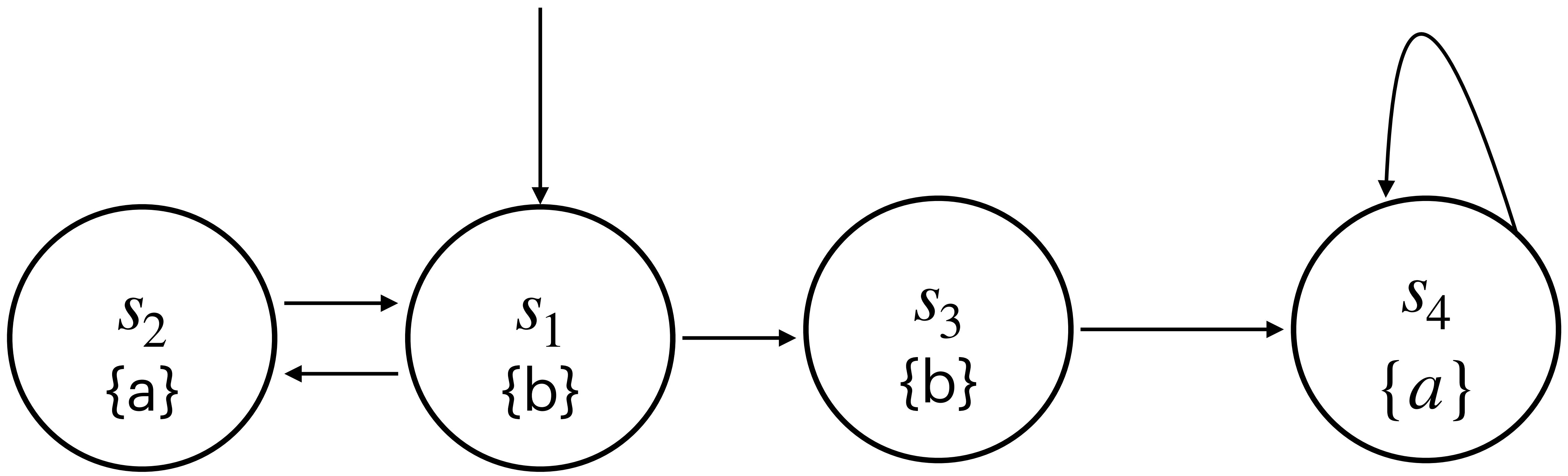
$$< M > \not\models F_1$$



Not all paths have $\forall \Diamond q$

CTL :Examples

$F_{LTL} = \Diamond \mathbf{N} a$ $\qquad$ $F_{CTL} = \forall \Diamond \forall \mathbf{N} a$



$M \vDash F_{LTL}$

$M \nvDash F_{CTL}$

$\Diamond \mathbf{N} a \equiv \mathbf{N} \Diamond a$ $\qquad$ $\forall \Diamond \forall \mathbf{N} a \not\equiv \forall \mathbf{N} \forall \Diamond a$

CTL :Examples

$$\forall \Box \forall \Diamond a \overset{?}{\equiv} \Box \Diamond a$$ Yes!

Infinitely often a.

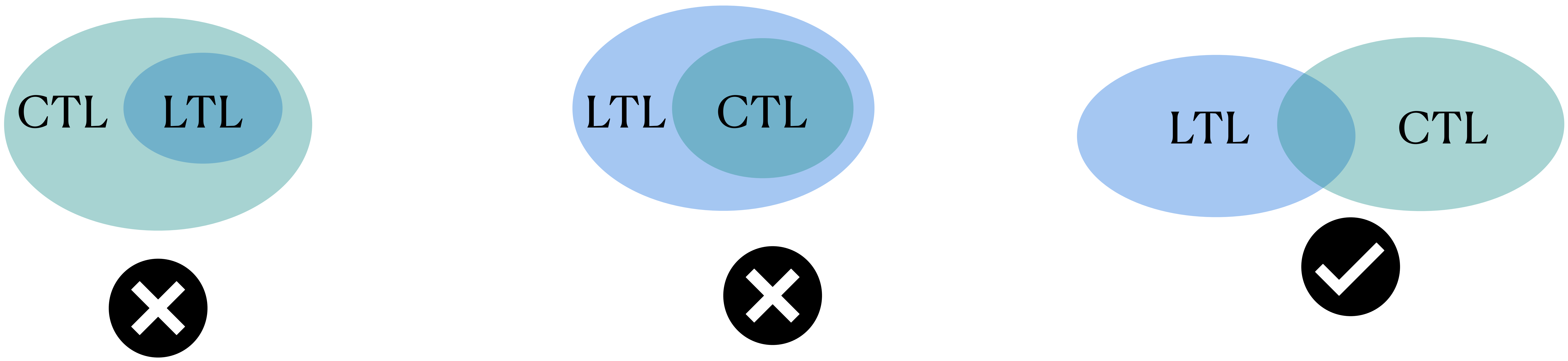
$$\forall (a \mathbf{W} b) \equiv a \mathbf{W} b$$

$$\forall \Diamond a \equiv \Diamond a$$

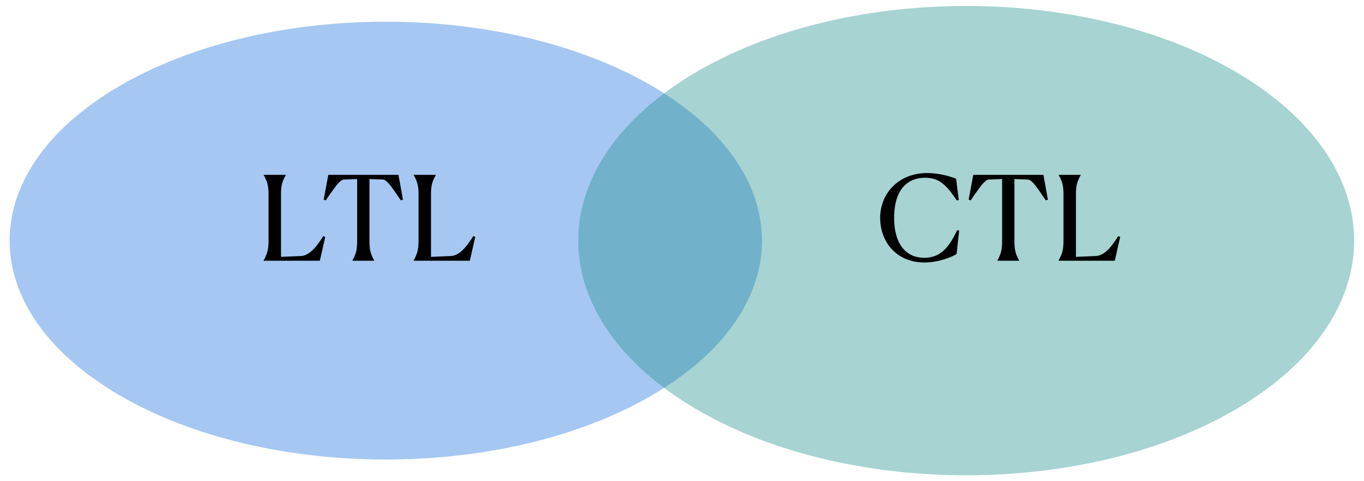
…

LTL vs CTL

LTL reasons about paths vs CTL reasons about states



LTL vs CTL



LTL reasons about paths vs CTL reasons about states

Many CTL formula can't be expressed as LTL.

For those containing paths quantified existentially. $\forall \Box (p \rightarrow \exists \Diamond q)$

Many LTL formula can't be expressed as CTL.

Those that select a range of paths with a property.

$\Diamond p \rightarrow \Diamond q$

$\Box \Diamond p \rightarrow \Box \Diamond q$