CTL (*)

LTL f.lae implicitly <u>universally</u> quantify on <u>paths</u>

$$s \models \varphi \iff \forall \pi \in Paths(s). \quad \pi \vdash \varphi$$

Natures of (discrete) Time

closer to reactive systems

Example : LTL cannot precisely express

"for all computations it is possible φ"

|———— $\forall \square$ ————| |— $\exists \diamond$ —| φ

$$\boxed{CTL = LTL + \exists \, path}$$

(Clarke & Emerson 81,
Queille & Sifakis 82-83)
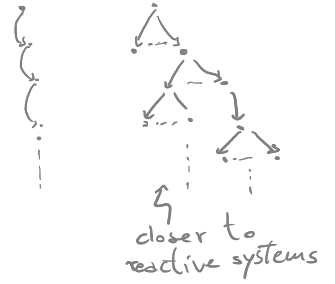
for all paths   for some path

Syntax

STATE F.LAE $\phi ::= true \mid \overset{AP}{\underset{\cup}{a}} \mid \neg \phi \mid \phi \wedge \phi \mid \forall \varphi \mid \exists \varphi$

path f.lae $\varphi ::= \circ \phi \mid \phi \, U \, \phi$

Example Safety $\forall \square (\neg c_1 \vee \neg c_2)$ $\forall \square \left(\bigwedge_{1 \leq i < j \leq u} \neg c_i \vee \neg c_j \right)$

Liveness $\bigwedge_{1 \leq i \leq u} \forall \square \forall \diamond c_i$ Mutex in CTL

Another CTL liveness f.la : $\forall \square (req \rightarrow \forall \diamond res)$

<u>Obs</u> Temporal operators <u>cannot be immediately</u> preceded by other temporal operators :

  • $\exists \square \diamond \varphi$ ✗
  • $\exists \square \forall \diamond \varphi$ ✓

Also, $\forall (\cdots \wedge \cdots)$ $\exists \neg \cdots$ are not legal !