COL750: Foundations of Automatic Verification (Jan-May 2023)

Lectures 07 & 08 (CTL Model Checking and BDDs)

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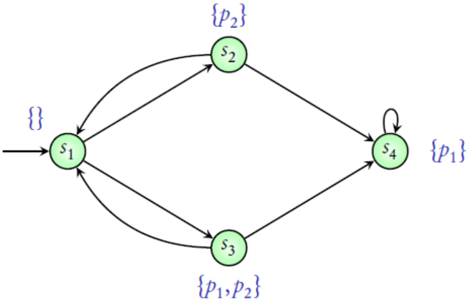
Existential Normal Form for CTL

- $\phi := true \mid p_i \mid \phi_1 \wedge \phi_2 \mid \neg\phi \mid EX\phi \mid E(\phi_1 U \phi_2) \mid EG\phi$
- For every CTL formula there exists an equivalent CTL formula in ENF

Algorithms for EX, EU, and EG[1]

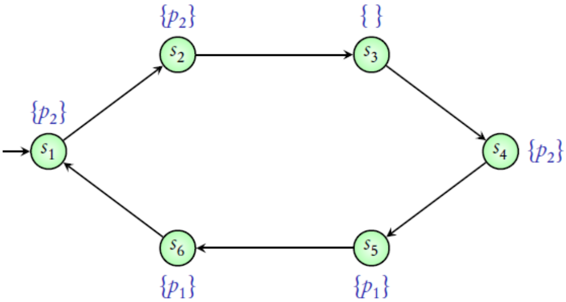
$$\mathbf{E}\,\mathbf{X}\,(p_1 \wedge \neg p_2)$$



[1] all examples here are sourced from B. Srivathsan's NPTEL course slides on Model Checking

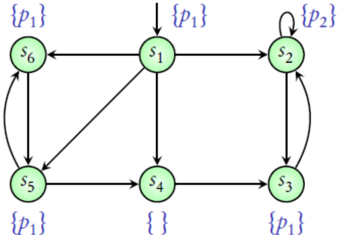
Algorithms for EX, EU, and EG

$$\mathbf{E}\,(\neg\, p_1\; \mathbf{U}\; \neg\, p_2)$$



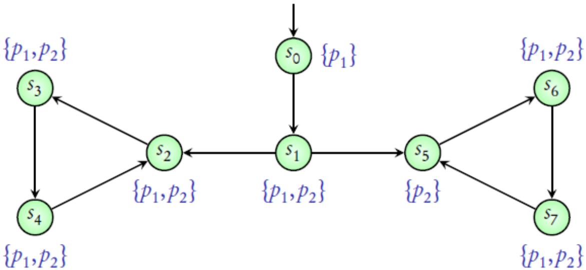
Algorithms for EX, EU, and EG

$\mathbf{E}\,\mathbf{G}\,p_1$



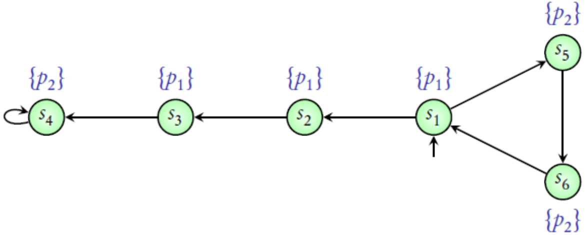
CTL Model Checking – Example 1

$$\mathbf{E\,X\,E\,G}\,(p_1 \wedge p_2)$$



CTL Model Checking – Example 2

$$\mathbf{E}\, p_1\, \mathbf{U}\, (\mathbf{E}\,\mathbf{G}\, p_2)$$



EX

```
function SAT_EX (φ)
 /* determines the set of states satisfying EX φ */
local var X, Y
begin
    X := SAT (φ);
    Y := pre_∃(X);
    return Y
end
```

EU

function $\mathtt{SAT_{EU}}\,(\phi, \psi)$
/* determines the set of states satisfying $\mathrm{E}[\phi \ \mathrm{U}\ \psi]$ */
local var W, X, Y
begin
    $W := \mathtt{SAT}\,(\phi);$
    $X := S;$
    $Y := \mathtt{SAT}\,(\psi);$
    repeat until $X = Y$
    begin
        $X := Y;$
        $Y := Y \cup (W \cap \mathrm{pre}_{\exists}(Y))$
    end
    return Y
end

EG

```
function SAT_EG (φ)
/* determines the set of states satisfying EG φ */
local var X, Y
begin
    Y := SAT (φ);
    X := ∅;
    repeat until X = Y
    begin
        X := Y;
        Y := Y ∩ pre_∃(Y)
    end
    return Y
end
```

State-space Explosion Problem

- Correctness and Termination
- Efficiency

Thank you!