Backing and Undercutting in DeLP (Extended-DeLP)

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Structured Argumentation

See Argument & Computation, Vol 5 No 1, 2014 for a set of tutorials on Structured Argumentation.

Conceptual View

Definition of Status of Arguments

Definition of Defeat among Arguments

Definition of Conflict among Arguments

Definition of Argument

Definition of the Underlying (Logical) Language

Backing and Undercutting in Defeasible Logic Programming

Introduction

- *We will present Extended Defeasible Logic Programming (E-DeLP)*
- *Introduces the possibility of attacking and supporting defeasible rules:*
  - *Attack for defeasible rules allows for the representation of Pollock's undercutting defeaters (to be discussed).*
  - *Support for defeasible rules allows for the representation of Toulmin's backings.*

Defeasible Logic Programming (*DeLP*)

García, A.J., Simari, G.R.: Defeasible logic programming: An argumentative approach. Theory and Practice of Logic Programming 4(1-2), 95–138. 2004

Also, see Argument & Computation Vol 5 No 1, 2014 for a set of tutorials on Structured Argumentation.

Defeasible Logic Programming (DeLP)

- *KR&R: Combines Logic Programming and Argumentation.*
- *Allows for the representation of strict and defeasible knowledge.*
- *A defeasible argumentation inference mechanism warrants the entailed conclusions through a dialectical process.*
- *Allows for the representation of rebutting defeaters.*

DeLP – Knowledge Representation

A DeLP program $\mathcal{P} = (\Pi, \Delta)$

Facts and Strict Rules	*Defeasible Rules*
chicken	flies $\prec$ bird
scared	~flies $\prec$ chicken
bird $\leftarrow$ chicken	flies $\prec$ chicken, scared
	nests_in_trees $\prec$ flies

Consistent

Potentially Contradictory

DeLP – *Arguments*

Argument $\langle \mathcal{A}, L \rangle$ for L

1) $\mathcal{A} \subseteq \Delta$
2) $\Pi \cup \mathcal{A} \mathrel{|\!\sim} L$
3) $\Pi \cup \mathcal{A} \not\mathrel{|\!\sim} \mathrm{P}, {\sim}\mathrm{P}$
4) There is no $\mathcal{A}' \subset \mathcal{A}$ satisfying 2) and 3)

chicken **scared** **bird $\leftarrow$ chicken**	**flies $\prec$ bird** **~flies $\prec$ chicken** **flies $\prec$ chicken, scared** **nests_in_trees $\prec$ flies**

DeLP – *Arguments*

Argument $\langle \mathcal{A}, L \rangle$ for L

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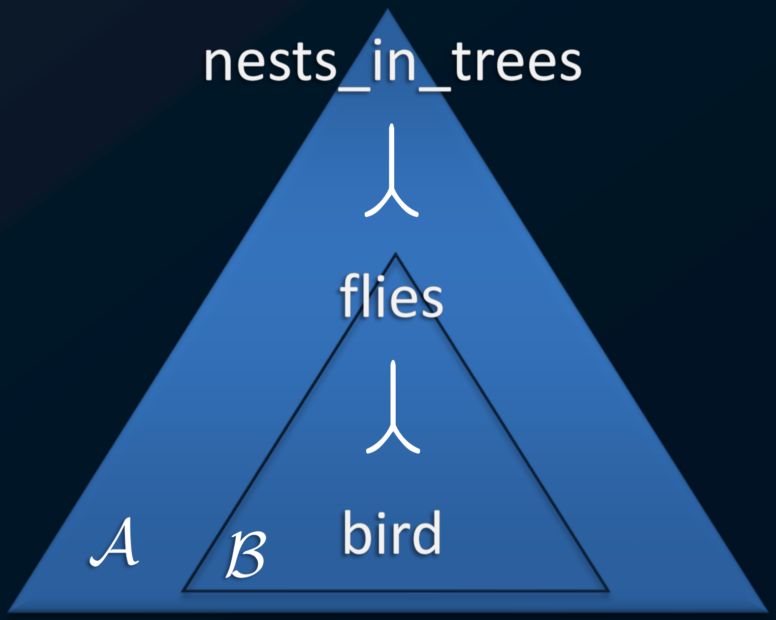
4) There is no $\mathcal{A}' \subset \mathcal{A}$ satisfying 2) and 3)

chicken scared bird $\leftarrow$ chicken	flies $\mathrel{-\!\!\prec}$ bird ~flies $\mathrel{-\!\!\prec}$ chicken flies $\mathrel{-\!\!\prec}$ chicken, scared nests_in_trees $\mathrel{-\!\!\prec}$ flies



$\mathcal{A}$= {nests_in_trees $\mathrel{-\!\!\prec}$ flies, flies $\mathrel{-\!\!\prec}$ bird}

$\langle \mathcal{A}$, nests_in_trees$\rangle$

DeLP – *Arguments*

Argument $\langle \mathcal{A}, L \rangle$ for L

1) $\mathcal{A} \subseteq \Delta$
2) $\Pi \cup \mathcal{A} \mid\!\sim L$
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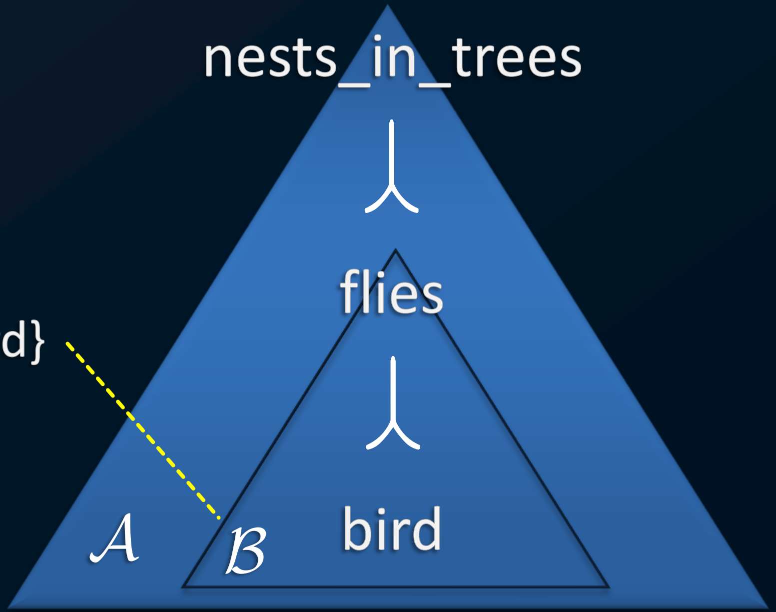
4) There is no $\mathcal{A}' \subset \mathcal{A}$ satisfying 2) and 3)

An argument $\langle \mathcal{B}, H \rangle$ is a sub-argument of $\langle \mathcal{A}, L \rangle$ if $\mathcal{B} \subseteq \mathcal{A}$

$\langle \mathcal{B}$, flies$\rangle$

$\mathcal{B}$= {flies $\prec$ bird}



$\mathcal{A}$= {nests_in_trees $\prec$ flies, flies $\prec$ bird}

$\langle \mathcal{A}$, nests_in_trees$\rangle$

DeLP – *Arguments*

Argument $\langle \mathcal{A}, L \rangle$ for L

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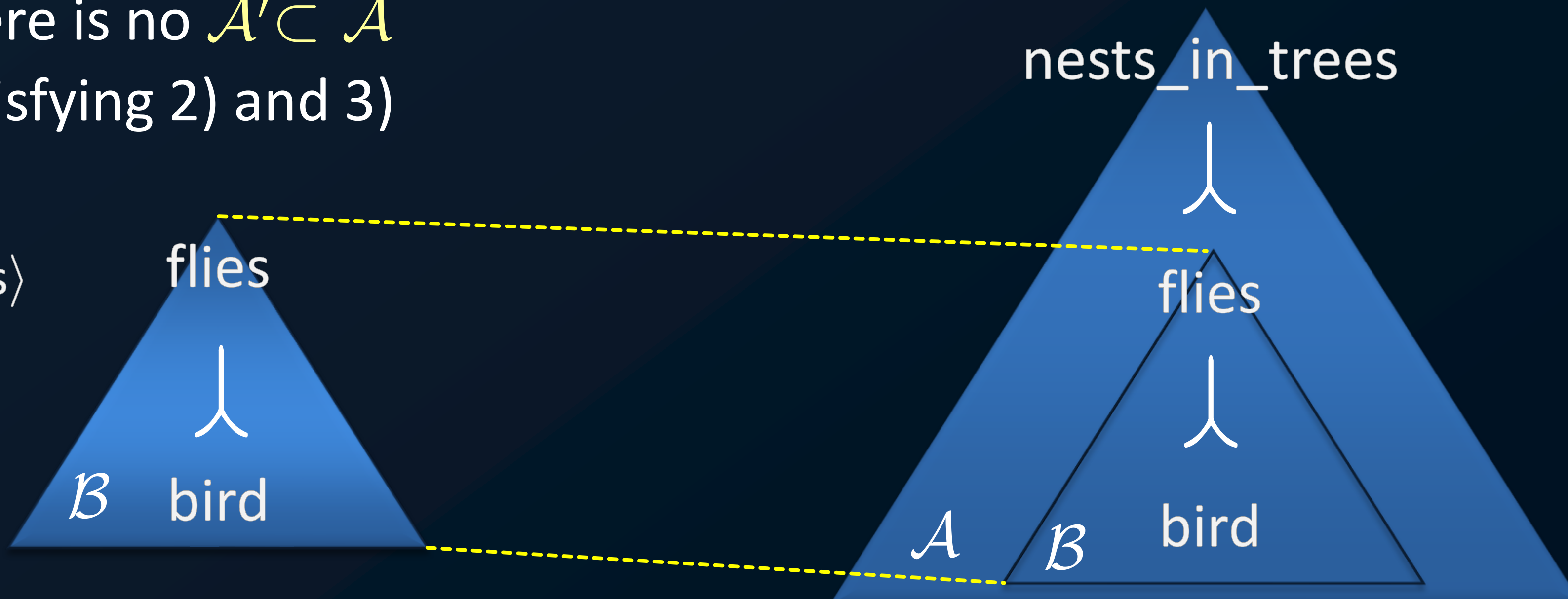

$\mathcal{B}$= {flies $\prec$ bird}

$\mathcal{A}$= {nests_in_trees $\prec$ flies, flies $\prec$ bird}

$\langle \mathcal{A}$, nests_in_trees$\rangle$

DeLP – *Defeat*

An argument $\langle \mathcal{A}, L \rangle$ defeats another argument $\langle \mathcal{B}, Q \rangle$ if there exists a sub-argument $\langle \mathcal{C}, R \rangle$ of $\langle \mathcal{B}, Q \rangle$ such that:

- $\langle \mathcal{A}, L \rangle$ is in *conflict* with $\langle \mathcal{C}, R \rangle$
- $\langle \mathcal{A}, L \rangle$ is *preferred* or *unrelated* to $\langle \mathcal{C}, R \rangle$

A comparison criterion is required to define a preference among arguments.

An argument $\langle \mathcal{A}, L \rangle$ ***defeats*** *another argument* $\langle \mathcal{B}, Q \rangle$ *if there exists a sub-argument* $\langle \mathcal{C}, R \rangle$ of $\langle \mathcal{B}, Q \rangle$ *such that*

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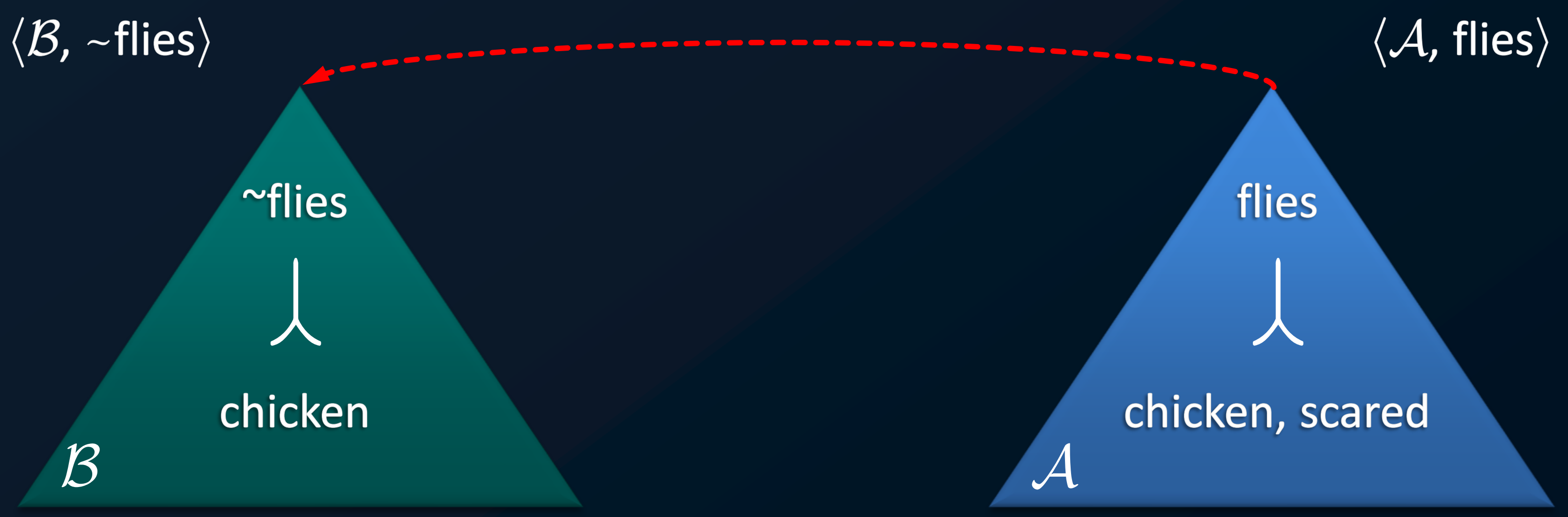

$\mathcal{B}$ = {~flies $\prec$ chicken}

$\mathcal{A}$ = { flies $\prec$ chicken, scared}

Using ***generalized specificity*** *as the comparison criterion*

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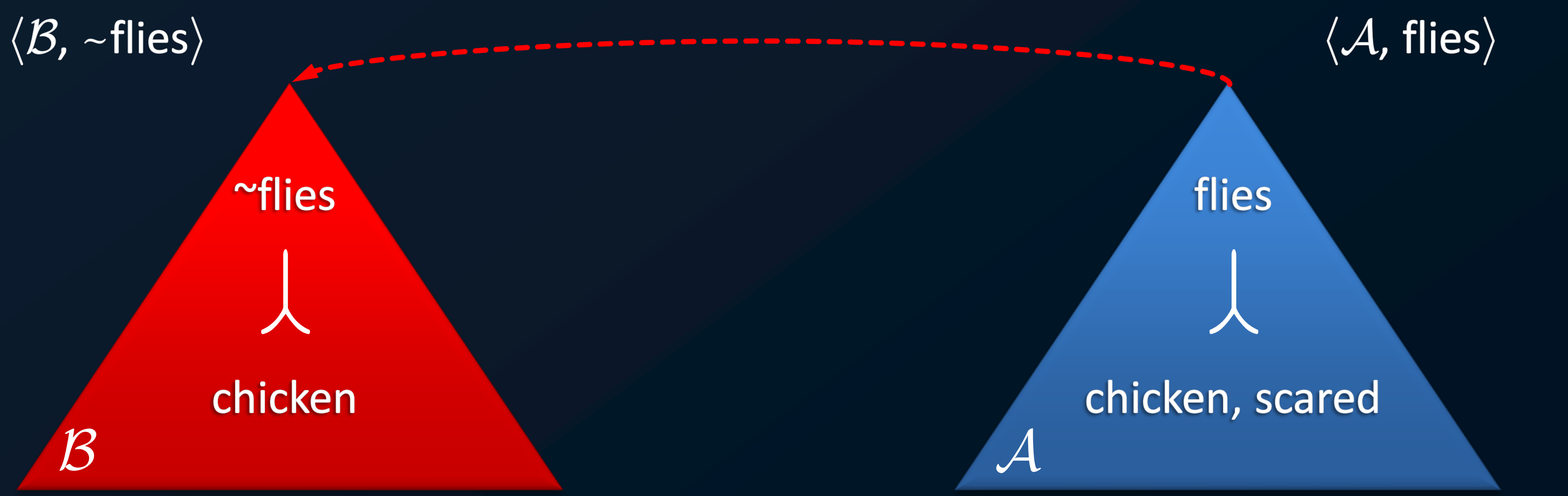

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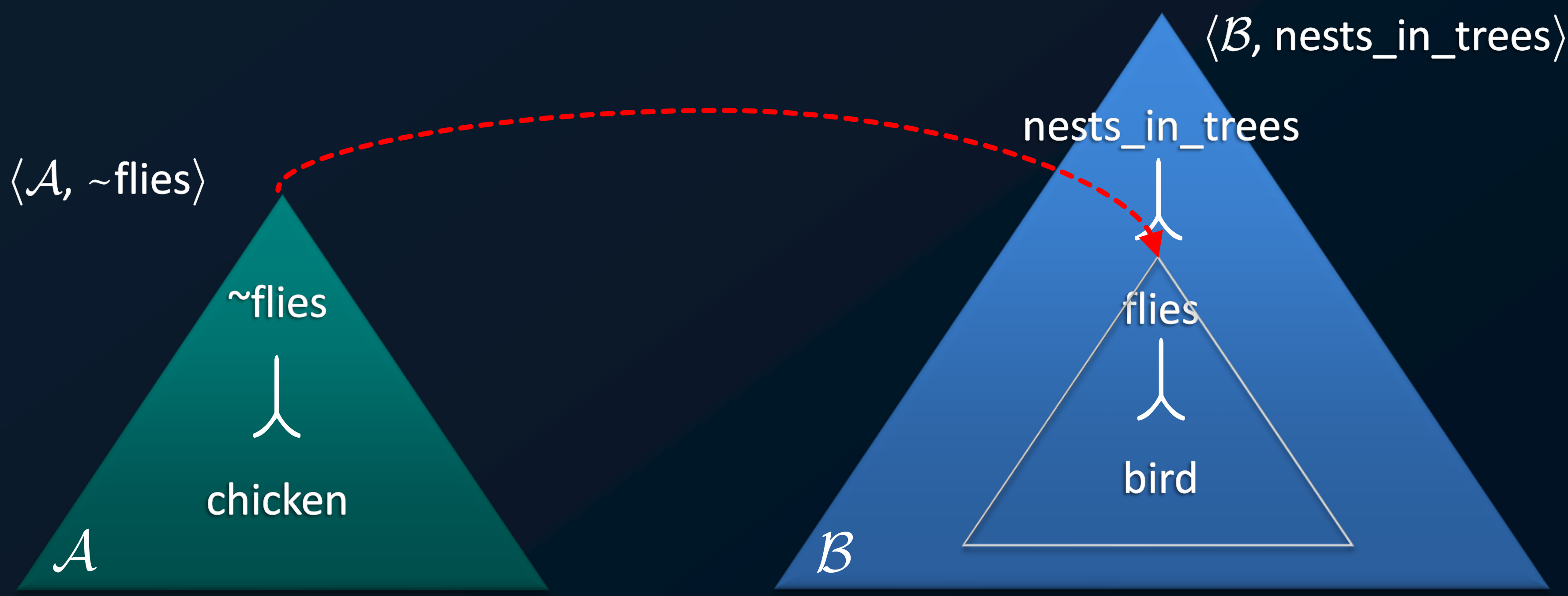

$\mathcal{A}$ = {~flies $\prec$ chicken}

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$\mathcal{C}$ = {flies $\prec$ bird}

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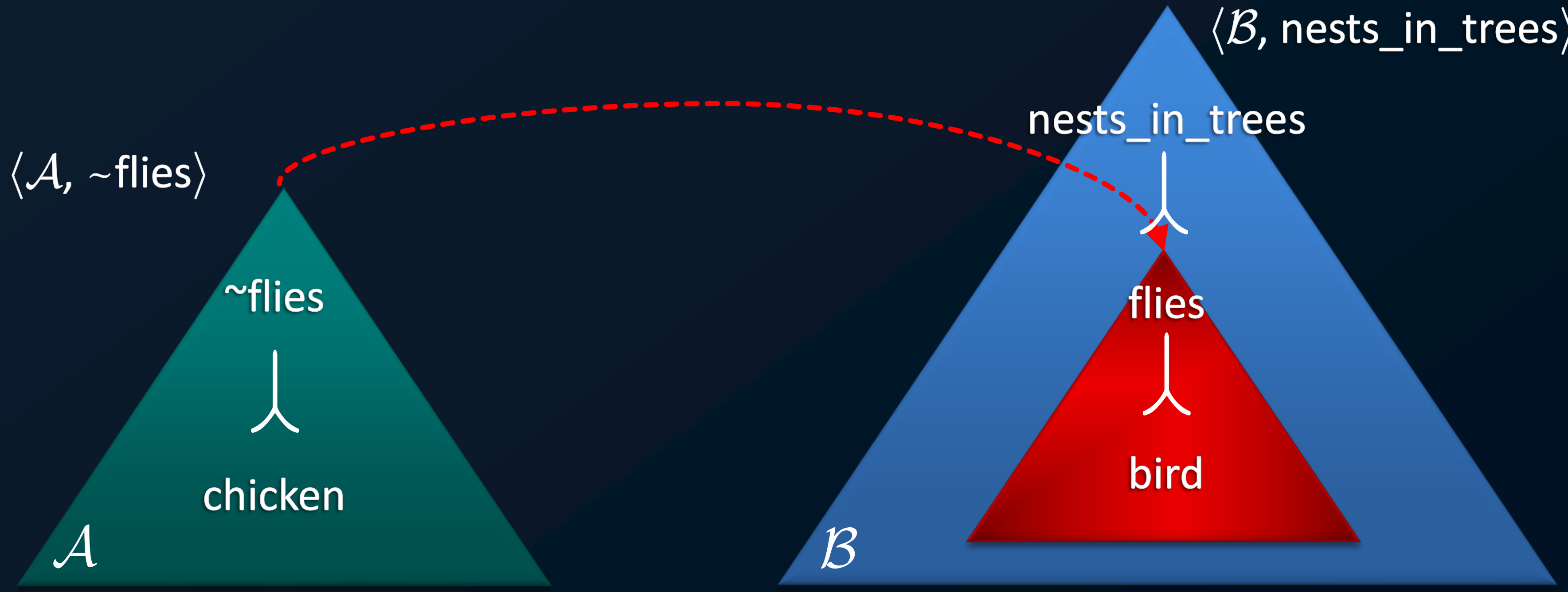

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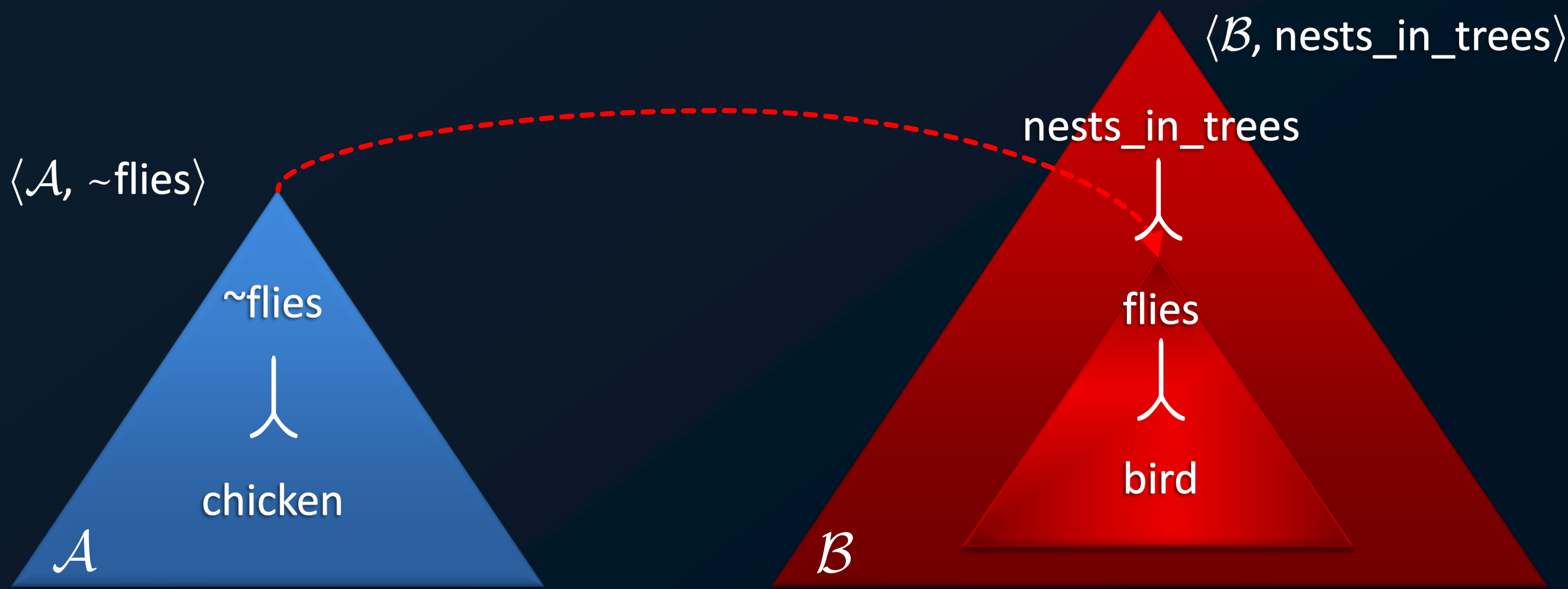

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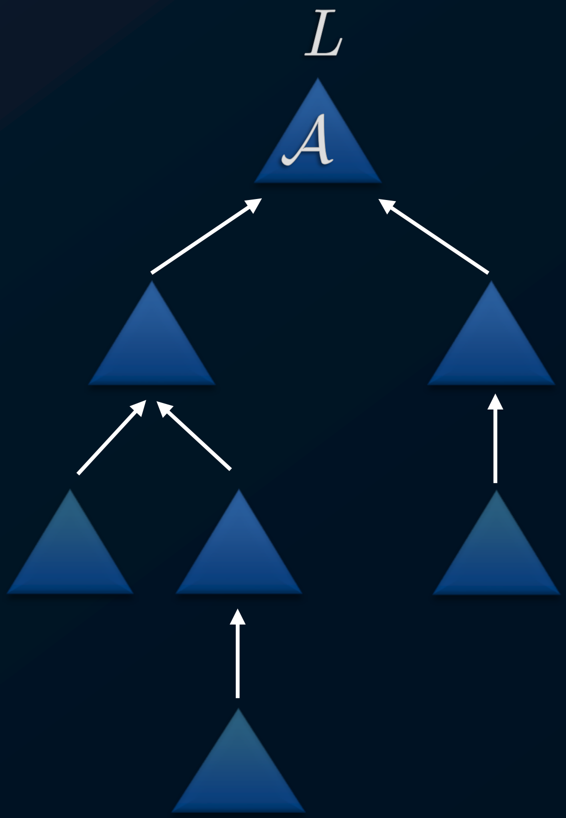
Using ***generalized specificity*** *as the comparison criterion*

DeLP – *Dialectical Process*

To determine whether an argument $\langle \mathcal{A}, L\rangle$ is finally acceptable, a dialectical tree with root $\langle \mathcal{A}, L\rangle$ is built.

- *Leaves are marked as U.*



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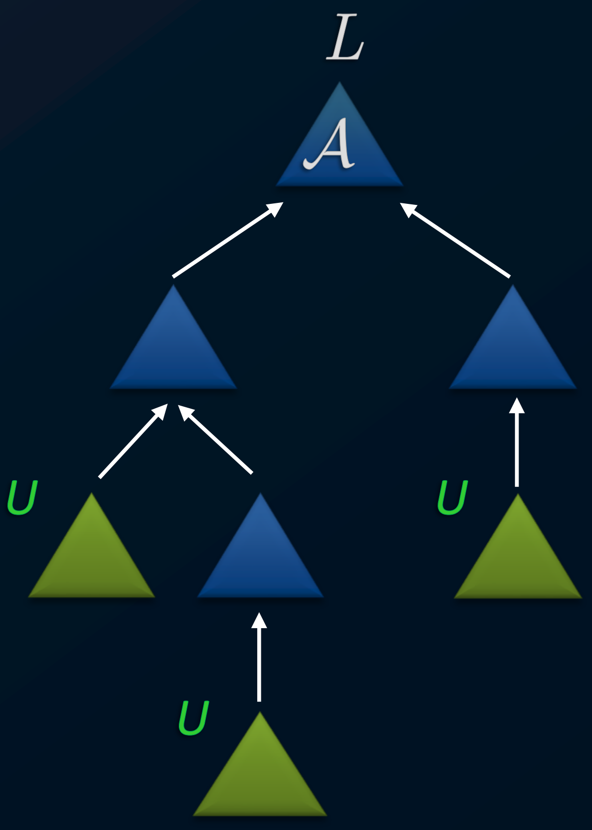
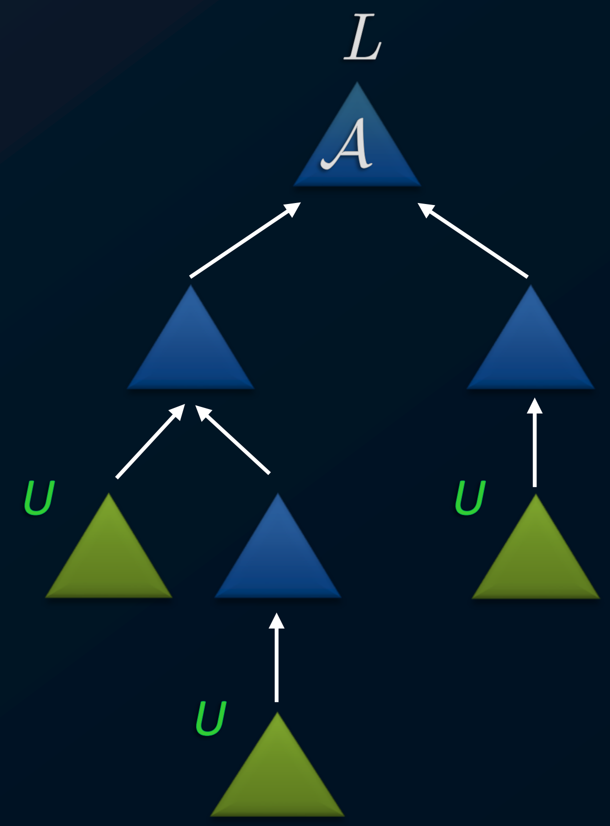


DeLP – *Dialectical Process*

To determine whether an argument $\langle \mathcal{A}, L \rangle$ is finally acceptable, a dialectical tree with root $\langle \mathcal{A}, L \rangle$ is built.

- *Leaves are marked as U.*
- *An inner node is marked as U iff all its children are D-nodes.*



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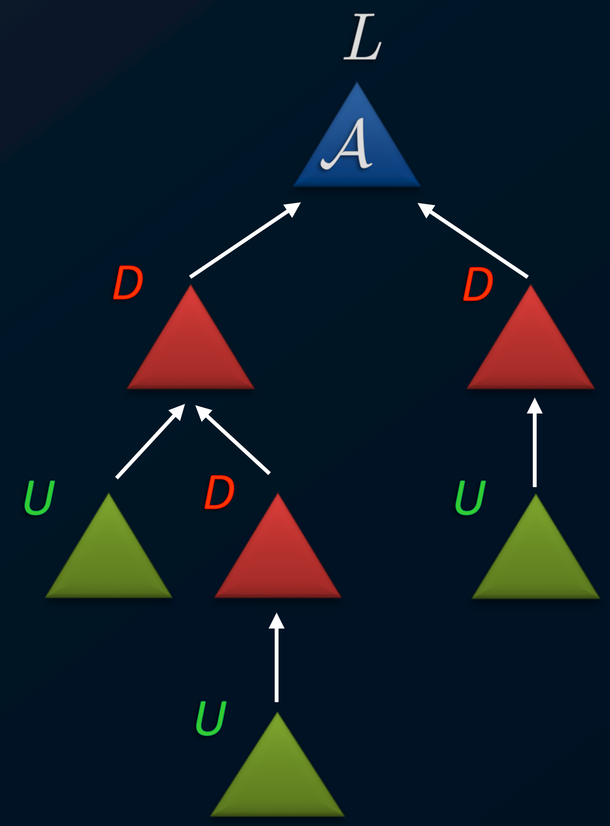

DeLP – *Dialectical Process*

To determine whether an argument $\langle \mathcal{A}, L \rangle$ is finally acceptable, a dialectical tree with root $\langle \mathcal{A}, L \rangle$ is built.

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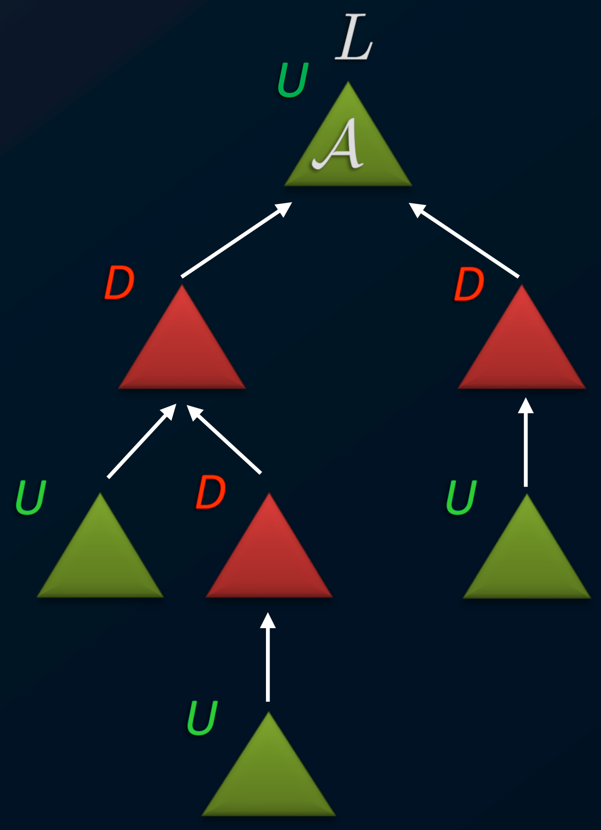
- *An inner node is marked as U iff all its children are D-nodes.*
- *An inner node is marked as D iff at least one of its children is an U-node.*



DeLP – *Dialectical Process*

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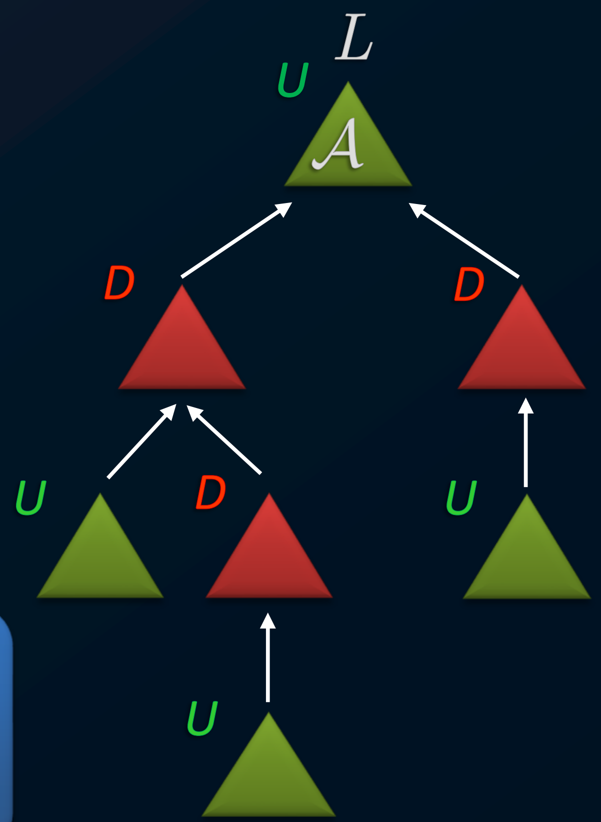

If the root $\langle \mathcal{A}, L \rangle$ is marked as U, then L is *warranted*

DeLP – *Dialectical Process*

To determine whether an argument $\langle \mathcal{A}, L \rangle$ is finally acceptable, a dialectical tree with root $\langle \mathcal{A}, L \rangle$ is built.

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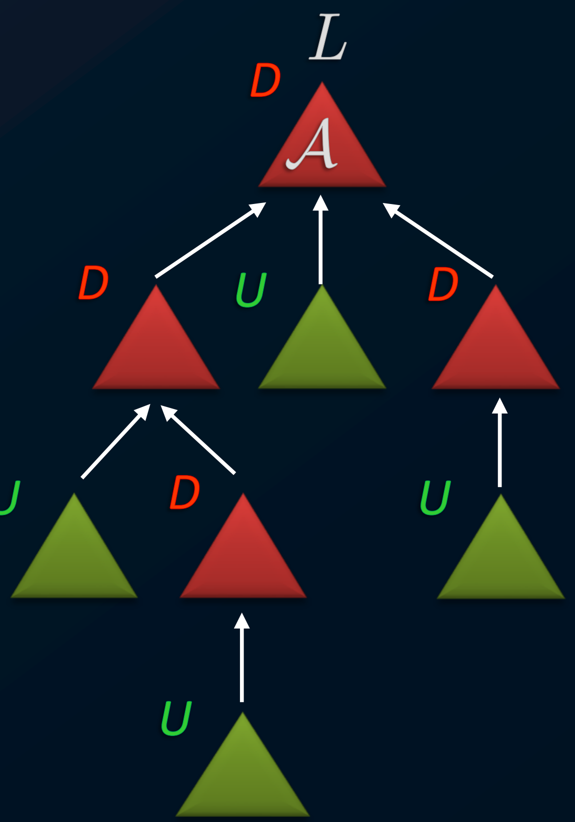
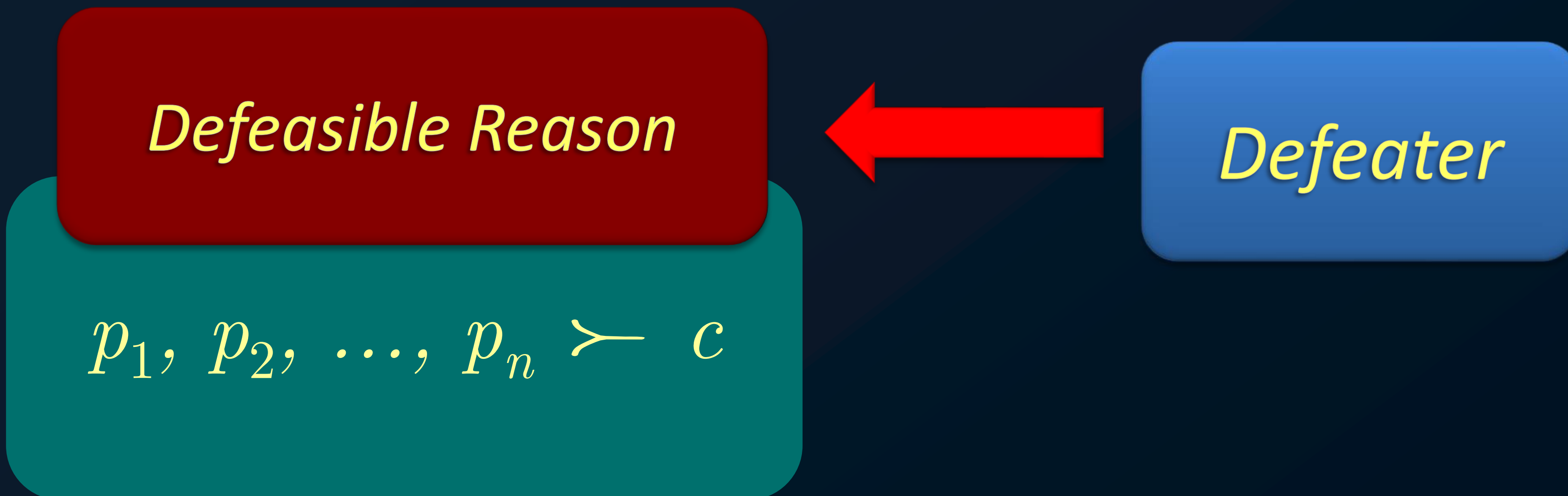


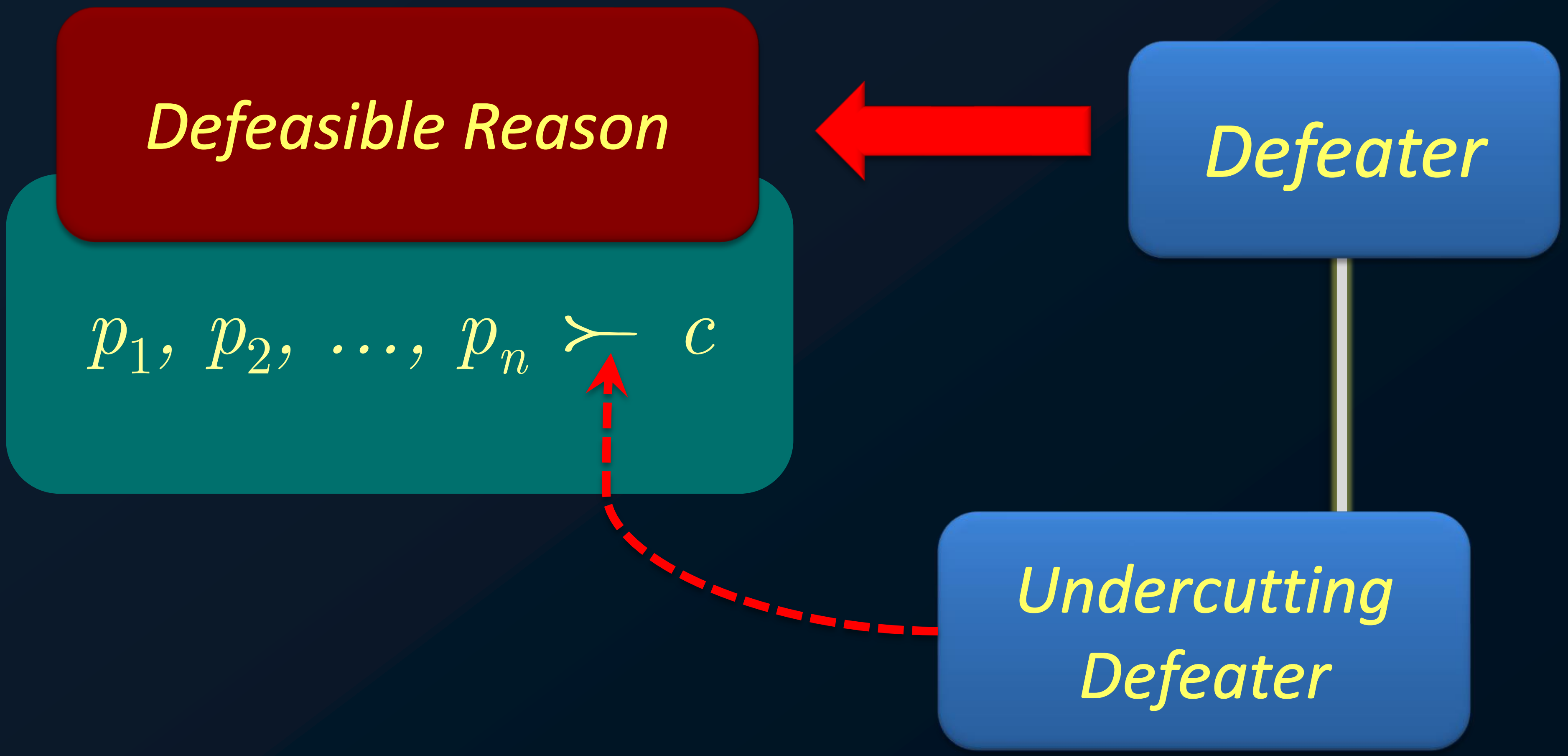
If the root $\langle \mathcal{A}, L \rangle$ is marked as U, then L is *not warranted*

Motivation for E-DeLP

Pollock's Undercutting Defeaters



Pollock's Undercutting Defeaters



Example

Object looks red → *Object is red*

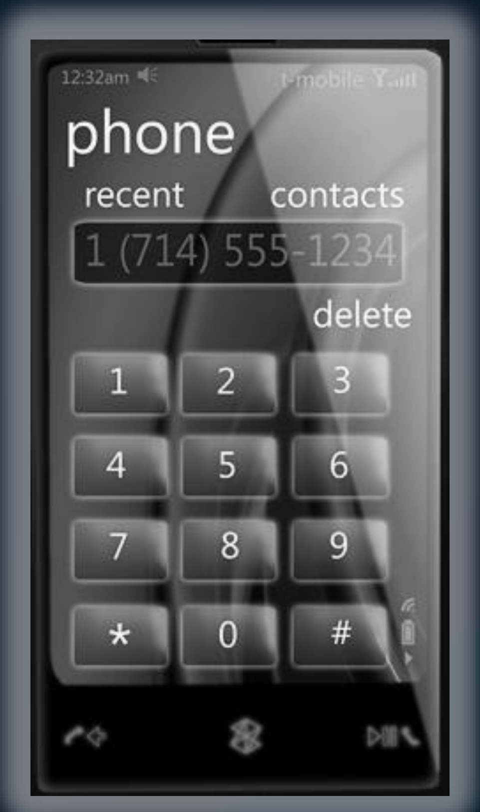
Example

Object looks red → Object is red

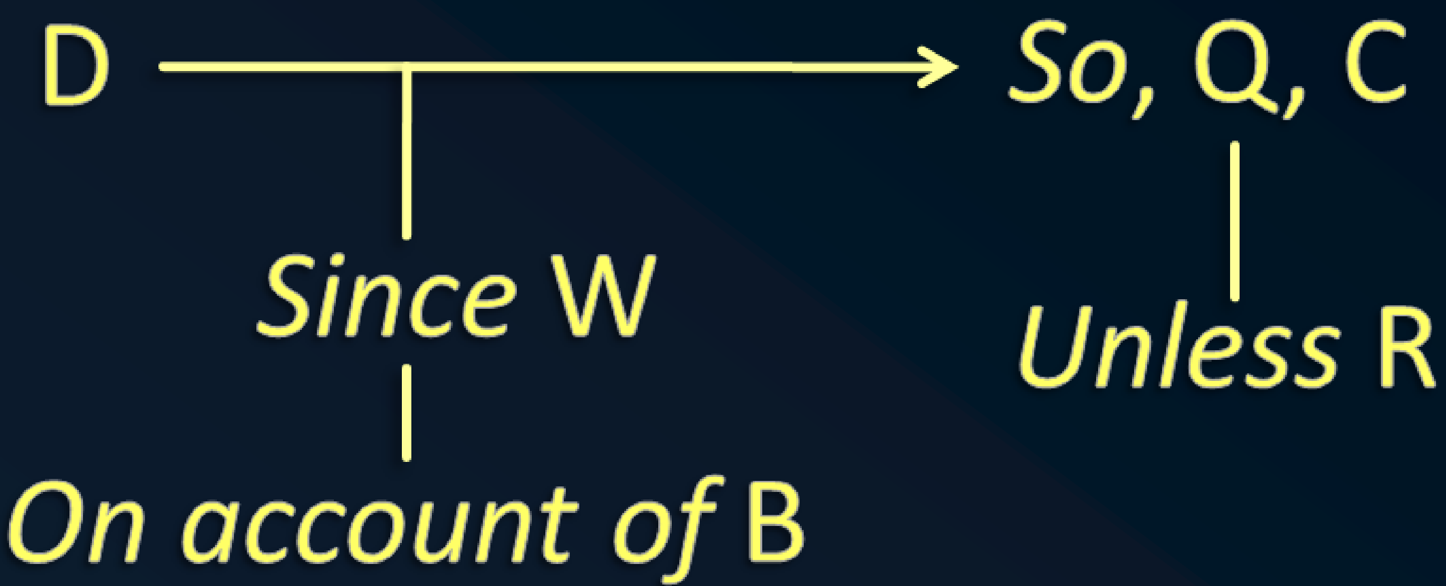
Object is illuminated by red lights

Example

Object looks red → *Object is red*



Toulmin's Scheme



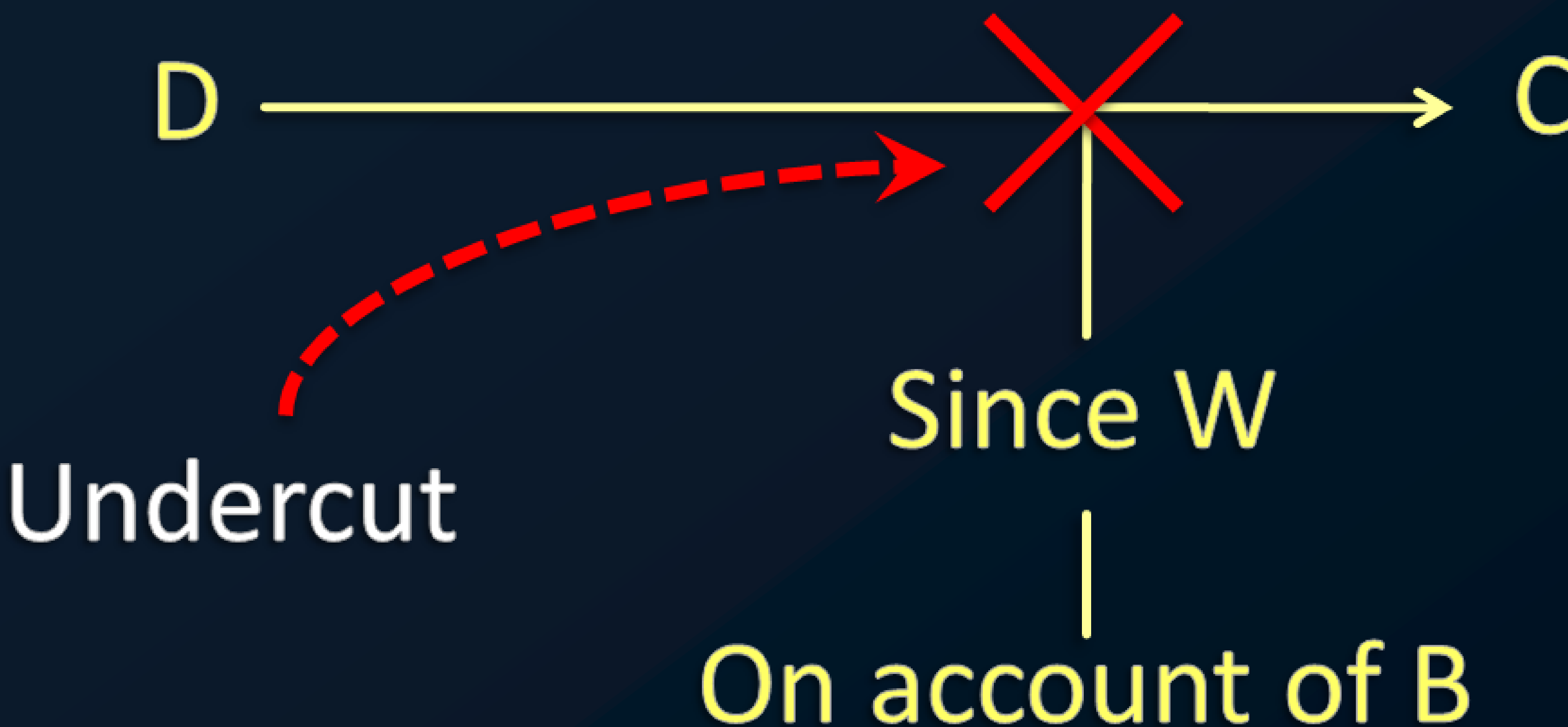
C: *Claim*
D: *Data*

W: *Warrant*
B: *Backing*

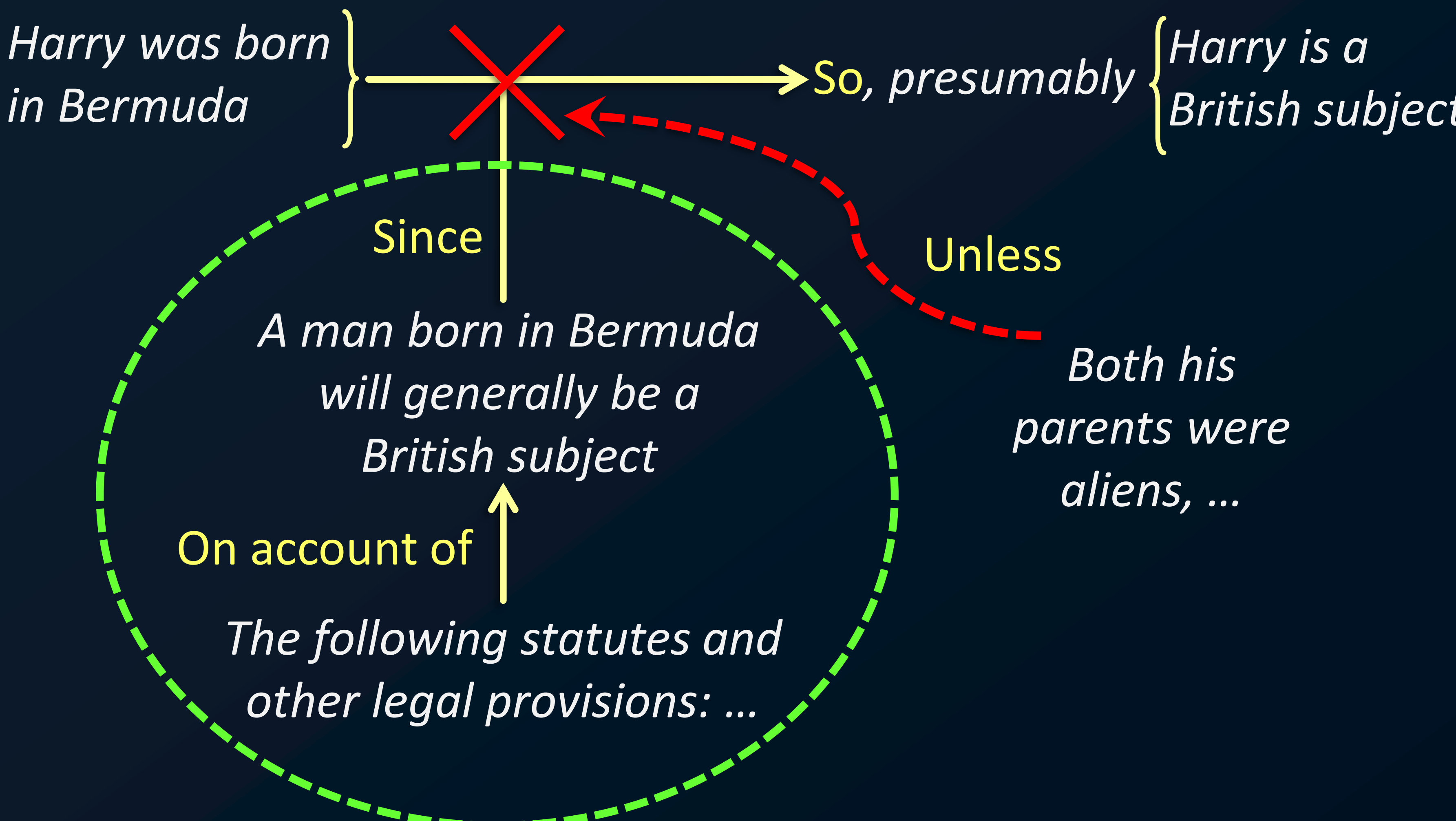
R: *Rebuttal*
Q: *Qualifier*

Toulmin's Backings

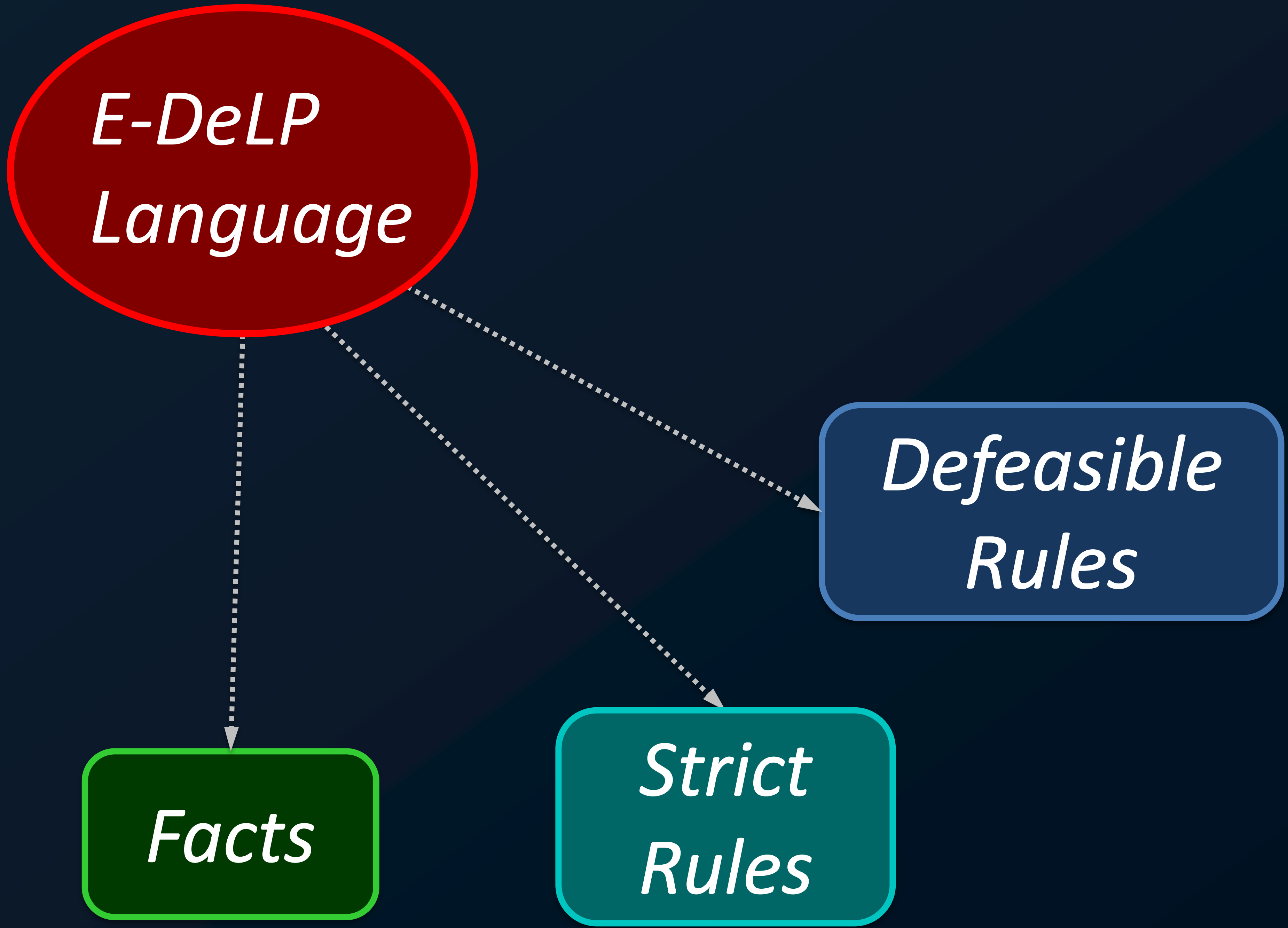
Pollock's Undercutting Defeaters

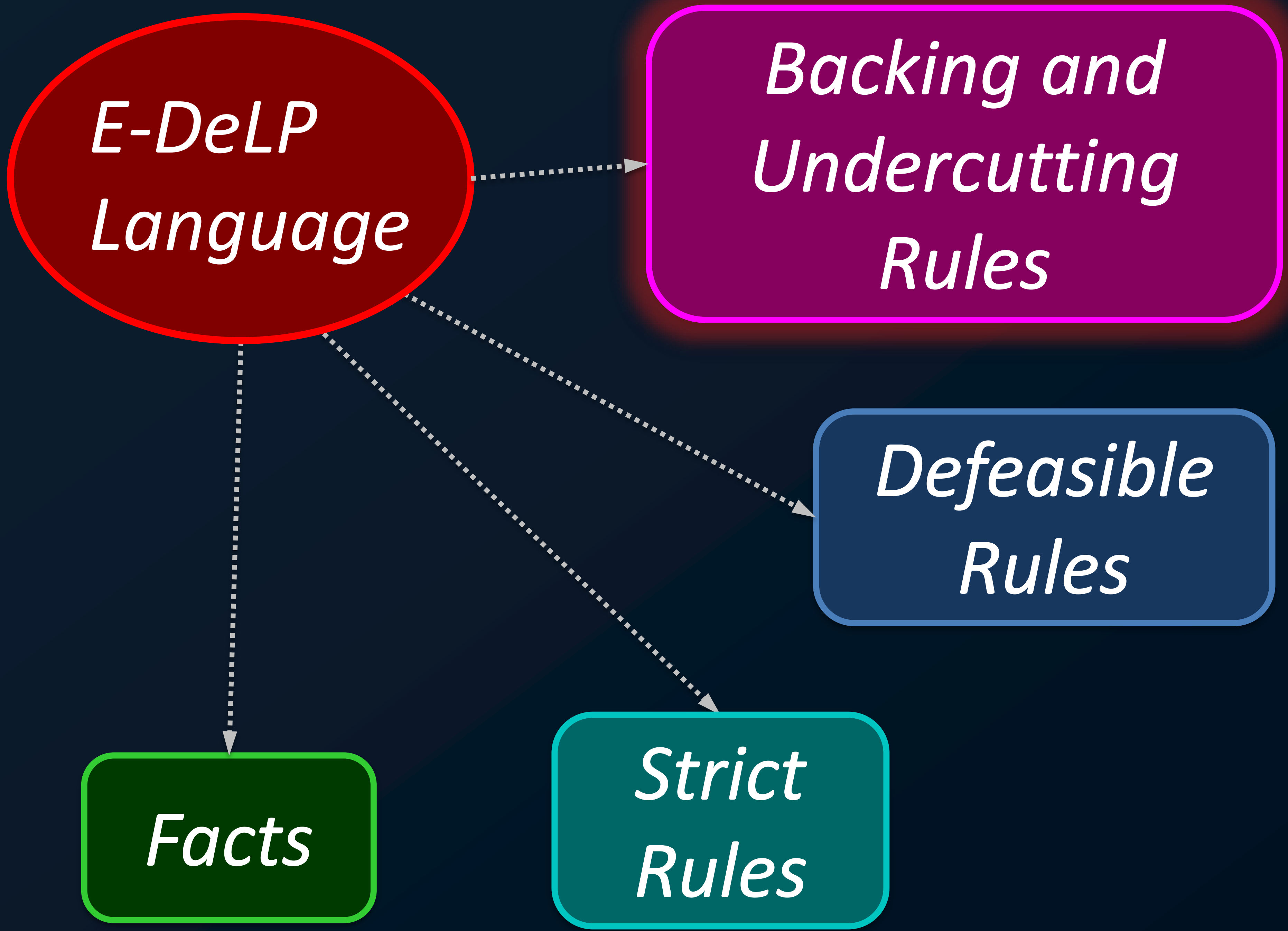


Toulmin's Example



Extended Defeasible Logic Programming (E-DeLP)


E-DeLP Language
Defeasible Rules
Strict Rules
Facts



E-DeLP Language
Backing and Undercutting Rules
Defeasible Rules
Strict Rules
Facts

E-DeLP – The Language

Π
- *Facts:* *ground literal* L
- *Strict rules:* $L_0 \leftarrow L_1, \ldots, L_n$

Δ
- *Defeasible rules:* $L_0 \prec L_1, \ldots, L_n$

DeLP

E-DeLP – The Language

$\Pi \begin{cases} \text{– } \textit{Facts: ground literal } \mathrm{L} \\ \text{– } \textit{Strict rules: } \mathrm{L}_0 \leftarrow \mathrm{L}_1, \dots, \mathrm{L}_n \end{cases}$

$\Delta \begin{cases} \text{– } \textit{Defeasible rules: } \mathrm{L}_0 \prec \mathrm{L}_1, \dots, \mathrm{L}_n \end{cases}$

– *Backing rules:* [d-rule] $\longleftarrow\!\oplus$ $[\mathrm{L}_1, \dots, \mathrm{L}_n]$

E-DeLP – The Language

Π
- *Facts:* *ground literal* L
- *Strict rules:* $L_0 \leftarrow L_1, \ldots, L_n$

Δ
- *Defeasible rules:* $L_0 \prec L_1, \ldots, L_n$
- *Backing rules:* $[\text{d-rule}] \longleftarrow\!\oplus\ [L_1, \ldots, L_n]$
- *Undercutting rules:* $[\text{d-rule}] \longleftarrow\!\otimes\ [L_1, \ldots, L_n]$

E-DeLP – The Language

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- *Facts: ground literal* L
- *Strict rules:* $L_0 \longleftarrow L_1, \ldots, L_n$

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- *Defeasible rules:* $L_0 \prec L_1, \ldots, L_n$

Σ
- *Backing rules:* [d-rule] $\longleftarrow\!\oplus$ $[L_1, \ldots, L_n]$
- *Undercutting rules:* [d-rule] $\longleftarrow\!\otimes$ $[L_1, \ldots, L_n]$

Extended defeasible logic program:

$$\mathcal{P} = (\Pi, \Delta, \Sigma)$$

Example

A possible representation for Toulmin's example in E-DeLP:

$$\mathcal{P}_1 = (\Pi_1, \Delta_1, \Sigma_1)$$

Π_1 ={ born_in_bermuda(harry), british_parliament_acts,
alien_parents(harry) }

Δ_1 = { british_subject(X) $\prec$ born_in_bermuda(X) }

Σ_1 = { [british_subject(X) $\prec$ born_in_bermuda(X)] $\longleftarrow\otimes$
[alien_parents(X)],

[british_subject(X) $\prec$ born_in_bermuda(X)] $\longleftarrow\oplus$
[british_parliament_acts] }

E-DeLP – Arguments

From an extended defeasible logic program (e-de.l.p.) $\mathcal{P}$, three different types of arguments can be obtained:

- *Claim Argument*
- *Undercutting Argument*
- *Backing Argument*

E-DeLP – Arguments

Claim Argument $\langle \mathcal{A}, L \rangle$ *for a literal* L :

1) $\mathcal{A} \subseteq (\Delta \cup \Sigma)$

2) $\Pi \cup \mathcal{A} \mid\!\sim L$

3) $\Pi \cup \mathcal{A}$ *is non-contradictory*

4) $\mathcal{A}$ *is minimal: there is no* $\mathcal{B} \subsetneq \mathcal{A}$ satisfying 2) and 3)

E-DeLP – Arguments

Undercutting Argument $\langle \mathcal{A}, r \rangle_u$ *for a d-rule* r *is*

$\mathcal{A}$ = { $[r] \longleftarrow\!\otimes [L_1, \ldots, L_n]$ } $\cup\, \mathcal{A}'$ *and:*

1) $\mathcal{A} \subseteq (\Delta \cup \Sigma)$

2) $\Pi \cup \mathcal{A}' \mathrel{|\!\!\sim}_{\mathcal{P}} L_i \ (1 \leqslant i \leqslant n)$

3) $\Pi \cup \mathcal{A}'$ *is non-contradictory*

4) $\mathcal{A}'$ *is minimal: there is no* $\mathcal{B} \subsetneq \mathcal{A}'$ *satisfying* 2) *and* 3)

E-DeLP – Arguments

Backing Argument $\langle \mathcal{A}, r \rangle_b$ *for a d-rule* r *is*

$\mathcal{A}$ = { $[r] \longleftarrow \oplus [L_1, \ldots, L_n]$ } $\cup \mathcal{A}'$ *and:*

1) $\mathcal{A} \subseteq (\Delta \cup \Sigma)$

2) $\Pi \cup \mathcal{A}' \mathrel{|\!\!\sim}_{\mathcal{P}} L_i \quad (1 \leqslant i \leqslant n)$

3) $\Pi \cup \mathcal{A}'$ *is non-contradictory*

4) $\mathcal{A}'$ *is minimal: there is no* $\mathcal{B} \subsetneq \mathcal{A}'$ *satisfying* 2) *and* 3)

Example

$\mathcal{P}_2 = (\Pi_2, \Delta_2, \Sigma_2)$

Π_2 = { switch_on(l), night, lamp_in_room(l,r), electricity, broken_lamp(l) }

Δ_2 = { light_on(X) $\prec$ switch_on(X)

illuminated_room(X) $\prec$ day

$\sim$illuminated_room(X) $\prec$ night

illuminated_room(X) $\prec$ night, lamp_in_room(Y, X), light_on(Y) }

Σ_2 = { [light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [electricity]

[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [$\sim$electricity, emergency_lamp(X)]

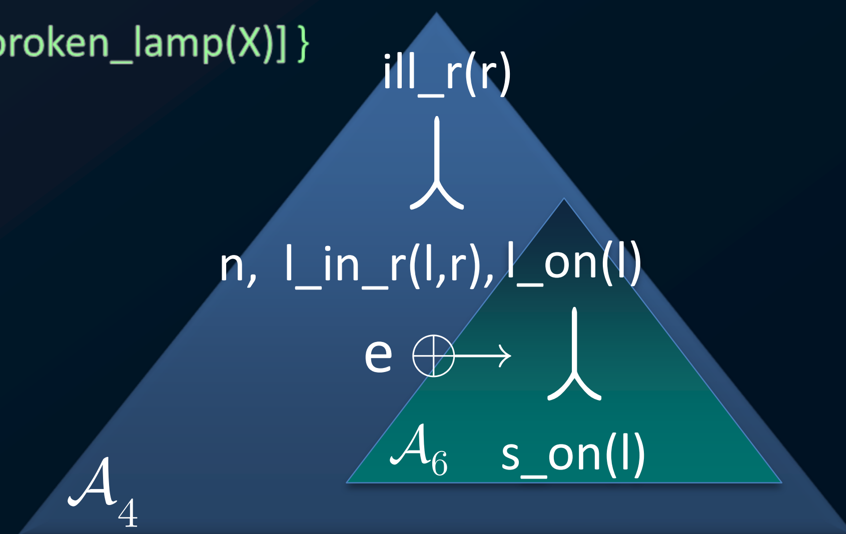
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\otimes$ [$\sim$electricity]

[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\otimes$ [electricity, broken_lamp(X)] }

Π_2 = { switch_on(l), night, lamp_in_room(l,r), electricity, broken_lamp(l) }

Δ_2 = { light_on(X) $\prec$ switch_on(X)
illuminated_room(X) $\prec$ day
$\sim$illuminated_room(X) $\prec$ night
illuminated_room(X) $\prec$ night, lamp_in_room(Y, X), light_on(Y) }

Σ_2 = { [light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [electricity]
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [$\sim$electricity, emergency_lamp(X)]
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\otimes$ [$\sim$electricity]
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\otimes$ [electricity, broken_lamp(X)] }



$\langle \mathcal{A}_4$, ill_r_(r)$\rangle$

$\mathcal{A}_4$ = { ill_r(r) $\prec$ n, l_in_r(l,r), l_on(l)
l_on(l) $\prec$ s_on(l)
[l_on(l) $\prec$ s_on(l)] $\longleftarrow\!\oplus$ [e] }

$\langle \mathcal{A}_6$, l_on(l) $\prec$ s_on(l)$\rangle_b$

$\mathcal{A}_6$ = { [l_on(l) $\prec$ s_on(l)] $\longleftarrow\!\oplus$ [e] }

$\Pi_2 = \{$ switch_on(l), night, lamp_in_room(l,r), electricity, broken_lamp(l) $\}$

$\Delta_2 = \{$ light_on(X) $\prec$ switch_on(X)
illuminated_room(X) $\prec$ day
$\sim$illuminated_room(X) $\prec$ night
illuminated_room(X) $\prec$ night, lamp_in_room(Y, X), light_on(Y) $\}$

$\Sigma_2 = \{$ [light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [electricity]
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\oplus$ [$\sim$electricity, emergency_lamp(X)]
[light_on(X) $\prec$ switch_on(X)] $\longleftarrow\!\otimes$ [$\sim$electricity]
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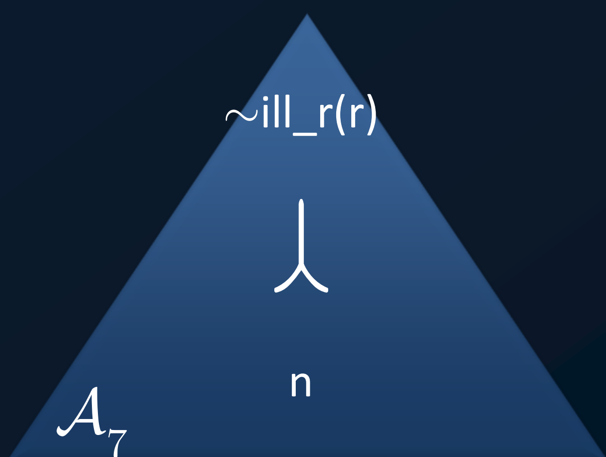
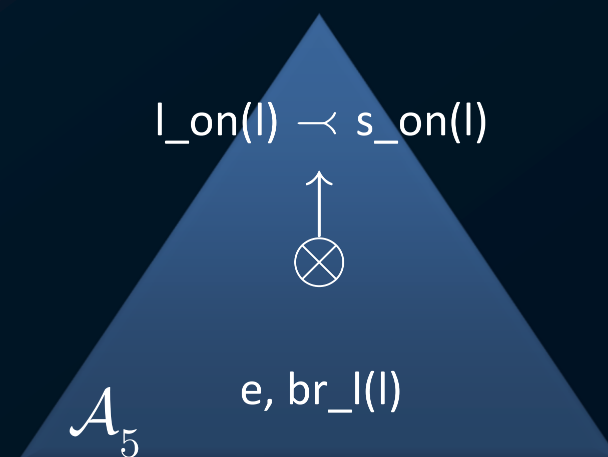




$\langle \mathcal{A}_7, \sim$ill_r(r)$\rangle$ $\mathcal{A}_7 = \{ \sim$ill_r(r) $\prec$ n $\}$

$\langle \mathcal{A}_5,$ l_on(l) $\prec$ s_on(l)$\rangle_u$
$\mathcal{A}_5 = \{$ [l_on(l) $\prec$ s_on(l)] $\longleftarrow\!\otimes$ [e, br_l(l)] $\}$

E-DeLP – Attack

Rebutting Attack: $\langle \mathcal{A}_1, L_1 \rangle$ *rebuts* $\langle \mathcal{A}_2, L_2 \rangle$ at the literal L *if there exists a claim sub-argument* $\langle \mathcal{A}, L \rangle$ *of argument* $\langle \mathcal{A}_2, L_2 \rangle$ *such that* L *and* L_1 *disagree.*

Undercutting Attack: An undercutting argument $\langle \mathcal{A}, r \rangle$ *undercuts* $\langle \mathcal{B}, L \rangle$ at the rule r *if* $r \in \mathcal{B}$.

Undermining Attack: $\langle \mathcal{A}_1, L_1 \rangle$ *undermines* $\langle \mathcal{A}_2, L_2 \rangle$ *at the literal* P *if* $\langle \mathcal{A}_1, L_1 \rangle$ *rebuts* $\langle \mathcal{A}_2, L_2 \rangle$ *at the literal* P*, and* P *is a presumption*.

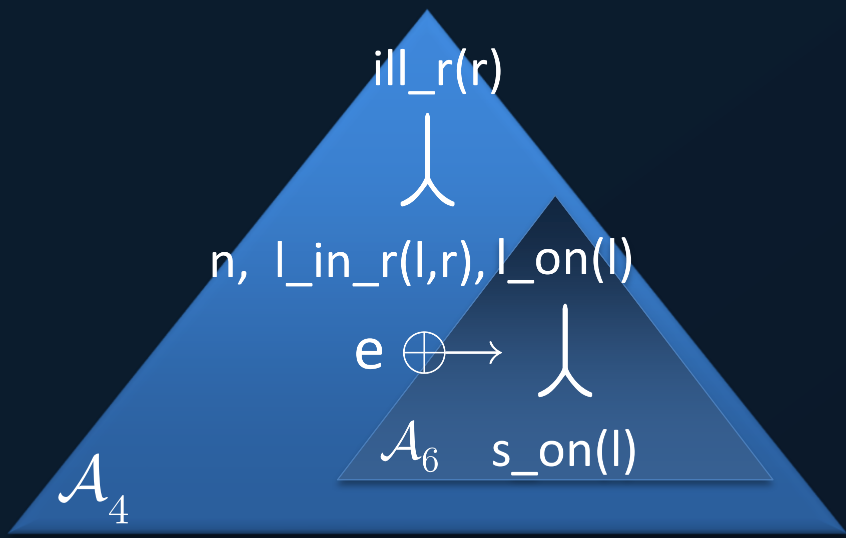
E-DeLP - *Defeat*

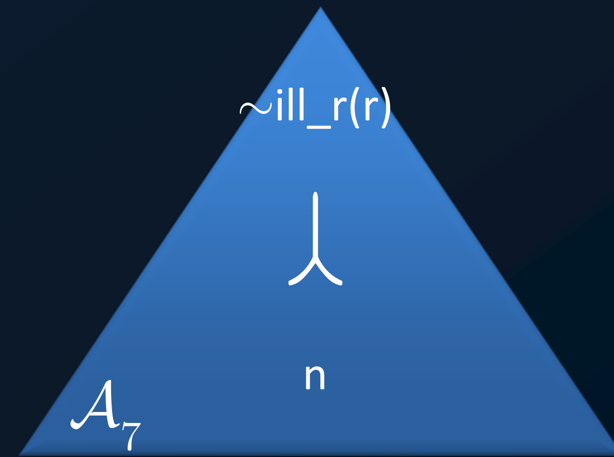
Three forms of defeat may occur between arguments:

Rebutting Defeat: $\langle \mathcal{A}_1, L_1 \rangle$ *rebuts* $\langle \mathcal{A}_2, L_2 \rangle$ *at the literal* L, *and the attacked sub-argument* $\langle \mathcal{A}, L \rangle$ of $\langle \mathcal{A}_2, L_2 \rangle$ *is such that* $\langle \mathcal{A}, L \rangle \not\succ \langle \mathcal{A}_1, L_1 \rangle$.

Undercutting Defeat: $\langle \mathcal{A}, R \rangle$ *undercuts* $\langle \mathcal{B}, H \rangle$ *at the defeasible rule* R, *if* $R \in \mathcal{B}$.

Undermining Defeat: $\langle \mathcal{A}_1, L_1 \rangle$ *undermines* $\langle \mathcal{A}_2, L_2 \rangle$ *at the literal* L, *and the attacked sub-argument* $\langle \mathcal{A}, L \rangle$ *of* $\langle \mathcal{A}_2, L_2 \rangle$ *is such that* $\langle \mathcal{A}, L \rangle \not\succ \langle \mathcal{A}_1, L_1 \rangle$.





Π_2 = { switch_on(l), night, lamp_in_room(l,r), electricity, broken_lamp(l) }

Δ_2 = { light_on(X) $\prec$ switch_on(X)
illuminated_room(X) $\prec$ day
~illuminated_room(X) $\prec$ night
illuminated_room(X) $\prec$ night, lamp_in_room(Y, X), light_on(Y) }

Σ_2 = { [light_on(X) $\prec$ switch_on(X)] $\leftarrow\!\oplus$ [electricity]
[light_on(X) $\prec$ switch_on(X)] $\leftarrow\!\oplus$ [~electricity, emergency_lamp(X)]
[light_on(X) $\prec$ switch_on(X)] $\leftarrow\!\otimes$ [~electricity]
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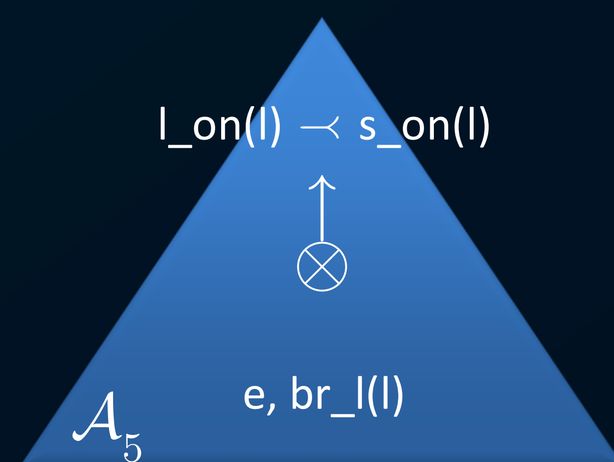

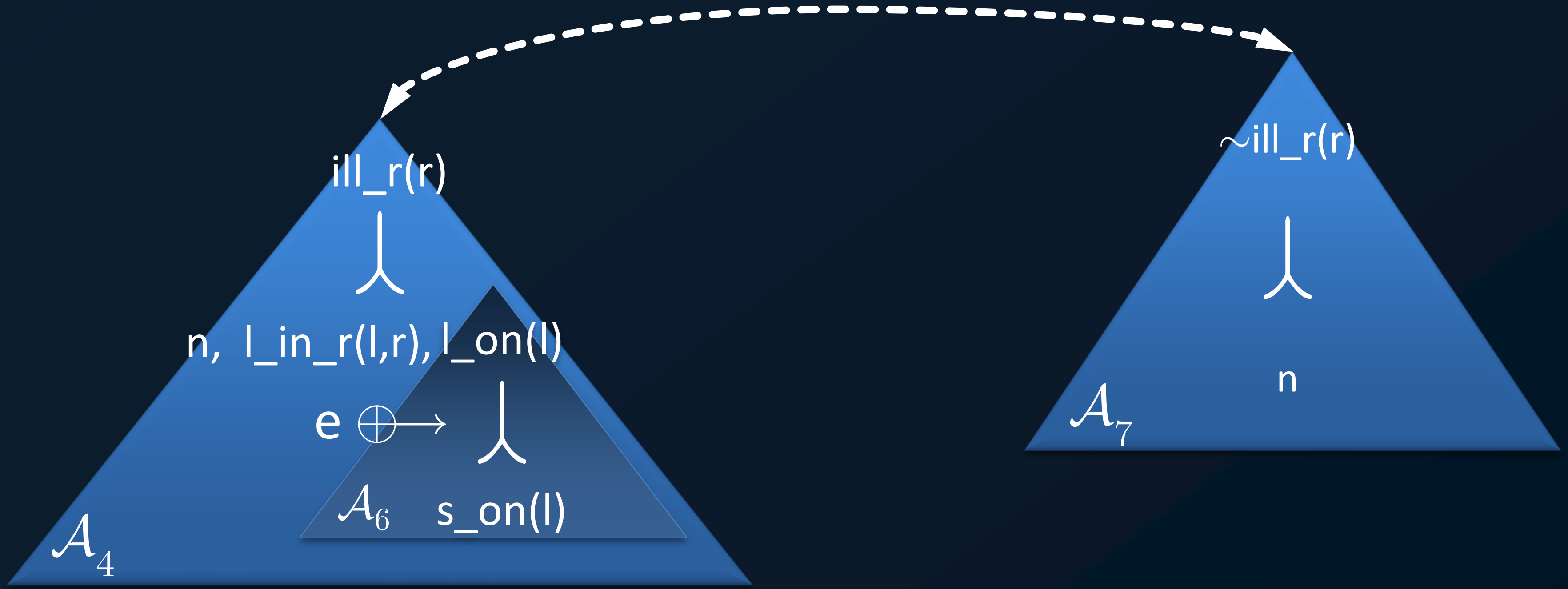

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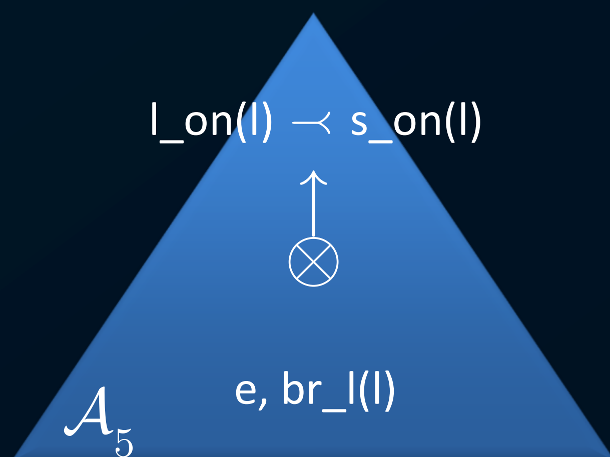

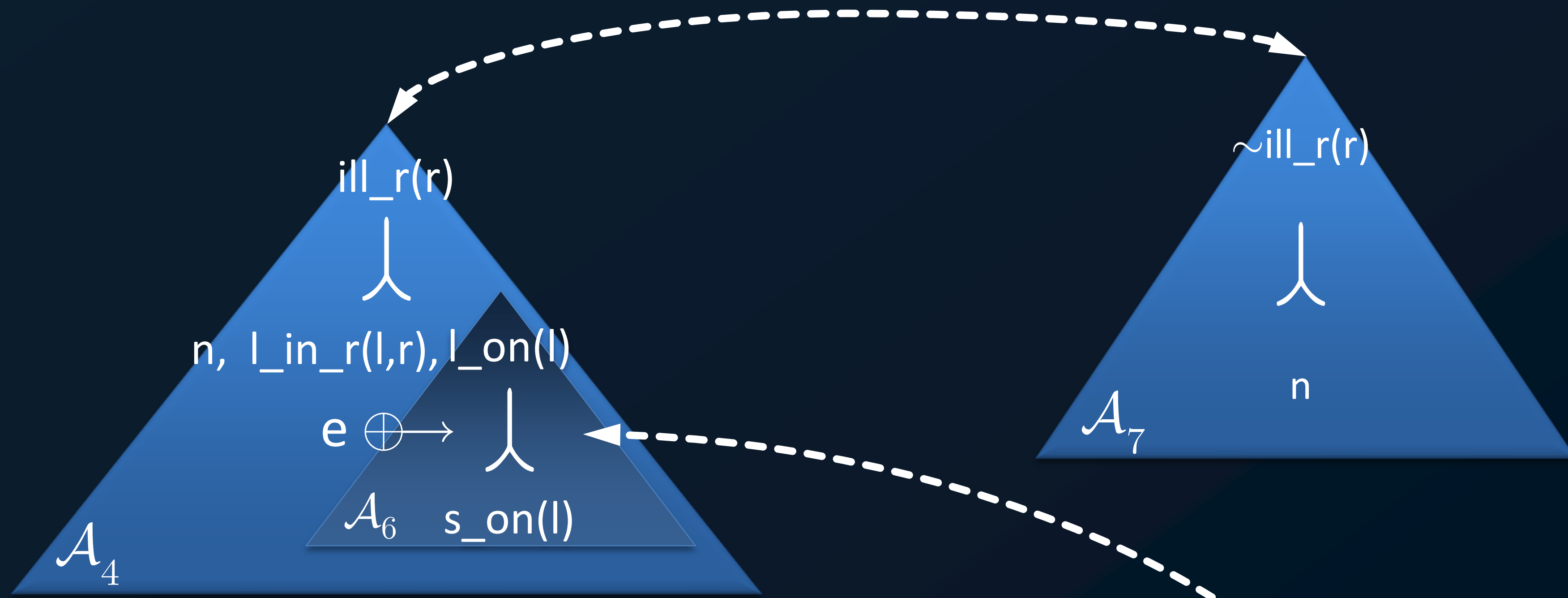

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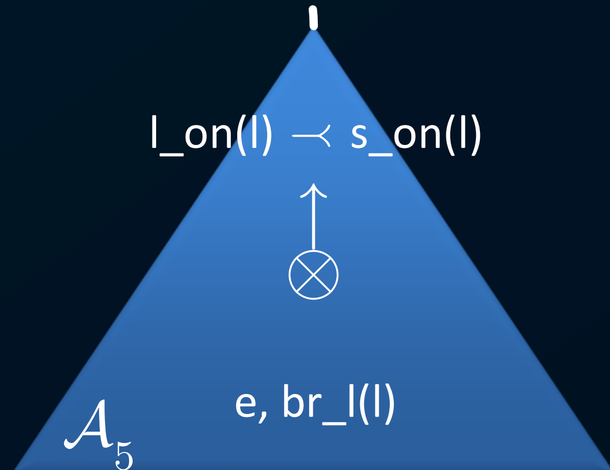

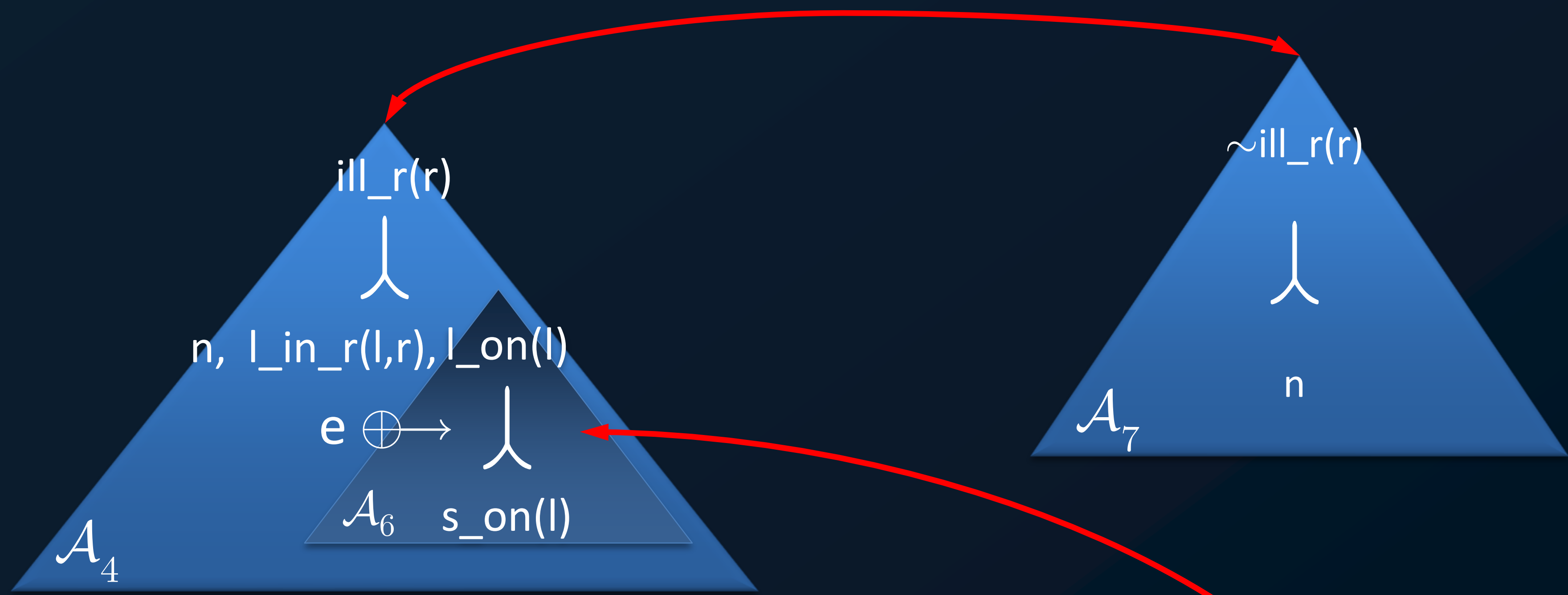

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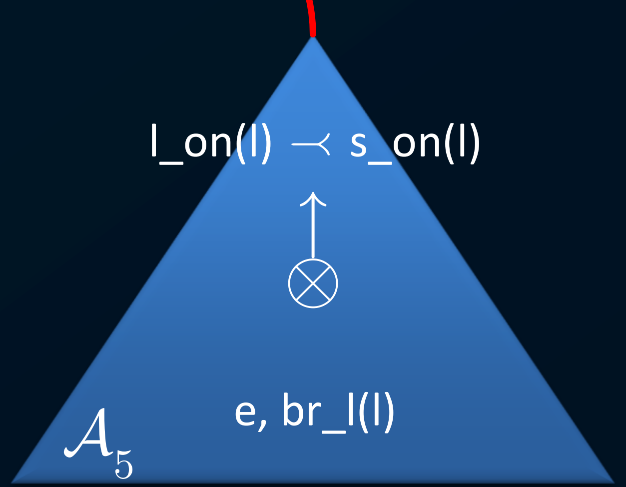
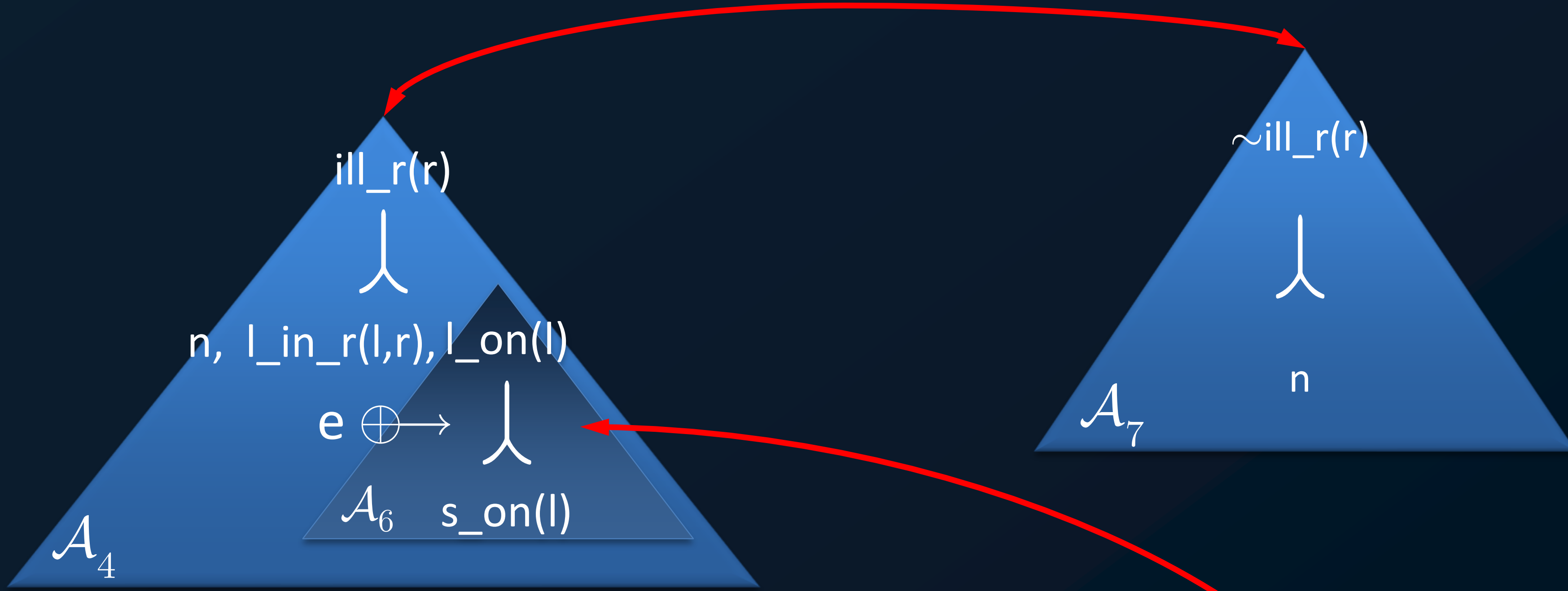


Criterion:
$\langle \mathcal{A}_4, \text{ill\_r\_(r)} \rangle \succ \langle \mathcal{A}_7, \sim\text{ill\_r(r)} \rangle$
$\langle \mathcal{A}_5, \text{l\_on(l)} -\!\!\prec \text{s\_on(l)} \rangle_u \succ \langle \mathcal{A}_6, \text{l\_on(l)} -\!\!\prec \text{s\_on(l)} \rangle_b$



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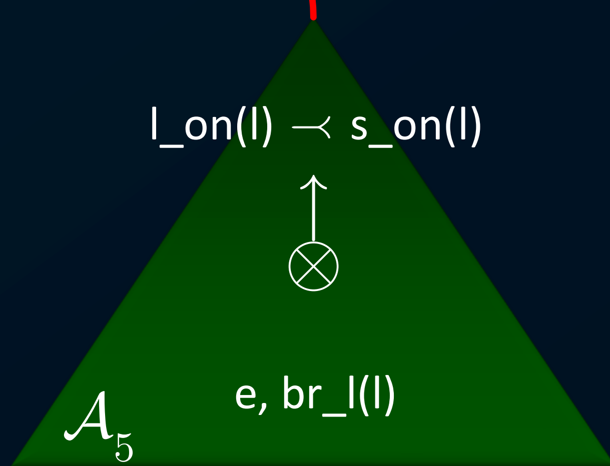

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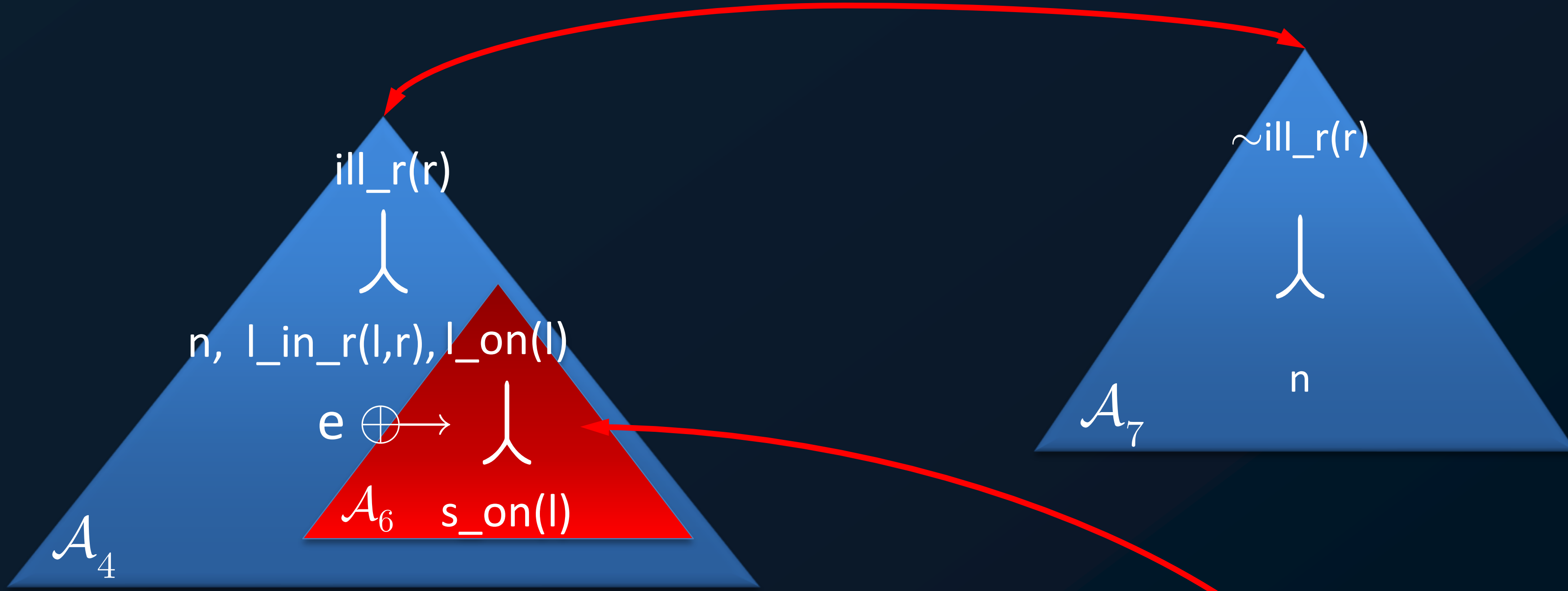
$\langle \mathcal{A}_5$, l_on(l) $\prec$ s_on(l)$\rangle_u \succ \langle \mathcal{A}_6$, l_on(l) $\prec$ s_on(l)$\rangle_b$



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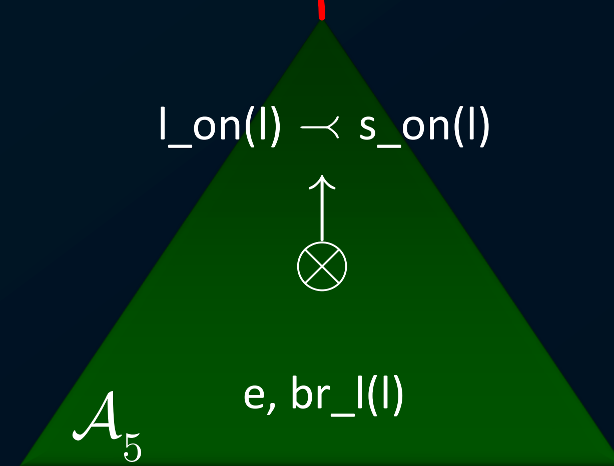

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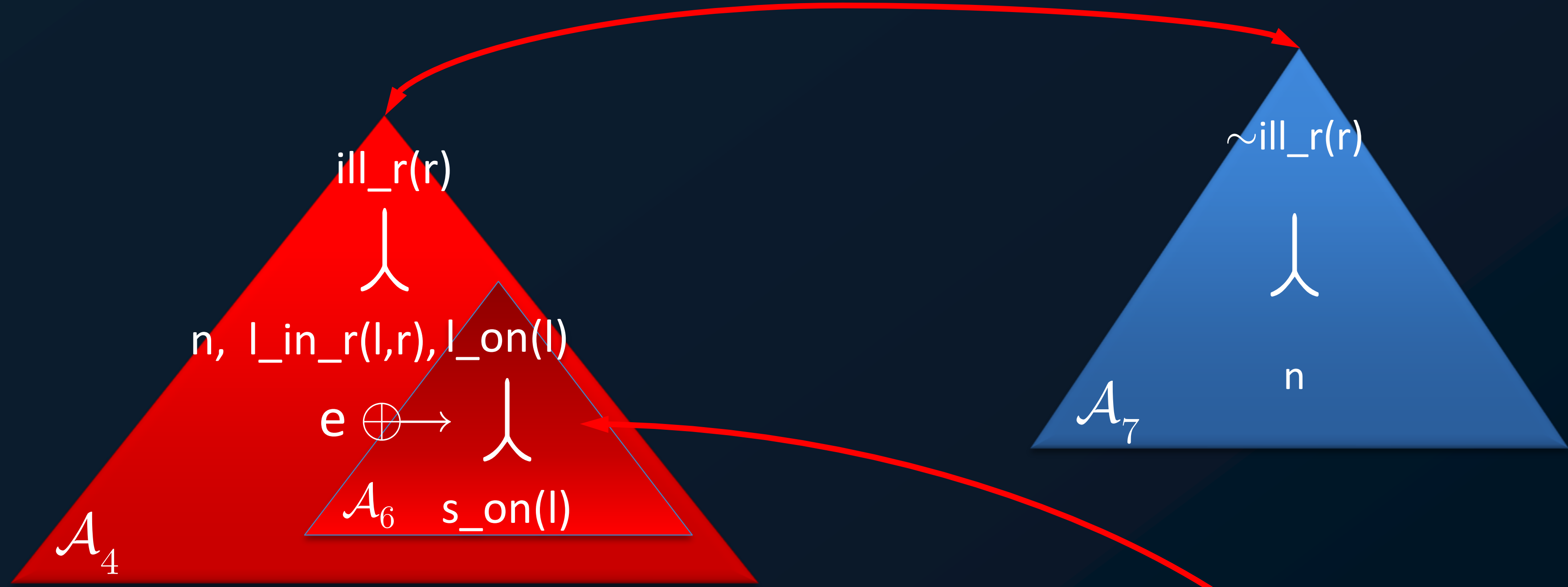

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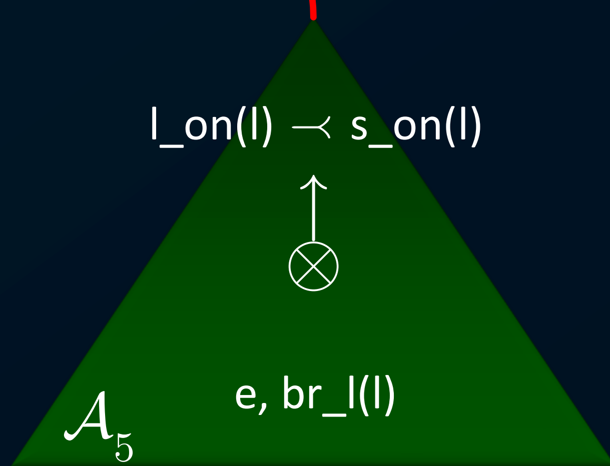

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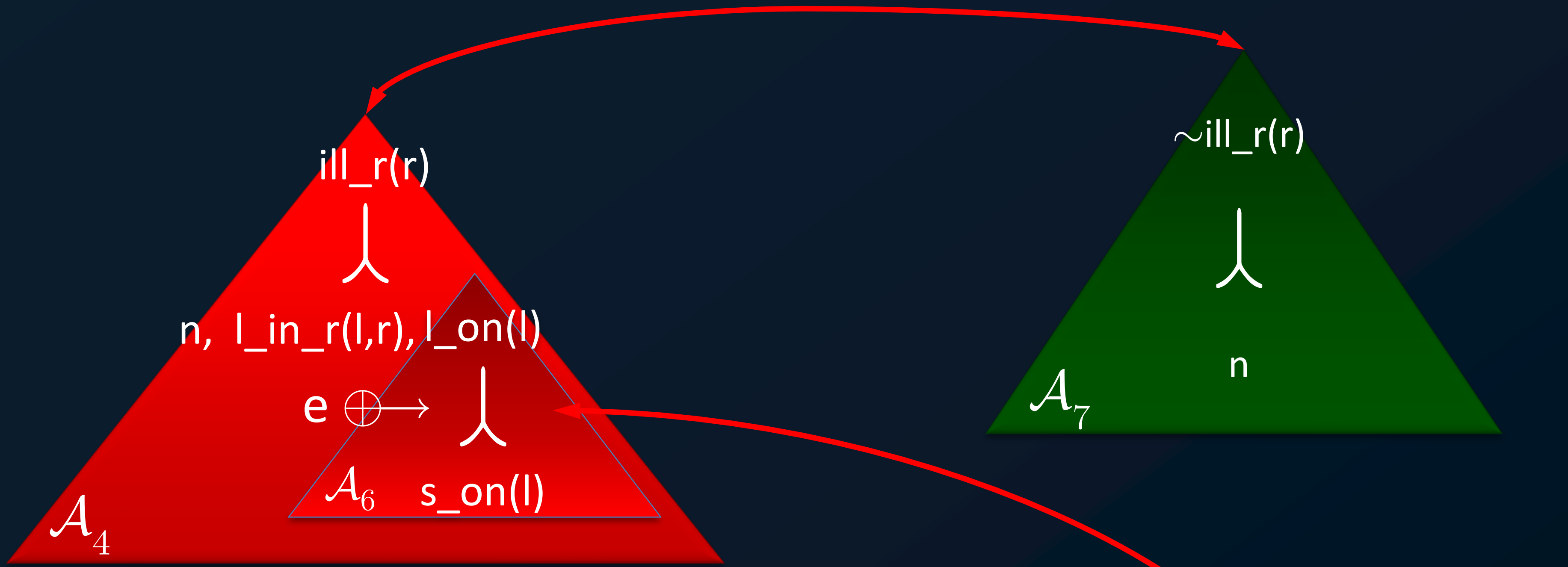

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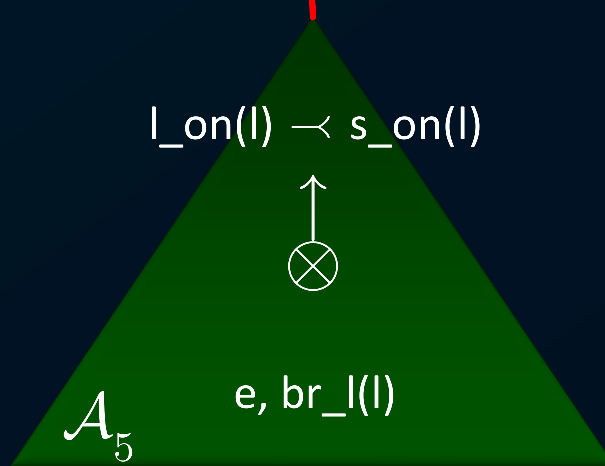

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Conclusions

- *We have extended DeLP to capture two important notions in modeling argumentation*
- *And, Backing & Undercutting Rules are used to represent these notions:*
  - *Toulmin's backings are represented by providing support for defeasible rules*
  - *Pollock's undercutting defeaters can be expressed by an attack to a defeasible rule*

Thank you!

Questions?