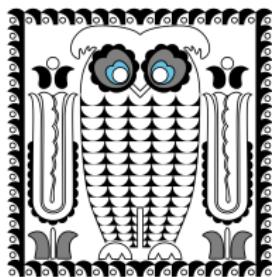


PROLOG 2025

ELTE, LOGIC DEPARTMENT

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September 24, 2025

Cut

CUT

Prolog works with backtracing which can lead to inefficiency, i.e. wasting time and memory on possibilities that lead nowhere.

We can control backtracking by the cut predicate: !/0

Cut is a goal that always succeeds, so  will always get through it.

```
p(X) :- b(X), c(X), d(X), e(X).
```

vs

```
p(X) :- b(X), c(X), !, d(X), e(X).
```

CUT

The cut only commits us to choices made since the parent goal was unified with the **left-hand side** of the clause containing the cut.

```
q :- p1, ..., pm, !, r1, ..., rn.
```

when we reach the cut it commits us:

- to this particular clause of **q**
- to the choices made by **p₁, ..., p_m**
- **NOT** to choices made by **r₁, ..., r_n**

GREEN CUT

Let's consider the following `max/3` predicate:

```
max(X, Y, Y) :- X =< Y.  
max(X, Y, X) :- X > Y.
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```
?- max(2, 3, 3)  
[
```

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max(X, Y, X) :- X > Y.
```

```
?- max(2, 3, 3)  
yes  
?- max(7, 3, 7)
```

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max(X, Y, Y) :- X =< Y.  
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?- max(2, 3, 3)	
yes	
?- max(7, 3, 7)	
yes	

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Let's consider the following `max/3` predicate:

```
max(X, Y, Y) :- X =  
= Y.  
max(X, Y, X) :- X >  
Y.
```

<pre>?- max(2, 3, 3) yes ?- max(7, 3, 7) yes</pre>	<pre>?- max(2, 3, 2)</pre>
---	----------------------------

GREEN CUT

Let's consider the following `max/3` predicate:

```
max(X, Y, Y) :- X =  
= Y.  
max(X, Y, X) :- X >  
Y.
```

<code>?- max(2, 3, 3)</code>	<code>?- max(2, 3, 2)</code>
yes	no
<code>?- max(7, 3, 7)</code>	<code>?- max(2, 3, 5)</code>
yes	

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yes	no
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yes	no	
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<code>?- max(2, 3, 3)</code>	<code>?- max(2, 3, 2)</code>	<code>?- max(2, 3, Y)</code>
yes	no	<code>Y = 3</code>
<code>?- max(7, 3, 7)</code>	<code>?- max(2, 3, 5)</code>	<code>?- max(7, 3, _)</code>
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= Y.  
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Y.
```

<code>?- max(2, 3, 3)</code>	<code>?- max(2, 3, 2)</code>	<code>?- max(2, 3, Y)</code>
<code>yes</code>	<code>no</code>	<code>Y = 3</code>
<code>?- max(7, 3, 7)</code>	<code>?- max(2, 3, 5)</code>	<code>?- max(7, 3, _)</code>
<code>yes</code>	<code>no</code>	<code>true</code>

GREEN CUT

Let's consider the following `max/3` predicate:

```
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= Y.  
max(X, Y, X) :- X >  
Y.
```

<code>?- max(2, 3, 3)</code>	<code>?- max(2, 3, 2)</code>	<code>?- max(2, 3, Y)</code>
yes	no	<code>Y = 3</code>
<code>?- max(7, 3, 7)</code>	<code>?- max(2, 3, 5)</code>	<code>?- max(7, 3, _)</code>

After `?- max(2, 3, Y)` if asked for more solutions, Prolog will try to satisfy the second clause, which is completely useless – since we know the two clauses are exclusive (hence, it returns with `false`).

GREEN CUT

We can fix this by adding a cut to the rule:

```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) :- X > Y.
```

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```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) :- X > Y.
```

Now

- If the `X =< Y` succeeds, the cut commits us to this choice, and the second clause of `max/3` is not considered.
- If the `X =< Y` fails, Prolog goes on to the second clause.

WITHOUT CUT

```
max(X, Y, Y) :- X =< Y.  
max(X, Y, X) :- X > Y.
```

WITH CUT

WITHOUT CUT

```
max(X, Y, Y) :- X =< Y.  
max(X, Y, X) :- X > Y.
```

WITH CUT

The screenshot shows a Prolog interface with two sections. The top section, titled 'WITHOUT CUT', contains the code for the `max/3` predicate. The bottom section, titled 'WITH CUT', also contains the same code but includes a cut (`!.`) at the end of the first clause. The interface includes a toolbar with a gear icon, a query input field with `?- max(2,3,Z).`, and a results area showing `Z = 3`. Below the results are buttons for 'Next', '10', '100', '1,000', and 'Stop'.

```
?- max(2,3,Z).  
Z = 3  
Next 10 100 1,000 Stop
```

WITHOUT CUT

```
max(X, Y, Y) :- X <= Y.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface. At the top, there is a toolbar with a gear icon and the text "max(2,3,Z)." Below the toolbar is a button labeled "Z = 3". Underneath these are four buttons: "Next", "10", "100", "1,000", and "Stop". A horizontal bar separates this from the query area. In the query area, the question mark prompt "?-" is followed by the query "max(2,3,Z).".

WITH CUT

The screenshot shows a Prolog interface. At the top, there is a toolbar with a gear icon and the text "max(4,3,Z)." Below the toolbar is a button labeled "Z = 4". Underneath these are four buttons: "Next", "10", "100", and "1,000". A horizontal bar separates this from the query area. In the query area, the question mark prompt "?-" is followed by the query "max(4,3,Z).".

WITHOUT CUT

```
max(X, Y, Y) :- X <= Y.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface with the following elements:

- A top bar with a gear icon and the text `max(2,3,Z).`
- A variable `Z = 3` displayed below the bar.
- A row of buttons: `Next`, `10`, `100`, `1,000`, and `Stop`.
- A query window with the prompt `?-` followed by the query `max(2,3,Z).`

WITH CUT

```
max(X, Y, Y) :- X <= Y, !.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface with the following elements:

- A top bar with a gear icon and the text `max(4,3,Z).`
- A variable `Z = 4` displayed below the bar.
- A query window with the prompt `?-` followed by the query `max(4,3,Z).`

WITHOUT CUT

```
max(X, Y, Y) :- X <= Y.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface. At the top, there is a toolbar with a gear icon and the text "max(2,3,Z)." Below the toolbar, the variable **Z** is displayed with the value **3**. A row of buttons below the toolbar includes "Next", "10", "100", "1,000", and "Stop". The main query window displays the question **?- max(2,3,Z).** followed by a period, indicating the query has been submitted.

This screenshot shows another instance of the Prolog interface. The top part of the window displays the query **max(4,3,Z).** The variable **Z** is shown with the value **4**. The main query window shows the question **?- max(4,3,Z).** followed by a cursor, indicating the user is about to submit the query or has just submitted it.

WITH CUT

```
max(X, Y, Y) :- X <= Y, !.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface. The top part of the window displays the query **max(2,3,Z).** The variable **Z** is shown with the value **3**. The main query window shows the question **?- max(2,3,Z).** followed by a cursor, indicating the user is about to submit the query or has just submitted it.

WITHOUT CUT

```
max(X, Y, Y) :- X <= Y.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface with two main sections. The top section displays the query `max(2,3,Z).` and its result `Z = 3`. Below this are buttons for "Next", "10", "100", "1,000", and "Stop". The bottom section shows the query `?- max(2,3,Z).` followed by a question mark. This pattern repeats for the second example below.

This screenshot is identical to the one above it, showing the same interface and results for the query `max(2,3,Z)`.

WITH CUT

```
max(X, Y, Y) :- X <= Y, !.  
max(X, Y, X) :- X > Y.
```

The screenshot shows a Prolog interface with two main sections. The top section displays the query `max(2,3,Z).` and its result `Z = 3`. The bottom section shows the query `?- max(2,3,Z).` followed by a question mark and an input cursor, indicating that the query is still being processed or has not yet been run.

This screenshot is identical to the one above it, showing the same interface and results for the query `max(2,3,Z)`.

GREEN CUT, RED CUT

GREEN CUT: cuts that do not change the meaning of a predicate.

E.g. `max/3` – the new code gives exactly the **same answers** as the old version, but it is **more efficient**.

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E.g. `max/3` – the new code gives exactly the **same answers** as the old version, but it is **more efficient**.

To see how red cuts work, let's modify our `max/3`:

```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) :- X > Y.
```

The second clause is basically redundant. Let's remove it!

```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) .
```

Now what?

RED CUT

```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) .
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
?- max(2, 3, X)
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.  
max(X, Y, X) .
```

```
[?- max(2, 3, X)  
X = 3]
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
?- max(2, 3, X)      ] ?- max(4, 3, X)  
X = 3
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
[ ?- max(2, 3, X)      ] [ ?- max(4, 3, X)      ]  
[ X = 3                 ] [ X = 4                 ]
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
[?- max(2, 3, X)      ] [?- max(4, 3, X)      ] [?- max(2, 3, 2)  
X = 3                  ] X = 4
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
[?- max(2, 3, X)      ] [?- max(4, 3, X)      ] [?- max(2, 3, 2)      ]  
X = 3                  X = 4                  true
```

RED CUT

```
max(X, Y, Y) :- X =< Y, !.
```

```
max(X, Y, X) .
```

```
[?- max(2, 3, X)      ] [?- max(4, 3, X)      ] [?- max(2, 3, 2)      ]  
X = 3                  X = 4                  true
```

Now  will be able to answer alternative questions/queries, but not yes-no ones.

Because of the form of the query, it will go directly to the second clause, and only check `max(X, Y, X) .`, which is obviously true – syntactically.

RED CUT

```
[max(X,Y,Y) :- X <= Y, !.  
max(X,Y,X).] [?- max(2,3,2)  
true]
```

...however, we can patch it with a unification after the cut:

```
max(X,Y,Z) :- X <= Y, !, Y = Z.  
max(X,Y,X).
```

RED CUT

```
[max(X,Y,Y) :- X <= Y, !.  
max(X,Y,X).] [?- max(2,3,2)  
true]
```

...however, we can patch it with a unification after the cut:

```
max(X,Y,Z) :- X <= Y, !, Y=Z.  
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```

Mind the `Z` in the head of the rule! This `(X,Y,Z)` tempts  to try to substitute in the first clause, since `(X,Y,Z)` under appropriate circumstances can unify with `(X,Y,X)`!

RED CUT

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[max(X,Y,Y) :- X <= Y, !.  
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true]
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After `X <= Y` ($2 \leq 3$) succeeds, we ask if $3=2$, which will be **false**.

RED CUT

```
[max(X,Y,Y) :- X <= Y, !.  
max(X,Y,X).] [?- max(2,3,2)  
true]
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...however, we can patch it with a unification after the cut:

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After `X <= Y` (`2 <= 3`) succeeds, we ask if `3=2`, which will be `false`.

Because of the `!`  cannot go back and try another setup for substitution (`max(X, Y, X)`), it will be stuck with what was given before the `!`.

RED CUT

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[max(X,Y,Y) :- X <= Y, !.  
max(X,Y,X).] [?- max(2,3,2)  
true]
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...however, we can patch it with a unification after the cut:

```
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Mind the `Z` in the head of the rule! This `(X, Y, Z)` tempts  to try to substitute in the first clause, since `(X, Y, Z)` under appropriate circumstances can unify with `(X, Y, X)`!

After `X <= Y` (`2 <= 3`) succeeds, we ask if `3=2`, which will be **false**.

Because of the `!`  cannot go back and try another setup for substitution (`max(X, Y, X)`), it will be stuck with what was given before the `!`.

However, if we ask `max(4, 3, X)`, it will be able to go to the second clause after failing with the first, since it fails already before the `!`, at `X <= Y`.

RED CUT

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RED CUT: a cut that changes the meaning of the predicate. If we remove it, we do not get an equivalent program. Using red cut the resulting program

- will not be fully declarative (we interfere with the control flow)
- can be harder to read
- might be prone to subtle programming mistakes

NEGATION AS FAILURE

Combining `!`, `fail.` we can express **negation**:

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bigMac(a).
```

```
bigKahunaBurger(b).
```

```
bigMac(c).
```

```
whopper(d).
```

```
enjoys(vincent,X) :- bigKahunaBurger(X), !, fail.
```

```
enjoys(vincent,X) :- burger(X).
```

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```

```
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```

```
enjoys(vincent,X) :- bigKahunaBurger(X), !, fail.
```

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?- enjoys(vincent,a).
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```

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```

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```

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```

```
true
```

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bigKahunaBurger(b).
```

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```

```
whopper(d).
```

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enjoys(vincent,X) :- bigKahunaBurger(X), !, fail.
```

```
enjoys(vincent,X) :- burger(X).
```

```
?- enjoys(vincent,a).
```

```
true
```

a gets substituted in `bigKahunaBurger (X)` where it will fail and go for the second clause. Among `burgers` `bigMac` is the first, so it succeeds, the query will be true.

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```

```
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```

```
bigKahunaBurger(b) .
```

```
bigMac(c) .
```

```
whopper(d) .
```

```
enjoys(vincent,X) :- bigKahunaBurger(X),!, fail.
```

```
enjoys(vincent,X) :- burger(X) .
```

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```

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?- enjoys(vincent,b) .  
false
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bigMac(a).  
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bigMac(c).  
whopper(d).  
  
enjoys(vincent,X) :- bigKahunaBurger(X),!, fail.  
enjoys(vincent,X) :- burger(X).  
  
?- enjoys(vincent,b).  
false
```

Prolog tries to substitute `b` in `bigKahunaBurger(X)` in the first clause. It will succeed, since `bigKahunaBurger(b)` ., so it goes on, through `!` all the way to `fail`. Because of the !  cannot go back and look for other possible substitutions for `b`...

NEGATION AS FAILURE

The cut-fail combination offers us some form of negation.

It is called **negation as failure**, and defined as follows:

```
neg(Goal) :- Goal, !, fail.  
neg(Goal).
```

If Goal succeeds, make the clause fail, otherwise let it go on.

Since negation as failure is frequently used in  , there is a built-in predicate for it: \+

NEGATION AS FAILURE

3 equivalent expressions of the fact that `vincent enjoys` all sorts of `burgers` except for `bigKahunaBurger`:

```
enjoys(vincent,X) :- bigKahunaBurger(X), !, fail.  
enjoys(vincent,X) :- burger(X).
```

```
enjoys(vincent,X) :- burger(X), neg(bigKahunaBurger(X)).
```

```
enjoys(vincent,X) :- burger(X), \+bigKahunaBurger(X).
```

Negation as failure is not a logical negation.

After the `!` we cannot go back, the program will fail.

This is why we need to have `burger(X)` before `\+`. We need to allow freely select, substitute from our set of `burgers` first.



A trick with `fail`

A TRICK WITH FAIL

Let's say we want  not only to give us a suggestion about what `burgers vincent` would like, but we want to be able to have a full list of these `burgers`!

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Let's say we want  not only to give us a suggestion about what `burgers vincent` would like, but we want to be able to have a full list of these `burgers`!

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bigMac(a).  
bigKahunaBurger(b).  
bigMac(c).  
whopper(d).  
  
enjoys(vincent,X) :- burger(X), \+bigKahunaBurger(X).  
  
whattobuyto(Y) :- enjoys(Y,X), write(X), nl, fail; true.
```

A TRICK WITH FAIL

Let's say we want  not only to give us a suggestion about what `burgers vincent` would like, but we want to be able to have a full list of these `burgers`!

```
burger(X) :- bigMac(X).  
burger(X) :- bigKahunaBurger(X).  
burger(X) :- whopper(X).  
  
bigMac(a).  
bigKahunaBurger(b).  
bigMac(c).  
whopper(d).  
  
enjoys(vincent,X) :- burger(X), \+bigKahunaBurger(X).  
  
whattobuyto(Y) :- enjoys(Y,X), write(X), nl, fail; true.
```

Until there are `burgers` that have never been tested, `fail` will make  going back to `burgers` – since  backtracks locally. At the point

where all the `burgers` in the KB have been checked,  will go back to the main rule (`whattobuyto`) to see if there are any other ways to save the day,