

Recitation: Unification

11-711: Algorithms for NLP

November 20, 2015

Example

Here is a small lexicon of feature structures:

1. DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$

2. N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$

3. VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$

Example

And here are two
context-free grammar rules
with unification
constraints:

$NP \rightarrow DET N$

$\langle NP \text{ det} \rangle = \langle DET \rangle$

$\langle NP \rangle = \langle N \rangle$

1.

$S \rightarrow NP VP$

$\langle NP \text{ num} \rangle = \langle VP \text{ num} \rangle$

$\langle S \text{ subj} \rangle = \langle NP \rangle$

$\langle S \rangle = \langle VP \rangle$

2.

Example

And here are two
context-free grammar rules
with unification
constraints:

$$\text{NP} \rightarrow \text{DET N}$$
$$\langle \text{NP det} \rangle = \langle \text{DET} \rangle$$
$$\langle \text{NP} \rangle = \langle \text{N} \rangle$$

1.

$$\text{S} \rightarrow \text{NP VP}$$
$$\langle \text{NP num} \rangle = \langle \text{VP num} \rangle$$
$$\langle \text{S subj} \rangle = \langle \text{NP} \rangle$$
$$\langle \text{S} \rangle = \langle \text{VP} \rangle$$

2.

Converted to feature
structures:

$$\left[\begin{array}{l} \text{NP} \quad \boxed{1} \quad [\text{det} \quad \boxed{2}] \\ \text{DET} \quad \boxed{2} \\ \text{N} \quad \boxed{1} \end{array} \right]$$
$$\left[\begin{array}{l} \text{S} \quad \boxed{1} \quad [\text{subj} \quad \boxed{2}] \\ \text{NP} \quad \boxed{2} \quad [\text{num} \quad \boxed{3}] \\ \text{VP} \quad \boxed{1} \quad [\text{num} \quad \boxed{3}] \end{array} \right]$$

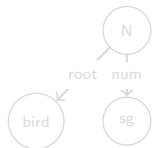
Example

Let's convert the feature structures to their DAG representations:

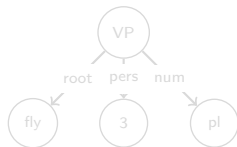
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


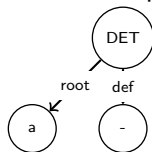
VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


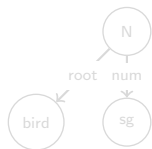
Example

Let's convert the feature structures to their DAG representations:

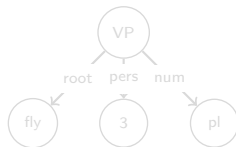
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


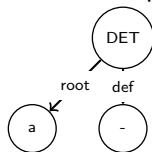
VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


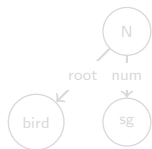
Example

Let's convert the feature structures to their DAG representations:

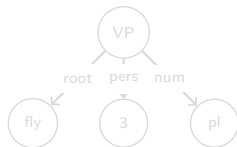
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


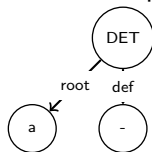
VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


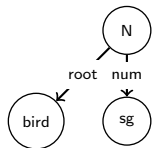
Example

Let's convert the feature structures to their DAG representations:

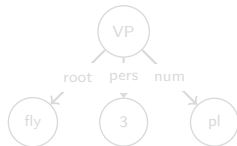
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


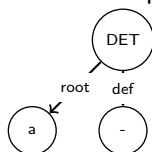
VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


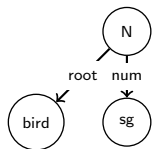
Example

Let's convert the feature structures to their DAG representations:

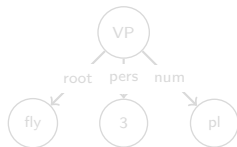
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


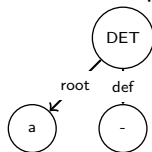
VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


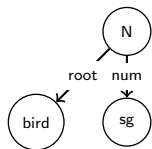
Example

Let's convert the feature structures to their DAG representations:

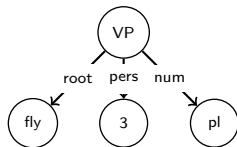
DET:

$$\begin{bmatrix} \text{root} & \text{a} \\ \text{def} & - \end{bmatrix}$$


N:

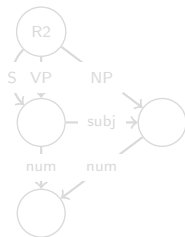
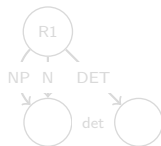
$$\begin{bmatrix} \text{root} & \text{bird} \\ \text{num} & \text{sg} \end{bmatrix}$$


VP:

$$\begin{bmatrix} \text{root} & \text{fly} \\ \text{pers} & 3 \\ \text{num} & \text{pl} \end{bmatrix}$$


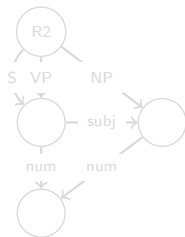
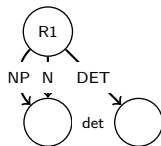
Example

Let's convert the feature structures to their DAG representations:



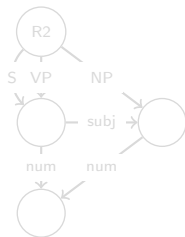
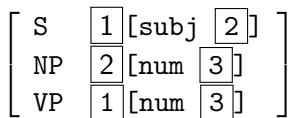
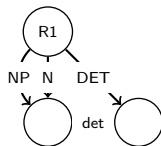
Example

Let's convert the feature structures to their DAG representations:



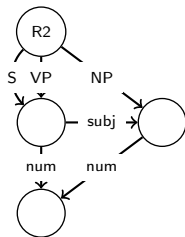
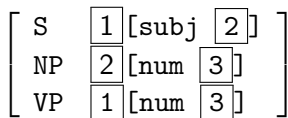
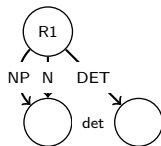
Example

Let's convert the feature structures to their DAG representations:



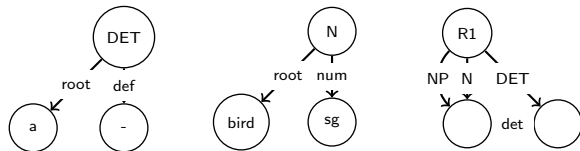
Example

Let's convert the feature structures to their DAG representations:



Example

Let's try to unify DET and N using Grammar Rule (1):



Algorithm

function UNIFY(*f1-orig*, *f2-orig*) **returns** f-structure or failure

f1 ← Dereferenced contents of *f1-orig*

f2 ← Dereferenced contents of *f2-orig*

if *f1* and *f2* are identical **then**

f1.pointer ← *f2*

return *f2*

else if *f1* is null **then**

f1.pointer ← *f2*

return *f2*

else if *f2* is null **then**

f2.pointer ← *f1*

return *f1*

else if both *f1* and *f2* are complex feature structures **then**

f2.pointer ← *f1*

for each *f2-feature* **in** *f2* **do**

f1-feature ← Find or create a corresponding feature in *f1*

if UNIFY(*f1-feature.value*, *f2-feature.value*) **returns** failure **then**

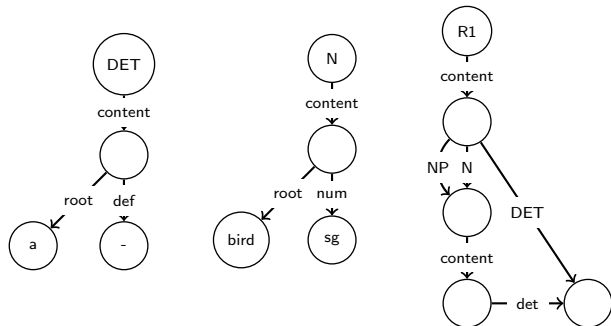
return failure

return *f1*

else return failure

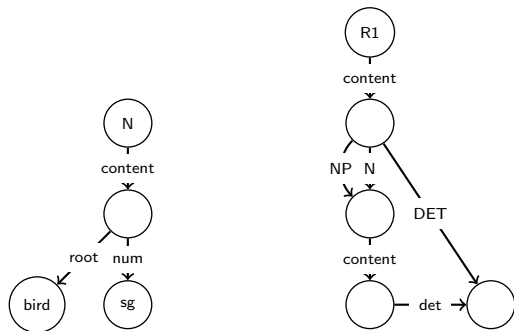
Example

Let's try to unify DET and N using Grammar Rule (1):
Insert pointers (I'm omitting content / pointer arcs when they are unused):



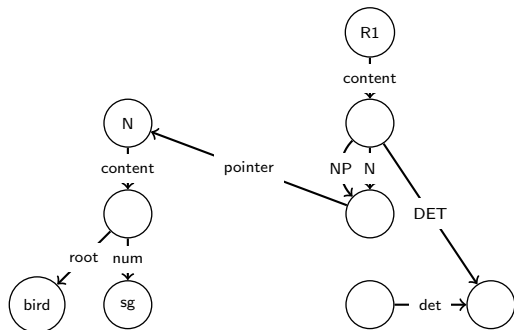
Example

Let's try to unify DET and N using Grammar Rule (1):
Unify the N lexical entry with the N node in R1:



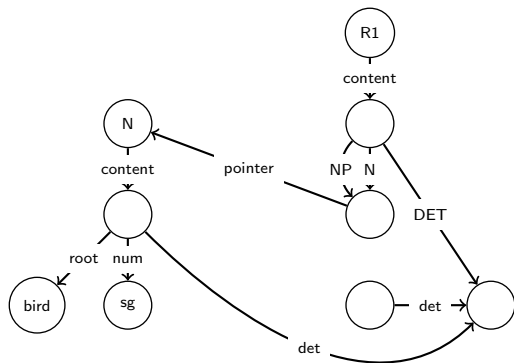
Example

Let's try to unify DET and N using Grammar Rule (1):
Unify the N lexical entry with the N node in R1:



Example

Let's try to unify DET and N using Grammar Rule (1):
Unify the N lexical entry with the N node in R1:

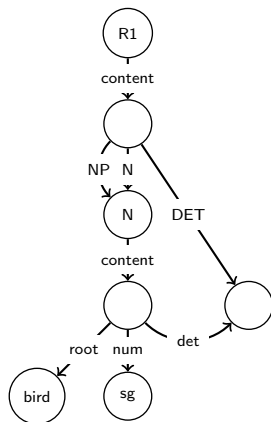


Example

Let's try to unify DET and N using Grammar Rule (1):

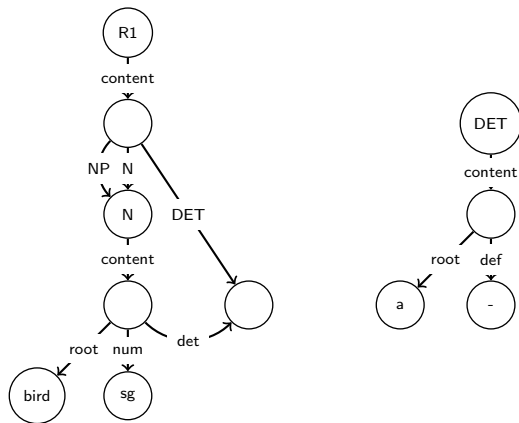
Unify the N lexical entry with the N node in R1:

Throw away extra/dead links



Example

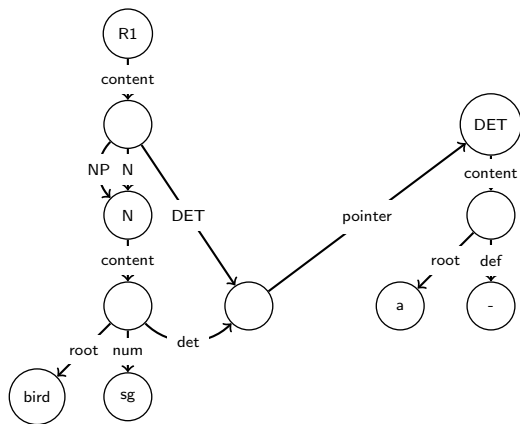
Let's try to unify DET and N using Grammar Rule (1):
Unify the DET lexical entry with the DET node in R1:



Success! Now we get a new NP rooted at the NP node.

Example

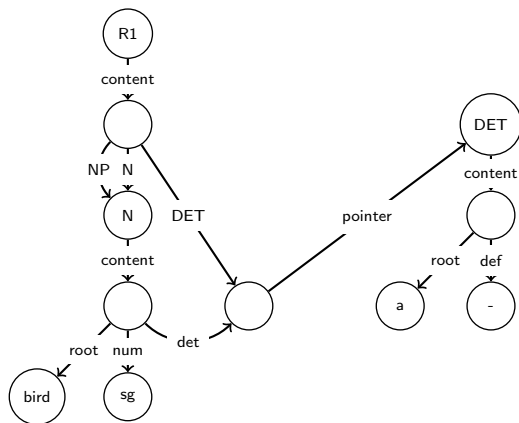
Let's try to unify DET and N using Grammar Rule (1):
Unify the DET lexical entry with the DET node in R1:



Success! Now we get a new NP rooted at the NP node.

Example

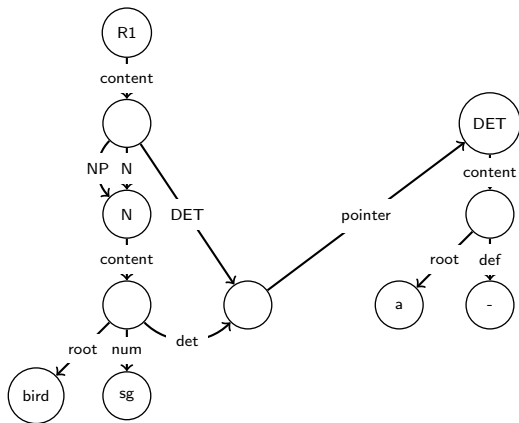
Let's try to unify DET and N using Grammar Rule (1):
Unify the DET lexical entry with the DET node in R1:



Success! Now we get a new NP rooted at the NP node.

Example

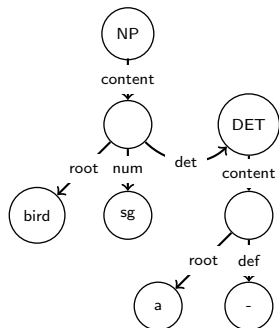
Let's try to unify DET and N using Grammar Rule (1):
Unify the DET lexical entry with the DET node in R1:



Success! Now we get a new NP rooted at the NP node.

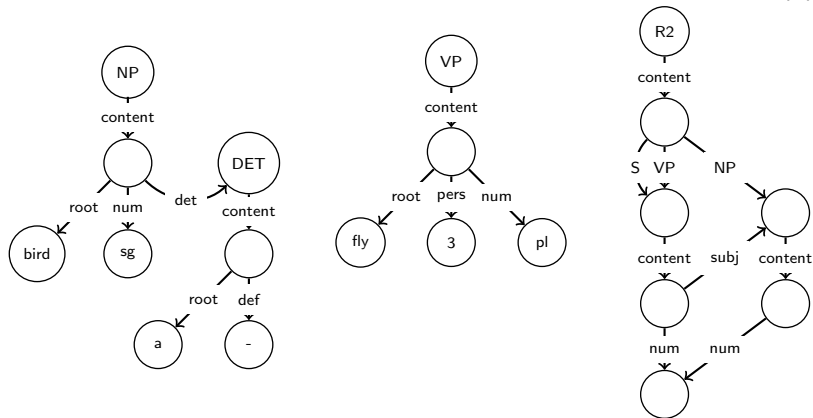
Example

Now we get a new NP rooted at the NP node (extra/dead links removed).



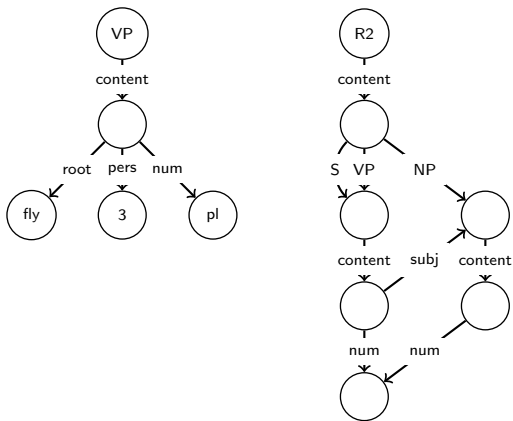
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):



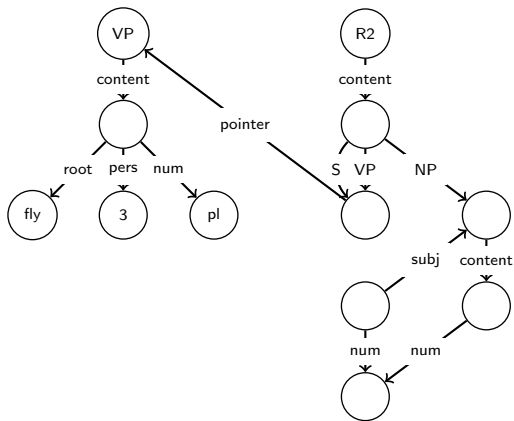
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the VP lexical entry with the VP node in R2:



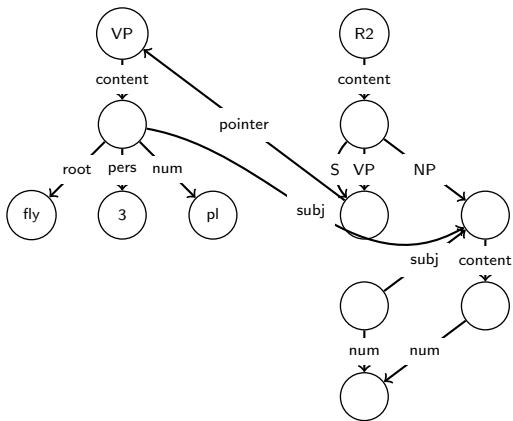
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the VP lexical entry with the VP node in R2:



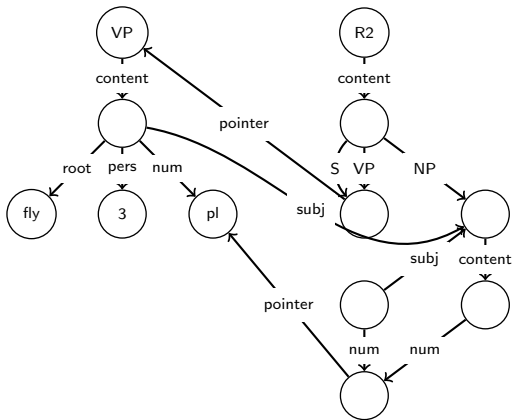
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the VP lexical entry with the VP node in R2:



Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the VP lexical entry with the VP node in R2:

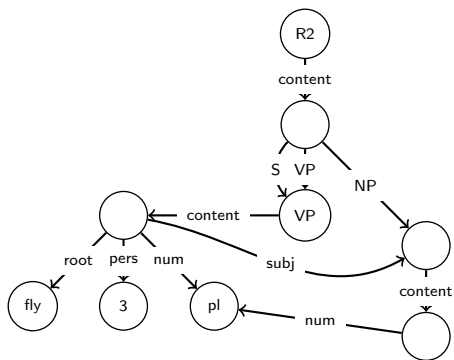


Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):

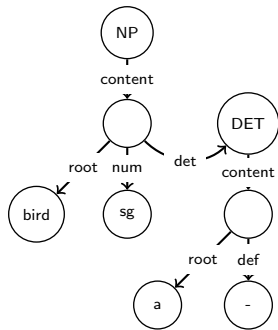
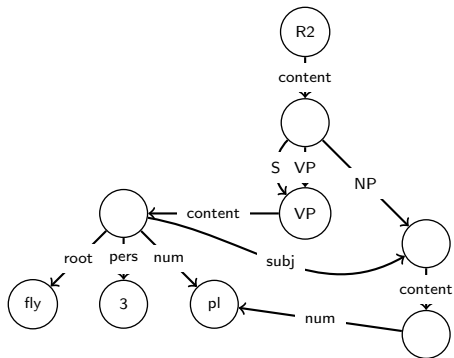
Unify the VP lexical entry with the VP node in R2:

Remove extra/dead links:



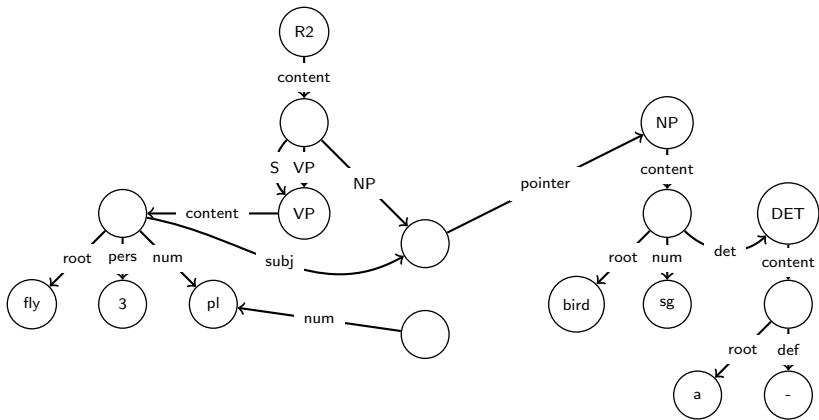
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the NP with the NP node in the result:



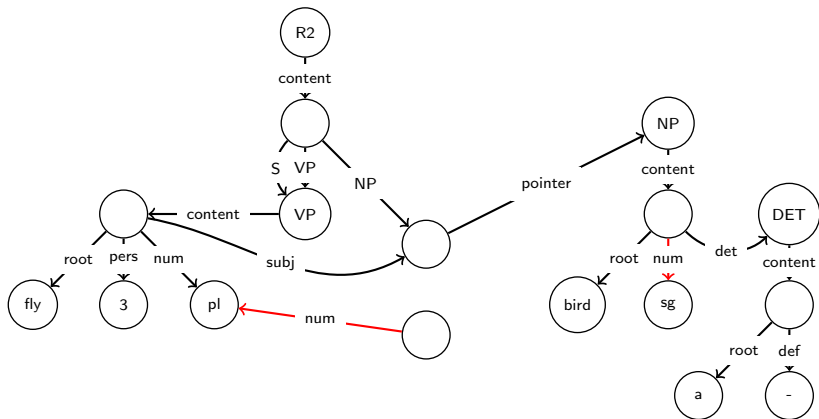
Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the NP with the NP node in the result:



Example

Let's unify the resulting NP with the VP lexical entry using Rule (2):
Unify the NP with the NP node in the result:



FAIL!