

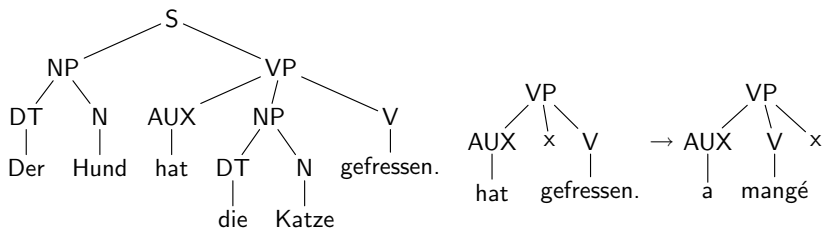
Compositions of extended top-down tree transducers

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M1 Internship defense

Supervised by Andreas Maletti
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Universität Stuttgart

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Natural Language Processing (NLP), in particular Machine Translation:



Le chien a mangé le chat.

1 Motivations

2 Introduction

- Geographic and human context
- What is an xtt?
- Compositions of xtt

3 Compositions of unweighted nl-xtt

- Goal
- Compatibility procedure
- Composition
- Recombination of the rules

4 Conclusion

- My work
- Perspectives

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Universität Stuttgart, Institut für Maschinelle Sprachverarbeitung.

Team:

- Andreas Maletti (Supervisor)
- Daniel Quernheim (PhD Student)
- Fabienne Braune (PhD Student)
- Nina Seemann (PhD Student)

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Top-Down Tree Automaton:

$$\mathcal{A} = (Q, \Sigma, I, R)$$

- Q : finite set of states
- Σ : alphabet
- I : initial states
- R : rules of the shape $q \rightarrow f(q_1, \dots, q_n)$

$$\mathcal{A} = (\{q_0, q_1\}, \{f^{(2)}, a^{(0)}, b^{(0)}\}, \{q_0\}, \{\rho_1, \rho_2, \rho_3\})$$

$$\rho_1 : q_0 \rightarrow f(q_1, q_2)$$

$$\rho_2 : q_1 \rightarrow a$$

$$\rho_3 : q_2 \rightarrow b$$

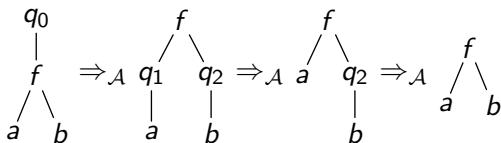


Figure: $f(a, b) \in \mathcal{L}(\mathcal{A})$

Extended Top-Down Tree Transducer (xtt):

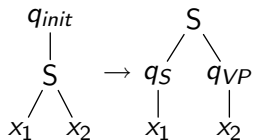
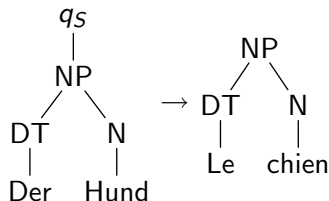
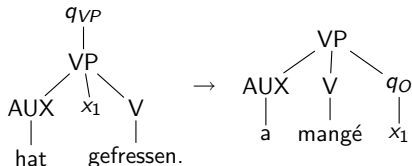
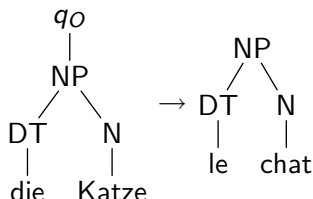
$$M = (Q, \Sigma, \Delta, I, R)$$

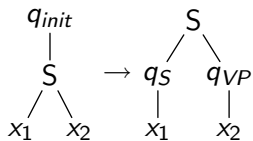
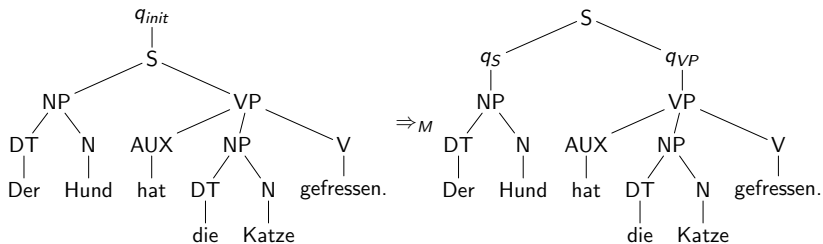
- Q : finite set of states
- Σ : input alphabet
- Δ : output alphabet
- I : initial states
- R : rules of the shape

$$q(t(x_1, \dots, x_n)) \rightarrow t'(q_1(x_{i_1}), \dots, q_k(x_{i_k})), \quad \begin{array}{l} t \in T_{\Sigma}(X), \\ t' \in T_{\Delta}(Q(X)) \end{array}$$

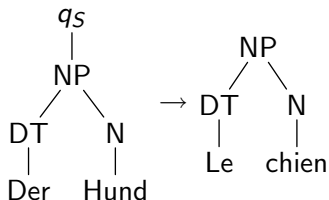
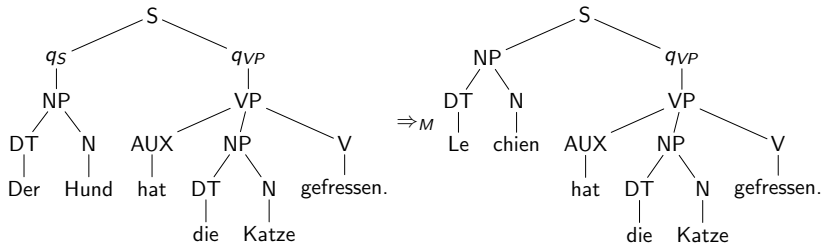
- linear: each variable is at most once in the right-hand side
- nondeleting: each variable is at least once in the right-hand side
- erasing: the right-hand is in $Q(X)$

$$M = (\{q_{init}, q_S, q_{VP}, q_O\}, \Sigma, \Delta, R)$$

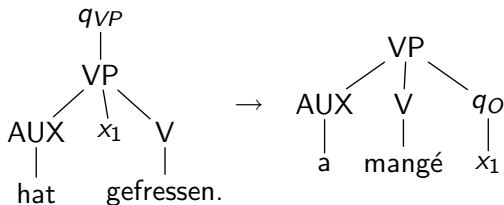
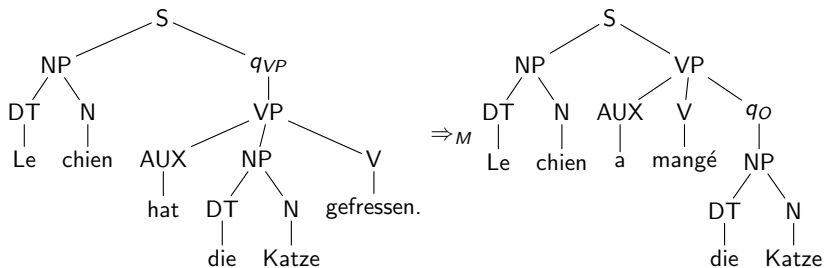
(a) ρ_1 (b) ρ_2 (c) ρ_3 (d) ρ_4

(e) ρ_1 

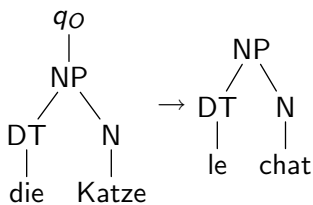
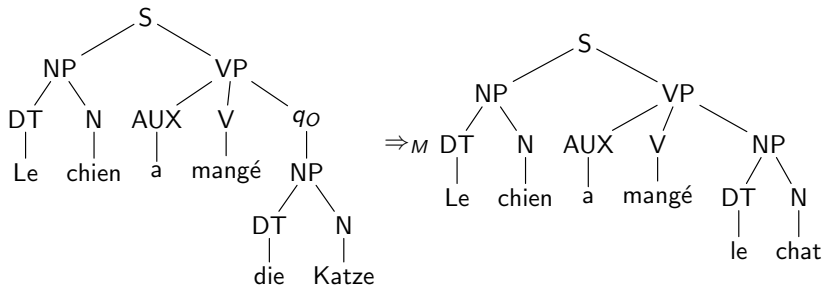
(f) Derivation: Step 1

(g) ρ_2 

(h) Derivation: Step 2

(i) ρ_3 

(j) Derivation: Step 3

(k) ρ_4 

(l) Derivation: Step 4

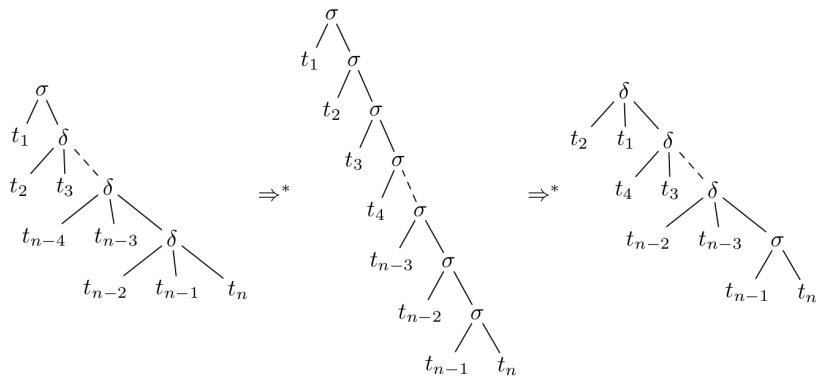
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Machine Translation \Rightarrow Divide and Conquer approach.

- a reordering component, which changes the order of subtrees,
- an insertion component, which adds subtrees to the output, and
- a translation component, which just translates the words.

Nl-xtt are not closed under composition



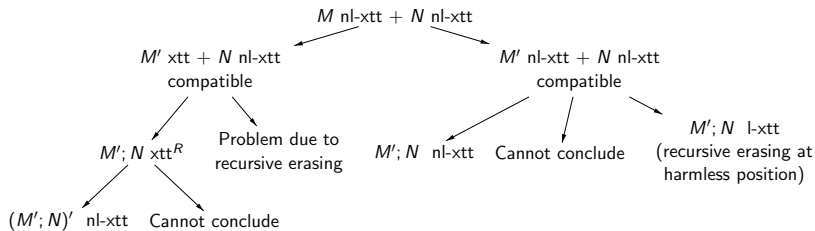
Xtt are not closed under composition

$$\alpha \Rightarrow^* \begin{array}{c} \gamma^n \\ | \\ \alpha \end{array} \Rightarrow^* \begin{array}{c} \sigma \\ / \quad \backslash \\ \gamma^n \quad \gamma^n \\ | \quad \quad | \\ \alpha \quad \quad \alpha \end{array}$$

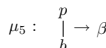
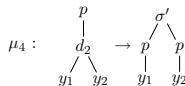
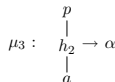
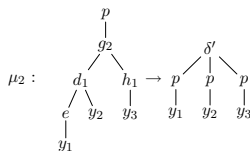
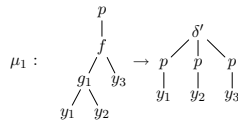
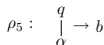
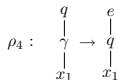
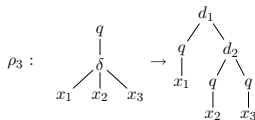
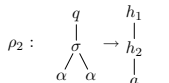
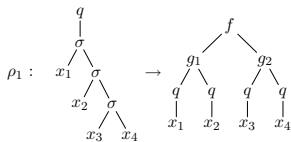
Figure: The first transformation is processed thanks to rule $q(x) \rightarrow \gamma(q(x))$, and the second one thanks to $p_0(x) \rightarrow \sigma(p(x), p(x))$.

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Running example: Rules of M and N



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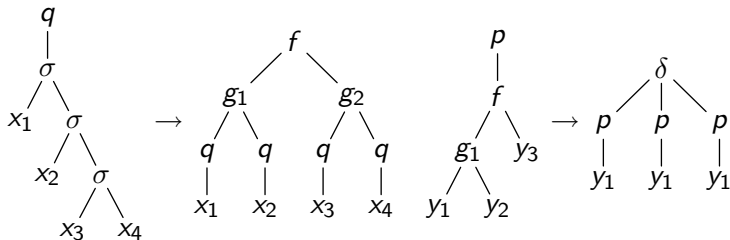


Figure: ρ_1 and μ_1

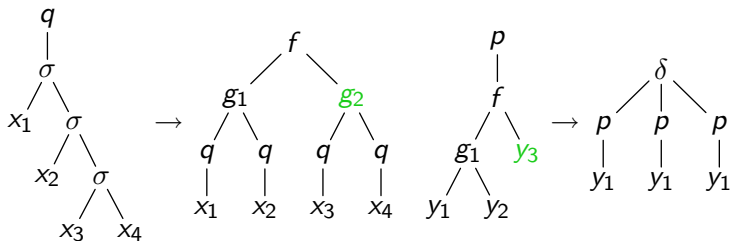


Figure: ρ_1 is not compatible with μ_1

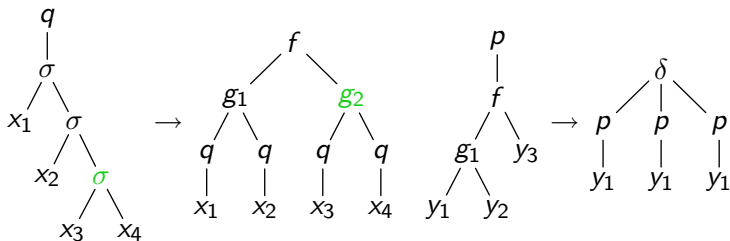


Figure: Find where to cut in the left-hand side

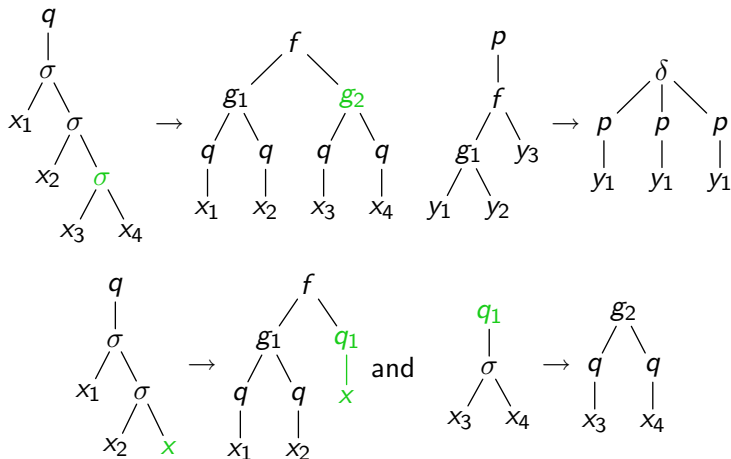
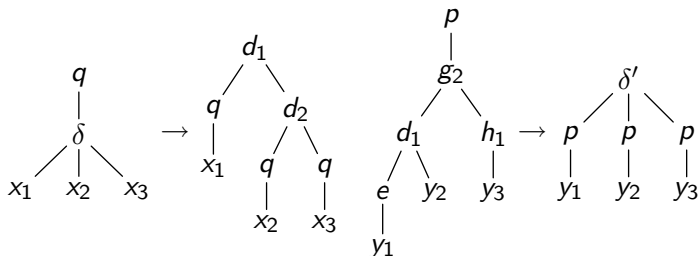


Figure: Create new rules

Figure: ρ_3 and μ_2

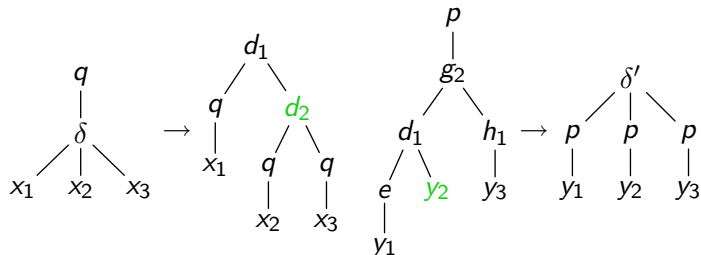


Figure: ρ_3 is not compatible with μ_2

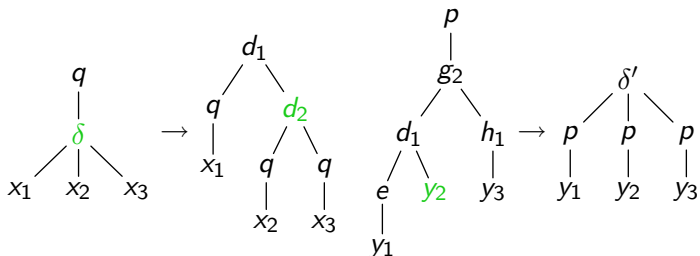


Figure: Find where to cut in the left-hand side

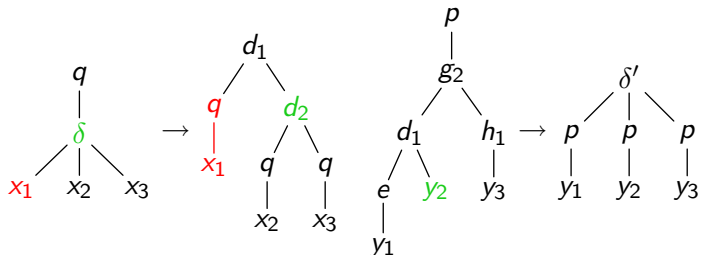


Figure: Check the variables under the cut on the left-hand side

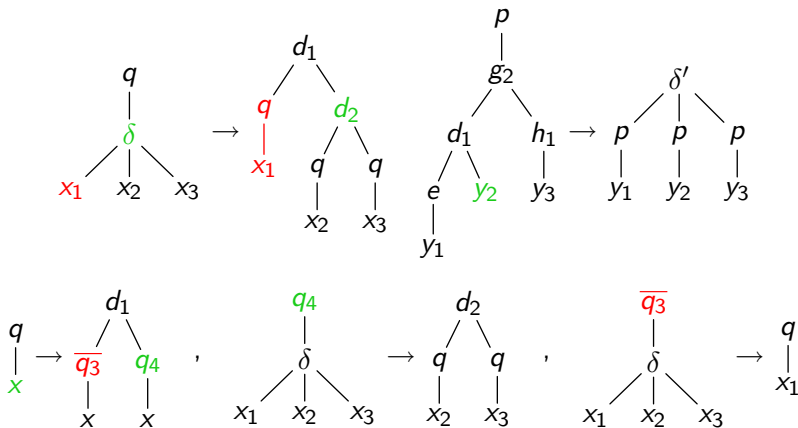


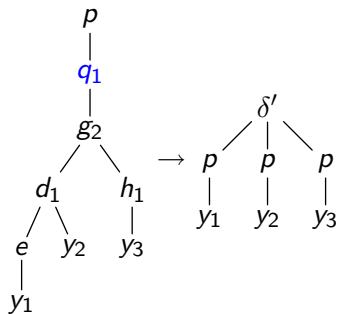
Figure: Create new rules

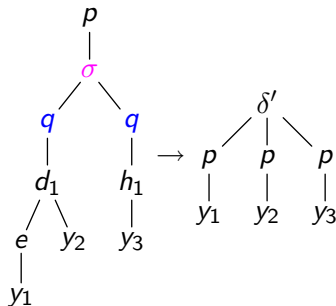
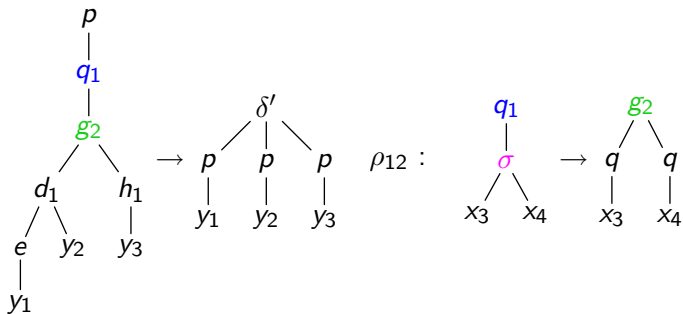
Compatibility step

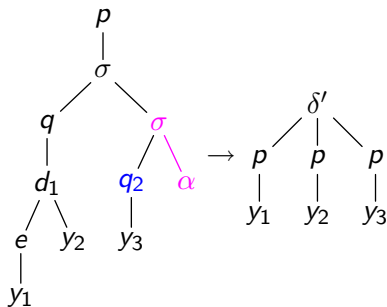
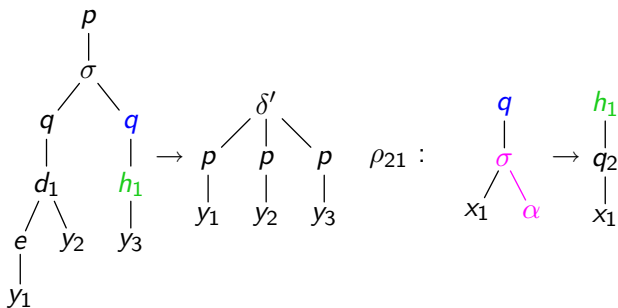
For all nl-xtt M and N , the compatibility procedure turns M into an equivalent xtt M' that is compatible with N . M' might be nonlinear and deleting.

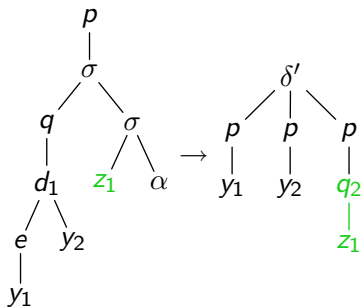
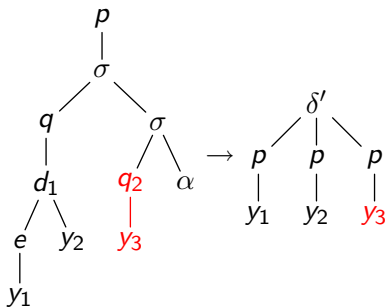
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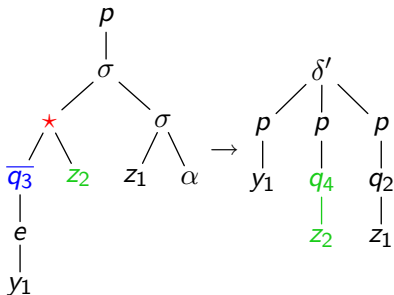
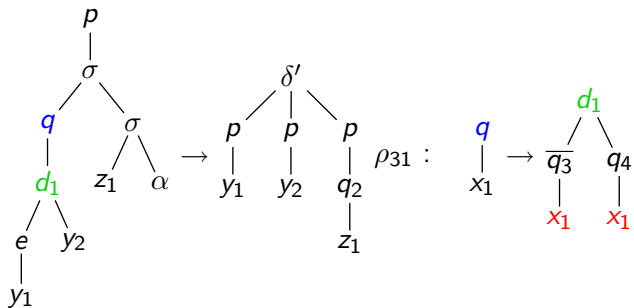
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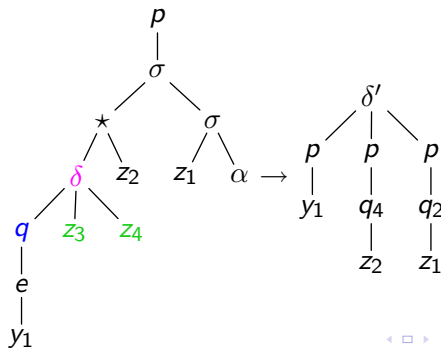
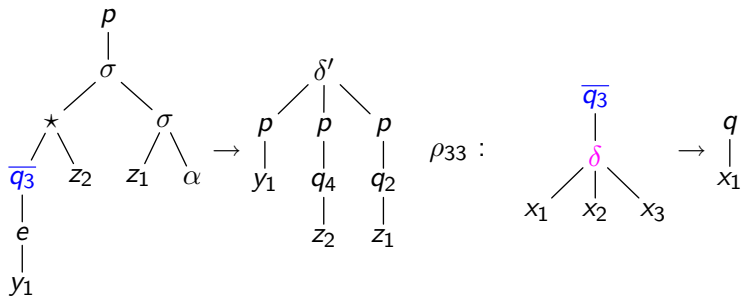


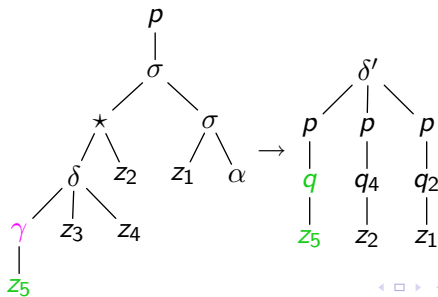
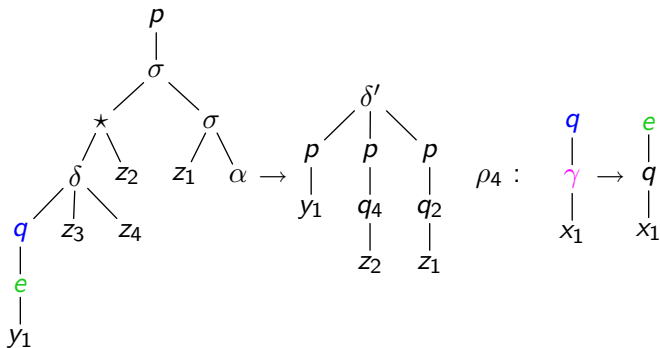


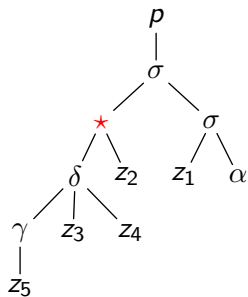




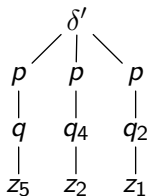




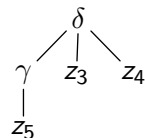




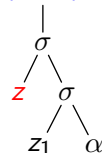
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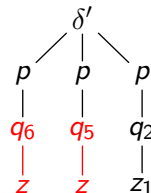
Unification:

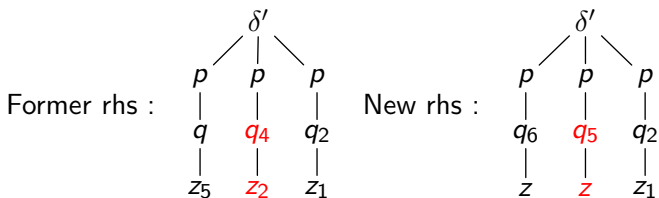


$$\varphi(z_2) = \varepsilon, \quad \varphi(z_5) = 11$$

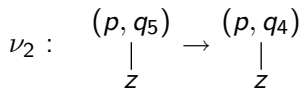
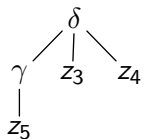
 $\nu_1 :$ (p, q_1) 

→

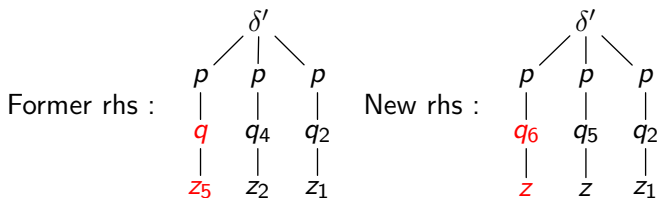




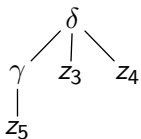
Unification:



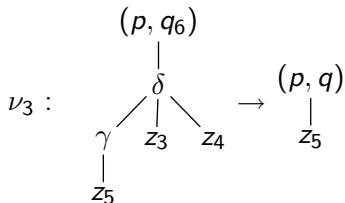
$$\varphi(z_2) = \varepsilon, \quad \varphi(z_5) = 11$$

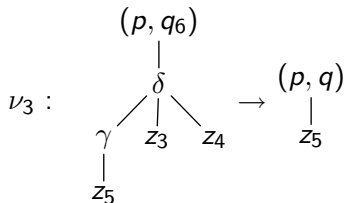
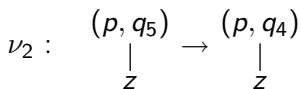
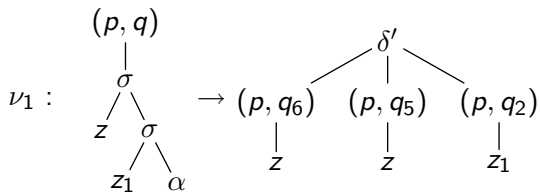


Unification:



$$\varphi(z_2) = \varepsilon, \quad \varphi(z_5) = 11$$





Composition step with no recursive erasing

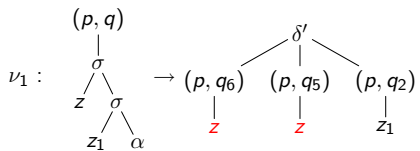
For all xtt M and N , such that

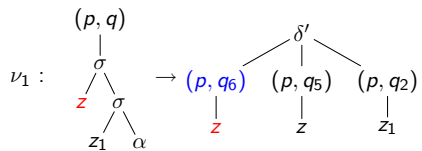
- N is linear and nondeleting,
- M has no recursive erasing, and
- M and N are compatible,

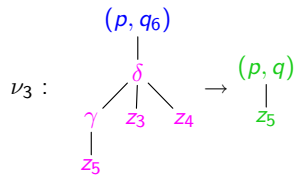
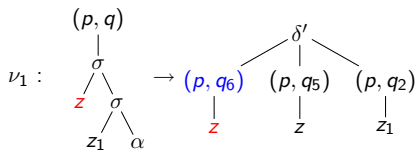
the composition step builds an xtt $M; N$ that computes the composition of M and N .

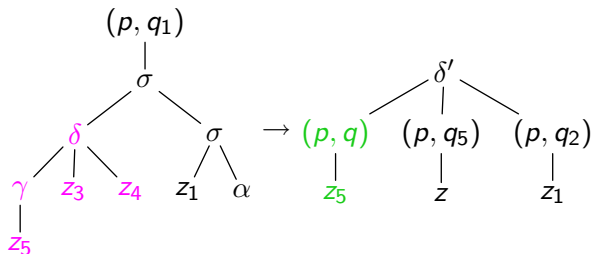
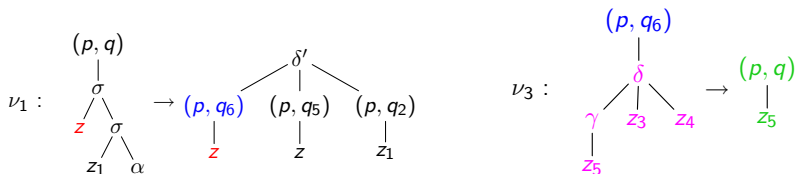
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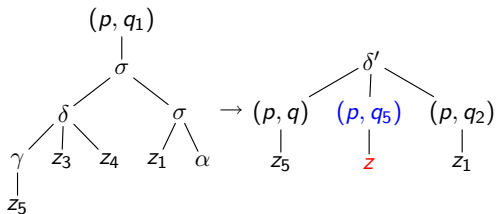




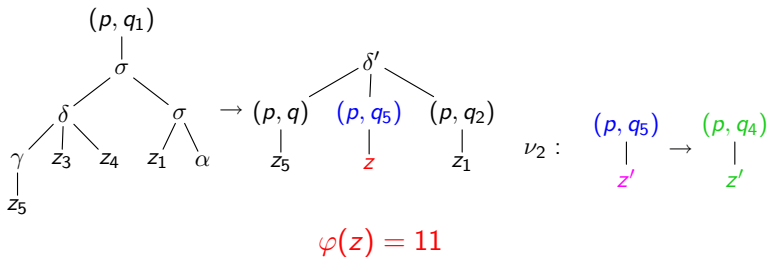


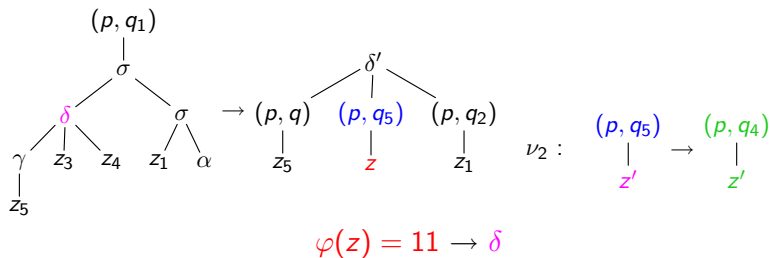


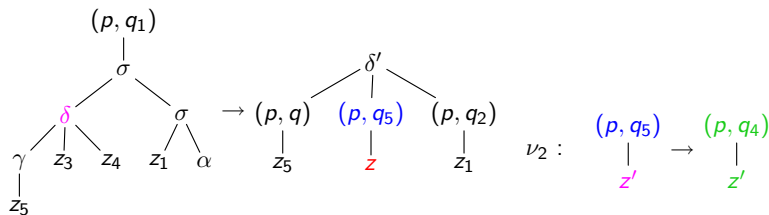
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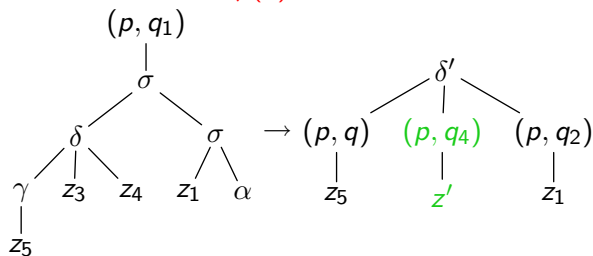
$$\varphi(z) = 11$$



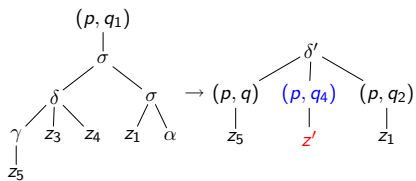




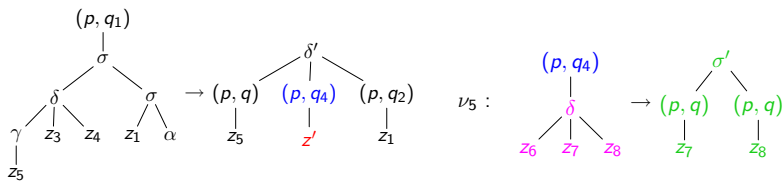
$$\varphi(z) = 11 \rightarrow \delta$$



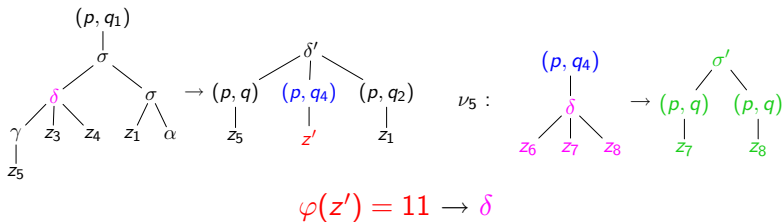
$$\varphi(z') = 11$$

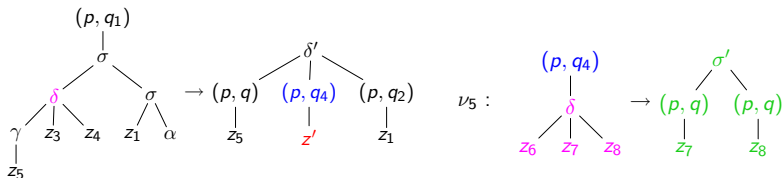


$$\varphi(z') = 11$$

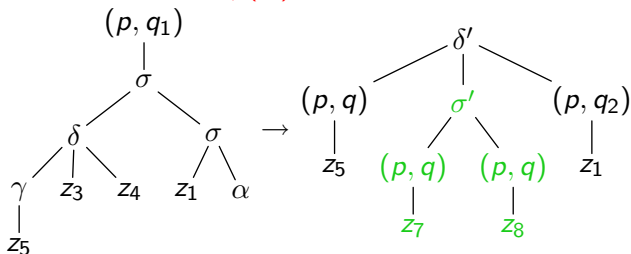


$$\varphi(z') = 11$$

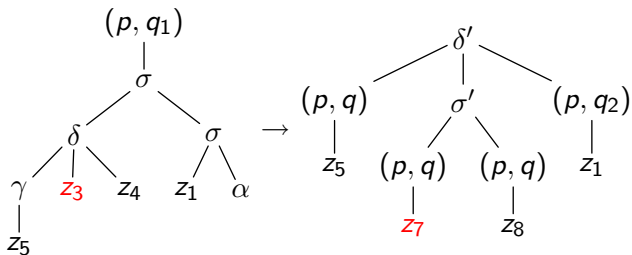




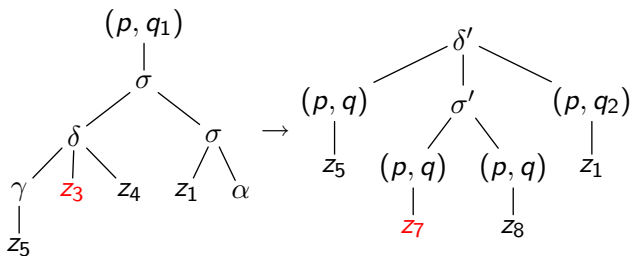
$$\varphi(z') = 11 \rightarrow \delta$$



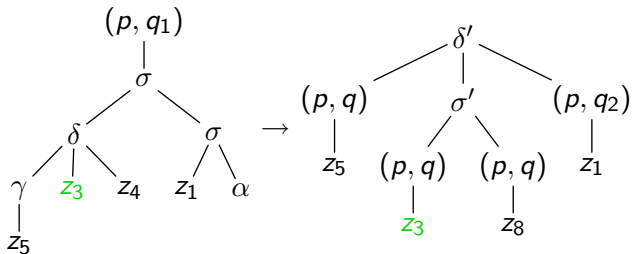
$$\varphi(z_7) = 112, \varphi(z_8) = 113$$

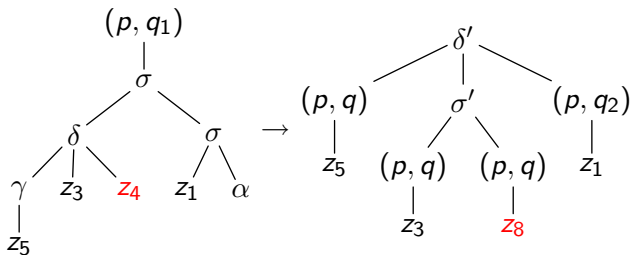


$$\varphi(z_7) = 112 \rightarrow z_3$$

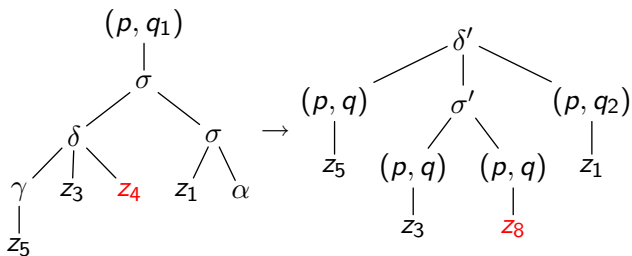


$$\varphi(z_7) = 112 \rightarrow z_3$$

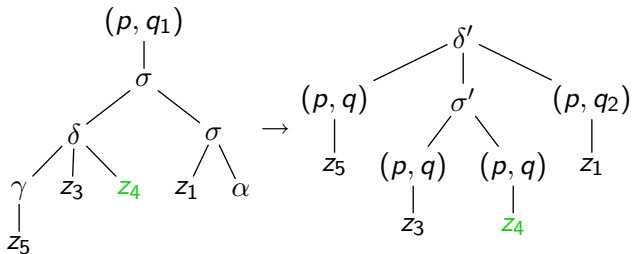




$$\varphi(z_8) = 113 \rightarrow z_4$$



$$\varphi(z_8) = 113 \rightarrow z_4$$



Recombination step

For all xtt $M; N$ output by the composition step, if the recombination succeeds then it returns an nl-xtt that computes the composition of M and N .

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My work

- Survey:
Weighted Extended Top-down Tree Transducers
Part III: Composition
In: Algebraic Foundations of Computer Science,
Lecture Notes in Computer Science, Springer
- Project:
Composition of Unweighted nl-xtt
An algorithm split into 3 procedures
Status: draft ready, preparing submission at a top NLP
conference.

Sommaire

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Perspectives

- Implement the algorithm.
- Run it on real NLP nl-xtt.
- Evaluate the proportions of cases where the algorithm does not answer.
- If it is important, try to decide these cases.

Thank you for your attention!