Tree Adjoining Grammars

Grammar Implementation with XMG

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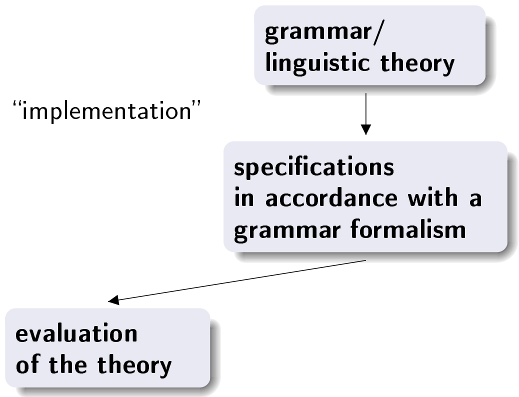
Outline

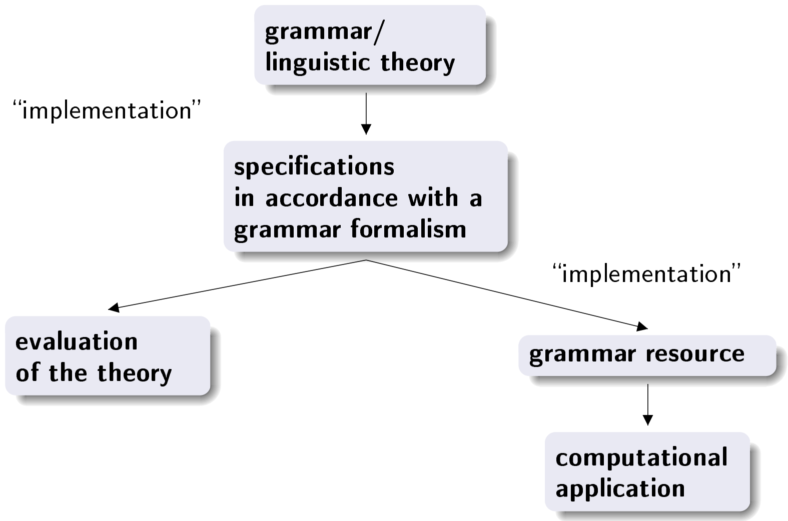
1. What is grammar implementation?
2. Two ways of tree template implementation:
   - Metarules
   - Metagrammars
3. eXtended Metagrammar (XMG)
4. A case study with XMG

Two kinds of grammar implementation

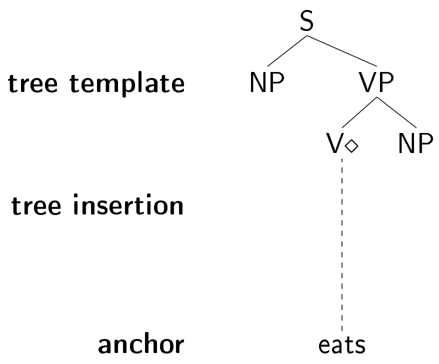


As is frequently pointed out but cannot be overemphasized, an important goal of formalization in linguistics is to enable subsequent researchers ***to see the defects of an analysis as clearly as its merits****; only then can progress be made efficiently.* [Dowty, 1979, 322]

Two kinds of grammar implementation



What kind of grammar resource?



The implementation task for LTAG

General task

Implement a large-coverage LTAG, i.e. based on the XTAG grammar!

Subtasks:

1. Generate unlexicalized trees (= tree templates)!
2. Generate a database of lexical anchors (= the lexicon)!
3. Connect the tree templates with the lexicon (= lexical insertion)!

Two ways of grammar implementation with TAG

- **XTAG tools** [XTAG Research Group, 2001]
  1. implementation tools (with metarules)
  2. editor/viewer for MorphDB and SynDB
  3. parser
- **XMG + lexConverter + TuLiPA**
  1. XMG: eXtensible MetaGrammar [Duchier et al., 2004]
  2. lexConverter (LEX2ALL)
  3. TuLiPA: Tübingen Linguistic Parsing Architecture [Parmentier et al., 2008]

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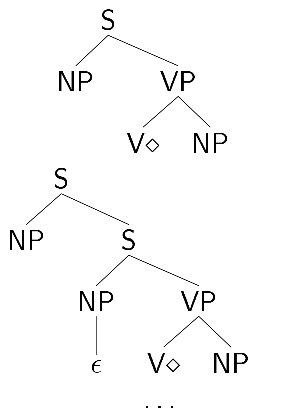
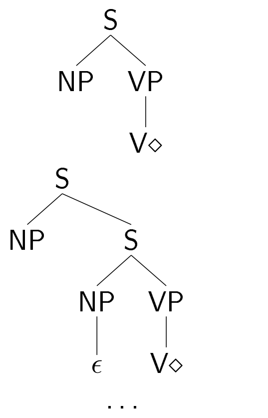
The situation

39 templates for transitive verbs



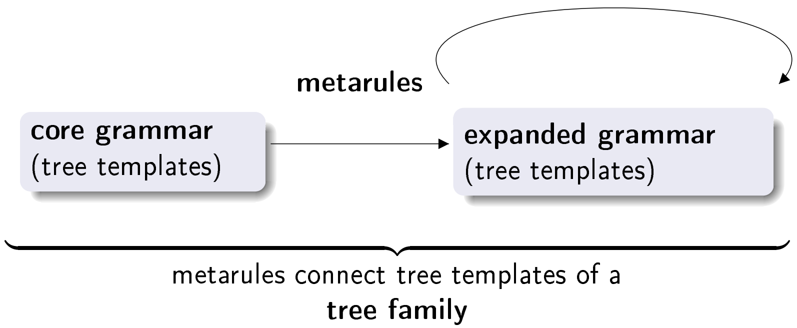
12 tree templates for intransitive verbs



Basically, XTAG defines a set of 221 unrelated tree templates.

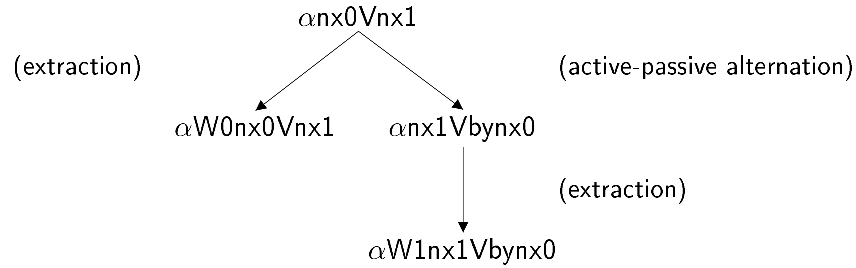
Metarules for LTAG

[Becker, 1994], [Becker, 2000], [Prolo, 2002]
Idea from GPSG [Gazdar, 1981]



Metarules for LTAG: Example

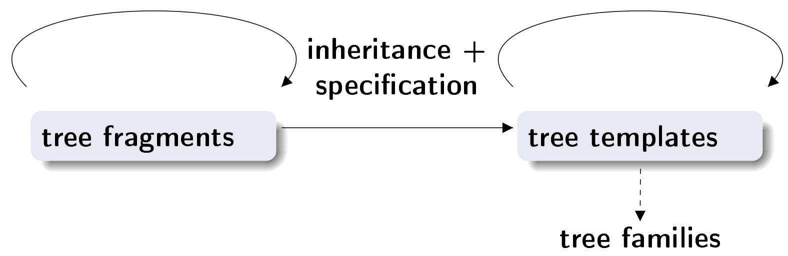
Tnx0nx1:



Metarules do not only add structure, they can also eliminate structure!

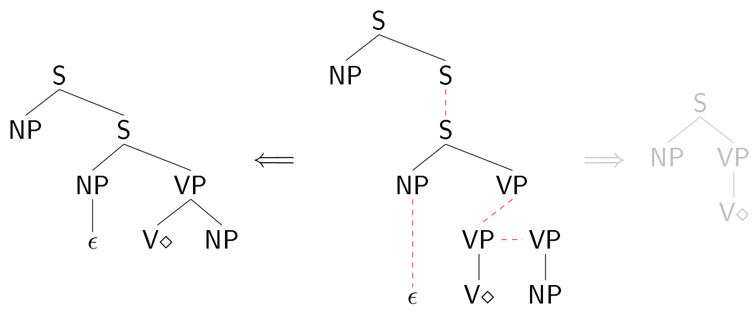
Metagrammars for LTAG

[Candito, 1996], [Xia, 2001], [Crabbé, 2005]

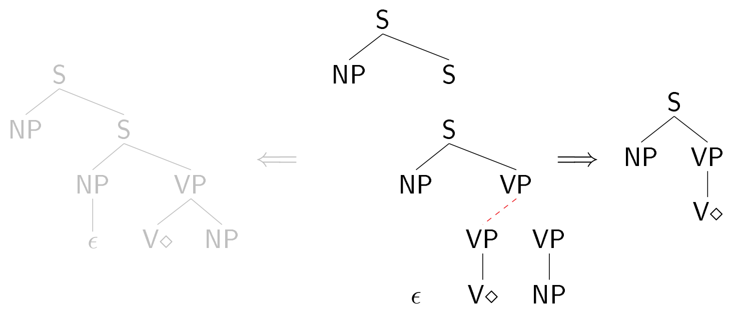


- **tree fragments**: additional layer of abstraction below the level of tree templates
- A tree template is the result of combining and specifying tree fragments and tree templates.
- The notion of **tree families** is independent from the construction of tree templates!

Metagrammars for LTAG: Example



Metagrammars for LTAG: Example



Outline

XMG - Background

- name of the metagrammar formalism and of a metagrammar compiler
- developed at LORIA, Nancy, France
- written in Oz/Mozart
- available at `http://sourcesup.cru.fr/xmg`

⇒ Other metagrammar implementations exist, but XMG is the most elaborate one.

Some existing implementations using XMG:

- French: FrenchTAG [Crabbé, 2005]
- English: XTAG with XMG [Alahverdzhieva, 2008]
- German: GerTT [Kallmeyer et al., 2008]

XMG - Description language for tree fragments

$\mathcal{L}_D$: Description language for tree fragments

Let ?x and ?y be nodes:

```
                  ( ?x -> ?y | ?x ->+ ?y | ?x ->* ?y |  )
                  ( ?x >> ?y | ?x >>+ ?y | ?x >>* ?y |  )
Description ::=   ( ?x = ?y |                           )
                  ( ?x[f=E] | ?x(p=E) |                 )
                  ( Description ∧ Description           )
```

->	immediate dominance
->+	dominance (transitive, non-reflexive closure)
->*	reflexive dominance (transitive, reflexive closure)
>>	immediate precedence
>>+	precedence (transitive, non-reflexive closure)
>>*	reflexive precedence (transitive, reflexive closure)
?x[f=E]	feature declaration
?x(p=E)	property declaration

XMG - Description language for tree fragments

$\mathcal{L}_D$: Description language for tree fragments

Let ?x and ?y be nodes:

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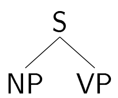
                  ( ?x -> ?y | ?x ->+ ?y | ?x ->* ?y |  )
                  ( ?x >> ?y | ?x >>+ ?y | ?x >>* ?y |  )
Description ::=   ( ?x = ?y |                           )
                  ( ?x[f=E] | ?x(p=E) |                 )
                  ( Description ∧ Description           )
```

Example:



can be described as

```
{ ?S -> ?NP,
  ?S -> ?VP1,
  ?NP >> ?VP1,
  ?S[cat=s],
  ?NP[cat=np],
  ?VP1[cat=vp] }
```


XMG - Description language for tree fragments

Tree descriptions can denote more than one tree fragment!
BUT: Each of the tree fragments has to comply with all of the tree descriptions!

⇒ Infinitely many trees satisfy

```
{ ?S -> ?NP,
  ?S -> ?VP1,
  ?NP >> ?VP1,
  ?S[cat=s],
  ?NP[cat=np],
  ?VP1[cat=vp] }
```

XMG only considers the **minimal model** of a tree description, hence trees that only contain nodes given in the description.

XMG - Description language - Classes

Tree descriptions are encapsuled in so-called **classes**:

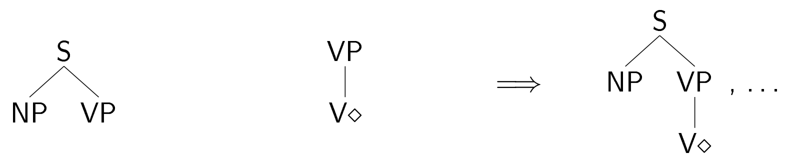
$\mathcal{L}_C$: Description language for the combination of tree descriptions

```
Class ::= Name → Content

              ( Description | Name |  )
Content ::=   ( Content ∨ Content |   )
              ( Content ∧ Content     )
```

- Node variables have a scope local to the class (= name space).
- When combining tree descriptions δ_1 and δ_2:
  1. XMG unifies δ_1 and δ_2, and
  2. XMG renames variables common variables.

XMG - Description languages - Examples




```
{ ?S -> ?NP,          { ?VP1 -> ?V,          { ?S -> ?NP,
  ?S -> ?VP1,           ?VP1[cat=vp],          ?S -> ?VP1,
  ?NP ≫ ?VP1,           ?V[cat=v],             ?NP ≫ ?VP1,
  ?S[cat=s],            ?V(mark=anchor) }      ?S[cat=s],
  ?NP[cat=np],                                 ?NP[cat=np],
  ?VP1[cat=vp] }                               ?VP1[cat=vp],
                                               ?VP2 -> ?V,
                                               ?VP2[cat=vp],
                                               ?V[cat=v],
                                               ?V(mark=anchor) }
```


XMG - The source code

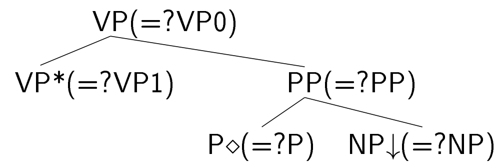
Tree fragments, tree templates and tree families are models of so-called **classes** (as known from object oriented programming).

```
class betavxPnx
declare ?VP0 ?VP1 ?PP ?P ?NP
{<syn>{
...
}}
```

- tree descriptions?
- feature structures?
- type of node (footnode, substitution node, anchor)?
- combination of trees?

XMG - The source code - The structure of trees

There are two ways to encode the structure of trees: (1) through tree descriptions, or (2) through brackets and linear order.



`class betavxPnx`
`declare ?VP0 ?VP1 ?PP ?P ?NP`
`{<syn>{`
`node ?VP0; node ?VP1;`
`node ?PP; node ?NP;`
`node ?P;`
?VP0 -> ?VP1; ?VP0 -> ?PP;
?PP -> ?P; ?PP -> ?NP;
?VP1 >> ?PP; ?P >> ?NP
`}}`
	`class betavxPnx`
	`declare ?VP0 ?VP1 ?PP ?P ?NP`
	`{<syn>{`
	node ?VP0 {
	node ?VP1
	node ?PP {
	node ?P
	node ?NP
	}
	} `}}`

XMG - The source code - Properties and feature structures

Firstly, the value types of features and properties have to be declared.

```
type MARK = {subst, foot, anchor, coanchor, nadj }
type CAT = {np,v,vp,s}
```

Secondly, properties and features must be declared as well.

```
property mark : MARK
feature cat : CAT
```

Finally, properties and features of nodes can be specified.

```
class betavxPnx
{ ...
node ?NP (mark = subst) [cat = np]
... }
```

XMG - The source code - Complex feature structures

How to declare and use complex features?

```
type AGR = [   3rdsing : bool,
               num : NUM,
               pers : PERS,
               gen : GEN        ]
feature agr:AGR
...
node ?NP [agr = [3rdsing = +] ]
...
```

Top-bottom-feature-structures

In XMG, there are predefined complex features top and bot for the specification of top-bottom-feature structures. Otherwise, feature specifications hold for both top and bottom.

Note: Links between features can be established by variables!

XMG - The source code - Reusing classes

General convention: Names of reused classes have [] as a postfix.

First method:

Class instantiations can be assigned to variables in the body. Only exported variables of the class can be used by means of the dot operator.

```
class betavxPnx
{ ...
?VPSpine = VPSpine[];
?VPSpine.?VP0 = ?XP;
... }
```

Second method:

Classes can be imported, such that all variables of the imported class, that have been exported, can be used directly.

```
class betavxPnx
import VPSpine[]
{...
?VP0 = ?XP;
... }
```


XMG - The source code - Evaluation

Which class represents a tree template, i.e. which class needs to be evaluated by XMG?

⇒ This is expressed/triggered by the command **value**.

```
class betavxPnx
...
value betavxPnx
```


XMG - The source code - Putting the pieces together I

```
type MARK = {subst, foot, anchor, coanchor, nadj}
type CAT = {np,v,vp,s,pp,p}

property mark : MARK
feature cat : CAT

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% TREE FRAGMENTS:
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

class VPSpine
export ?VP0 ?VP1
declare ?VP0 ?VP1
{ <syn>{
    node ?VP0 [cat=vp]{
      node ?VP1 (mark=foot) [cat=vp]
  }
  }
}

class PrepositionalPhrase
export ?PP ?P ?NP
declare ?PP ?P ?NP
{ <syn>{
    node ?PP [cat=pp] {
      node ?P (mark=anchor) [cat=p]
      node ?NP (mark=subst) [cat=np]
    }
  }
}
```

XMG - The source code - Putting the pieces together II

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% TREE TEMPLATES:
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

class betavxPnx
declare ?PrepP ?VPSpine
{
  ?PrepP = PrepositionalPhrase[];
  ?VPSpine = VPSpine[];
  <syn> {
    ?VPSpine.?VP0 -> ?PrepP.?PP;
    ?VPSpine.?VP1 >> ?PrepP.?PP
  }
}

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% EVALUTATION:
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

value betavxPnx
```


Outline

XMG - The source code - Declaring a tree family

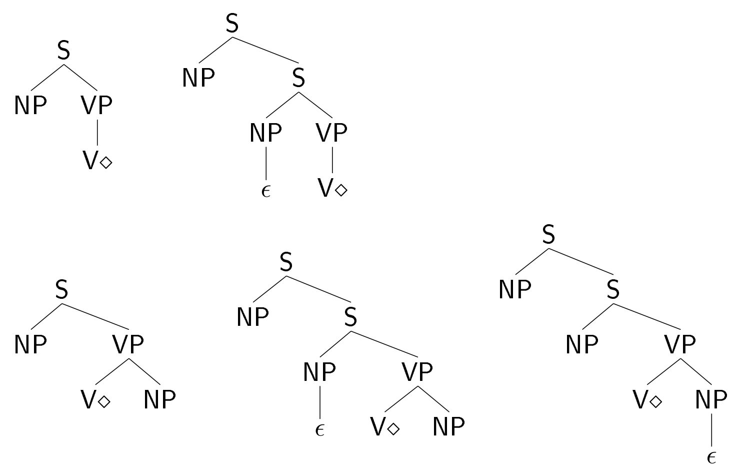
```
class Tnx0V
declare ?Tnx0V
{
        ?Tnx0V = ( alphanx0V[] | alphaW0nx0V[] )
}

...

value Tnx0V
```


XMG - Case study

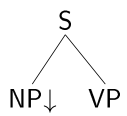
How to describe the tree families for intransitive (Tnx0V) and transitive (Tnx0Vnx1) tree templates?



XMG - Case study - The fragments

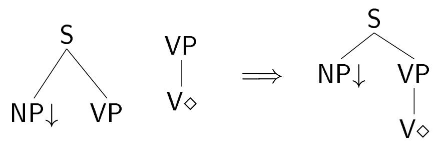

```
class VerbProjection
export ?VP ?V
declare ?VP ?V
{<syn>{
    node ?VP [cat = vp];
    node ?V (mark = anchor)[cat = v];
    ?VP -> ?V
  }
}
```


XMG - Case study - The fragments



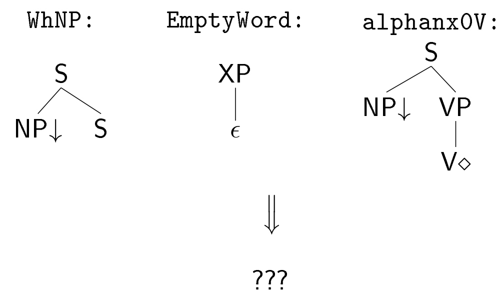

```
class Subject
export ?S ?NP ?VP
declare ?S ?NP ?VP
{ <syn>{
    node ?S [cat = s]{
        node ?NP (mark = subst)[cat = np]
        node ?VP [cat = vp]
        }
    }
}
```


XMG - Case study - Building a tree template




```
class alphanx0V
import VerbProjection[]
export ?S ?NP0
declare ?Subj ?S ?NP0
{
    ?Subj = Subject[];      ?NP0 = ?Subj.?NP;
    ?VP = ?Subj.?VP;        ?S = ?Subj.?S
}
```

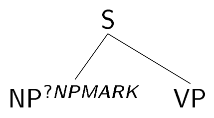

XMG - Case study - Adding fragments for extraction



In order to reuse `alphanx0V` here one has to underspecify the mark property of leaf nodes!

1. in subject and object fragments and in tree templates (e.g. `nx0V`)
2. only in subject and object fragments
3. ...

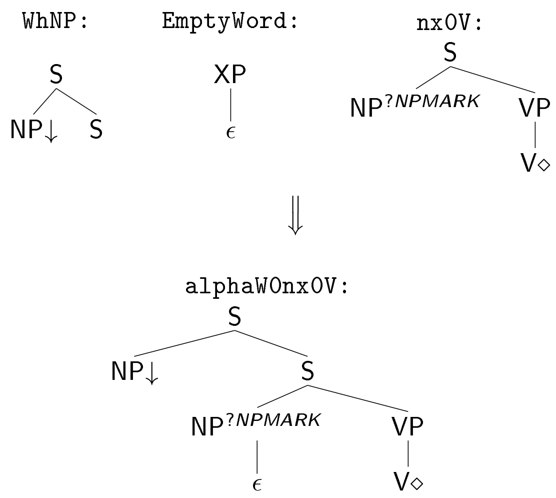
XMG - Case study - A redesigned subject fragment




```
class Subject
export ?S ?NP ?VP ?NPMARK
declare ?S ?NP ?VP ?NPMARK
{ <syn>{
    node ?S [cat = s]{
        node ?NP (mark = ?NPMARK)[cat = np]
        node ?VP [cat = vp]
        }
    }
}
```


XMG - Case study - Adding fragments for extraction

1. the modified subject class is used to define the class nx0V, which is then reused in alphaW0nx0V:



XMG - Case study - Adding fragments for extraction

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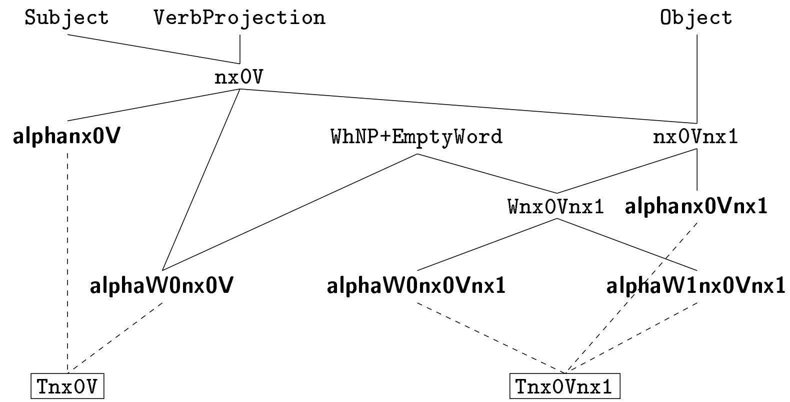
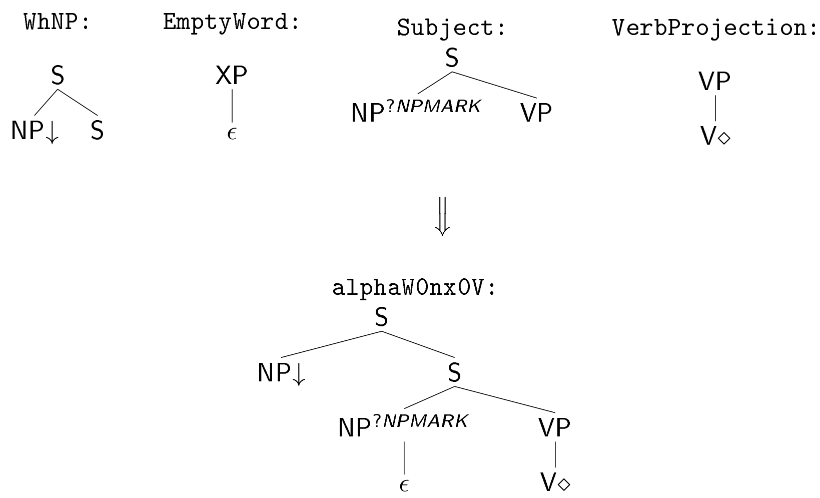


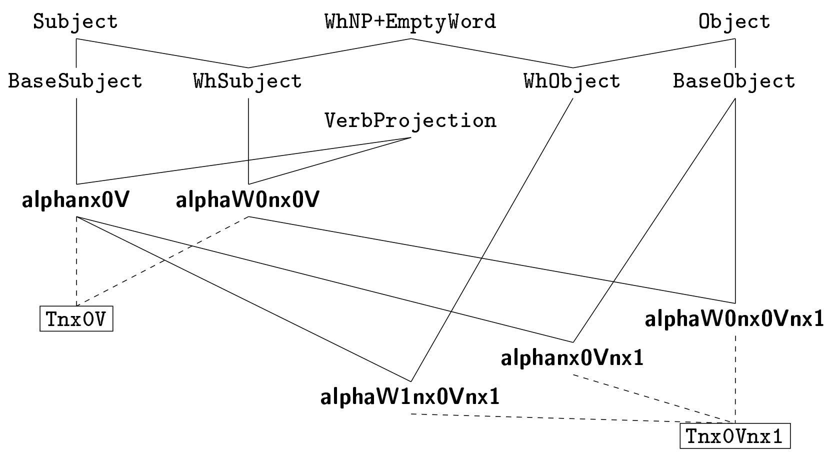
XMG - Case study - Adding fragments for extraction

2. alphaW0nx0V is directly defined through the modified subject class:



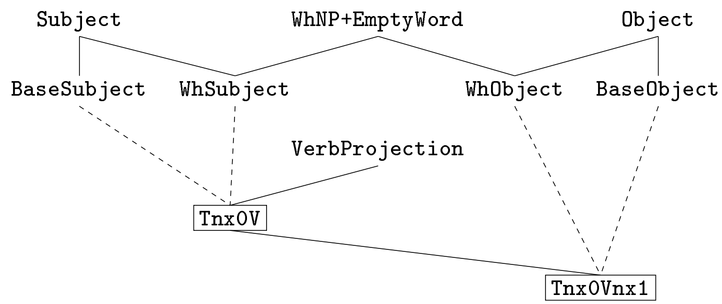
XMG - Case study - Adding fragments for extraction

2. `alphaW0nx0V` is directly defined through the modified subject class:



XMG - Case study - Adding fragments for extraction

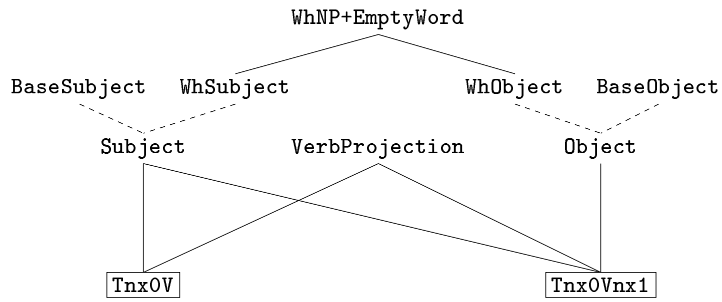
... **or** one dispenses with the evaluation of tree templates and uses only tree families:



NB: This probably makes necessary the use of **interface constraints** in order to rule out multiple Wh-extraction, i.e. to reuse the right members of tree families.

XMG - Case study - Adding fragments for extraction

... **or** one dispenses with the evaluation of tree templates and uses only **unrelated** tree families:



Along the lines of [Alahverdzhieva, 2008], no interface constraints necessary.

XMG - Summary

- XMG is a sophisticated tool for describing elementary trees and tree families in a factorized manner, i.e. based on tree fragments.
- XMG is declarative/monotonous.
- XMG is very flexible, hence it allows for very many different ways to describe the same grammar.
- How to choose among suitable metagrammars? Number of classes? Number of inheritance relations? Complexity of inheritance hierarchies?
  - ⇒ No obvious criterion for the non-trivial cases, particularly with broad coverage grammars.
  - ⇒ Considerably depends on what the grammar writer prefers ...

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