Introduction to Tree Adjoining Grammar

Grammar Implementation with XMG

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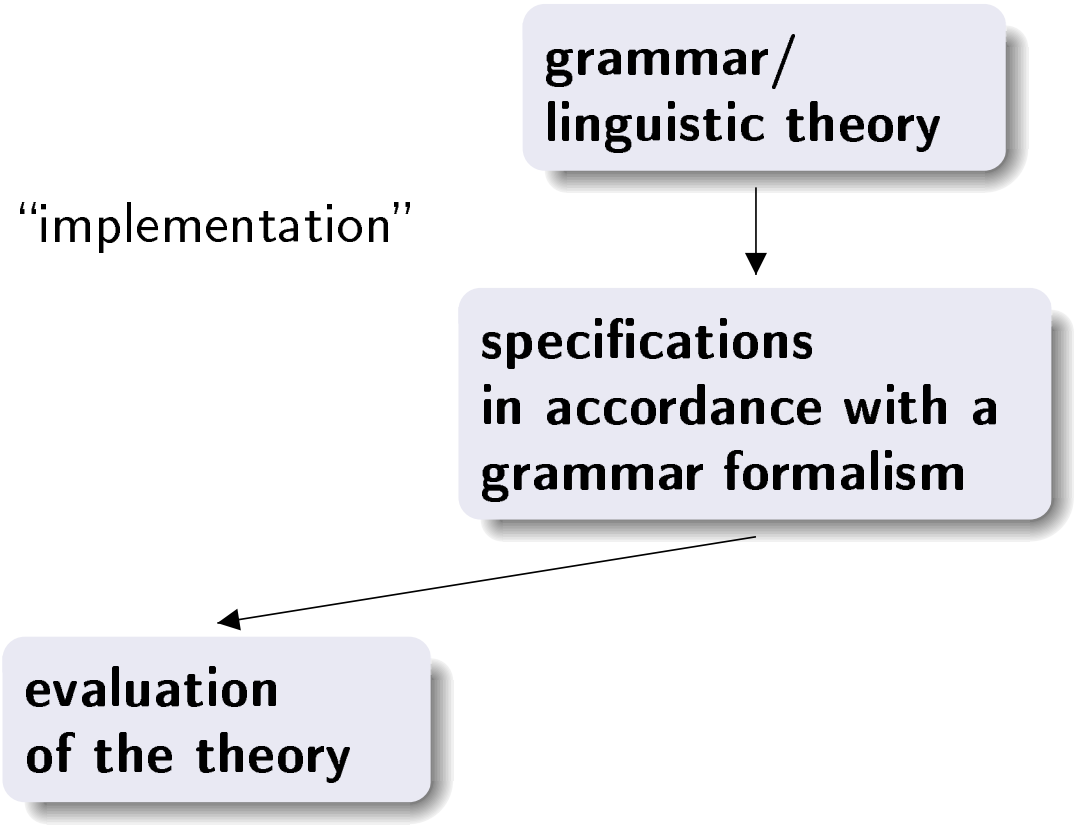
Outline

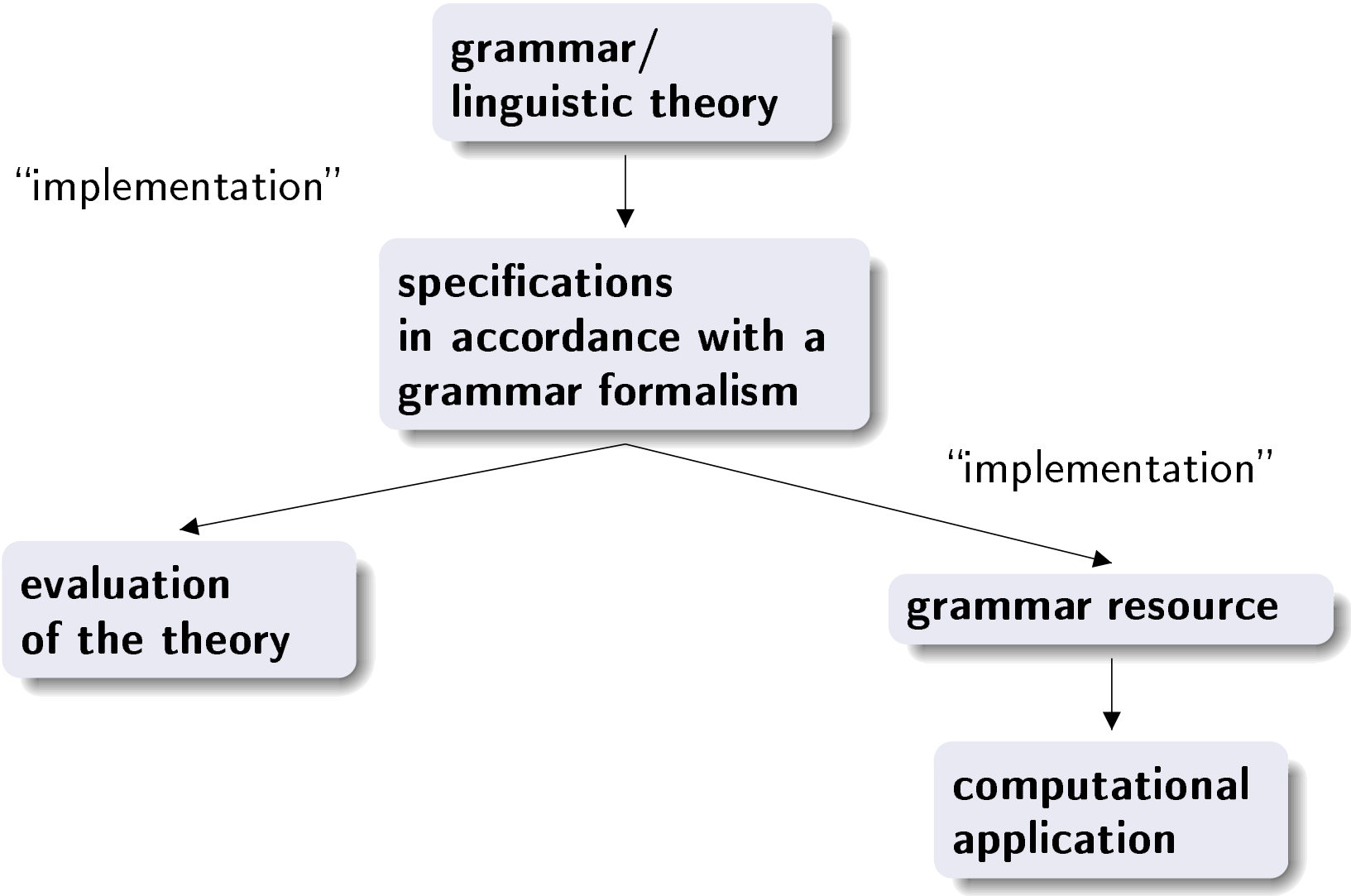
1. What is grammar implementation?
2. Two ways of tree template implementation:
   - Metarules
   - Metagrammars
3. eXtended Metagrammar (XMG)
4. A case study with XMG

Two kinds of grammar implementation

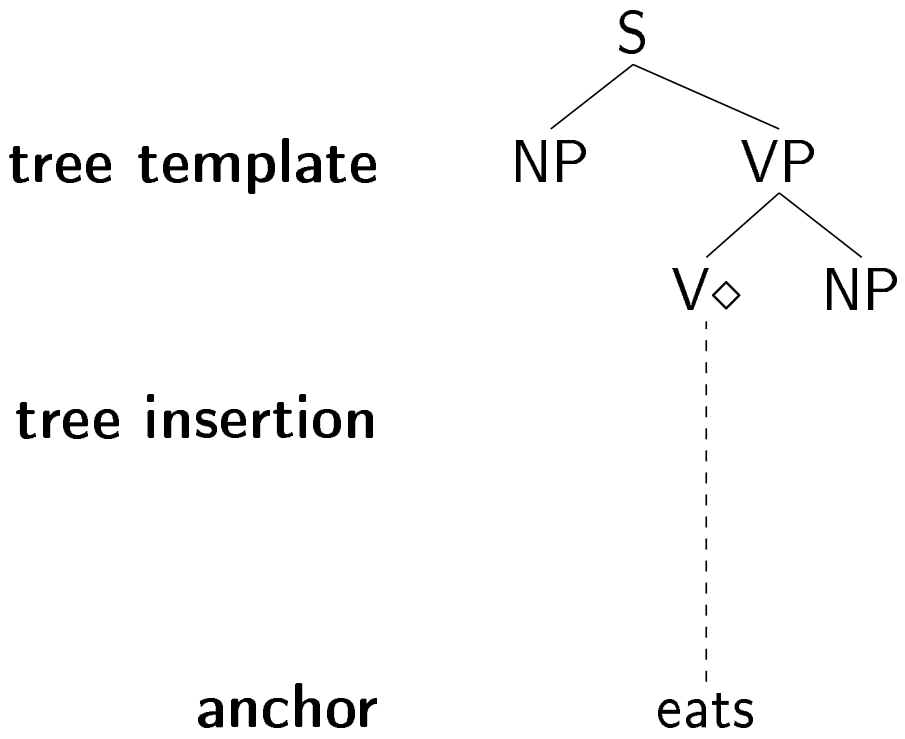


As is frequently pointed out but cannot be overemphasized, an important goal of formalization in linguistics is to enable subsequent researchers ***to see the defects of an analysis as clearly as its merits****; only then can progress be made efficiently.* [Dowty, 1979, 322]

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)!

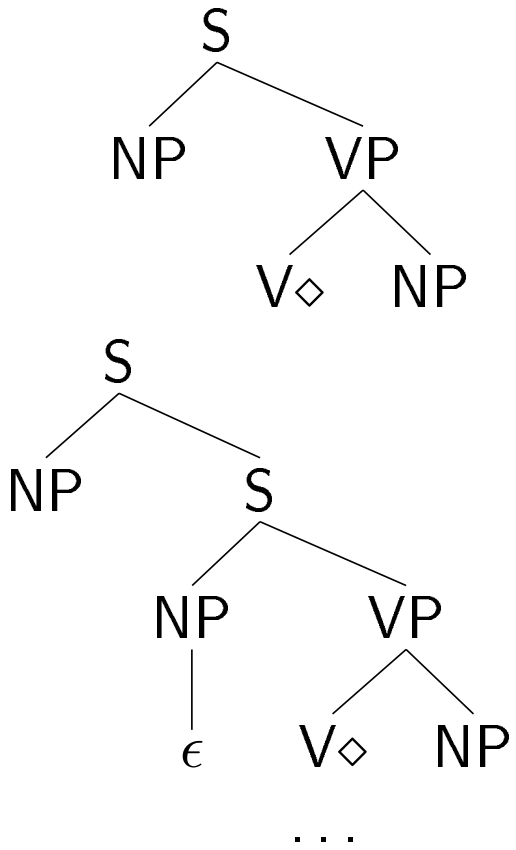
Two ways of grammar implementation with TAG

- **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]

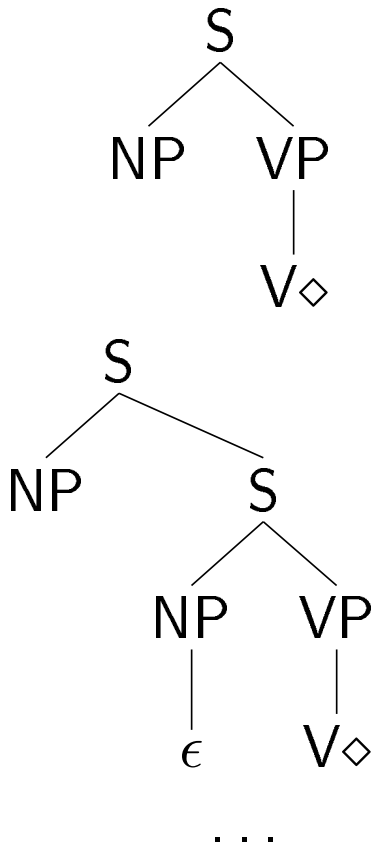
Outline

The situation

39 templates for transitive verbs



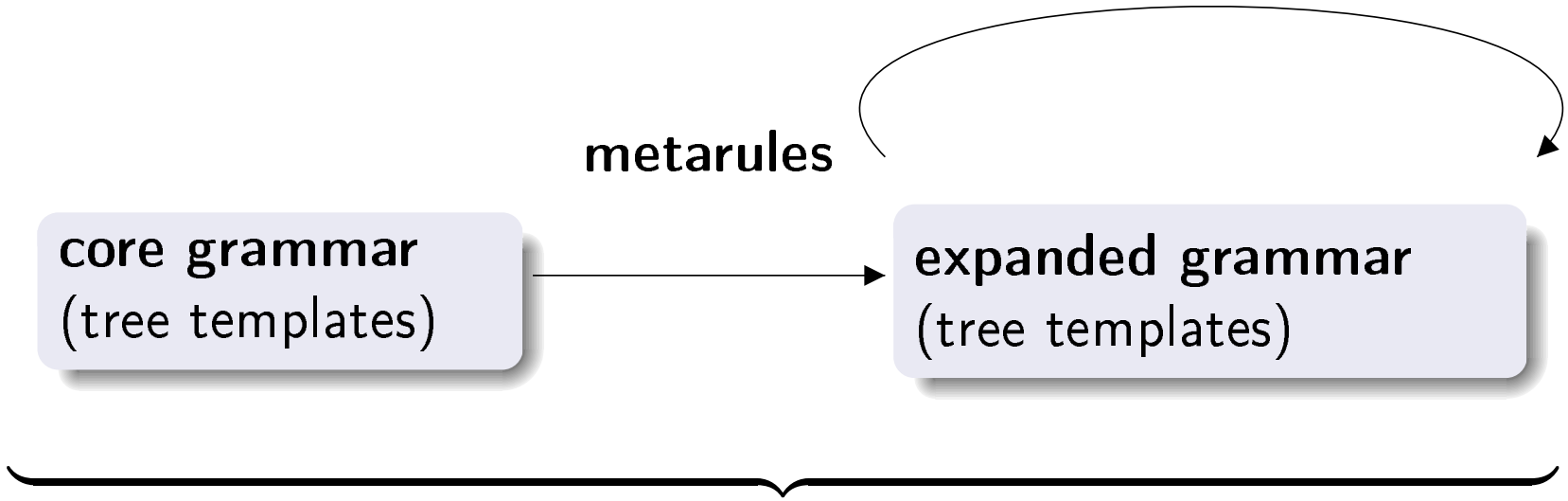
12 tree templates for intransitive verbs



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

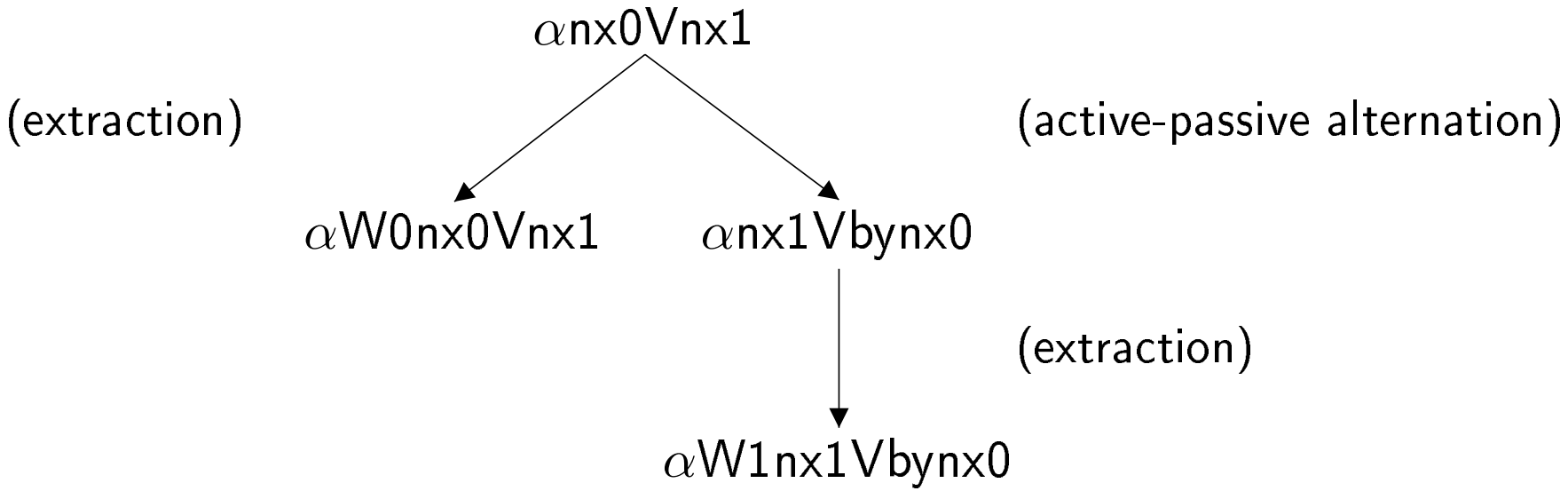
Metarules for LTAG

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



Metarules for LTAG: Example

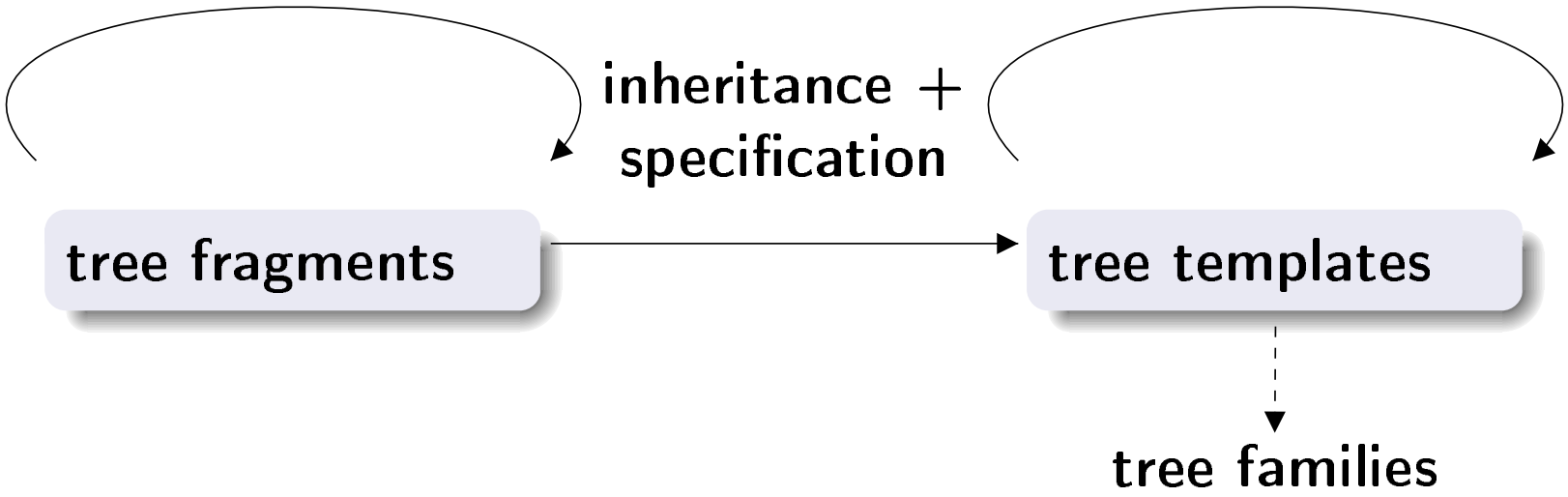
Tnx0nx1:



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

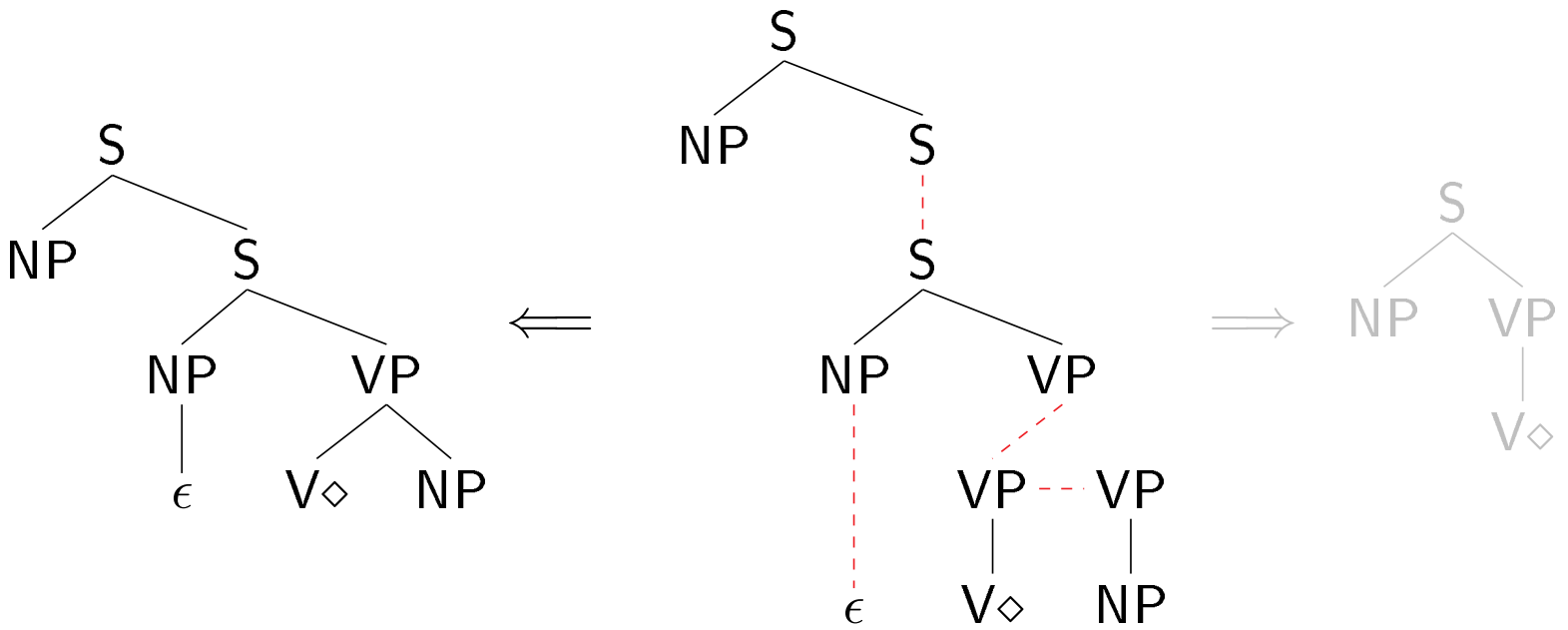
Metagrammars for LTAG

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

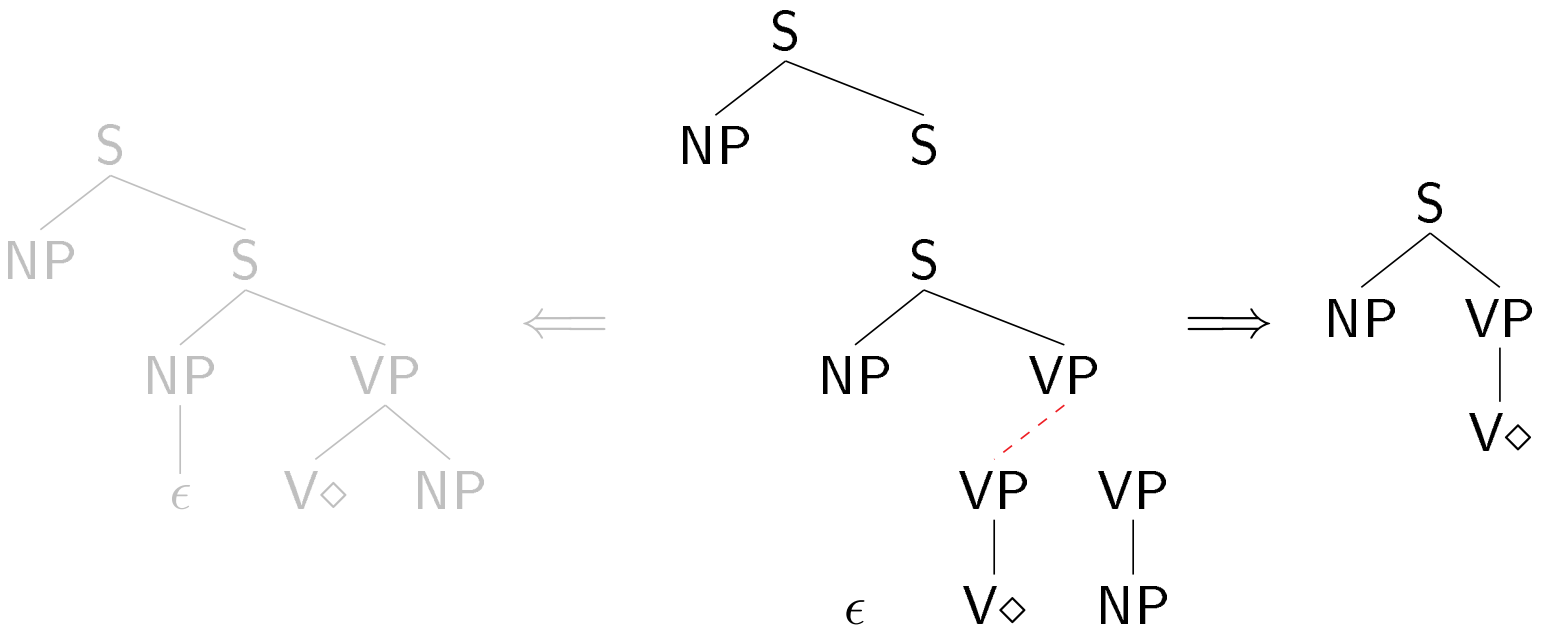


- **tree fragments**: additional layer of abstraction below the level of tree templates
- A tree template is the result of combining and specifying tree fragments and tree templates.
- The notion of **tree families** is independent from the construction of tree templates!

Metagrammars for LTAG: Example



Metagrammars for LTAG: Example



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`

$\Rightarrow$ 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]

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

Let ?x and ?y be nodes:

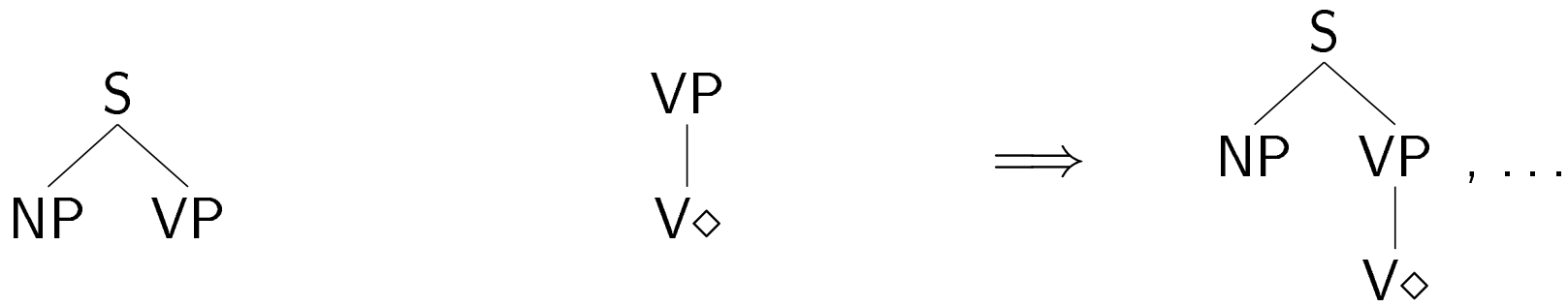
$$\texttt{Description} ::= \left(\begin{array}{l} \texttt{?x -> ?y} \mid \texttt{?x ->+ ?y} \mid \texttt{?x ->* ?y} \mid \\ \texttt{?x >> ?y} \mid \texttt{?x >>+ ?y} \mid \texttt{?x >>* ?y} \mid \\ \texttt{?x = ?y} \mid \\ \texttt{?x[f:E]} \mid \texttt{?x(p:E)} \mid \\ \texttt{Description} \wedge \texttt{Description} \end{array} \right)$$

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

$$\texttt{Class} ::= \texttt{Name} \rightarrow \texttt{Content}$$

$$\texttt{Content} ::= \left(\begin{array}{l} \texttt{Description} \mid \texttt{Name} \mid \\ \texttt{Content} \vee \texttt{Content} \mid \\ \texttt{Content} \wedge \texttt{Content} \end{array} \right)$$

XMG - Description languages - Examples




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

```
{ ?VP2 -> ?V,
  ?VP2[cat:vp],
  ?V[cat:v],
  ?V(mark:anchor) }
```

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

XMG - Node variables and compiling

- Node variables have a scope local to the class (= name space).
- Tree descriptions can denote more than one tree fragment!
  BUT: Each of the tree fragments has to comply with all of the tree descriptions!

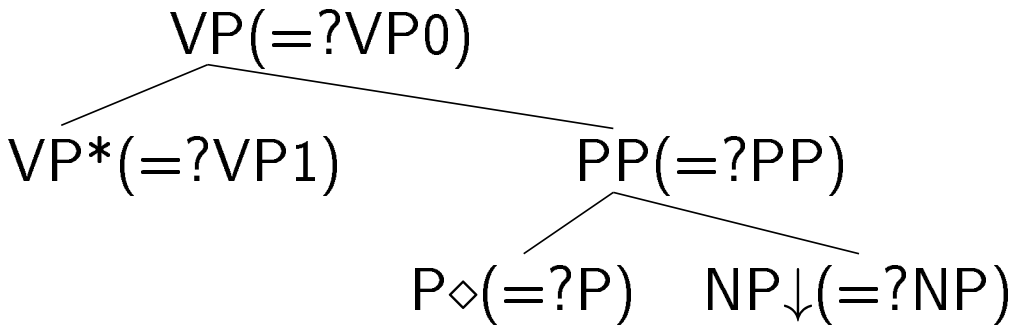
When the class `intransitive` is compiled:

1. XMG accumulates all tree descriptions involved in `intransitive`, and
2. XMG identifies tree fragments and tree templates by merging node variables or drawing edges.

E.g., in the previous example, the node variables `?VP1` and `?VP2` can be merged, or `?VP1` can dominate `?VP2`.

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, flex }
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.

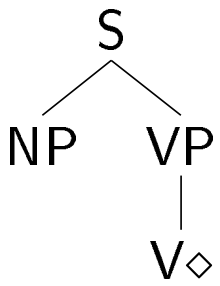
```
class betavxPnx
{ ...
?VPSpine = VPSpine[];
?VPSpine.?VP0 = ?XP;
... }
```

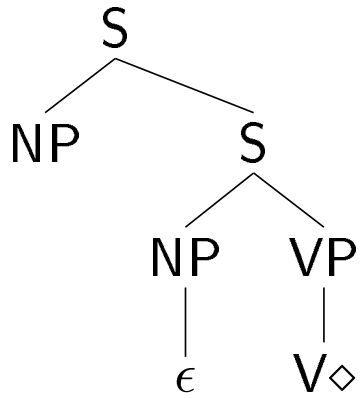
Second method:

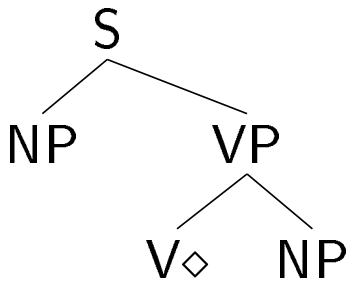
Classes can be imported, such that all variables of the imported class, that have been exported, can be used directly.

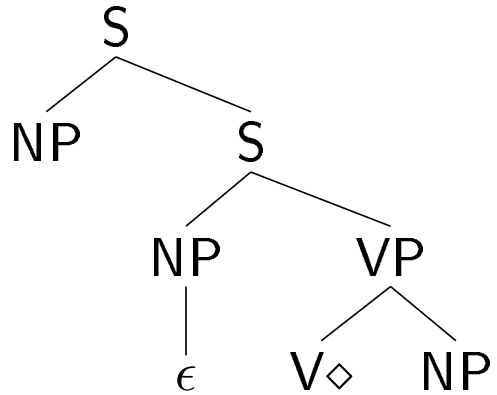
```
class betavxPnx
import VPSpine[]
{...
?VP0 = ?XP;
... }
```

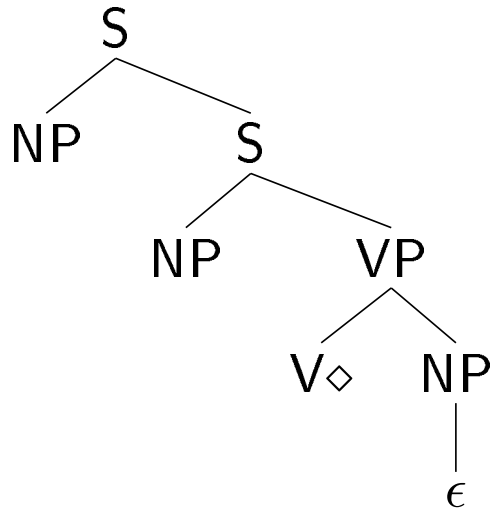
How to describe the tree families for intransitive (Tnx0V) and transitive (Tnx0Vnx1) tree templates?



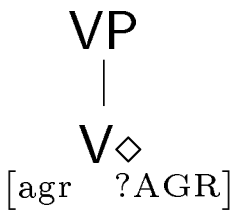






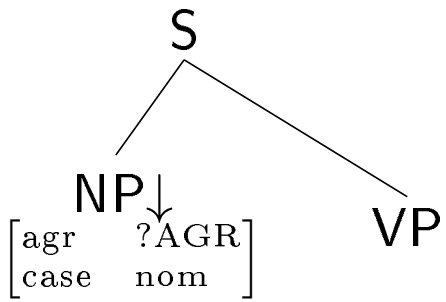


XMG - Case study - The fragments



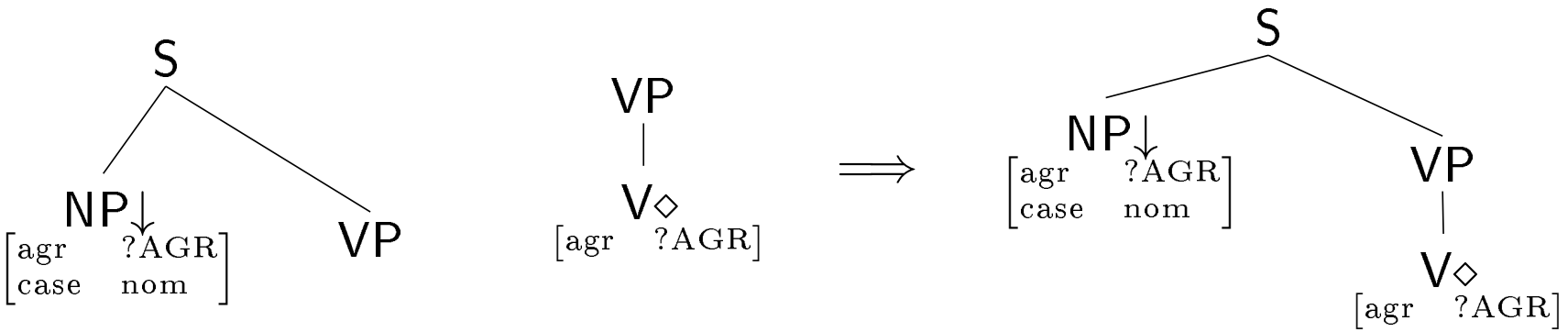

```
class VerbProjection
export ?VP ?V ?AGR
declare ?VP ?V ?AGR
{<syn>{
    node ?VP [cat = vp];
    node ?V (mark = anchor)[cat = v, agr = ?AGR];
    ?VP -> ?V
  }
}
```

XMG - Case study - The fragments



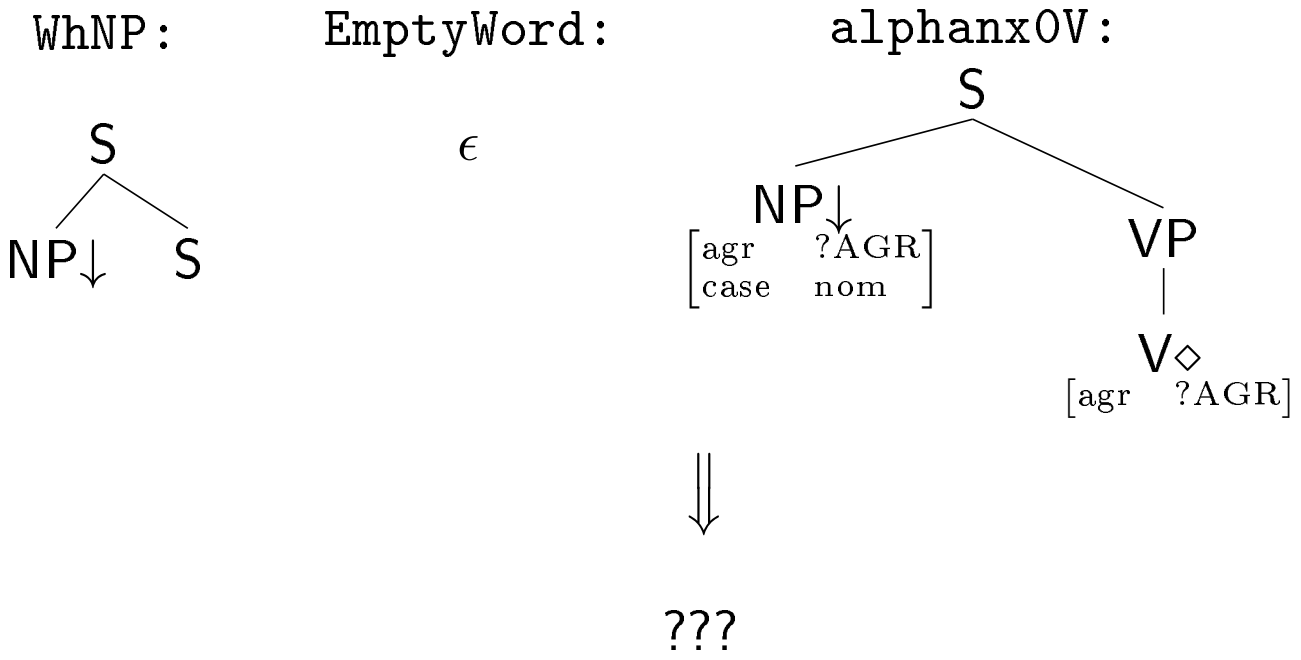

```
class Subject
export ?S ?NP ?VP ?AGR
declare ?S ?NP ?VP ?AGR
{ <syn>{
    node ?S [cat = s]{
        node ?NP (mark = subst)[cat = np, case = nom,
                                agr = ?AGR]
        node ?VP [cat = vp]
        }
    }
}
```

XMG - Case study - Building a tree template



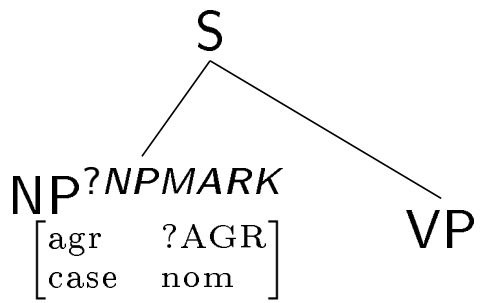

```
class alphanxOV
import VerbProjection[]
export ?S ?NPO
declare ?Subj ?S ?NPO
{
    ?Subj = Subject[];      ?NPO = ?Subj.?NP;
    ?VP = ?Subj.?VP;        ?S = ?Subj.?S;
    ?AGR = ?Subj.?AGR
}
```

XMG - Case study - Adding fragments for extraction



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

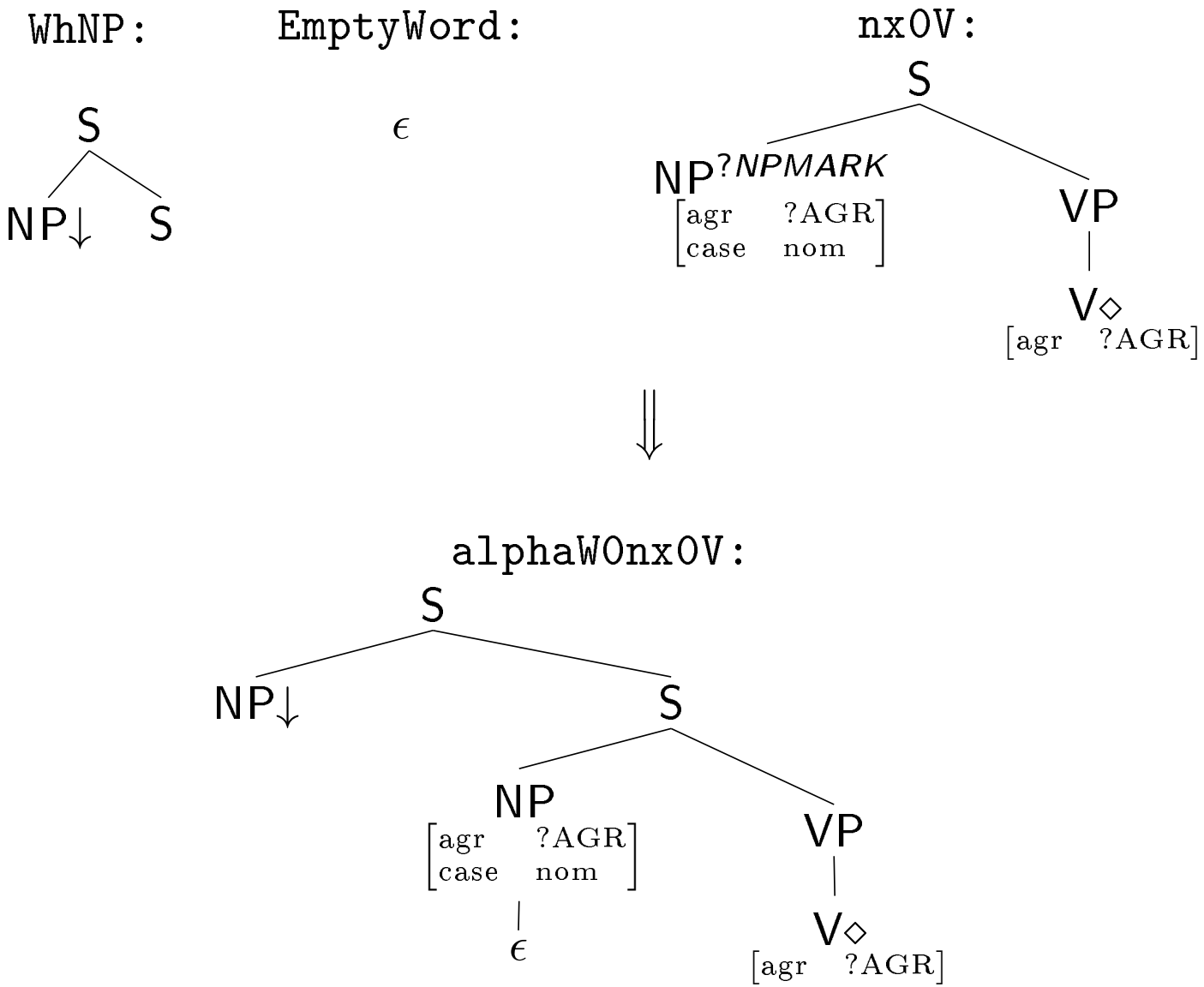
XMG - Case study - A redesigned subject fragment




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

Note: The modified subject class is used to define the class `nxOV`, which can be also reused in `alphanxOV`.

XMG - Case study - Adding fragments for extraction



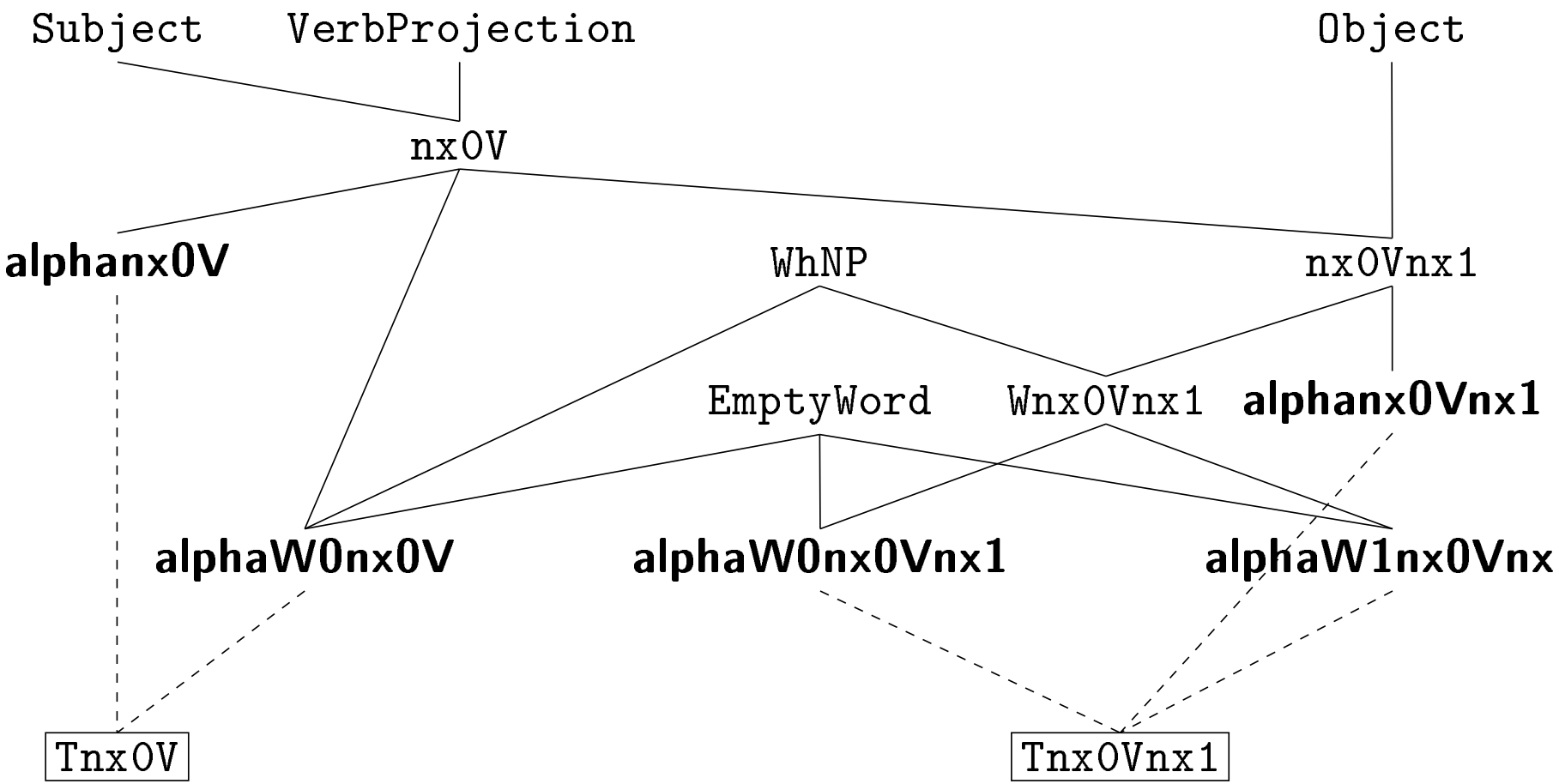
XMG - Case study - Declaring a tree family

```
class TnxOV
declare ?TnxOV
{
        ?TnxOV = ( alphanxOV[] | alphaWOnxOV[] )
}

...

value TnxOV
```

XMG - Case study - An XMG-hierarchy for TnxOV and TnxOVnx1



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