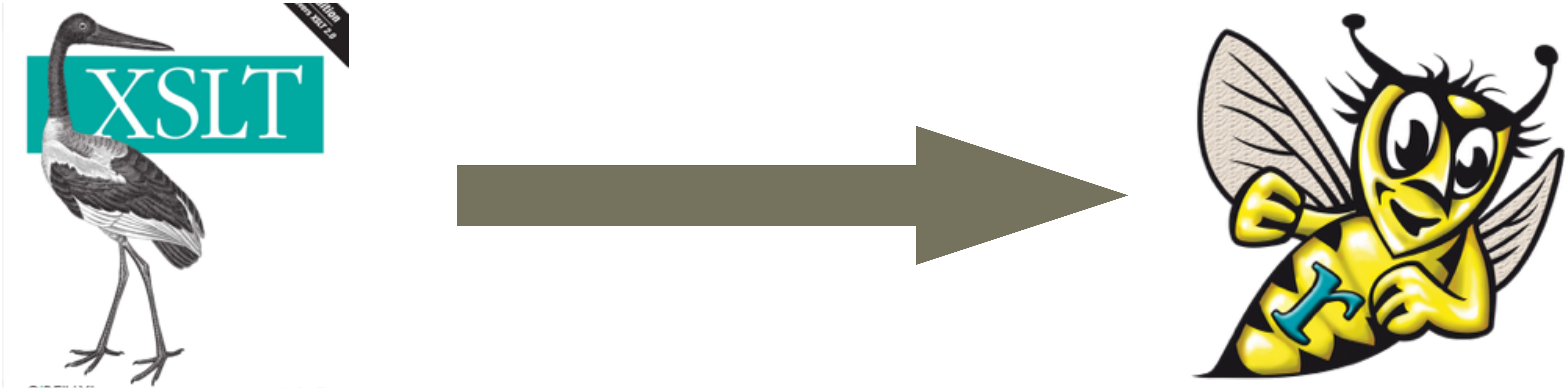
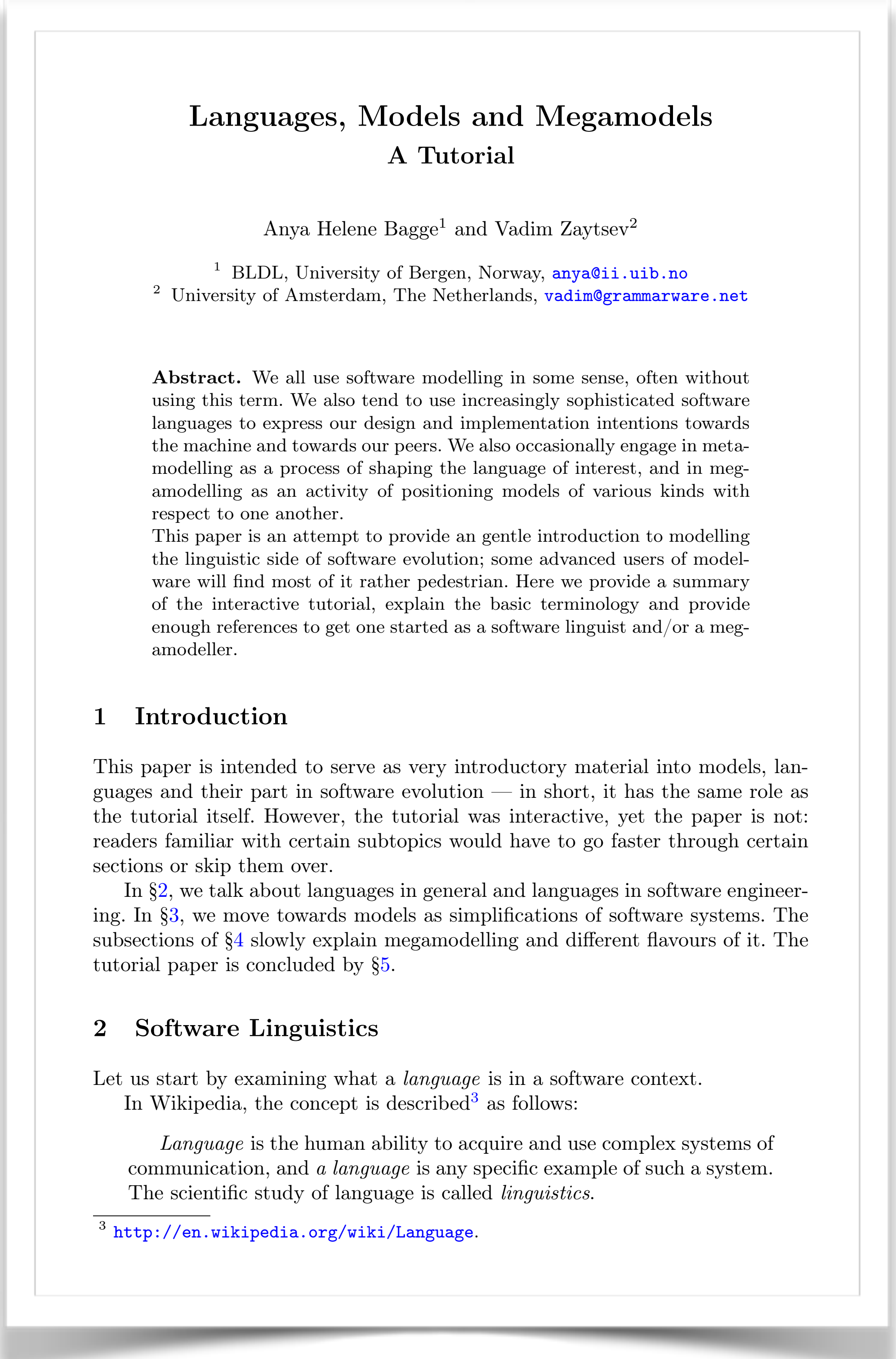


Evolution
of
Metaprograms

Dr. Vadim Zaytsev aka @grammarware
SATToSE 2015

Ready to megamodel?



Languages, Models and Megamodels

A Tutorial

Anya Helene Bagge[1] and Vadim Zaytsev[2]

[1] BLDL, University of Bergen, Norway, anya@ii.uib.no
[2] University of Amsterdam, The Netherlands, vadim@grammarware.net

Abstract. We all use software modelling in some sense, often without using this term. We also tend to use increasingly sophisticated software languages to express our design and implementation intentions towards the machine and towards our peers. We also occasionally engage in metamodelling as a process of shaping the language of interest, and in megamodelling as an activity of positioning models of various kinds with respect to one another.

This paper is an attempt to provide an gentle introduction to modelling the linguistic side of software evolution; some advanced users of modelware will find most of it rather pedestrian. Here we provide a summary of the interactive tutorial, explain the basic terminology and provide enough references to get one started as a software linguist and/or a megamodeller.

1 Introduction

This paper is intended to serve as very introductory material into models, languages and their part in software evolution — in short, it has the same role as the tutorial itself. However, the tutorial was interactive, yet the paper is not: readers familiar with certain subtopics would have to go faster through certain sections or skip them over.

In §2, we talk about languages in general and languages in software engineering. In §3, we move towards models as simplifications of software systems. The subsections of §4 slowly explain megamodelling and different flavours of it. The tutorial paper is concluded by §5.

2 Software Linguistics

Let us start by examining what a *language* is in a software context.

In Wikipedia, the concept is described[3] as follows:

> *Language* is the human ability to acquire and use complex systems of communication, and *a language* is any specific example of such a system. The scientific study of language is called *linguistics*.

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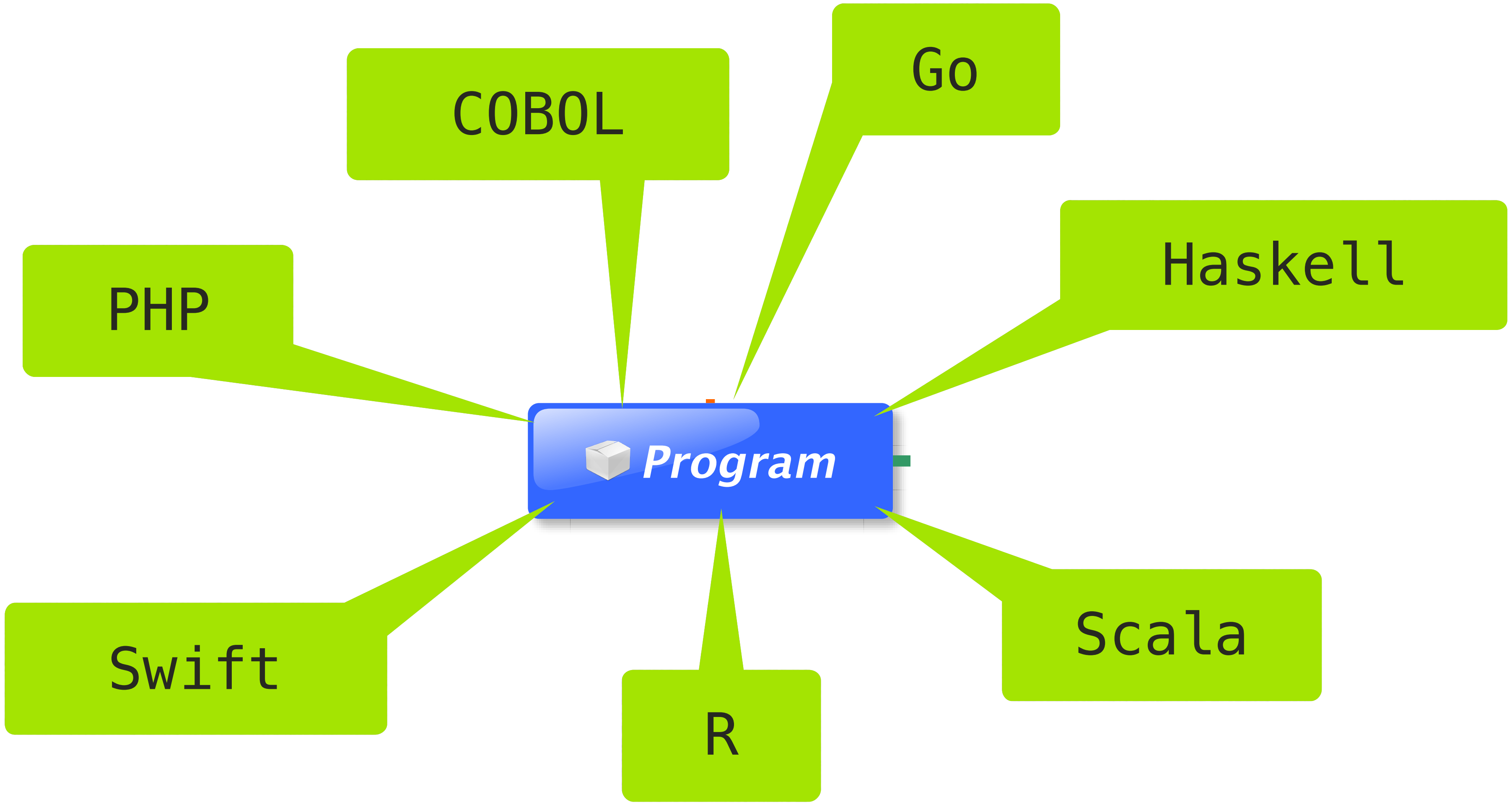
[3] http://en.wikipedia.org/wiki/Language.

http://ceur-ws.org/Vol-1354/paper-12.pdf

Program



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Go

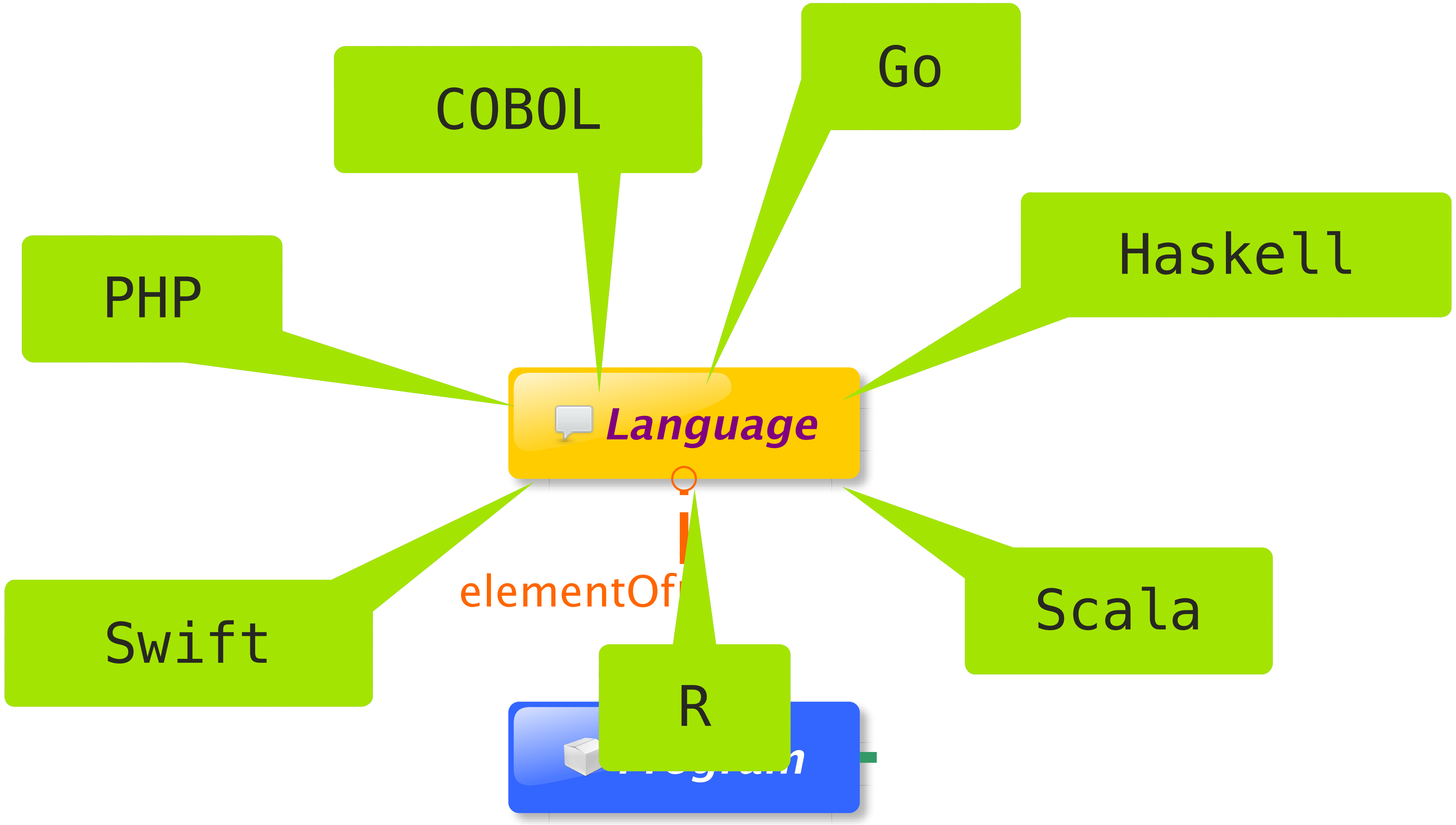
PHP

Haskell

Swift

R

Scala



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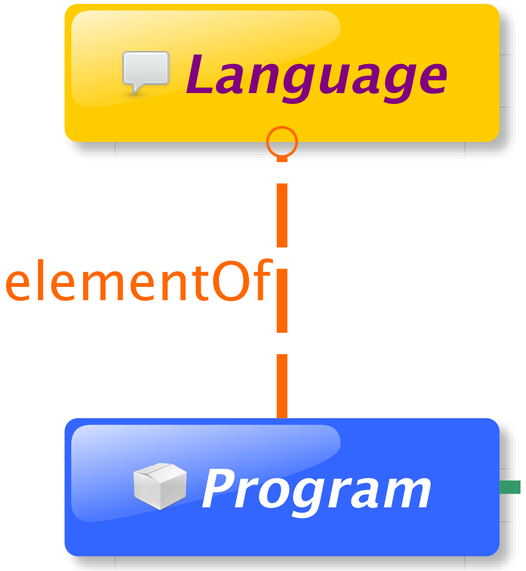

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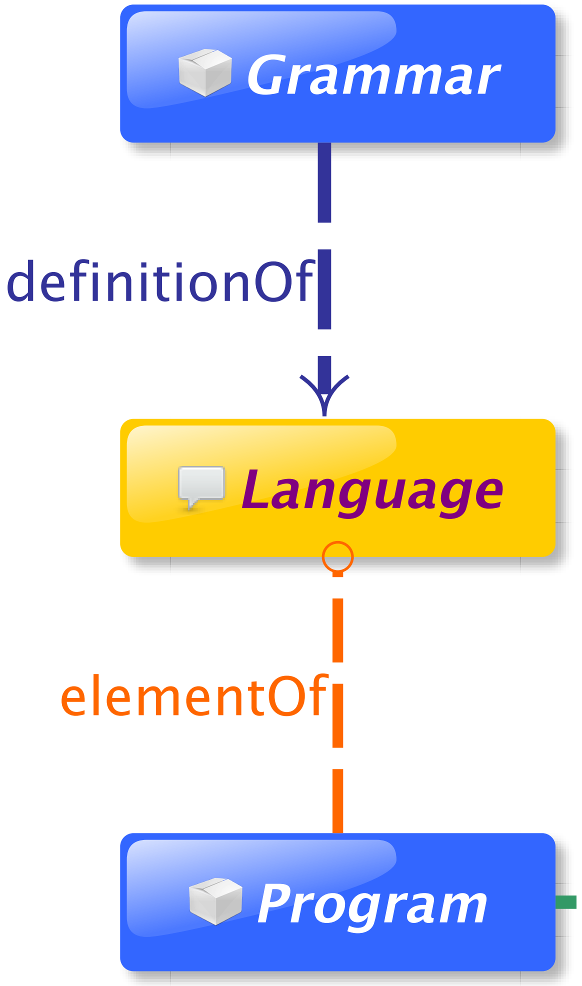

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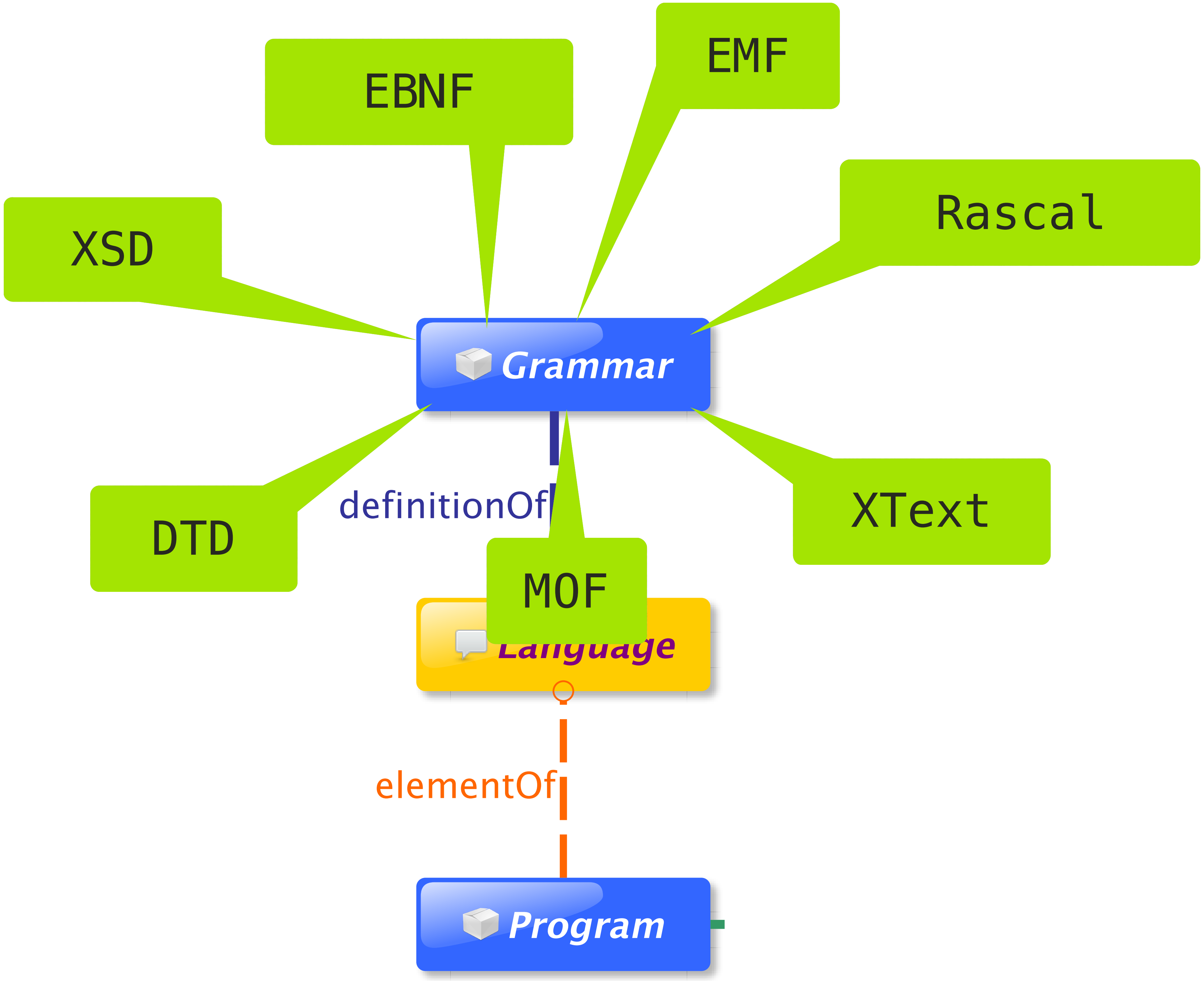
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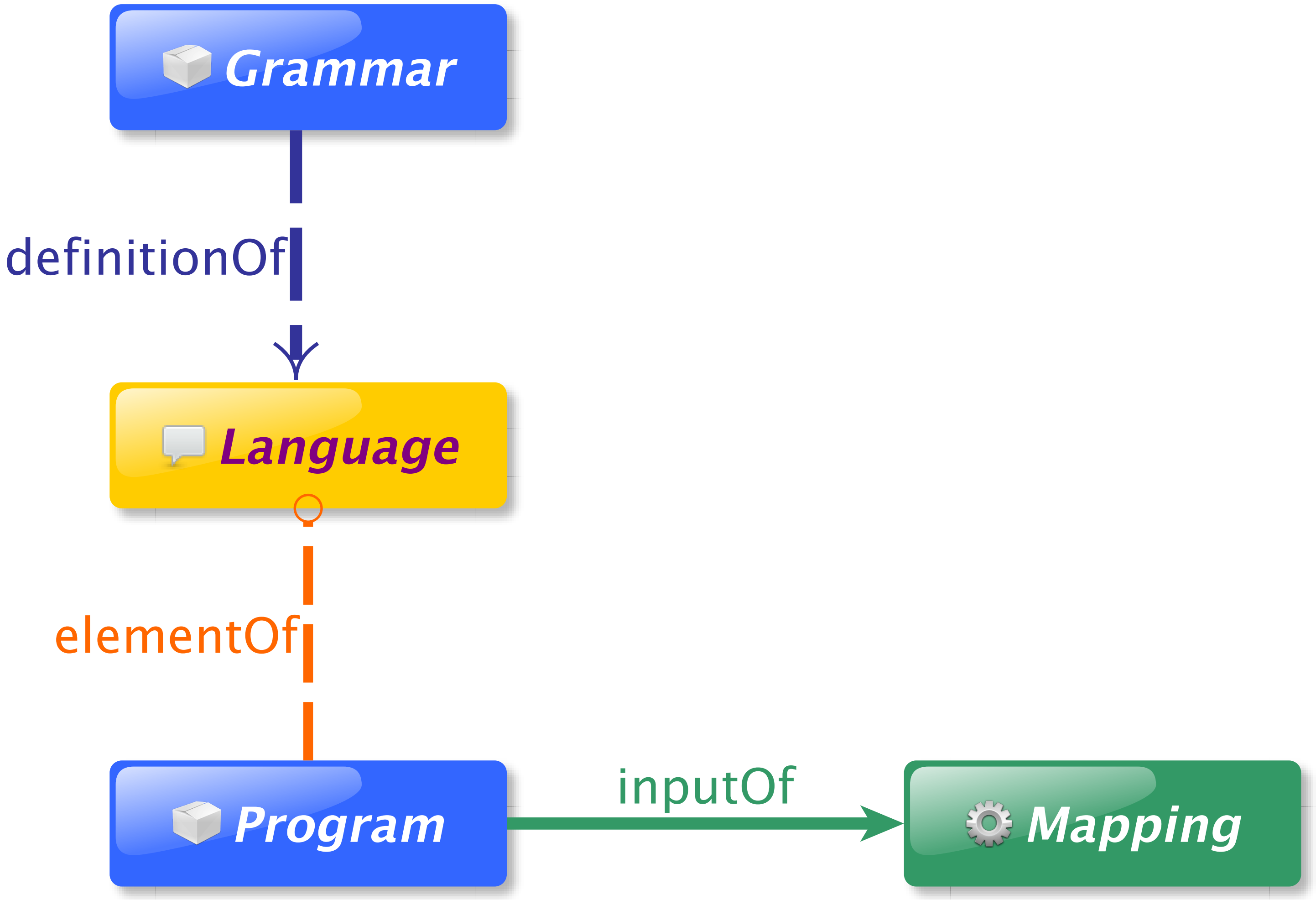
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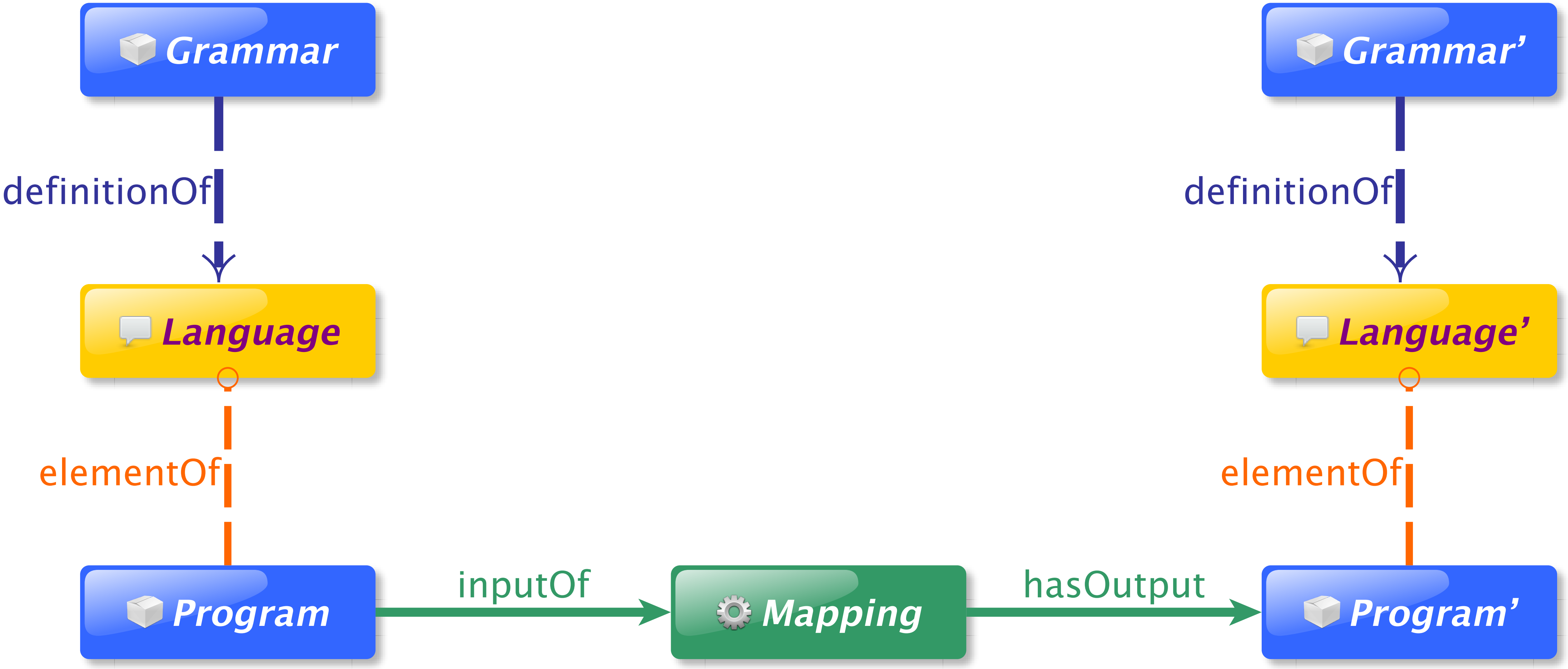

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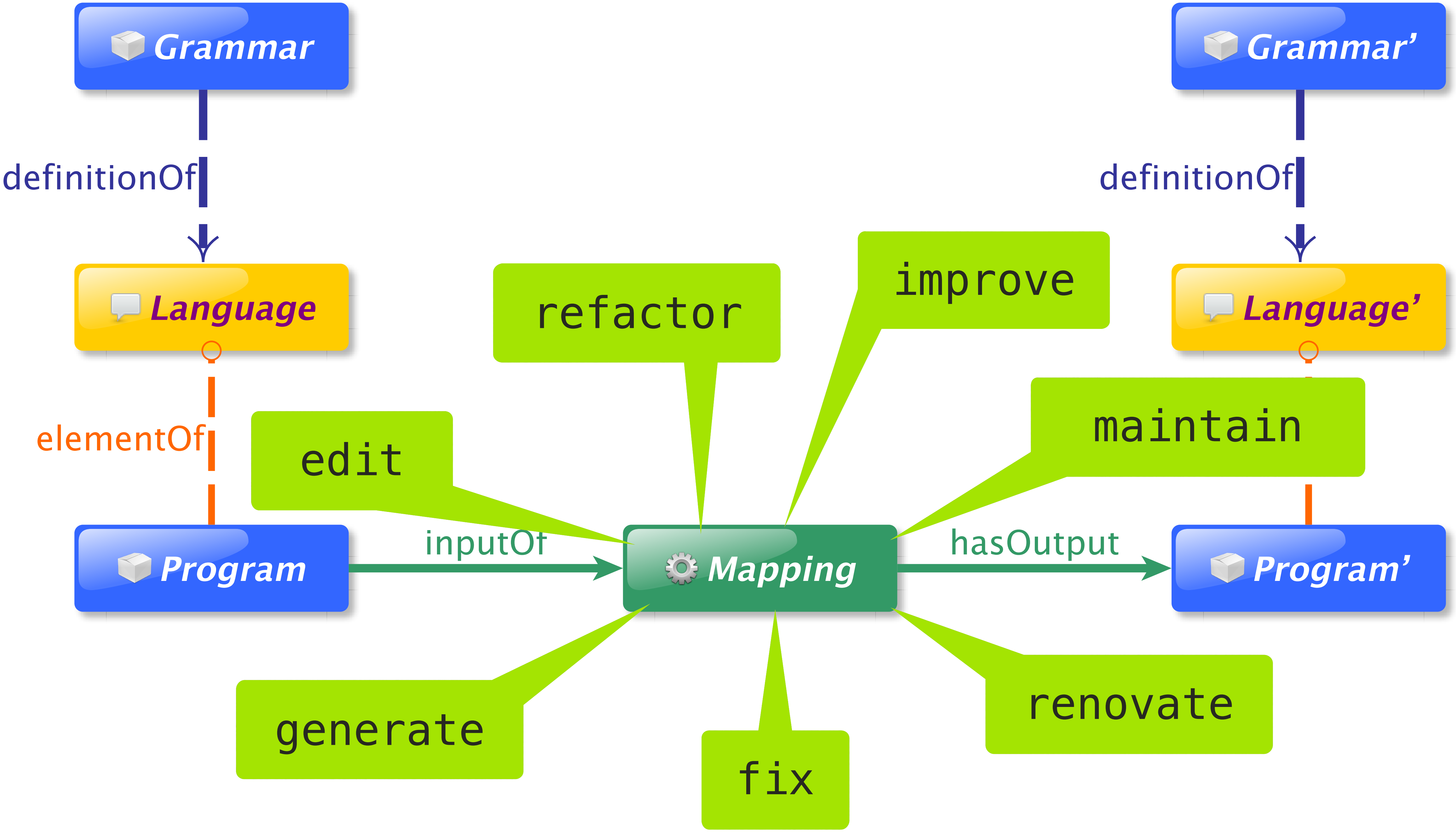
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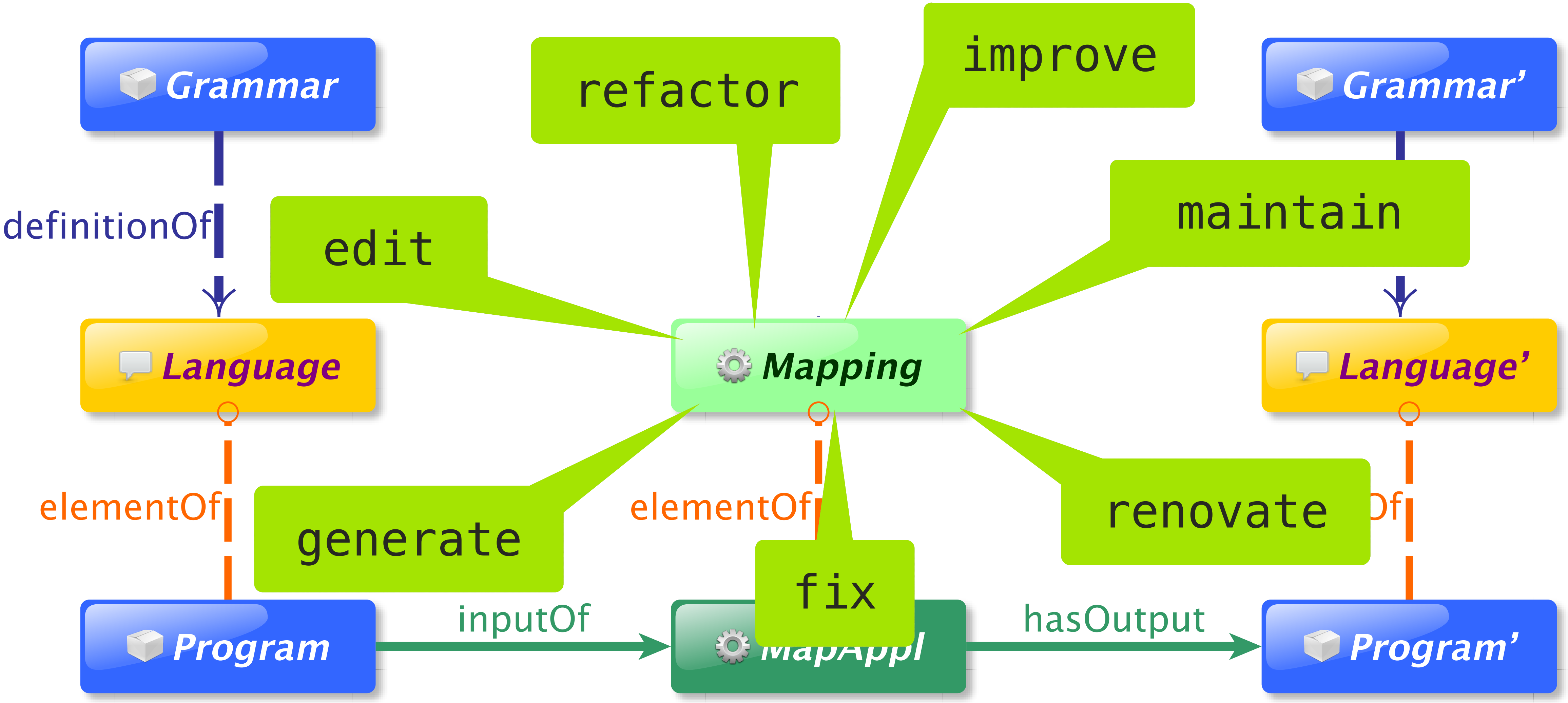

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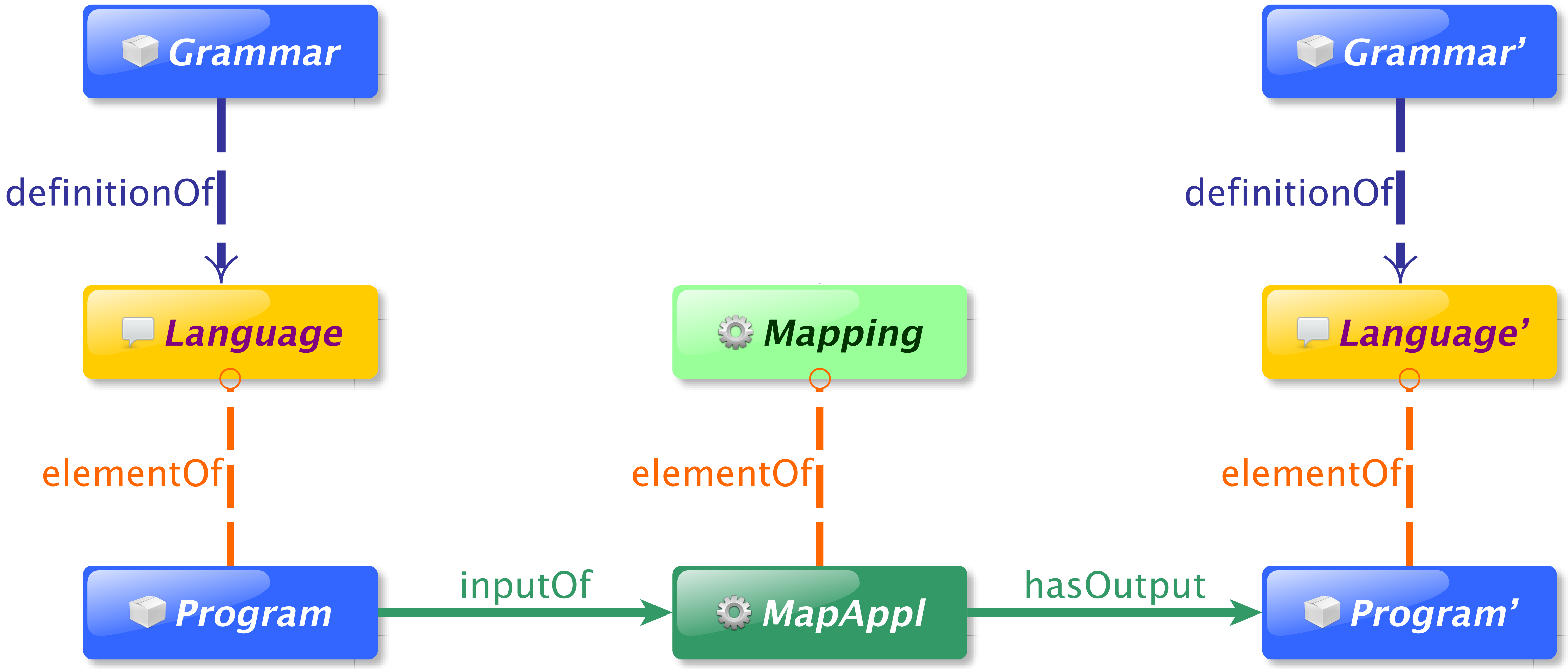
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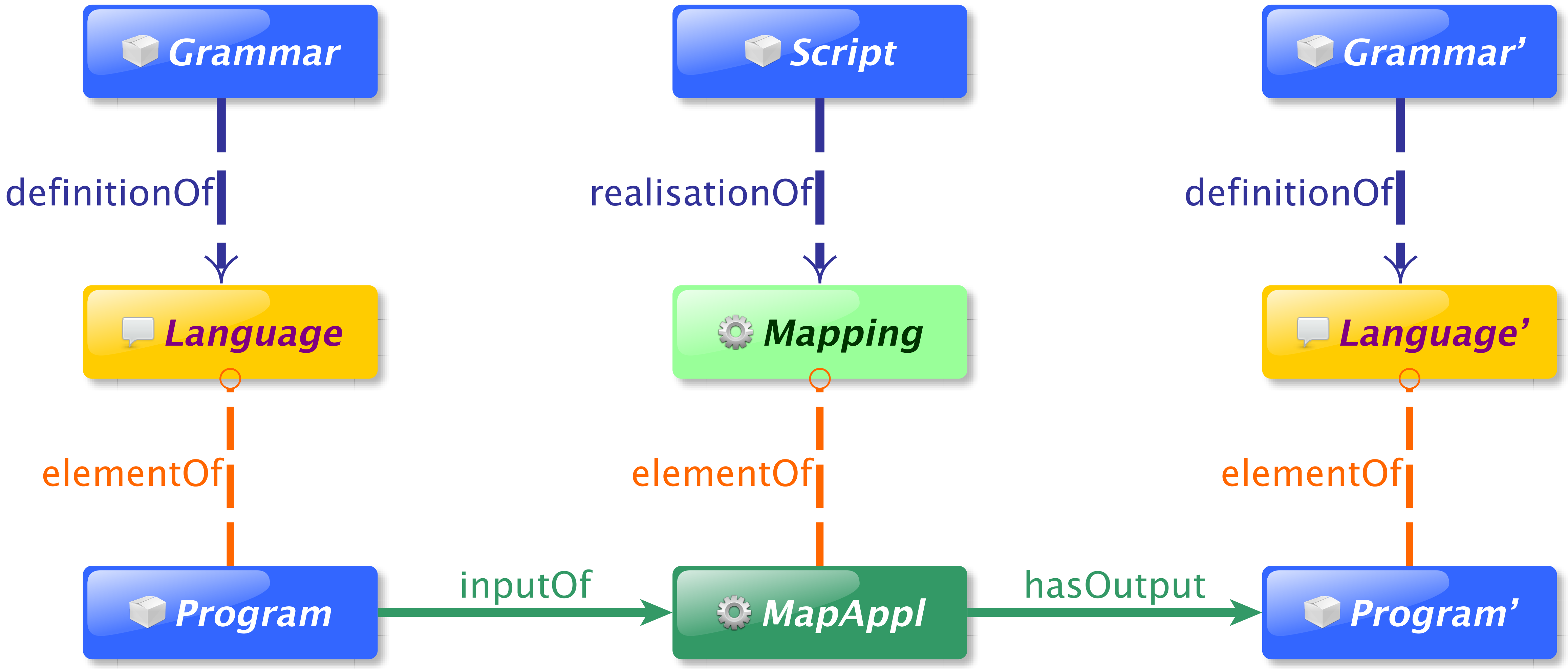
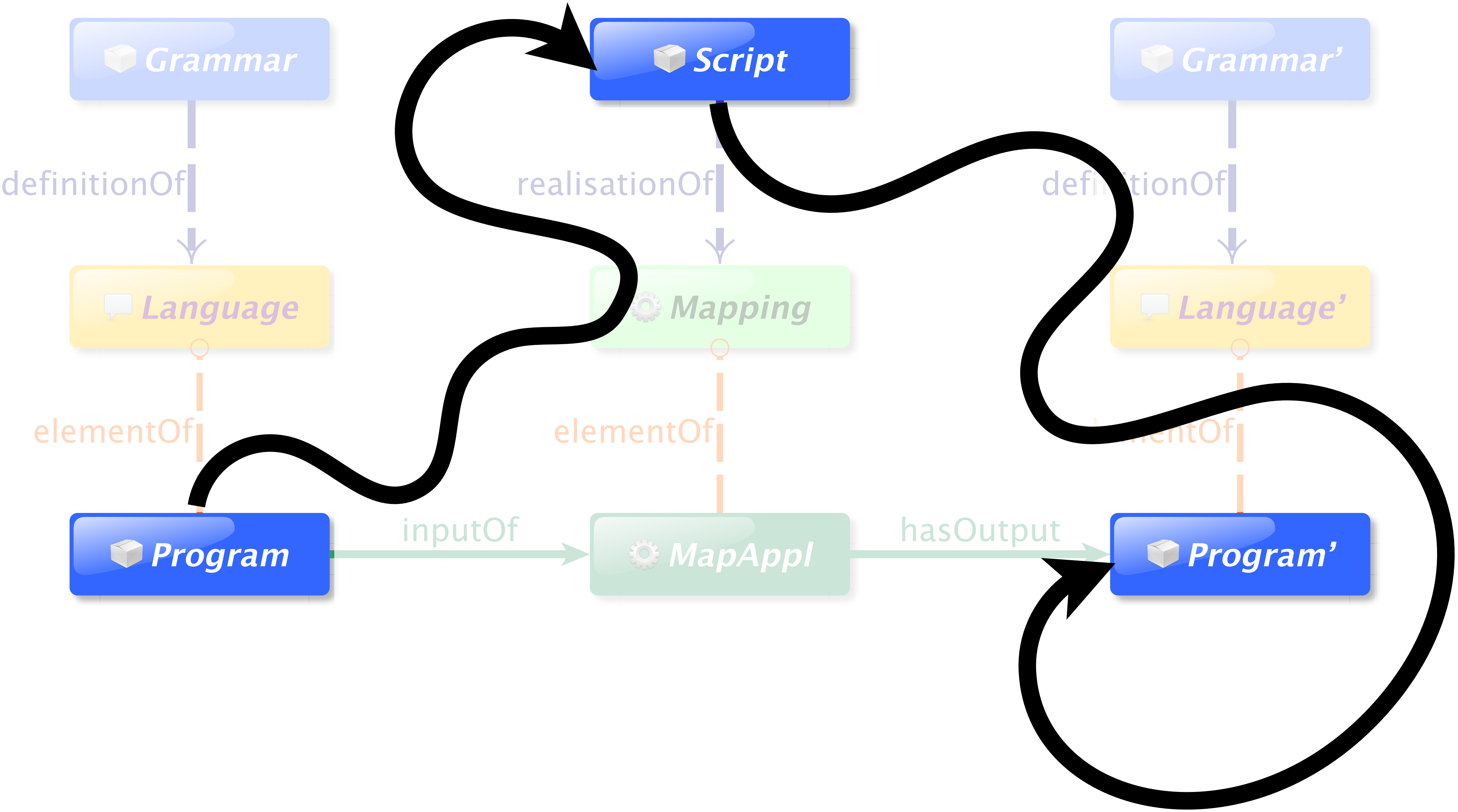
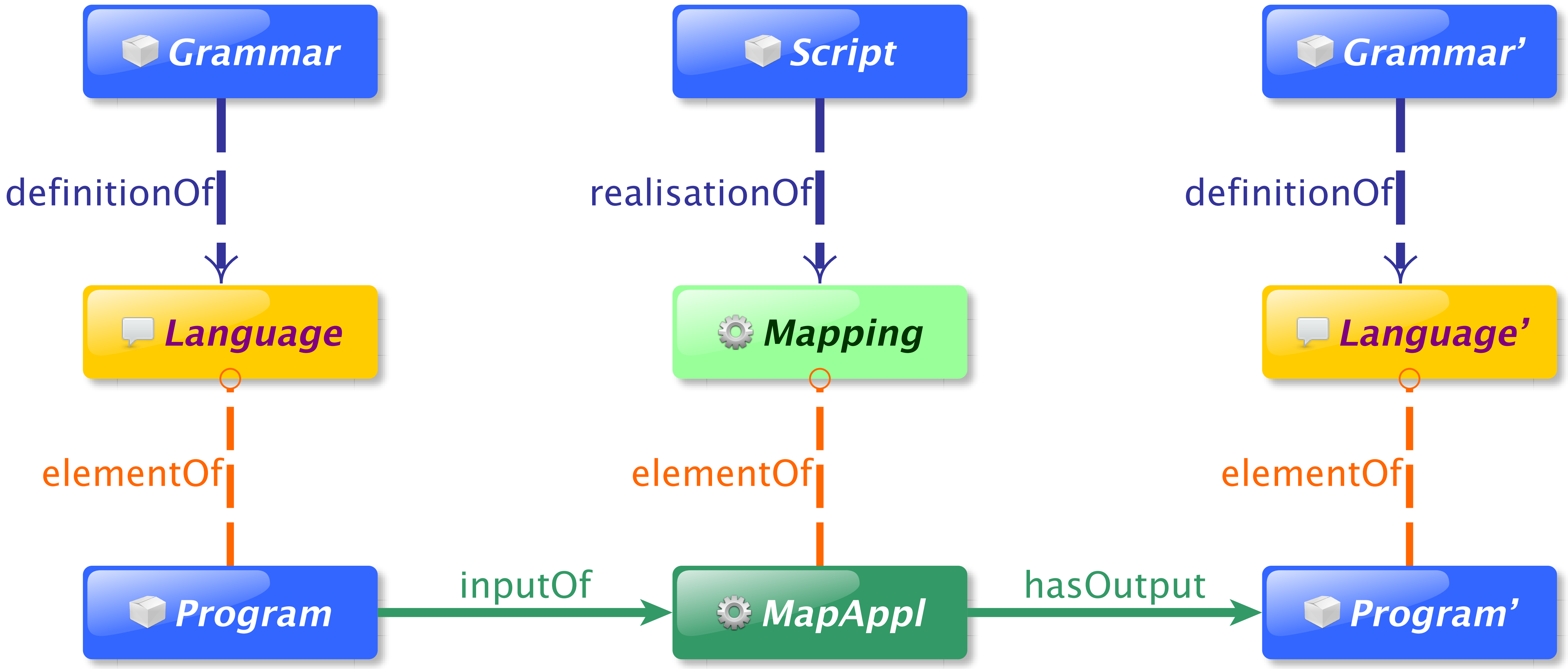
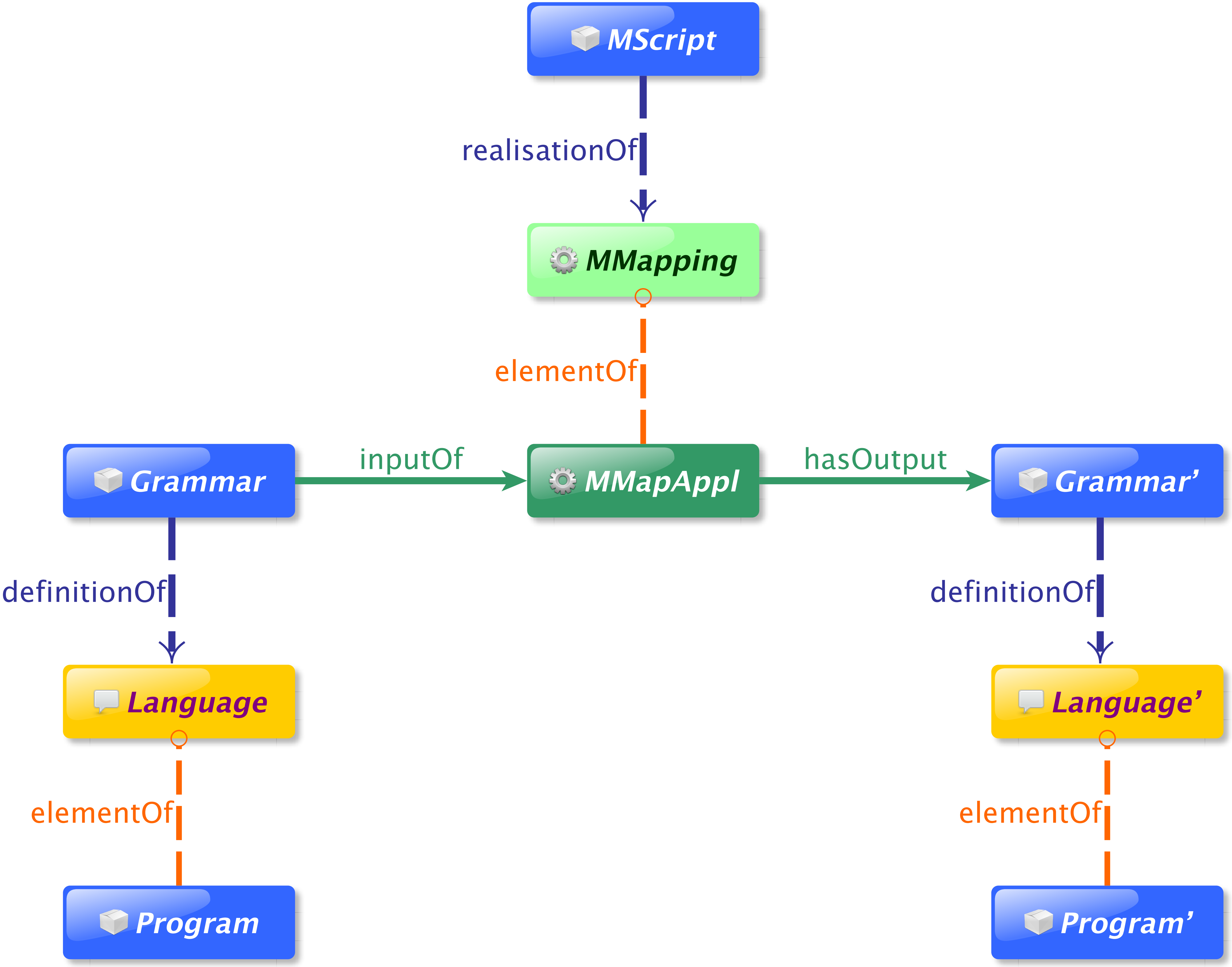


Metaprogram



Metaprogramming

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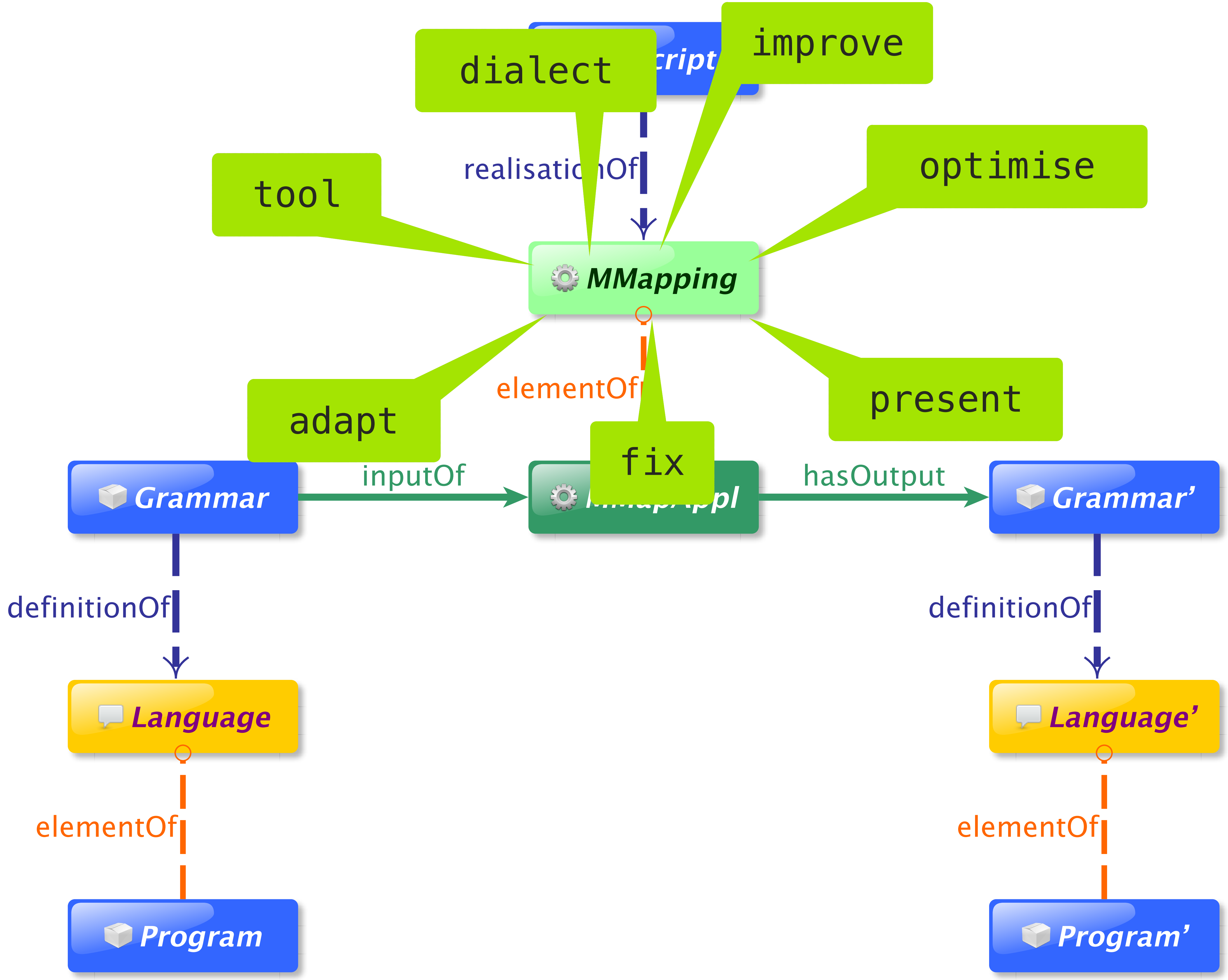

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Examples

Example: ANTLR→BGF

```
grammarDef
    :
    {
        try{
        DocumentBuilderFactory dbfac = DocumentBuilderFactory.newInstance();
        DocumentBuilder docBuilder = dbfac.newDocumentBuilder();
        doc = docBuilder.newDocument();
        root = doc.createElement("bgf:grammar");
        root.setAttribute("xmlns:bgf", "http://planet-sl.org/bgf");
        doc.appendChild(root);
        }catch (Exception e){System.out.println(e);}
    }
        'grammar' ID ';' NEWLINE rule+
    {
        try{
        Transformer trans = TransformerFactory.newInstance().newTransformer();
        trans.setOutputProperty(OutputKeys.OMIT_XML_DECLARATION, "no");
        trans.setOutputProperty(OutputKeys.INDENT, "yes");
        trans.transform(new DOMSource(doc), new StreamResult(new
FileOutputStream(output)));
        }catch (Exception e){System.out.println(e);}
    };
```

SLPS/topics/extraction/antlr/slps/antlr2bgf/StrippedANTLR.g

Example: SDF→BGF

```
equations

[map-sdf-definition-to-bgf]
&C*1 := trafoProds (accuProds (&M*1,))
==========================
main (definition &M*1)
=
<bgf:grammar xmlns:bgf="http://planet-sl.org/bgf">
  &C*1
</bgf:grammar>

[map-sdf-module-to-bgf]
&C*1 := trafoProds (accuProds (&M1,))
==========================
main ( &M1 )
=
<bgf:grammar xmlns:bgf="http://planet-sl.org/bgf">
  &C*1
</bgf:grammar>

[exclude-lexical-productions]
accuProds ( lexical syntax &Ps1, &P*1 ) = &P*1
```

SLPS/topics/extraction/sdf/Main.asf

Example: Java OM→BGF

```
for (Class<?> clss : classes)
{
    Element rule = doc.createElement("bgf:production");
    Element nonterminal = doc.createElement("nonterminal");
    Element rhs = doc.createElement("bgf:expression");
    nonterminal.appendChild(doc.createTextNode(clss.getSimpleName()));
    root.appendChild(rule);
    rule.appendChild(nonterminal);
    rule.appendChild(rhs);
    Collection<Element> tmp = new LinkedList<Element>();
    if (clss.isEnum())
    {
        compositor = "choice";
        unit = "empty";
        for (Object c : clss.getEnumConstants())
        {
            Element selectable = doc.createElement("selectable");
            tmp.add(selectable);
            Element selector = doc.createElement("selector");
            selectable.appendChild(selector);
            selector.appendChild(doc.createTextNode(c.toString()));
            Element expr = doc.createElement("bgf:expression");
            selectable.appendChild(expr);
            Element empty = doc.createElement("epsilon");
            expr.appendChild(empty);
        }
    } else if . . .
```

SLPS/topics/extraction/java/slps/java2bgf/Tool.java

Example: LDF→BGF

```
<?xml version="1.0"?>
<xsl:stylesheet xmlns:xsl="http://www.w3.org/1999/XSL/
Transform" xmlns:bgf="http://planet-sl.org/bgf"
xmlns:ldf="http://planet-sl.org/ldf" version="1.0">
   <xsl:output method="xml" encoding="UTF-8"/>
   <xsl:template match="/ldf:document">
      <bgf:grammar>
         <xsl:apply-templates select="//bgf:production"/>
      </bgf:grammar>
   </xsl:template>
   <xsl:template match="bgf:production">
      <xsl:if test="local-name(../..) != 'example'">
         <xsl:copy-of select="."/>
      </xsl:if>
   </xsl:template>
</xsl:stylesheet>
```

SLPS/topics/extraction/ldf/ldf2bgf.xslt

Example: TXL→BGF

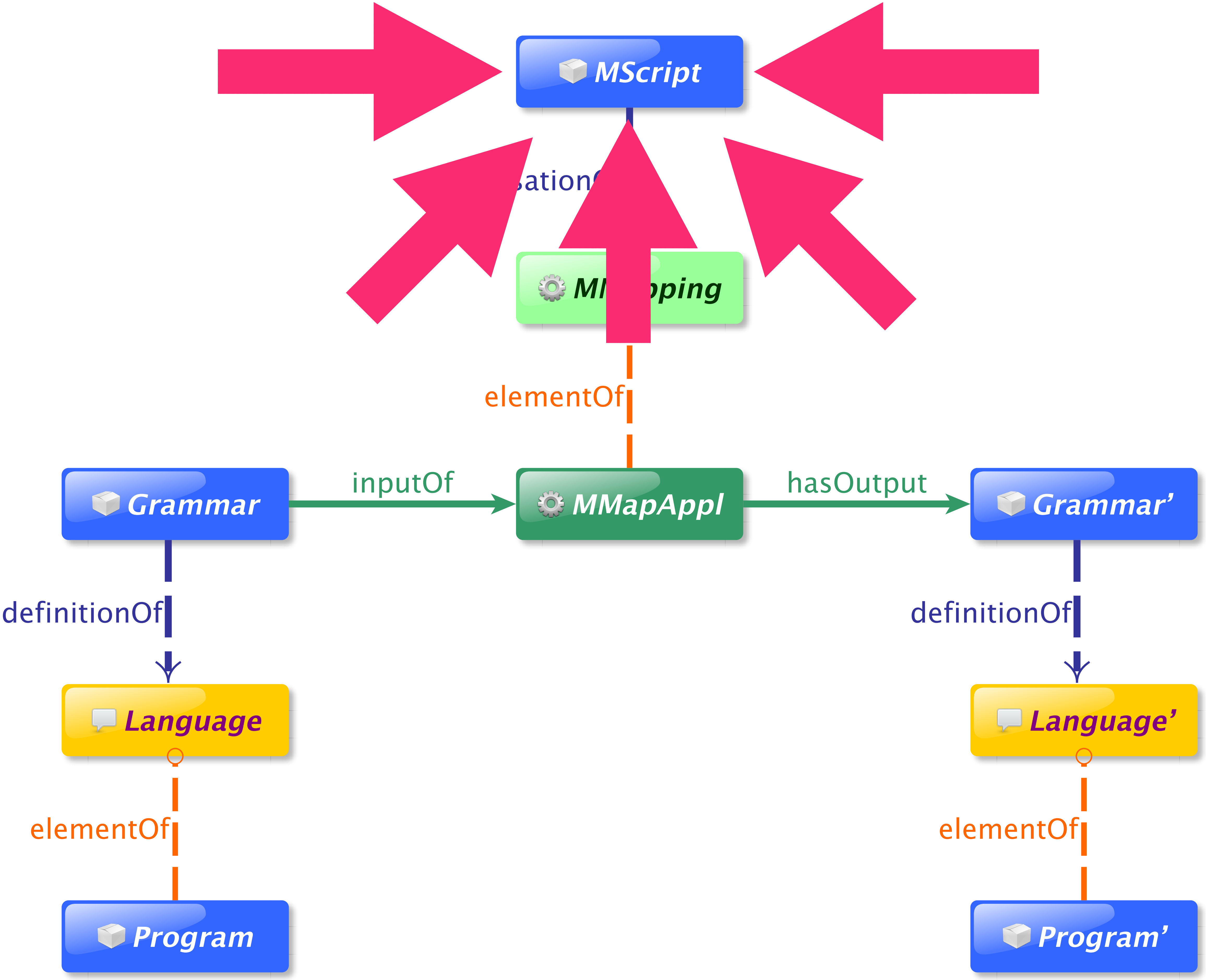
```
<xsl:template match="literalOrType">
    <xsl:choose>
        <xsl:when test="type/typeSpec/typeid/literal/unquotedLiteral/special='!'"/>
        <xsl:when test="type/typeSpec/opt_typeModifier/typeModifier='see'"/>
        <xsl:when test="type/typeSpec/opt_typeRepeater/typeRepeater='+'">
            <bgf:expression>
                    <plus>
                        <bgf:expression>
                            <nonterminal>
                                <xsl:value-of select="type/typeSpec/typeid/id"/>
                            </nonterminal>
                        </bgf:expression>
                    </plus>
                </bgf:expression>
            </xsl:when>
            <xsl:when test="type/typeSpec/opt_typeRepeater/typeRepeater='*' or type/
typeSpec/opt_typeModifier/typeModifier='repeat'">
                <bgf:expression>
                    <star>
                        <bgf:expression>
                            <xsl:if test="type/typeSpec/typeid/id">
                                <nonterminal>
                                    <xsl:value-of select="type/typeSpec/typeid/id"/>
                                </nonterminal>
                            </xsl:if> . . .
```

SLPS/topics/extraction/txl/txl2bgf.xslt

Example: XMI→BGF

```
<xsl:template match="/ecore:EPackage">
    <bgf:grammar>
        <xsl:apply-templates select="*"/>
    </bgf:grammar>
</xsl:template>
. . .
<xsl:when test="@xsi:type='ecore:EEnum'">
    <bgf:production>
        <nonterminal>
            <xsl:value-of select="$ourName"/>
        </nonterminal>
        <xsl:choose>
            <xsl:when test="count(eLiterals)=0">
                <bgf:expression>
                    <epsilon/>
                </bgf:expression>
            </xsl:when>
            <xsl:when test="count(eLiterals)=1">
                <xsl:apply-templates select="./eLiterals"/>
            </xsl:when>
            <xsl:otherwise>
                . . .
            </xsl:otherwise>
        </xsl:choose>
    </bgf:production>
</xsl:when>
```

SLPS/topics/extraction/ecore/ecore2bgf.xslt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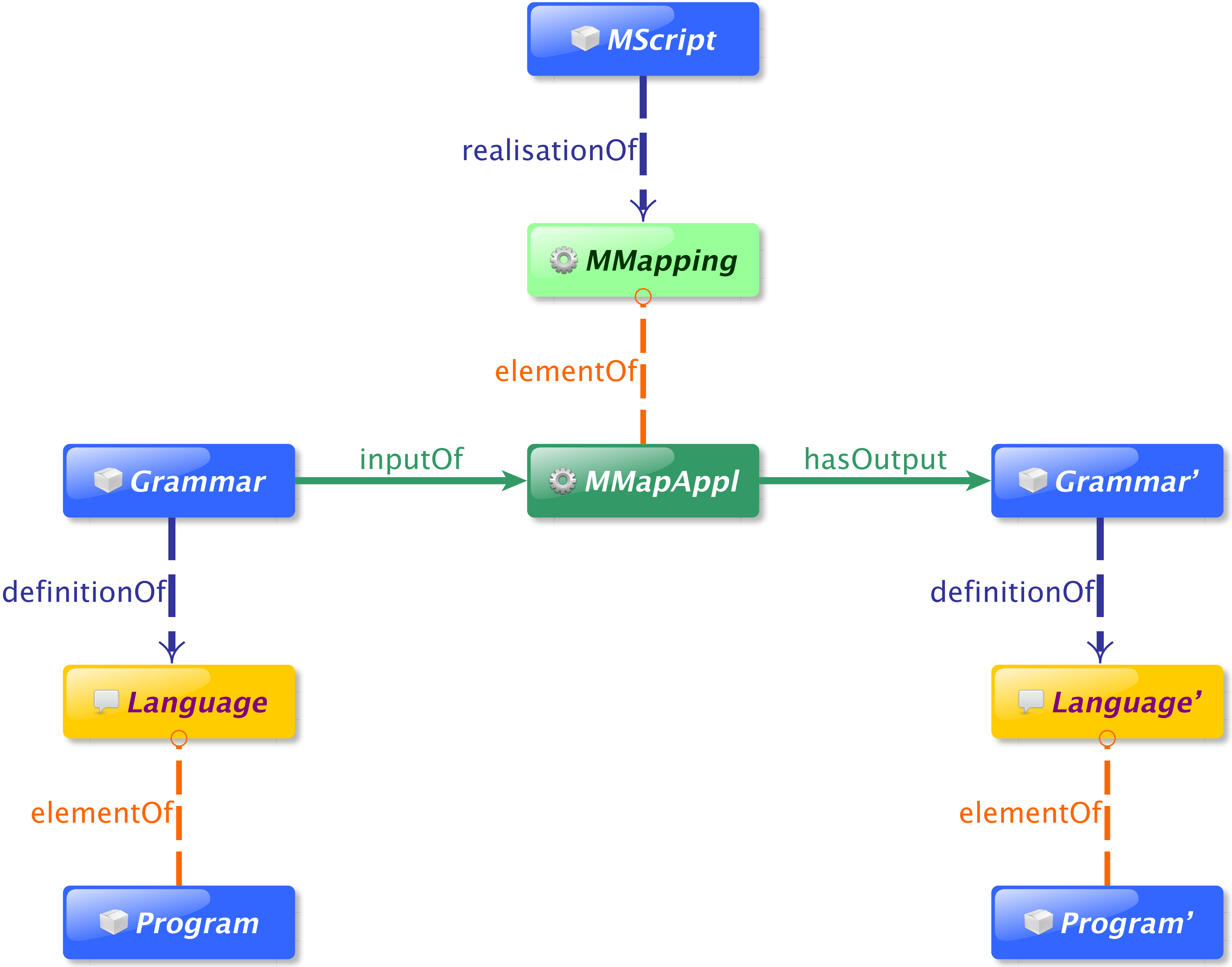
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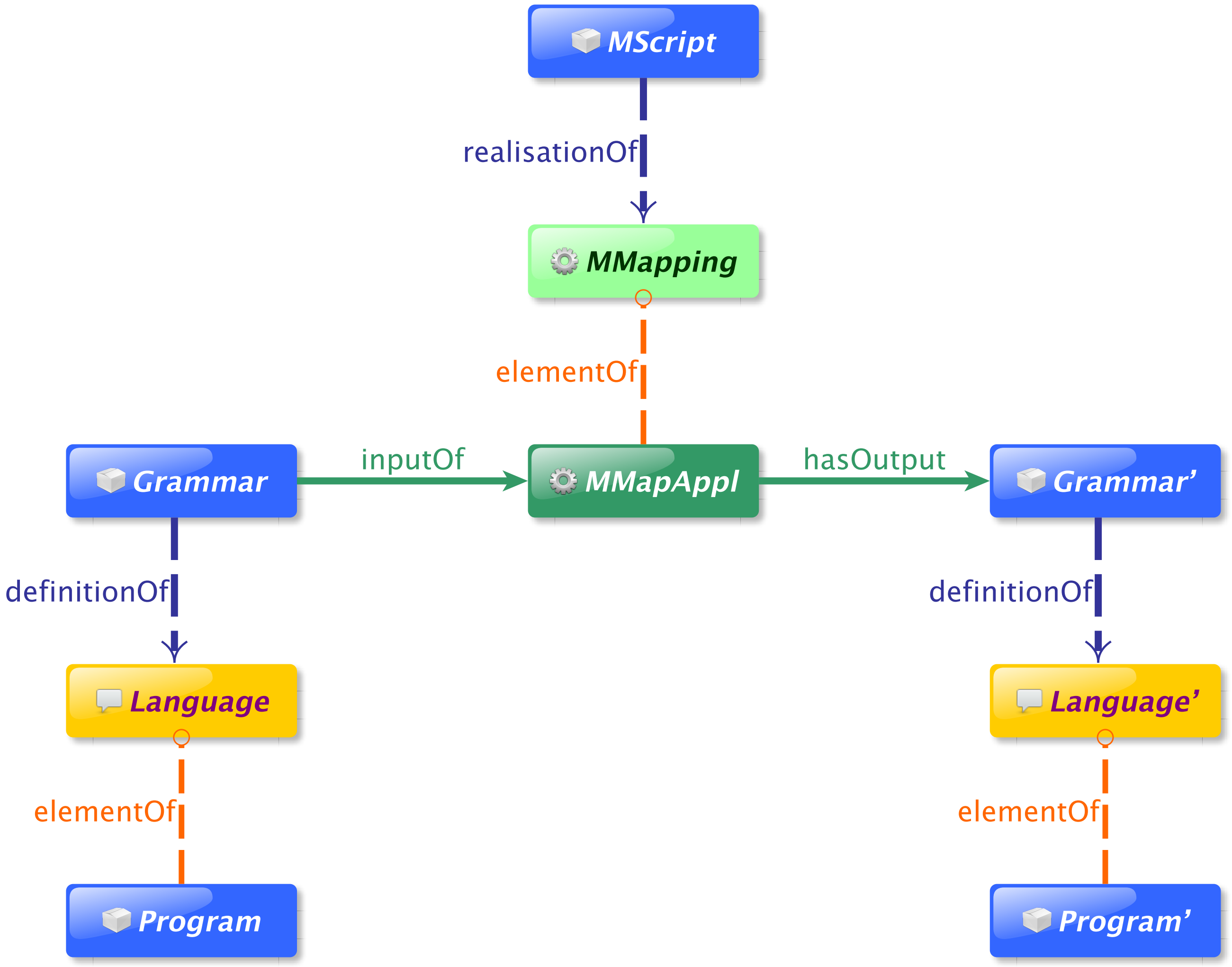
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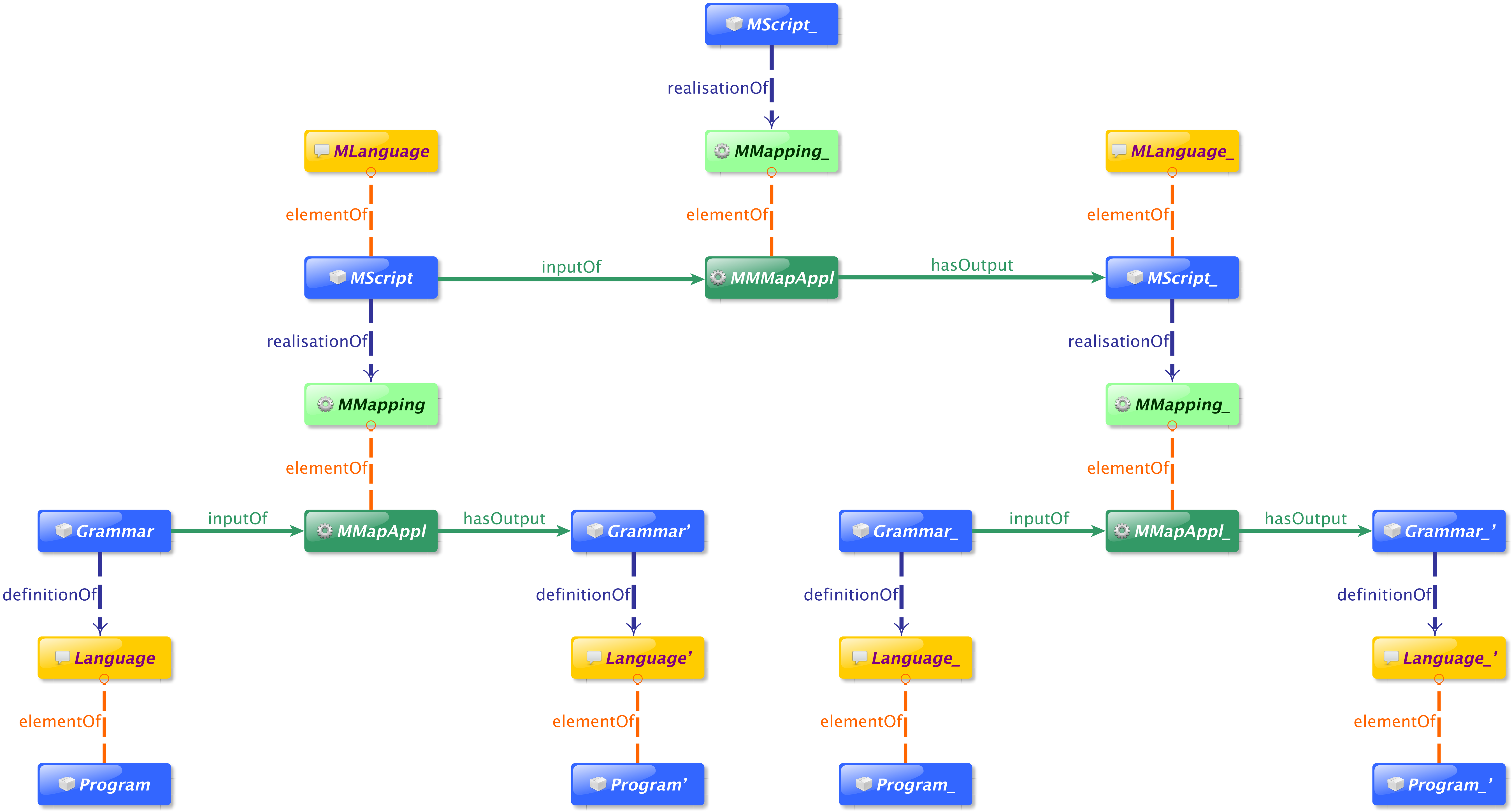
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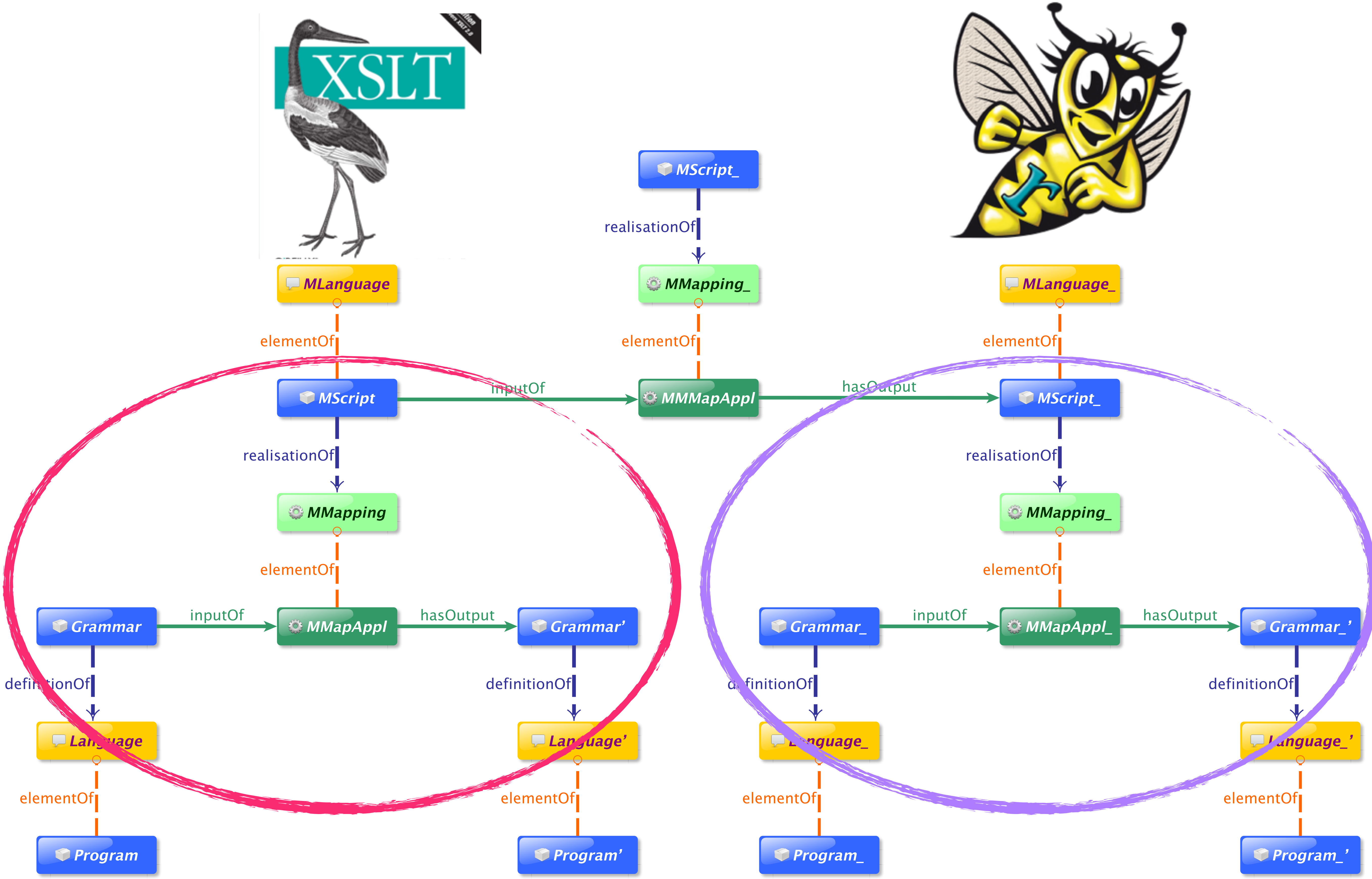
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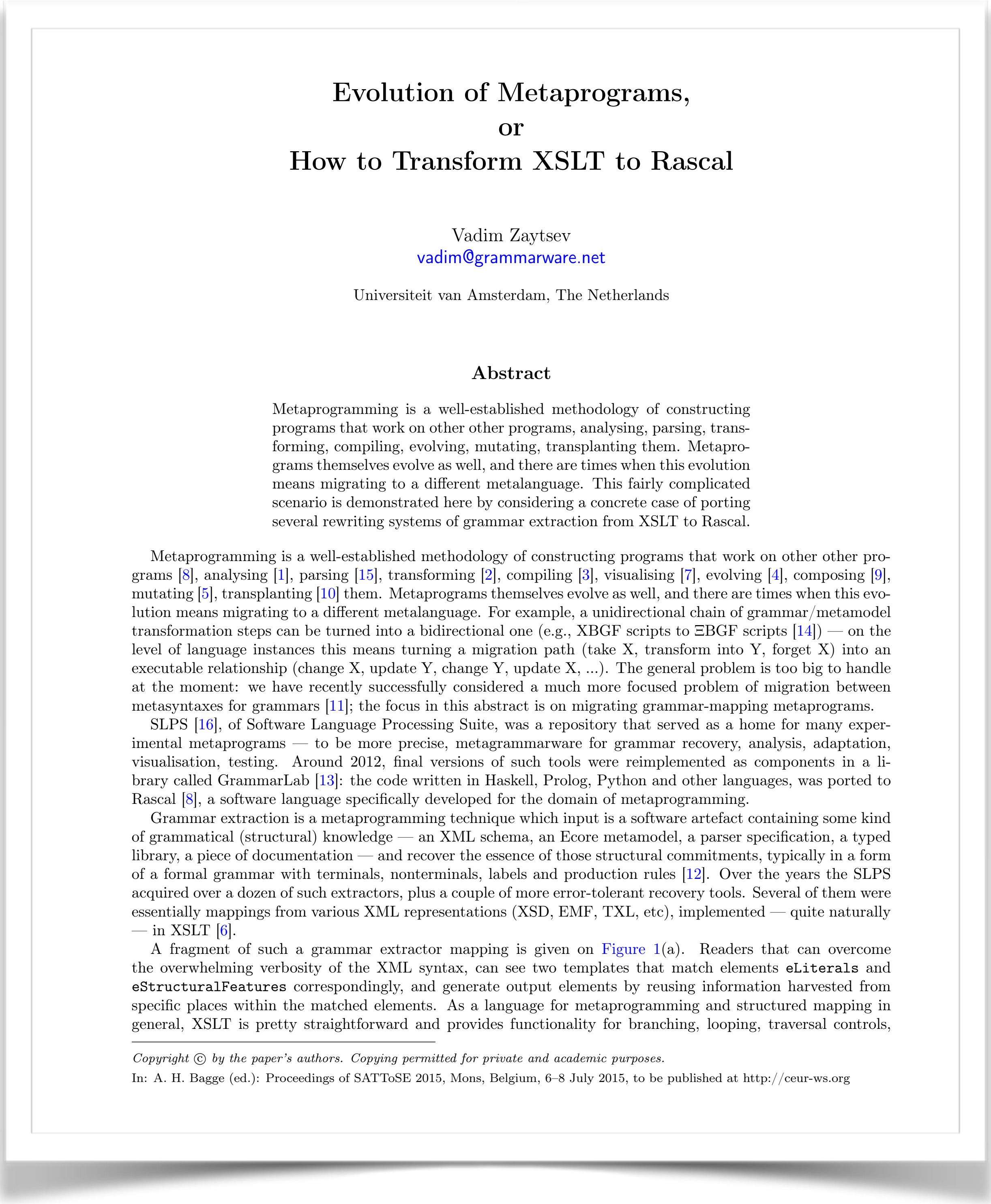
More in the paper:



Evolution of Metaprograms,
or
How to Transform XSLT to Rascal

Vadim Zaytsev
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Universiteit van Amsterdam, The Netherlands

Abstract

Metaprogramming is a well-established methodology of constructing programs that work on other other programs, analysing, parsing, transforming, compiling, evolving, mutating, transplanting them. Metaprograms themselves evolve as well, and there are times when this evolution means migrating to a different metalanguage. This fairly complicated scenario is demonstrated here by considering a concrete case of porting several rewriting systems of grammar extraction from XSLT to Rascal.

Metaprogramming is a well-established methodology of constructing programs that work on other other programs [8], analysing [1], parsing [15], transforming [2], compiling [3], visualising [7], evolving [4], composing [9], mutating [5], transplanting [10] them. Metaprograms themselves evolve as well, and there are times when this evolution means migrating to a different metalanguage. For example, a unidirectional chain of grammar/metamodel transformation steps can be turned into a bidirectional one (e.g., XBGF scripts to ΞBGF scripts [14]) — on the level of language instances this means turning a migration path (take X, transform into Y, forget X) into an executable relationship (change X, update Y, change Y, update X, ...). The general problem is too big to handle at the moment: we have recently successfully considered a much more focused problem of migration between metasyntaxes for grammars [11]; the focus in this abstract is on migrating grammar-mapping metaprograms.

SLPS [16], of Software Language Processing Suite, was a repository that served as a home for many experimental metaprograms — to be more precise, metagrammarware for grammar recovery, analysis, adaptation, visualisation, testing. Around 2012, final versions of such tools were reimplemented as components in a library called GrammarLab [13]: the code written in Haskell, Prolog, Python and other languages, was ported to Rascal [8], a software language specifically developed for the domain of metaprogramming.

Grammar extraction is a metaprogramming technique which input is a software artefact containing some kind of grammatical (structural) knowledge — an XML schema, an Ecore metamodel, a parser specification, a typed library, a piece of documentation — and recover the essence of those structural commitments, typically in a form of a formal grammar with terminals, nonterminals, labels and production rules [12]. Over the years the SLPS acquired over a dozen of such extractors, plus a couple of more error-tolerant recovery tools. Several of them were essentially mappings from various XML representations (XSD, EMF, TXL, etc), implemented — quite naturally — in XSLT [6].

A fragment of such a grammar extractor mapping is given on Figure 1(a). Readers that can overcome the overwhelming verbosity of the XML syntax, can see two templates that match elements `eLiterals` and `eStructuralFeatures` correspondingly, and generate output elements by reusing information harvested from specific places within the matched elements. As a language for metaprogramming and structured mapping in general, XSLT is pretty straightforward and provides functionality for branching, looping, traversal controls,

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In: A. H. Bagge (ed.): Proceedings of SATToSE 2015, Mons, Belgium, 6–8 July 2015, to be published at http://ceur-ws.org

http://grammarware.net/writes/#XSLT-to-Rascal2015

TL;DR

- Useless preliminary analysis
  - XSLT is declarative
  - Rascal is functional/imperative
  - XSLT is XML-like
  - Rascal is Java-like

TL;DR

- Translates well
  - named callables
  - pattern matching
  - condition checking
  - comprehensions

TL;DR

- Problems
  - XSLT is untyped: `<xsl:when test="…" />`
  - Multipattern matching: a|b
  - Vectors vs scalars
  - No variables in λ

Questions

- Does anyone recognise the problem?
- Has anyone ever done anything alike?
- Are there good solutions?
- Why is life so hard?

http://grammarware.github.io