XPath Queries in the Real World

David Baelde Anthony Lick Sylvain Schmitz

lsv
école normale supérieure paris–saclay
cnrs advancing the frontiers
université PARIS-SACLAY
IUF institut universitaire de France

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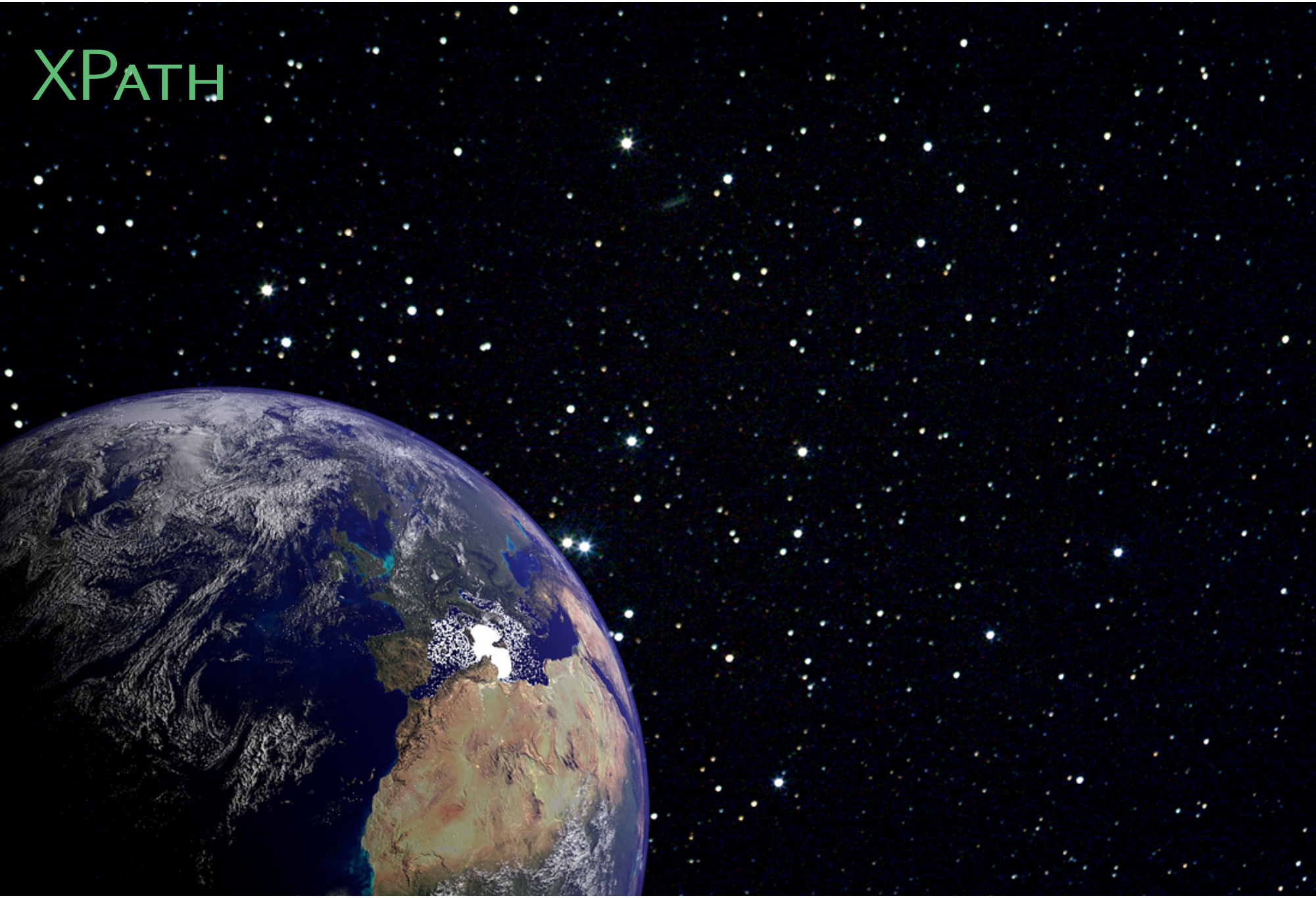
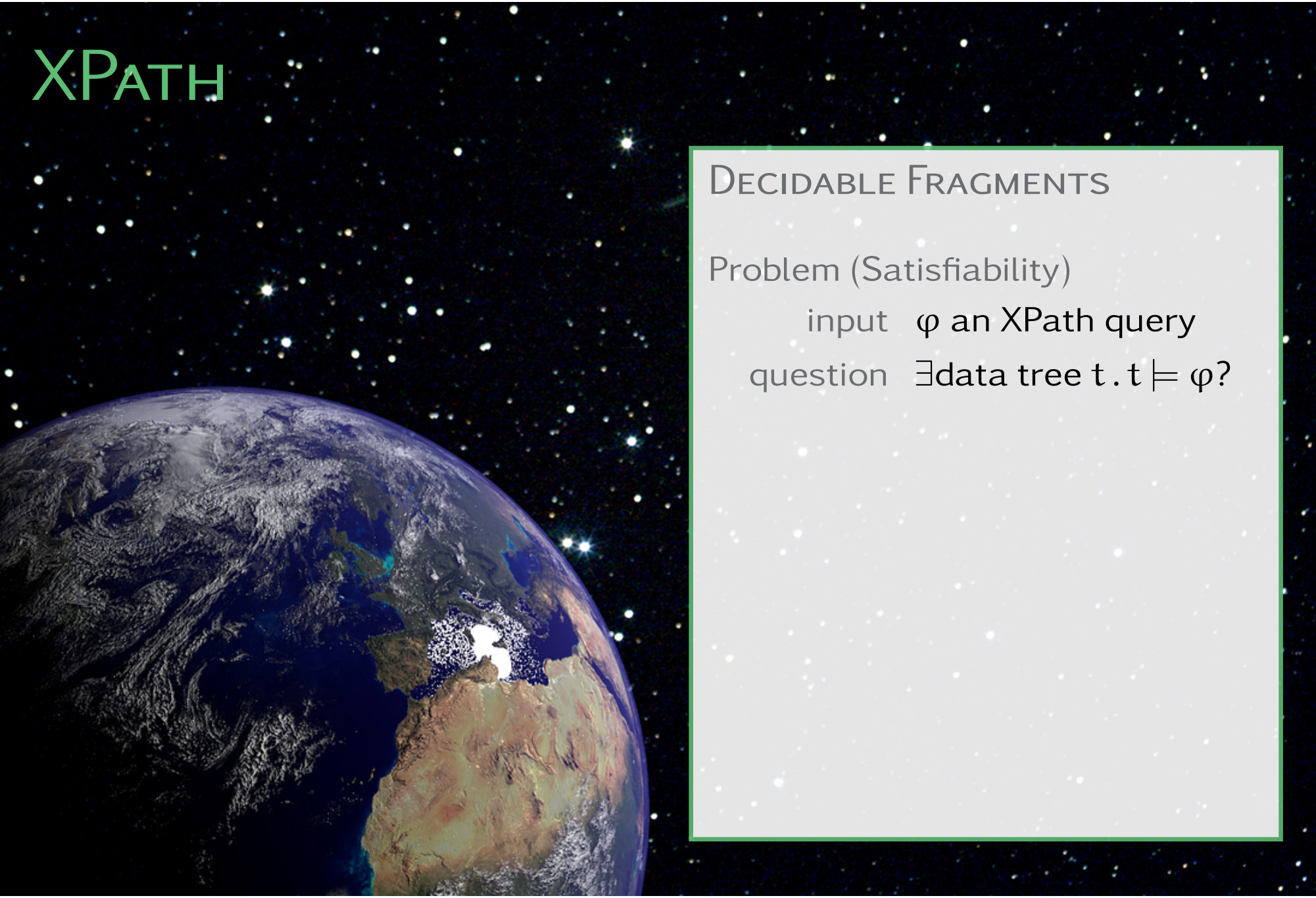
XPath



XPath



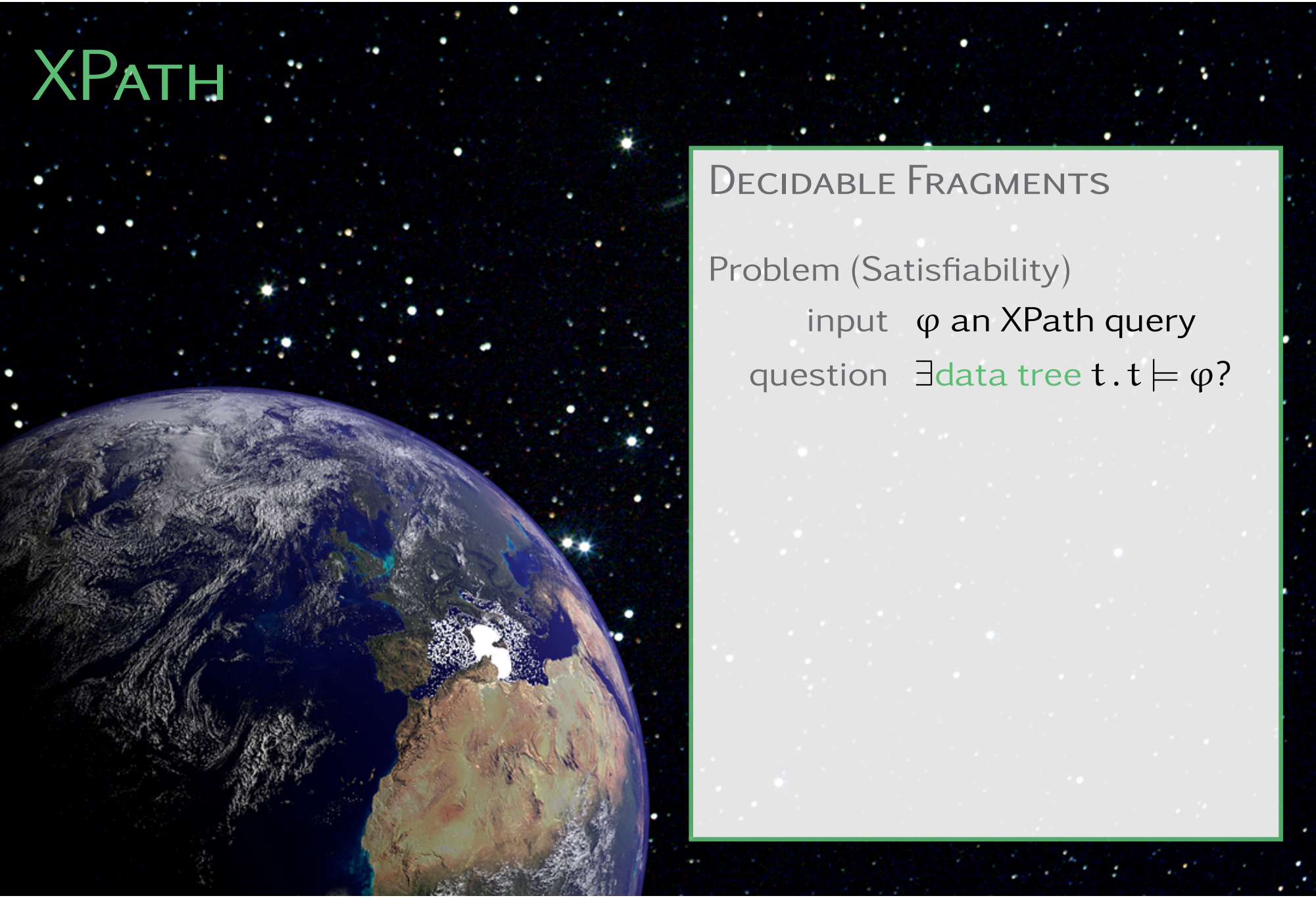
Decidable Fragments

Problem (Satisfiability)

input φ an XPath query

question $\exists$data tree t . $t \models \varphi$?

XPath



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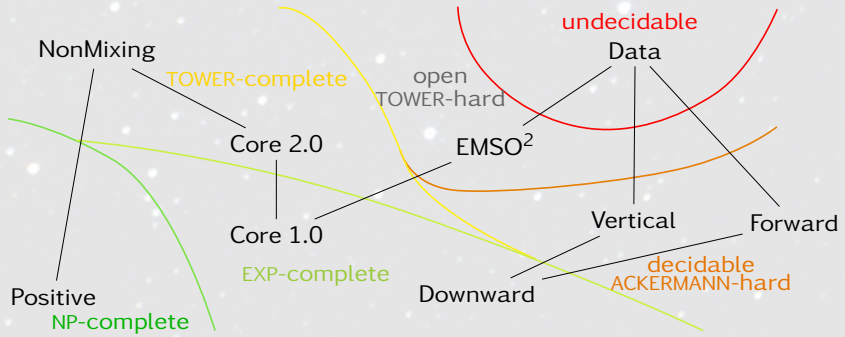
Expressiveness/Complexity



XPath

XML Path Language (XPath) 3.1

W3C Recommendation 21 March 2017

This version:
https://www.w3.org/TR/2017/REC-xpath-31-20170321/

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Most recent version of XPath 3:
https://www.w3.org/TR/xpath-3/

Most recent version of XPath:
https://www.w3.org/TR/xpath/

Most recent Recommendation of XPath:
https://www.w3.org/TR/2014/REC-xpath-30-20140408/

Editors:
Jonathan Robie, biblicalhumanities.org <jonathan.robie@biblicalhumanities.org>
Michael Dyck, Invited Expert <jmdyck@ibiblio.org>
Josh Spiegel, Oracle Corporation <josh.spiegel@oracle.com>

Please check the **errata** for any errors or issues reported since publication.

See also **translations**.

This document is also available in these non-normative formats: XML and Change markings relative to previous edition.

Abstract

XPath 3.1 is an expression language that allows the processing of values conforming to the data model defined in [XQuery and XPath Data Model (XDM) 3.1]. The name of the language derives from its most distinctive feature, the path expression, which provides a means of hierarchic addressing of the nodes in an XML tree. As well as modeling the tree structure of XML, the data model also includes atomic values, function items, and sequences. This version of XPath supports JSON as well as XML, adding maps and arrays to the data model and supporting them with new expressions in the language and new functions in [XQuery and XPath Functions and Operators 3.1]. These are the most important new features in XPath 3.1:

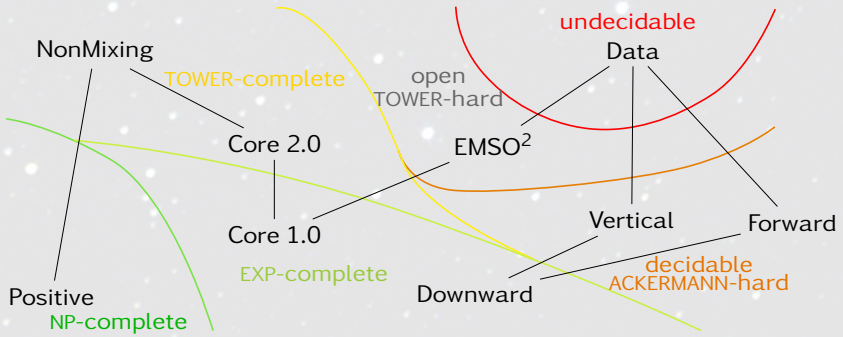
Decidable Fragments

Problem (Satisfiability)

input φ an XPath query

question $\exists$data tree t . $t \models \varphi$?

Expressiveness/Complexity



Overview

benchmark

- open source
- 21,141 XPath queries

coverage of decidable XPath fragments

- “vanilla”
- simple extensions

analysis

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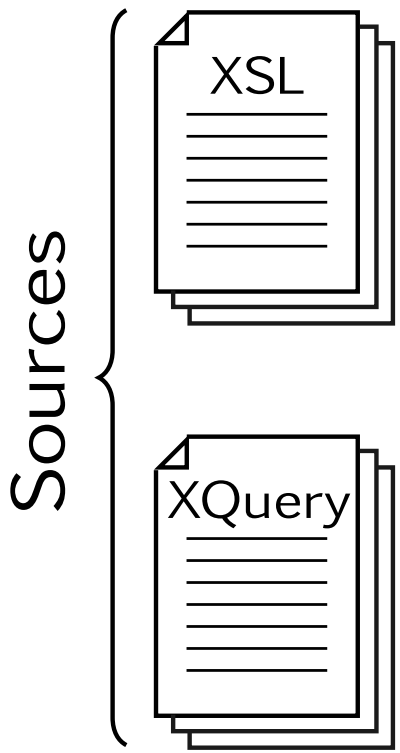
Benchmark Construction



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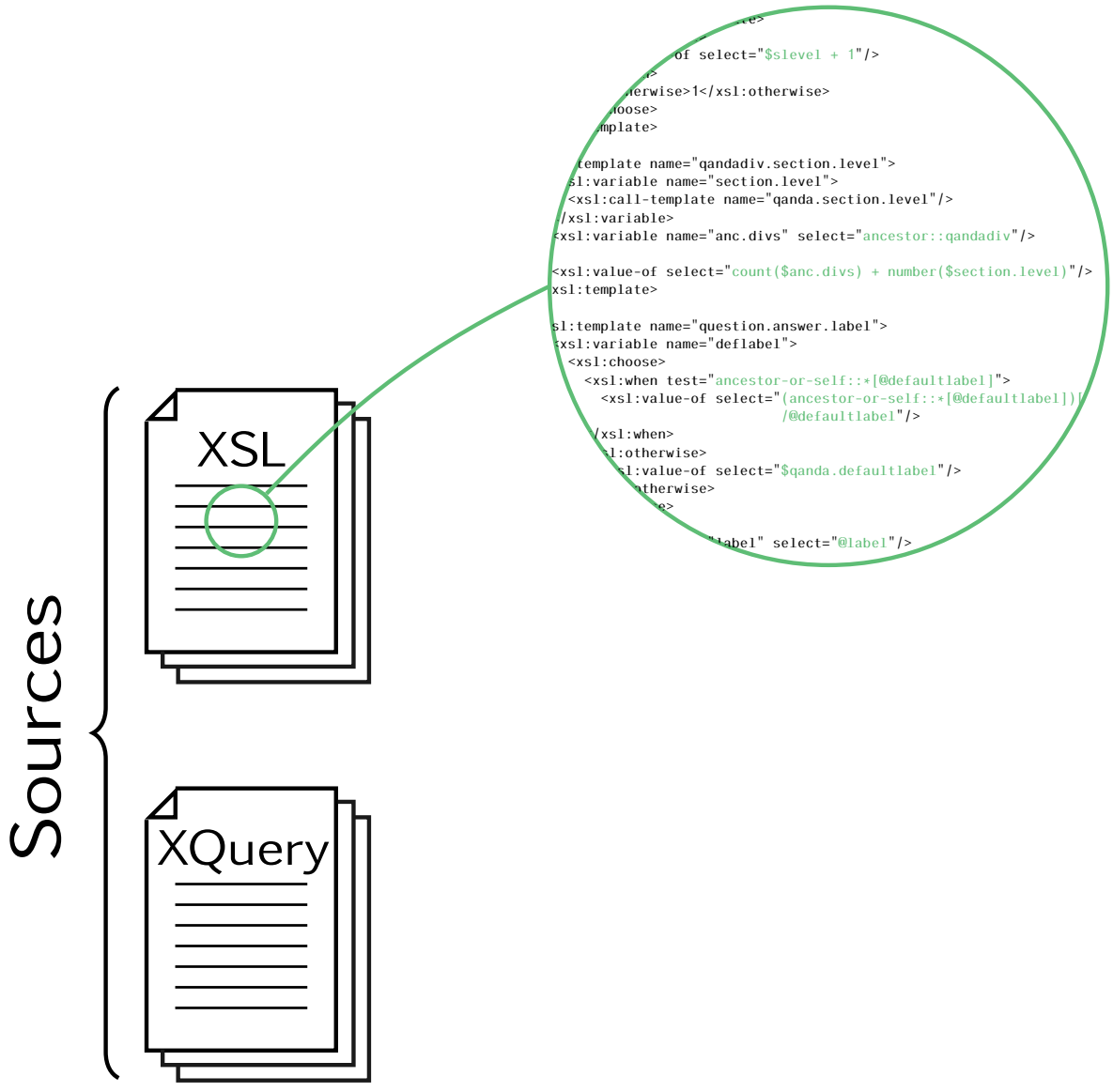

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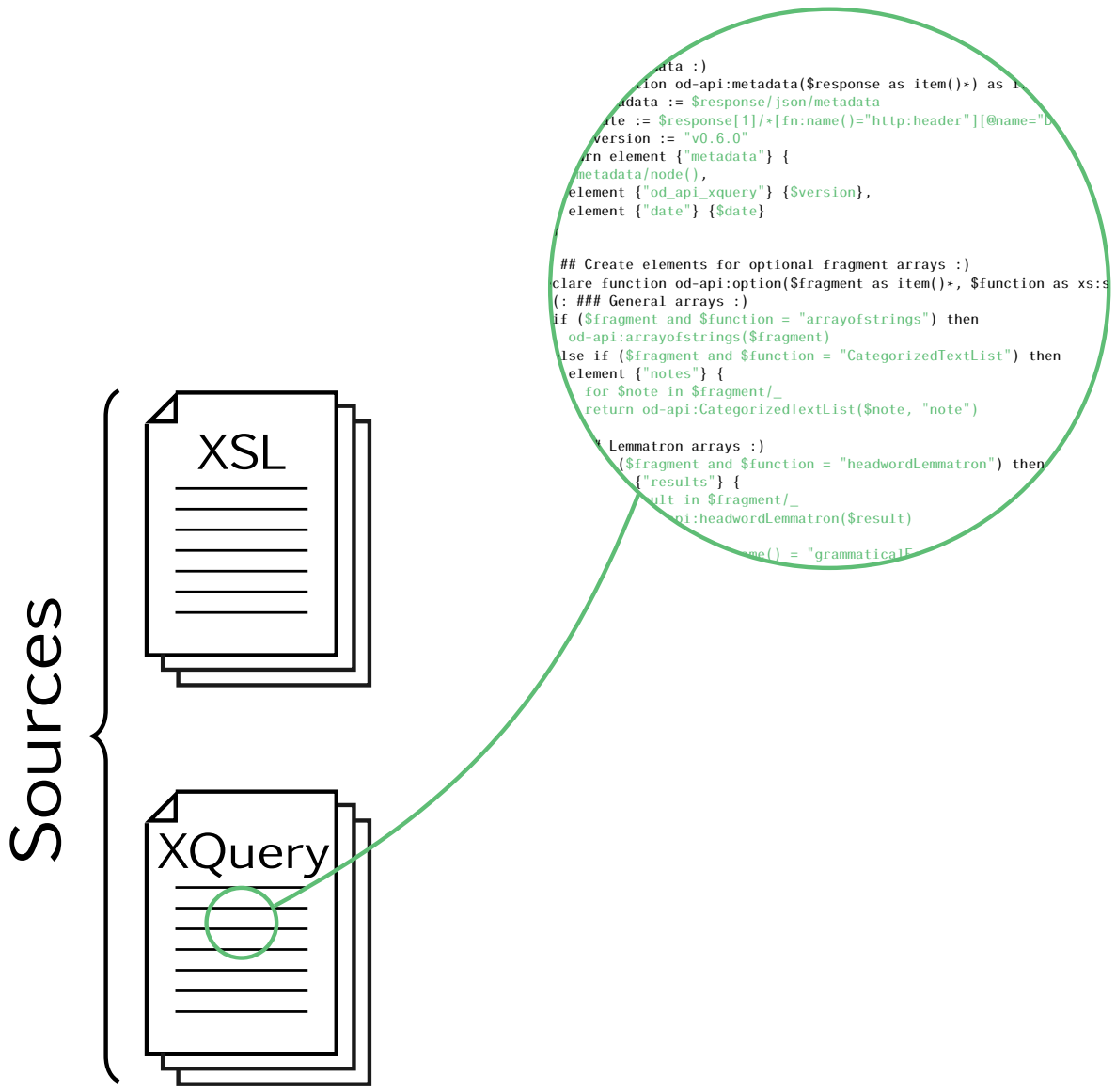

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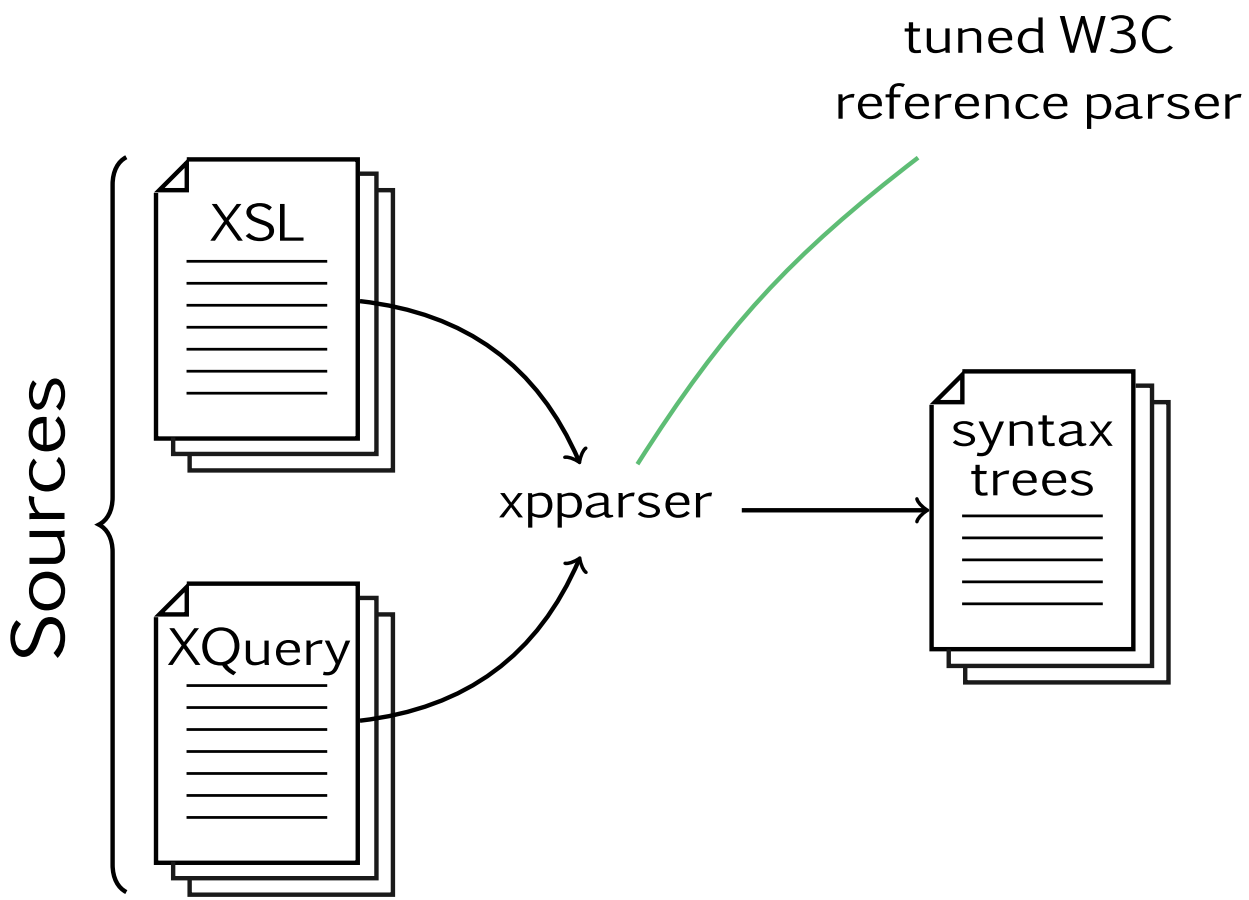

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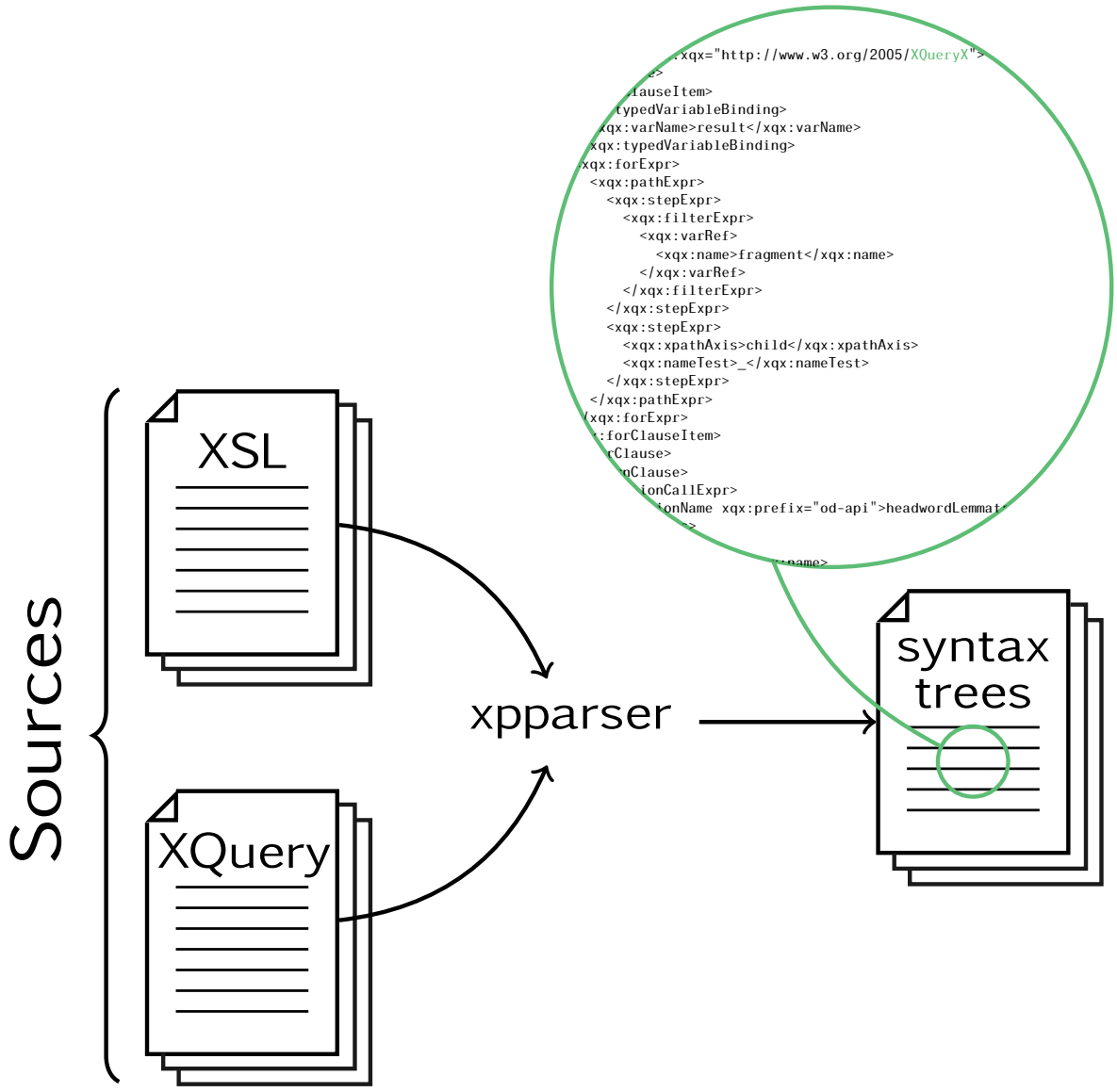

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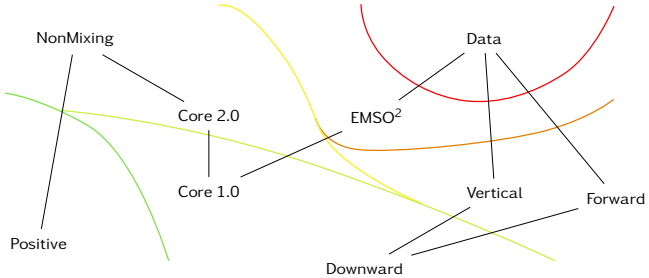

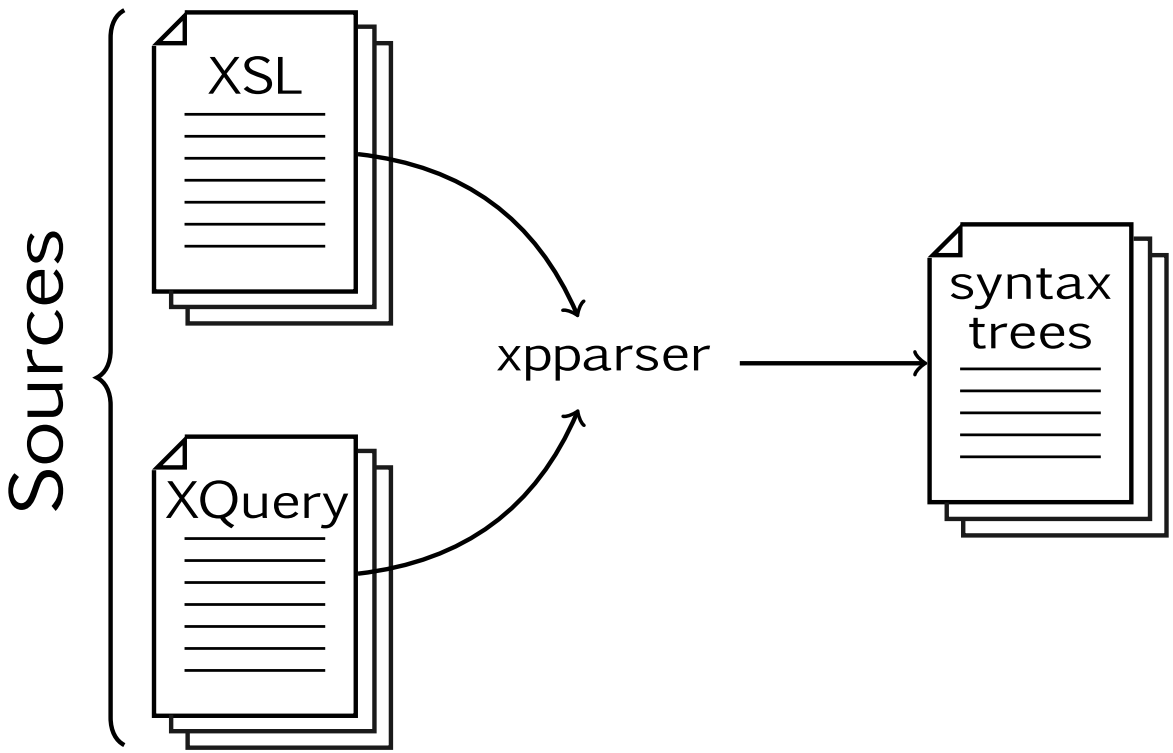

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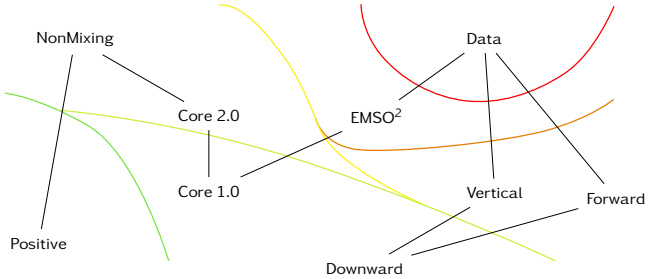
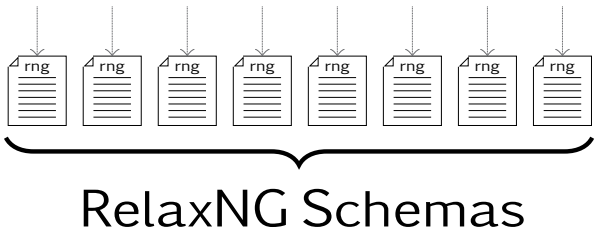
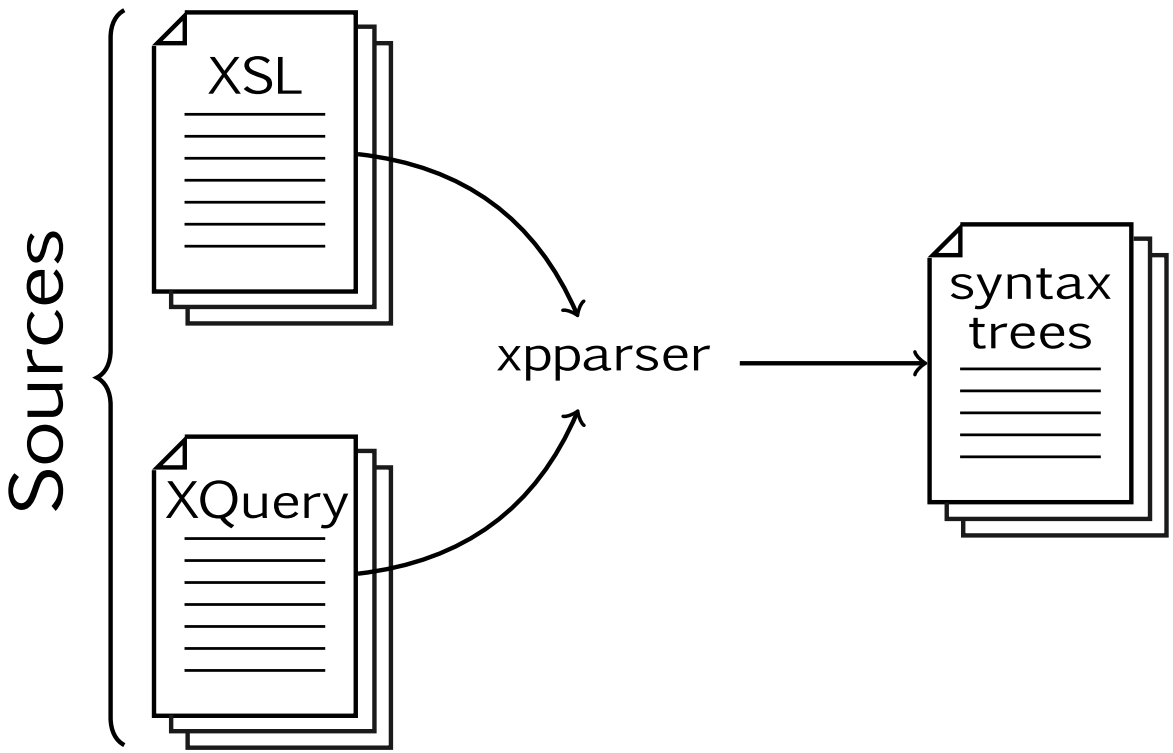




RelaxNG Schemas



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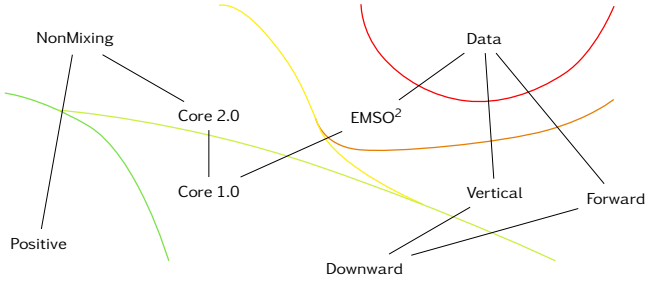

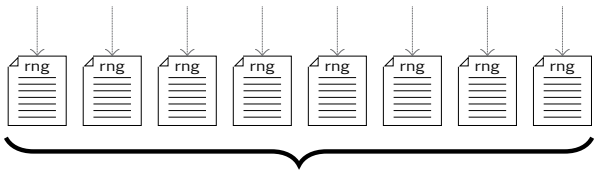

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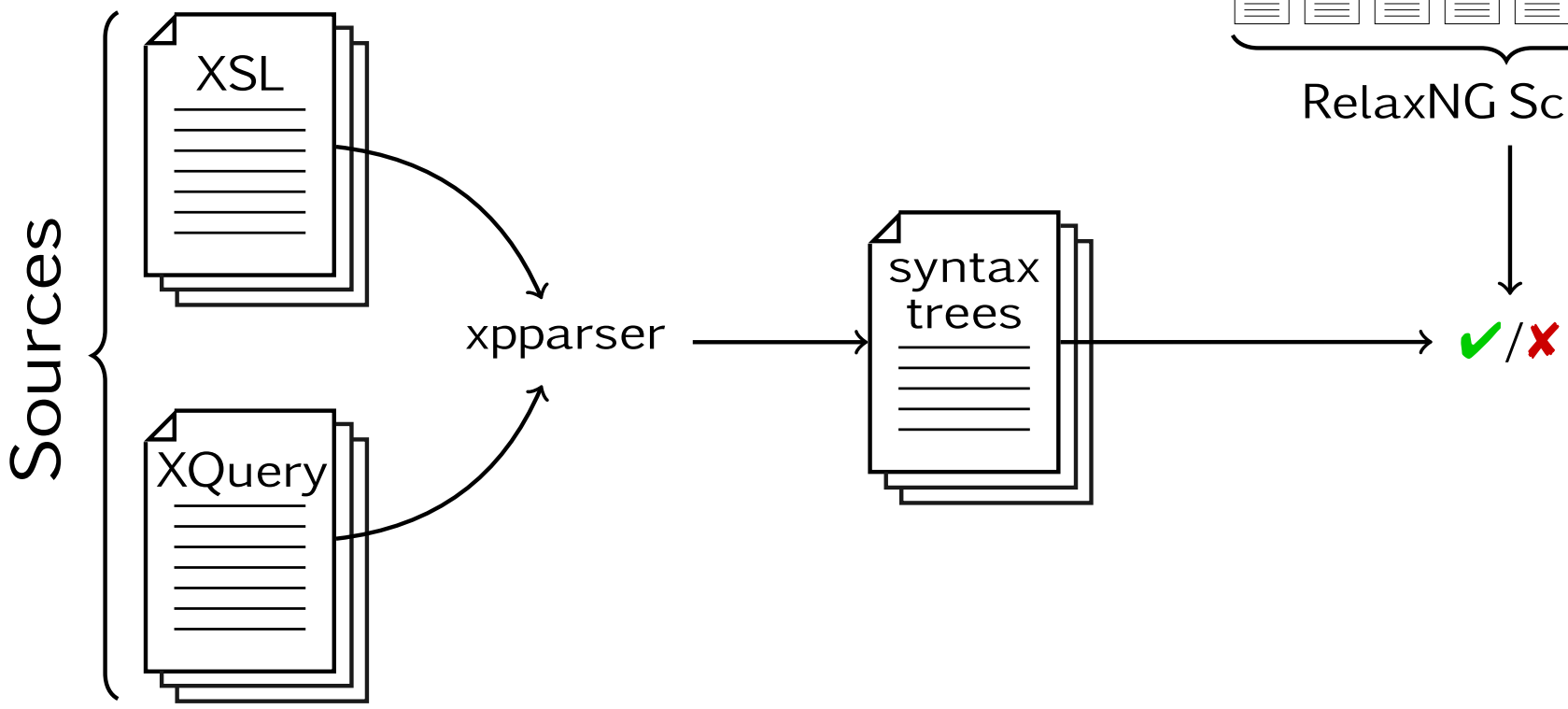

Benchmark Composition

Sources	Queries	Coverage		
		XPath 1.0	XPath 2.0	XPath 3.0
XSLT	14,675	98.4%	100.0%	100.0%
XQuery	6,466	76.1%	87.4%	99.8%
Total	21,141	91.6%	96.1%	99.9%

Benchmark: Functions

XPath and XQuery Functions and Operators 3.1

W3C Recommendation 21 March 2017

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Editor:
Michael Kay (XSLT WG), Saxonica <http://www.saxonica.com/>

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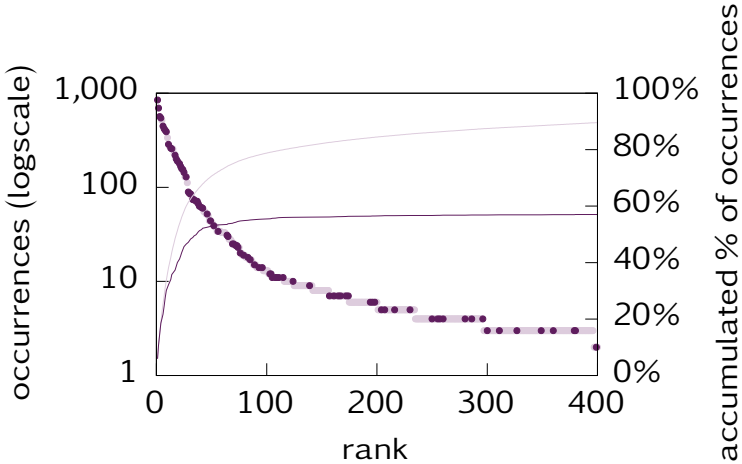

- standard functions (dark violet)
  57.23% of function calls
  76.32% in XSLT
  42.93% in XQuery
- non-standard ones (light violet)
  typically user-defined

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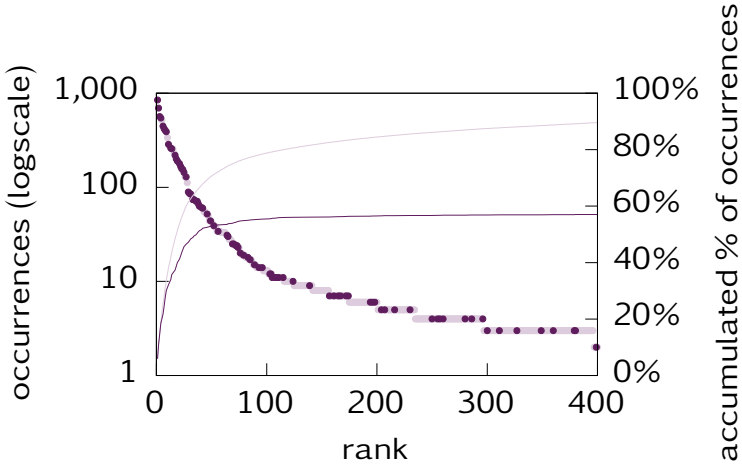

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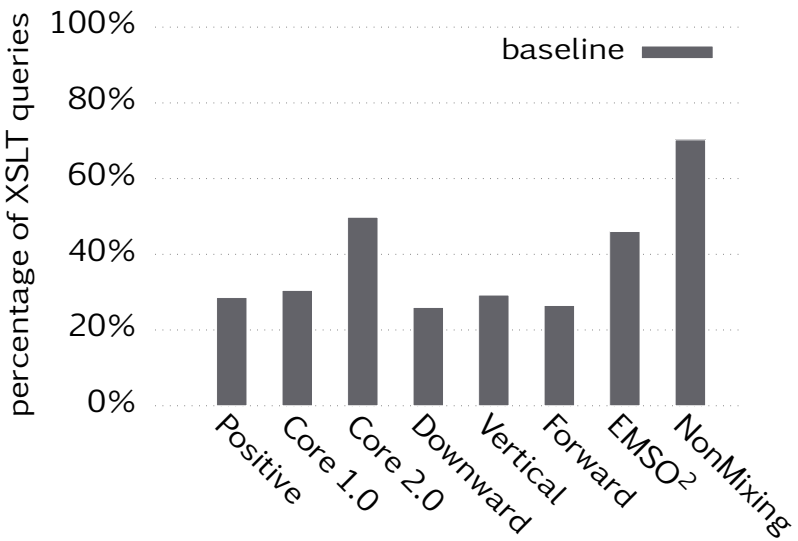
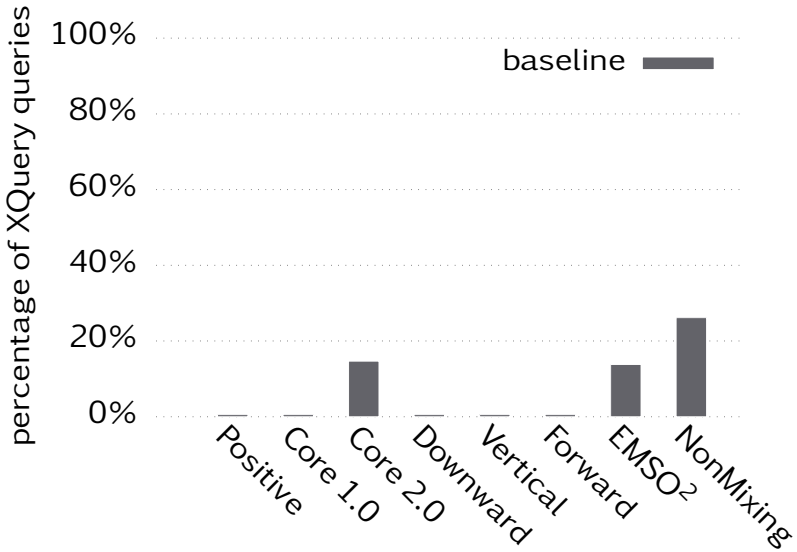
Basic Coverage





- poor coverage
- except for NonMixing fragment
  MSO + positive data tests & data joins not mixing $=$ and $\neq$

Extending fragments

A syntactic construct can be

expressed through equivalent requests

encoded through equisatisfiable requests

Extending fragments

A syntactic construct can be

expressed through equivalent requests

encoded through equisatisfiable requests

Extending fragments

A syntactic construct can be (polynomially)

expressed through (polynomial time computable) equivalent requests

encoded through (polynomial time computable) equisatisfiable requests

defines a front-end

Extensions

$/\pi$ root navigation, e.g.

```
//firstterm
```

$\$x$ free variables, e.g.

```
$module/merge
```

$\pi \triangle d$ data tests against constants, e.g.

```
refmeta/refmiscinfo[@class = 'version']
```

$\pi \triangle \pi$ positive data joins, e.g.

```
a/@href = preceding-sibling::li/a/@href
```

`last()` one-step positional predicates, e.g.

```
tocentry[position() = last()]
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`last()` one-step positional predicates, e.g.

```
tocentry[position() = last()]
```

Expressible Extensions

Example (expressible root navigation)

```
//firstterm
```



```
ancestor-or-self::*[not(parent::*)]//firstterm
```

Expressible Extensions

Example (expressible root navigation)

```
//firstterm
```

```
ancestor-or-self::*[not(parent::*)]//firstterm
```

Expressible Extensions

Example (expressible root navigation)

```
//firstterm
    ⇝
ancestor-or-self::*[not(parent::*)]//firstterm
```

Fact (¬expressible)

Root navigation cannot be expressed in DownwardXPath.

Encodable Extensions

Example (encodable free variables)

`$module/merge`

⇝ extend label set Σ to $\Sigma \times 2^{\{\text{free vars}\}}$

`//.[or`$_{a \in \Sigma, \$module \in S}(a, S)$`]/self::*[or`$_S$`(merge,`$S$`)]`

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Proposition (¬encodable, c.f. Figueira & Segoufin 2009)

Satisfiability in ForwardXPath extended with root navigation or free variables is undecidable.

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Proposition (¬encodable, c.f. Figueira & Segoufin 2009)
Satisfiability in ForwardXPath extended with root navigation or free variables is undecidable.

Proposition (¬poly. enc., c.f. Figueira & Segoufin 2009)
Satisfiability in DownwardXPath extended with `[position()=last()]` and `[position()!=last()]` is ACKERMANN-hard.

Extensions

	Positive	*Core 1.0*	*Core 2.0*	*Downward*	*Vertical*	*Forward*	*EMSO²*	*NonMixing*
$/\pi$								
$\$x$							nat.	nat.
$\pi \triangle d$	nat.							nat.†
$\pi \triangle \pi$	nat.			nat.*	nat.*	nat.*		nat.†
`last()`								

* support limited by available axes † support limited to non-mixing

Extensions

	Positive	*Core 1.0*	*Core 2.0*	*Downward*	*Vertical*	*Forward*	*EMSO²*	*NonMixing*
$/\pi$	expr.	expr.	expr.		expr.		expr.	expr.
$x							nat.	nat.
$\pi \triangle d$	nat.							nat.†
$\pi \triangle \pi$	nat.			nat.*	nat.*	nat.*		nat.†
last()			expr.					expr.

* support limited by available axes † support limited to non-mixing

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$x	enc.	enc.	enc.	¬expr.	enc.	¬enc.	nat.	nat.
$\pi \triangle d$	nat.	enc.	enc.	enc.	enc.	enc.	enc.	nat.†
$\pi \triangle \pi$	nat.	enc.	enc.	nat.*	nat.*	nat.*	enc.	nat.†
last()		enc.	expr.	¬p.enc.	enc.*	enc.*		expr.

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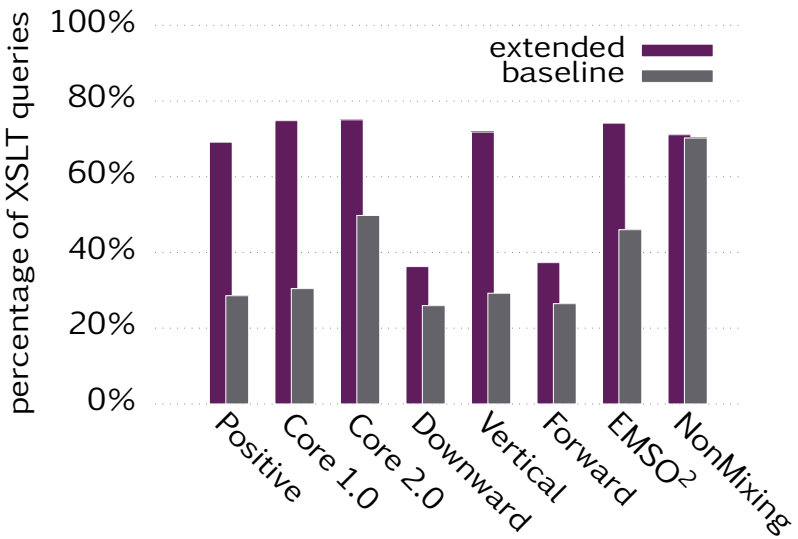
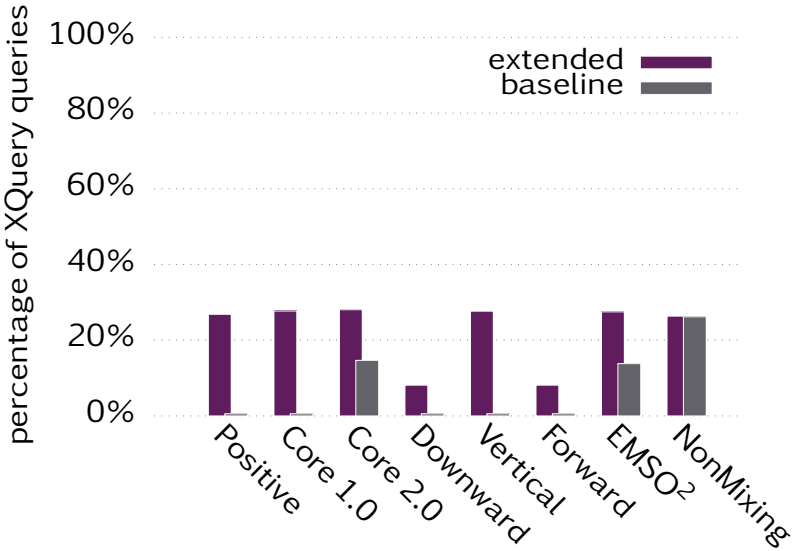
Extended Coverage

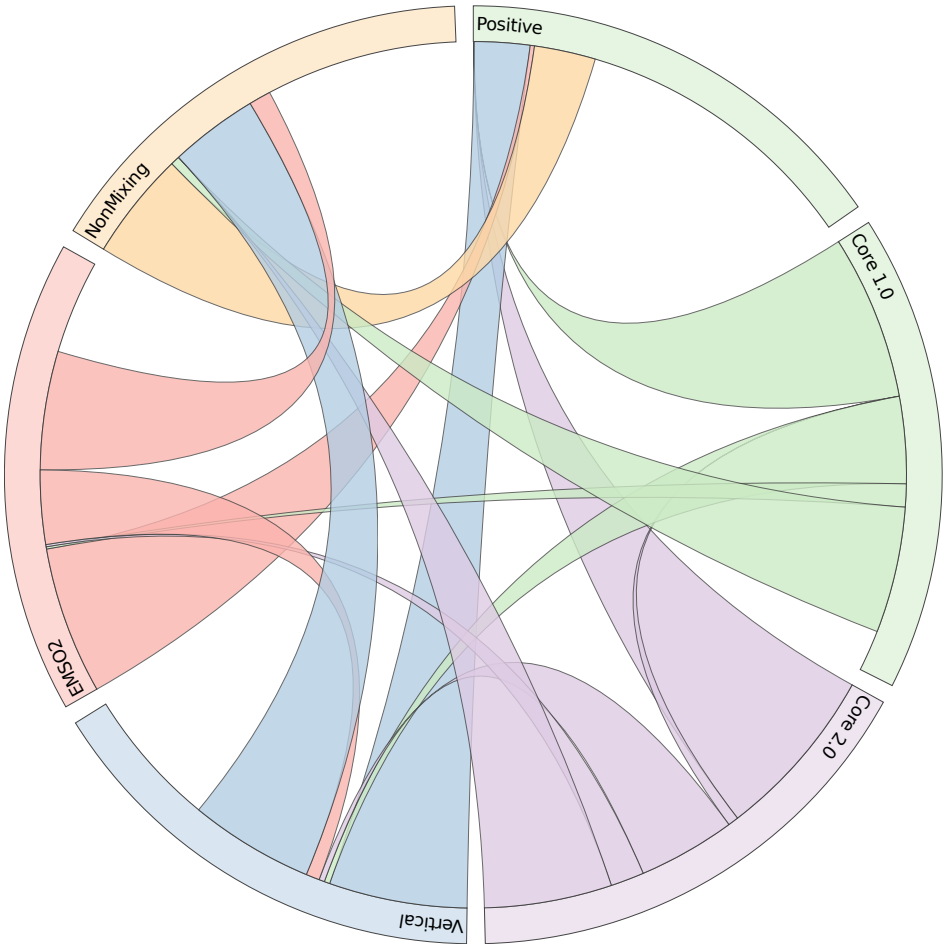




combined 60.86%

Core 2.0 75.03% of XSLT and 28.08% of XQuery

Comparison



Interactive interface

`http://www.lsv.fr/~schmitz/xpparser`

Function Support

Coverage with respect to XPath 3.0 std.

combined 78.33%

Core 2.0 82.14% of XSLT and 60.00% of XQuery

Extra support through SMT?

- interval encoding of trees for Positive fragment
- support for linear arithmetic and string functions like `concat()`, `contains()`, `string-length()`, etc.
- 62.75% coverage, 84.77% of XSLT wrt. XPath 3.0 std

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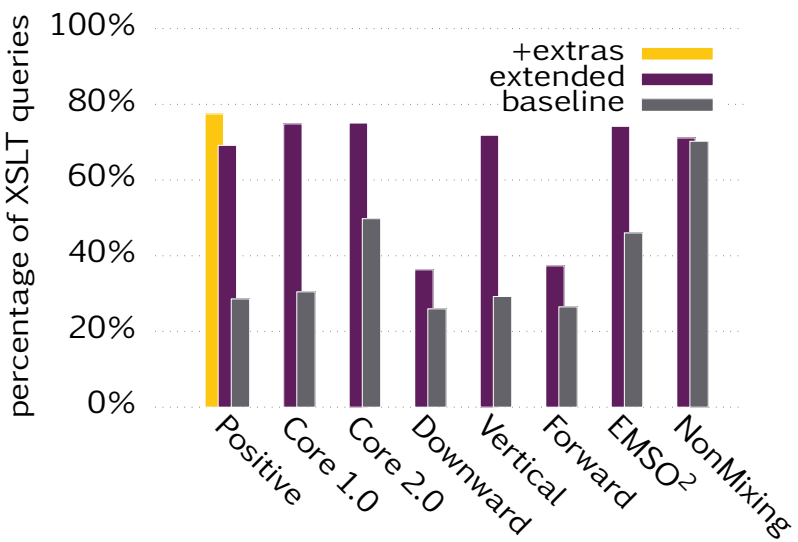

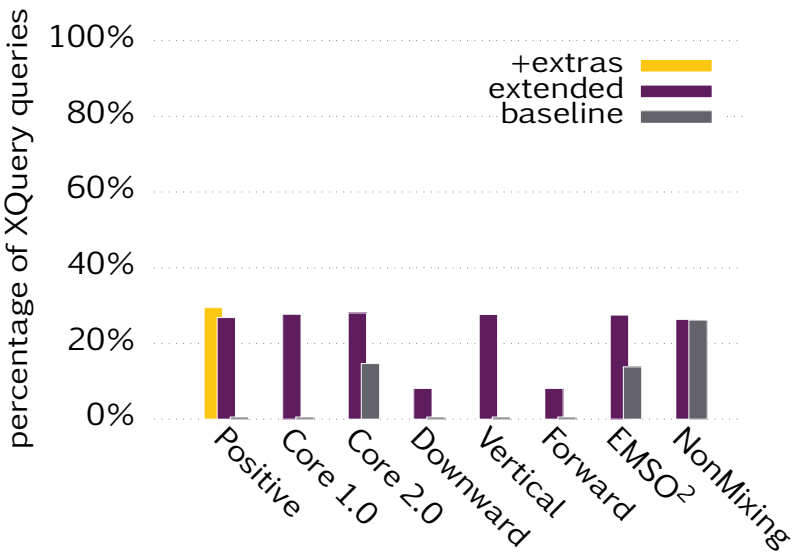

Conclusions

benchmark of 21,141 XPath queries

xpparser: swh:1:dir:081194c82832b17c4d1229313e85753dfb3ec4cd
benchmark: swh:1:dir:1ea68cf5bb3f9f3f2fe8c7995f1802ebadf17fb5

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- XSLT support vs. XQuery support
- challenge: function support
- future? SMT techniques

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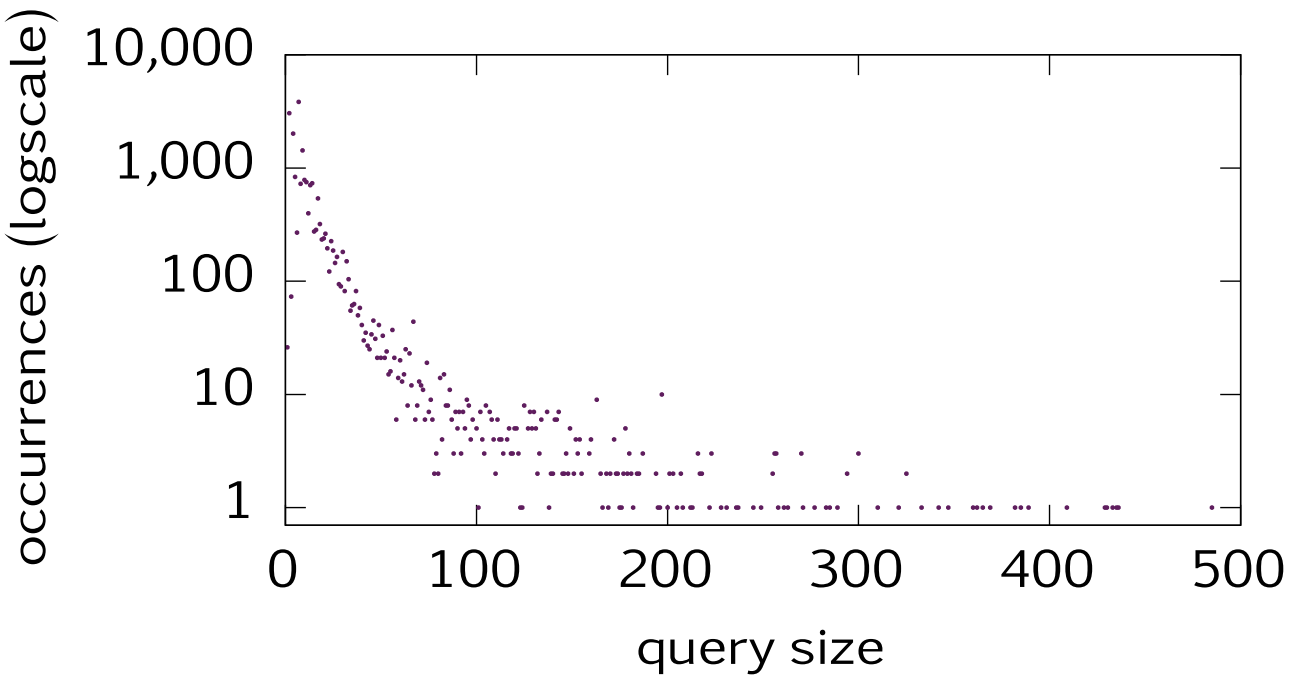
Benchmark: Size Distribution



Synthetic Benchmarks

Sources	Queries	Coverage XPath 1.0	XPath 2.0	XPath 3.0
XPathMark-FT	64	100.0%	100.0%	100.0%
XPathMark-PT	38	100.0%	100.0%	100.0%
XMark	66	92.4%	93.9%	100.0%
Total	168	97.0%	97.6%	100.0%