Portable EXPath Extension Functions

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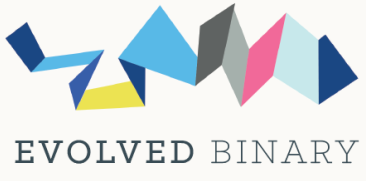
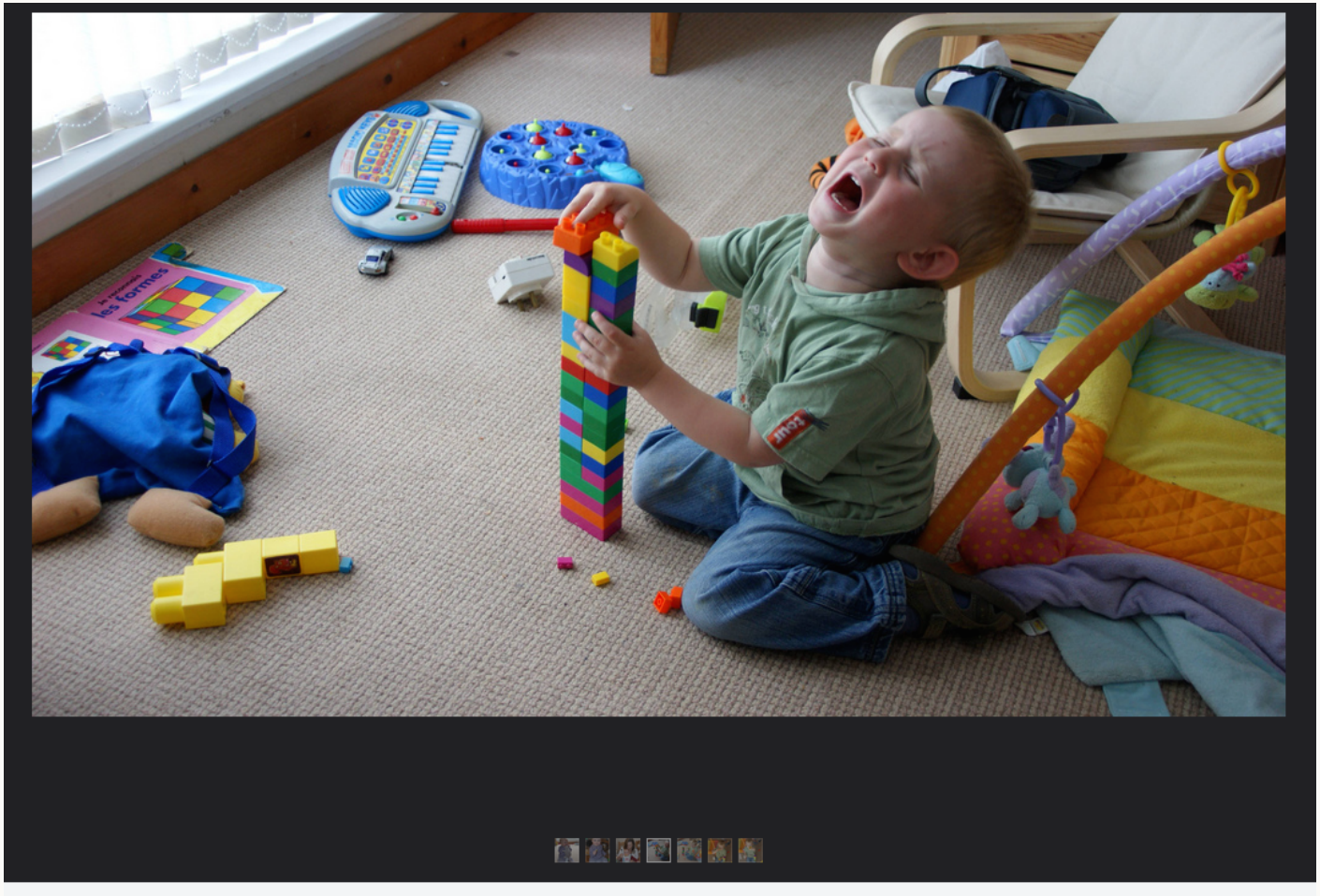


Adam Retter

- **Consultant**
  - Scala / Java
  - Concurrency
  - XQuery, XSLT
- **Open Source Hacker**
  - Predominantly NoSQL Database Internals
  - e.g. eXist, RocksDB, Shadoop (Hadoop M/R framework)
- **W3C Invited Expert for XQuery WG**
- **Author of the "eXist" book for O'Reilly**
- **XML Summer School Faculty (13/09/15)**

A talk about incompatibility...



TODO...

1. The Portability Problem
2. Previous Efforts
3. Processor Varieties
4. Our Solution

Context

- **XPDL**
  - XPath Derived Language e.g. XQuery/XSLT/XProc/XForms
  - Typically uses F+O as Standard Library
- **Assumption: We want to write apps in XPDLs**
  - Less code/impedance-mismatch
    - ~67% reduction in LoC vs Java [1]
  - Serve/Process the Web
  - Process structure/semi-structured data
  - Process mixed-content

[1] Developing an Enterprise Web Application in XQuery
http://download.28msec.com/sausalito/technical_reading/enterprise_webapps.pdf

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The Portability Problem

XPDLs are typically specified as open standards

...however...

Applications written in XPDLs are rarely useable across implementations

Vendor Extensions are EVIL!

- **Seem like a good idea at the time**
  - Easy/Quick to get something done
- **Many Types**
  - Syntax extensions
    - e.g `xquery "1.0-ml";`
  - Data Type Extensions
    - e.g `xs:binary-document`
  - Deviation from Standards
    - e.g `fn:matches($input*, $pattern)`
  - Indexes, Triggers, etc.
  - Extension Functions

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XPDL Extension Functions

- **Our focus, due to their impact**
  - Disguised by standard function call interface
    - `FunctionCall ::= EQName ArgumentList`
  - Distributed throughout an XPDL code-base
- **XPDL Extension Functions**
  - Typically implemented in lower-level language
    - C / C++ / Java / .NET etc.
  - Vendor/Processor specific
    - Consistent across processor versions?
  - EXPath
    - Requires reimplementation for every processor
    - Not supported by all processors

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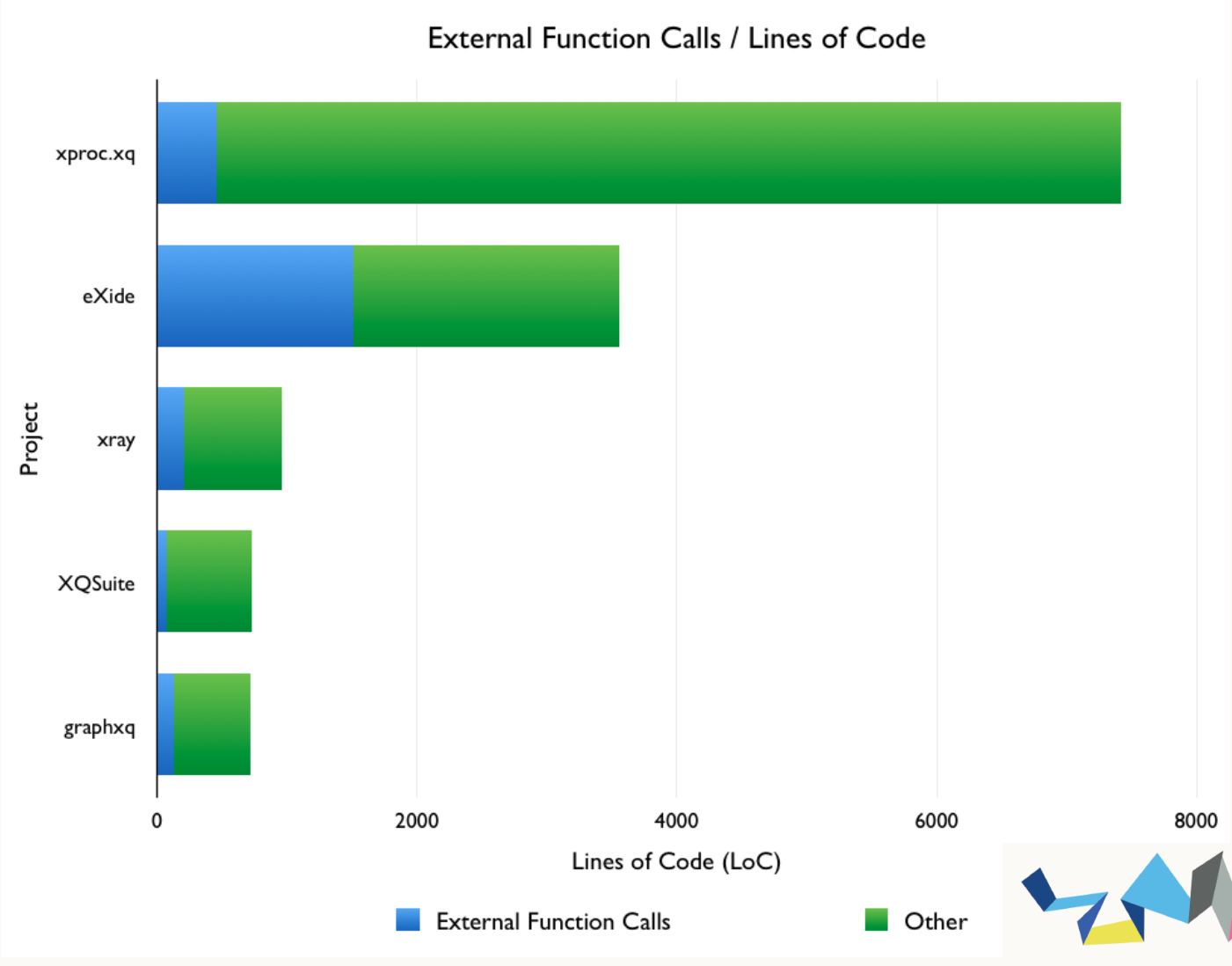
Impact of Extension Functions



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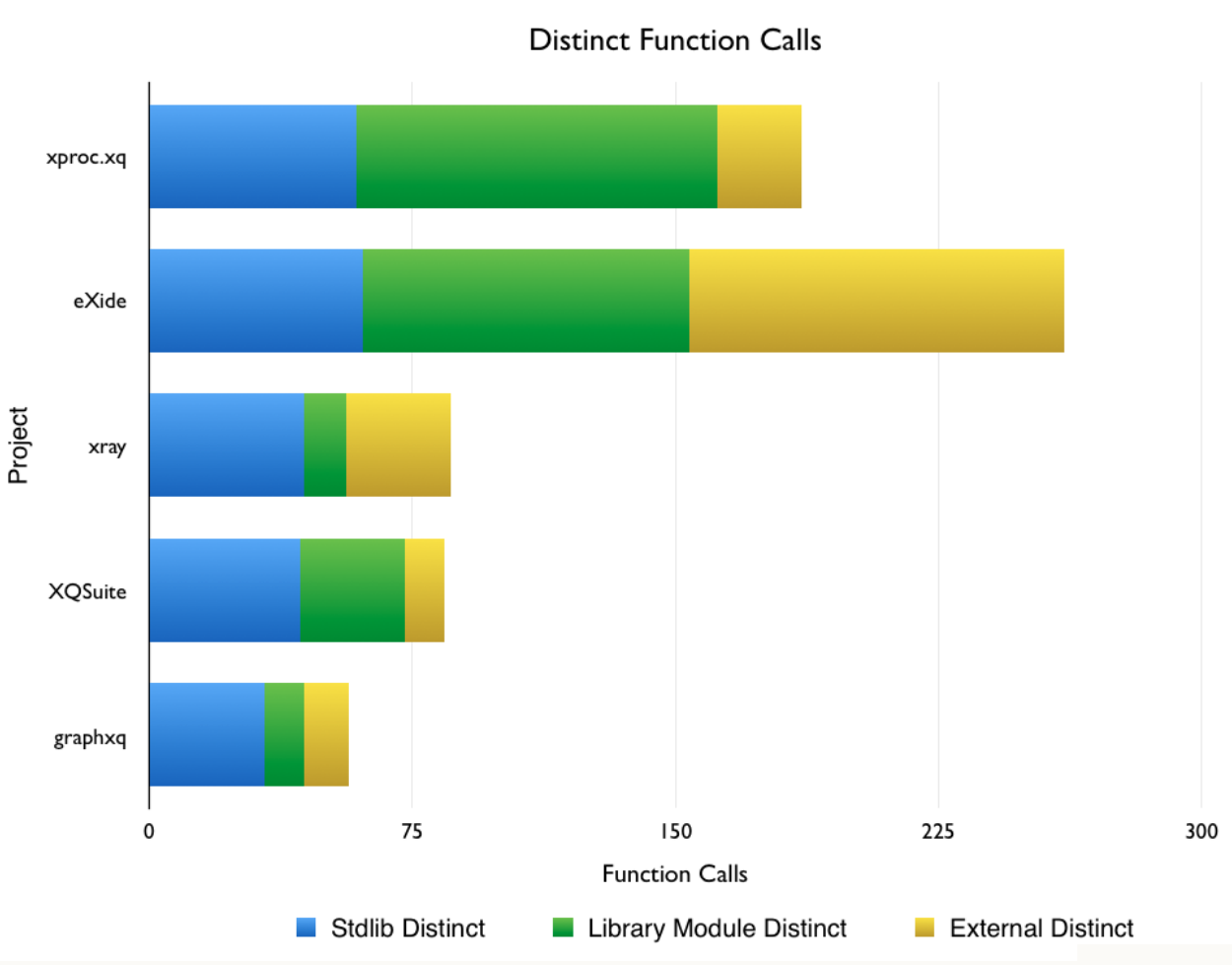
Impact of Extension Functions



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Vendor Extensions ultimately:

- **Introduce Hurdles to Portability**
- **Restrict user freedom**
  - Vendor lock-in
  - Lesson the impact of frameworks
- **Fragment the XPDL community**
  - Create knowledge/skills silos
  - Reduce code-sharing
  - Limit code-reuse
  - Reduce collaboration
  - XPDL Processor specific forks of XPDL apps

Other Efforts to Improve Portability

- **XSLT 1.1 (2000)**
  - Stated primary goal - " *improve stylesheet portability*"
  - Adds `xsl:script` for extension functions
  - Highly contentious. Abandoned!
- **EXSLT (2001)**
  - Extended the XSLT 1.0 Standard Library
  - Just a Specification
  - Each vendor implemented for own processor

Other Efforts to Improve Portability

- **FunctX (2006)**
  - A Library of >150 useful common functions
  - Implementations in both XQuery and XSLT
- **EXQuery (2008)**
  - Just one specification to date: RESTXQ
  - Common implementation in Java
- **EXPath (2009)**
  - Standards for extension functions
  - Some common implementations in Java

Lessons Learnt

- **Standards are nice, but require implementations**
  - Really need >50% of market-share to implement
- **Vendors are lazy/limited**
  - Standards are often retrospective!
- **Implementation Type Mapping (XSLT 1.1)**
  - Showed great promise for integration
  - Must be implementation language agnostic
- **No single language for low-level implementation**
  - Won't be accepted by developers
  - Won't be accepted by vendors

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Lessons Learnt

- XPDL Processors are surprisingly similar!

```
interface StandardFunc {
  Item item(QueryContext qc, InputInfo ii) throws QueryException;
}
```

```
interface BasicFunction {
  Sequence eval(Sequence[] args, Sequence contextSequence)
    throws XPathException;
}
```

```
interface ExtensionFunctionCall {
  SequenceIterator call(SequenceIterator[] arguments, XPathContext context)
    throws XPathException;
}
```

```
class XQFunction {
  public:
    Sequence createSequence(DynamicContext* context, int flags=0) const;
};
```

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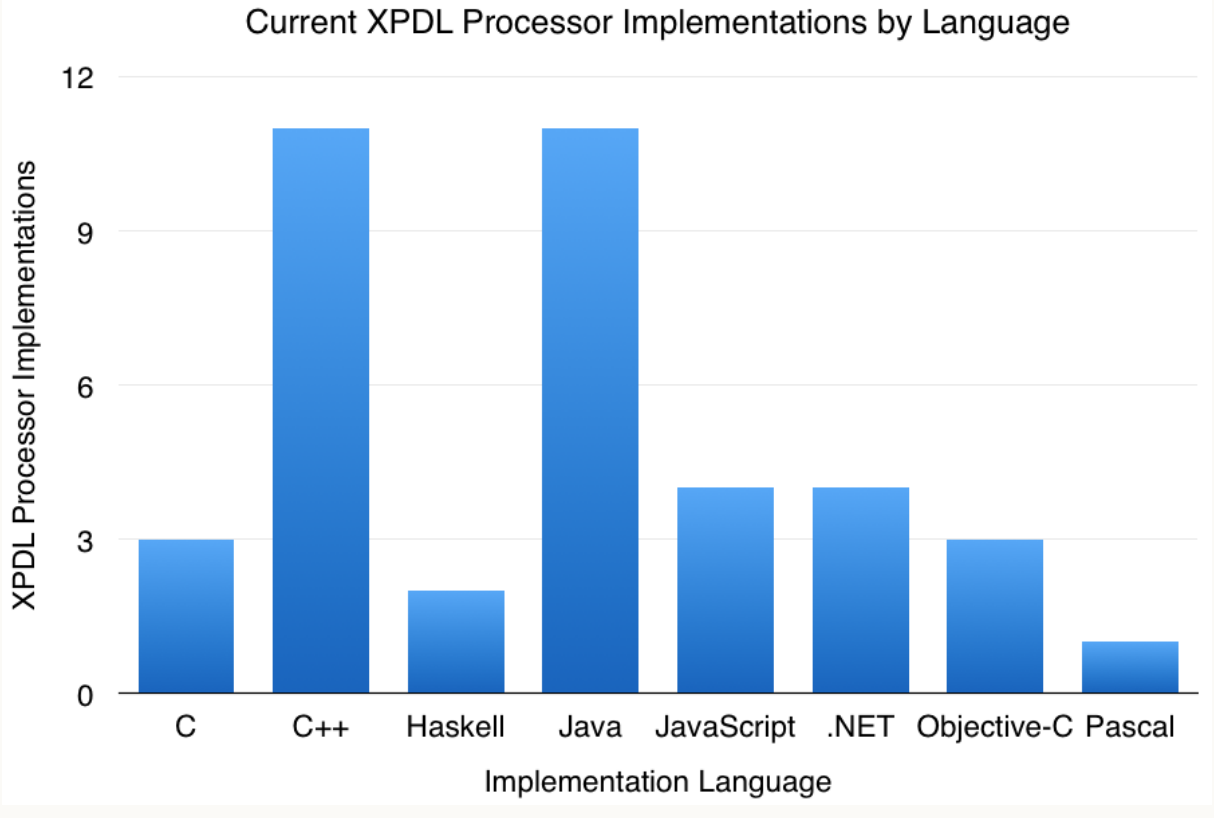
Processor Varieties

- **We want to support XPDL Extension Functions**
  - For all XPDL processors
  - What XPDL procesor implementations exist?



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Our Requirements

- **Focus on Extension Function Implementation**
  - Standardisation is alive in W3C and EXPath
  - Ideally implement just once (ever!)
  - Ideally compatible with any XPDL processor
- **Polyglot**
  - Must support at least Java and C++ implementations
  - Ideally also C for integration with other languages
- **Specify an Implementation Type Mapping**
  - XDM types to/from XPDL processor implementation language types

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Our Solution

- **Source-to-source Compilation**
  - Using the Haxe cross-platform tookit
  - Haxe Lang for high-level implementation
    - Similar to ECMAScript
  - Haxe cross-compiler for target implementation
- **XDM Implementation Type Mapping to Haxe Lang Interfaces**
- **Function Implementation Type Mapping to Haxe Lang Interfaces**
  - Based on: XPath 3.0 *Function Call*
  - Based on: XQuery 3.0 *Function Declaration*

Haxe XDM Impl. Type Mapping

```
interface Item {
  public function stringValue() : xpdl.xdm.String;
}

interface AnyType {}

interface AnyAtomicType extends Item extends AnyType {}

class Boolean implements AnyAtomicType {
  var value: Bool;
  public function new(value) {
    this.value = value;
  }
  public function stringValue() {
    return new xpdl.xdm.String(Std.string(value));
  }
  public function haxe() {
    return value;
  }
}

class String implements AnyAtomicType {
  var value: HString;
  public function new(value) {
    this.value = value;
  }
  public function stringValue() {
    return this;
  }
  public function haxe() {
    return value;
  }
}
```

Haxe Function Implementation Type Mapping

```
interface Function {

    public function signature() : FunctionSignature;

    public function eval(arguments: Array<Argument>, context: Context) : Sequence;
}

class FunctionSignature {
    var name: QName;
    var returnType: SequenceType;
    var paramLists: Array<Array<Param>>;

    public function new(name, returnType, paramLists) {
        this.name = name;
        this.returnType = returnType;
        this.paramLists = paramLists;
    }
}
```

- https://github.com/exquery/xpdl-extension-lib

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Proof-of-concept

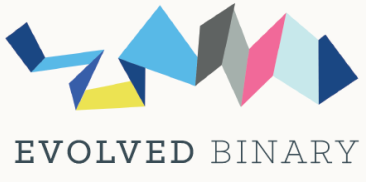
- **Implementation of EXPath File Module**
  - Implemented in Haxe Lang
  - Coded to XDM Implementation Type Mapping Interfaces
- **Focused on just `file:exists` function**
  - `file:exists($path as xs:string) as xs:boolean`
  - Function Call Type + Function Implementation Type
  - xs:string
  - xs:boolean
- **Status**
  - Runnable on **any** processor that supports Haxe Implementation Type Mapping

file:exists in Haxe

```
class ExistsFunction implements Function {

    private static var sig = new FunctionSignature(
        new QName("exists", FileModule.NAMESPACE, FileModule.PREFIX),
        new SequenceType(Some(new ItemOccurrence(Boolean))),
        [
            [
                new Param(new QName("path"),
                new SequenceType(Some(new ItemOccurrence(xpdl.xdm.Item.String))))
            ]
        ]
    );

    public function new() {}

    public function signature() {
        return sig;
    }

    public function eval(arguments : Array<Argument>, context: Context) {
        var path = arguments[0].getArgument().iterator().next().stringValue().haxe();
        var exists = FileSystem.exists(path);
        return new ArraySequence( [ new Boolean(exists) ] );
    }
}
```

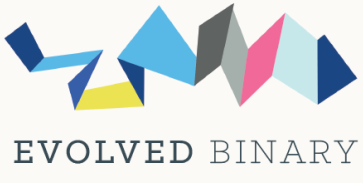
Proof-of-concept: Processor

- **Added support to eXist**
  - Static mapping of Haxe XDM types
  - Dynamic mapping of Haxe function call interfaces
    - Bytecode generation of classes and objects: cglib
  - Currently ~300 lines of Java code
- **Status**
  - https://github.com/eXist-db/exist/tree/xpdl-extensions/src/org/exist/xpdl
  - Supports Haxe XDM Function Implementation Type Mapping
  - Supports Haxe XDM Implementation Type Mapping

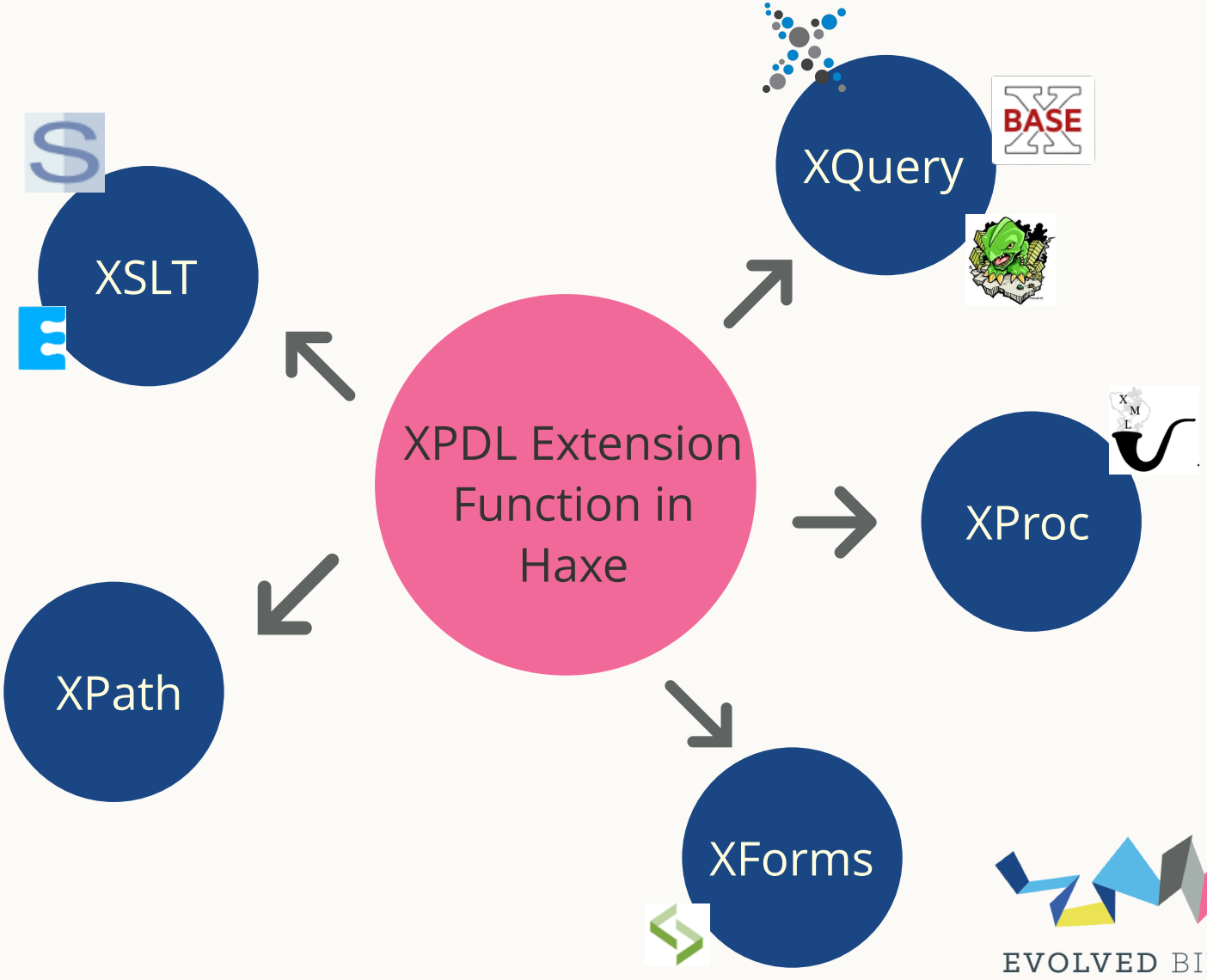


Conclusion

- **Implement Once**
- **Cross-Compile and Compile Once**
- **Supports any processor**
  - Requires Vendor to (*just* once) implement:
    - XDM Implementation Type Mapping
    - Function Implementation Type Mapping



Win!



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