XQuery

—

A typed language for XML

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XML is data on the Web

- Used as an exchange format between applications
  - XML & e-commerce: cXML, mpXML, etc.
  - XML & biology: BIOXML, GeneXML, etc.
  - XML & the news: NML
- Stored in back-end systems
  - Tamino, SQL/Server, etc.
- Published to user's interfaces
  - XHTML, VoiceXML, etc.

Example of a cXML document

```
<OrderRequestHeader orderID="DO1234" orderDate="1999-03-12"
                    requestedDeliveryDate="1999-03-24">
    <Total><Money currency="USD">12.34</Money></Total>
    <ShipTo>
       <Address>
            <Name xml:lang="en">Lucent Technologies</Name>
            <PostalAddress name="foo">
              <DeliverTo>Joe Smith</DeliverTo>
              <DeliverTo>Mailstop M-543</DeliverTo>
              <Street>123 Anystreet</Street>
              <City>Sunnyvale</City>
              <State>CA</State>
            </PostalAddress>
       </Address>
    </ShipTo>
    ...
```

Building XML applications

- Using XML *Interfaces*
  - Document Object Model (DOM)
  - Simple API for XML (SAX)
  - Java API for XML Parsing (JAXP)
- Using Programming languages
  - Java
  - C++
  - Perl
- Using dedicated XML languages
  - XPath for path expressions
  - XSLT for structural transformations

Example of a DOM Nodefilter in Java

```
Class NamedAnchorFilter implements NodeFilter
   {
      short acceptNode(Node n) {
        if (n.getNodeType()==Node.ELEMENT_NODE) {
           Element e = (Element)n;
           if (! e.getNodeName().equals("A"))
              return FILTER_SKIP;
           if (e.getAttributeNode("NAME") != null)
           return FILTER_ACCEPT;
        }
      return FILTER_SKIP;
      }
  }
```

What is XQuery ?

- A query language for XML
  - Aimed a supporting data intensive applications
- A W3C activity (XML Query Working Group)
  - Industry investment
  - Standardization effort
  - Coordination with XML Schema, XPath, XSLT, etc.
- A preliminary proposal
  - First working draft last february
  - Incomplete implementations (XML DevCon'2001)
  - Subject to changes
  - Receptive to feedbacks
- Hype, but also some interesting technical contributions

Example of a query in XQuery

List each publisher and the average price of its books.

```
FOR $p IN distinct(document("bib.xml")//publisher)
LET $a := avg(document("bib.xml")/book[publisher = $p]/price)
RETURN
  <publisher>
    <name> $p/text() </name> ,
    <avgprice> $a </avgprice>
  </publisher>
```

Why XQuery ?

- More logical/physical independance
  - Physical XML documents (e.g., in a file)
  - Virtual XML documents (e.g., view over a RDBMS)
  - Streaming documents (e.g., stock quotes)
- More declarativity
  - Concise syntax for complex data manipulations
  - Subject to optimization
- More types
  - Data values (int, float, string, date, etc.)
  - Detecting errors
    - e.g., a `book` does not have a `titel` but a `title`
  - Infering schemas
    - e.g., my program *does* generate VoiceXML

Outline

- Status of XQuery
- XML Query Data Model
- XQuery features
- XQuery typing with the XML Algebra
- XQuery architecture and Galax Prototype

W3C XML Query Working Group

`http://www.w3.org/XML/Query/`

- Composed of 32 companies
- Work started 18 months ago
- Chartered to produce a *data model*, an *algebra*, and *two syntaxes*
  - User-level syntax
  - XML syntax
- Collaboration with other groups
  - XML Schema, XSLT
  - XML Core (Information Set), I18N, SQL (ISO)

Current documents

- Requirements for XQuery
- Use cases (9)
  - Querying relational databases
  - Querying hierarchy and order in documents
  - Querying text in XML documents
  - Querying recursive documents
  - etc.
- Specifications
  - XML Query Data Model (June 2000)
  - XML Query Algebra (Dec 2000)
  - XML Query Syntax (XQuery - Feb 2001)

XML Query Data Model in a Nutshell

- Different kinds of nodes (9)
  - Document, Element, Attribute, Value, Namespace, PI, Comment, etc.
- Accessors
  - `name(e)`, `nodes(e)`, etc.
- Constructors
  - `elemNode qname attributes children`
- Typed values (int, string, etc.)
- Each node has an identity and a (optional) parent

XQuery Design

- functional
  - no side-effect
- compositional
  - made of basic expressions
  - expressions can be composed arbitrarily
- allows full recursion
  - user defined functions without restriction
- "declarative"
  - high-level FLWR block
- answers use cases
  - expressive
- formal semantics
  - by means of the XML Query algebra

XQuery expressions

- Constants
- Variables
- XPath expressions
- operators and functions
- FLWR (FOR LET WHERE RETURN) expressions
- SORT BY
- conditional
- $\exists$ $\forall$
- Aggregation
- Element/Attribute constructors

Values and variables

- Atomic values

```
1
"John Smith"
true
```

- Variables

```
$a     $mybook
```

- Elements and attributes:

```
<book>
  231
</book>
```

Operators and functions

- Arithmetic operations

```
1+3
```

- Comparison operations

```
(1+3) > 2
```

- Boolean operations

```
not(((1+3) > 2) or (($a > 2) and ($a < 6)))
```

- Collection operations (`Union`, `Except`, `Intersect`)
- Data model functions (`name`, `value`, etc)

XPath in XQuery

List the titles of books published by Morgan Kaufmann in 1998.

```
document("bib.xml")//book[publisher = "Morgan Kaufmann"
                          AND $year = "1998" ]/title
```

Iteration in XQuery

List the titles of books published by Morgan Kaufmann in 1998.

```
FOR $b IN document("bib.xml")//book
WHERE $b/publisher = "Morgan Kaufmann"
AND $b/year = "1998"
RETURN $b/title
```

Joins in XQuery

For each book found at both bn.com and amazon.com, list the title of the book and its price from each source.

```
<books-with-prices>
   FOR $b IN document("www.bn.com/bib.xml")//book,
       $a IN document("www.amazon.com/reviews.xml")//entry
   WHERE $b/title = $a/title
   RETURN
      <book-with-prices>
         $b/title,
         <price-amazon> $a/price/text() </price-amazon>,
         <price-bn> $b/price/text() </price-bn>
      </book-with-prices>
</books-with-prices>
```

Sorting in XQuery

List the titles and years of all books published by Addison-Wesley after 1991, in alphabetic order.

```
<bib>
   FOR $b IN document("www.bn.com/bib.xml")//book
      [publisher = "Addison-Wesley" AND @year > "1991"]
   RETURN
      <book>
         $b/@year,
         $b/title
      </book> SORTBY (title)
</bib>
```

Quantification in XQuery

Find titles of books in which both sailing and windsurfing are mentioned in the same paragraph.

```
FOR $b IN //book
WHERE SOME $p IN $b//para SATISFIES
   contains($p, "sailing")
   AND contains($p, "windsurfing")
RETURN $b/title
```

Global order in XQuery

In Report1, what happened between the first Incision and the second Incision?

```
FOR $proc IN
  document("report1.xml")//section[section.title="Procedure"],
    $bet  IN
  $proc//* AFTER ($proc//incision)[1]
           BEFORE ($proc//incision)[2]
RETURN $bet
```

Semantics of XQuery

- Semantics by mapping to the XML Query Algebra
  - "minimal" set of operations to support XQuery
  - Static and Dynamic semantics for this set
  - Nothing implicit!
- Dynamic semantics:
  - Given input values for documents and functions
  - What is the output document for each query expression
- Static semantics:
  - Given input types for documents and functions
  - Infer the type of the output for each query expressions

XML Algebra Core Operations

```
Exp ::= Const                          atomic constant
     |  Var                            variable
     |  @NameExp[Exp]                   attribute
     |  NameExp[Exp]                    element
     |  Exp, Exp                        sequence or union
     |  ()                              empty sequence
     |  if Exp then Exp else Exp        conditional
     |  for Var in Exp do Exp           iteration
     |  let Var = Exp do Exp            local binding
     |  FuncName (Exp ;...; Exp)        function application
     |  error                           error
     |  Exp BinaryOp Exp                binary operator
     |  UnaryOp Exp                     unary operator
     |  match Exp CaseRules             match

CaseRules ::= case Var : Type do Exp CaseRules
           |  else Exp
```

Types

```
t ::= y                    type variable
    |  Integer | Float
    |  String |  Boolean
    |  ()                  empty sequence
    |  0                   empty choice
    |  @Wild[t]            attribute
    |  Wild[t]             element
    |  t1 , t2            sequence
    |  t1 | t2             choice
    |  t {m, n}           repetition
```

Typing path expressions

```
type Bib =
  bib [ Book{0,*} ]
type Book =
  book [
    @year  [ Integer ],
    @isbn  [ String ],
    title  [ String ],
    author [ String ]{1,*}
  ]

let bib0 : Bib = document("algebrabib.xml")

bib0/book/author
:  author [ String ]{0,*}
```

More typing

- Constants

```
   39.95
:  Float

   "Lord of the Rings"
:  String
```

- Element creation

```
   price [ 39.95 ]
:  price [ Float ]
```

- Sequences

```
   book [ title [ "Lord of the Rings" ], price [ 39.95 ]
:  book [ title [ String ], price [ Float ] ]
```

Even more typing

- Let expressions

```
   let p = 39.95 in price [ p ]
:  price [ Float ]
```

- Typing conditionals

```
   let p = 39.95 do
   if p > 100
     then expensivebook[ p ]
     else cheapbook[ p ]
:  expensivebook [ Float ] | cheapbook [ Float ]
```

Query expansion

```
bib0/book

for v1 in bib0 do
  for v2 in nodes(v1) do
    match v2
      case v3 : book[AnyType] do v3
      else ()

: Book{0,*}
```

Typing iteration

```
nodes(book0)

:@year[Integer], @isbn[String], title[String], (author[String]){1,*}

for v1 in nodes(book0) do
  match v1
    case v2 : title[AnyType] do v2
    else silly[]

: silly[], silly[], title[String], (silly[]){1,*}
```

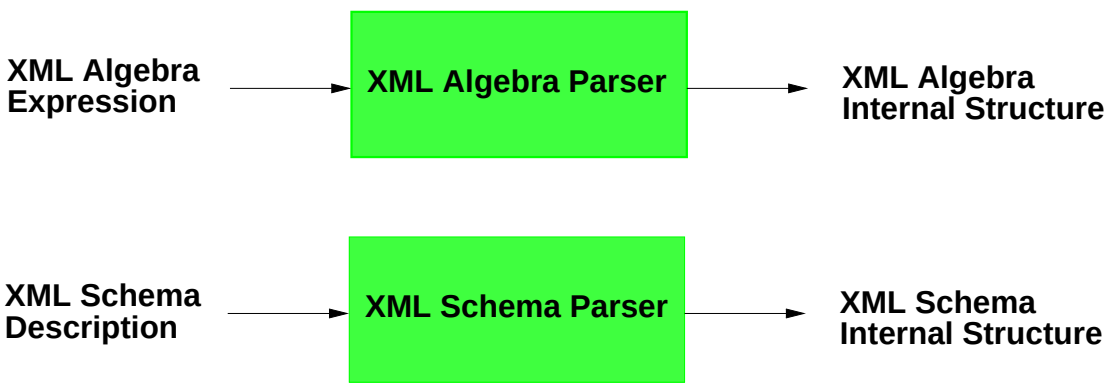
- Each components of the input forest is typed separately.

Galax Overview

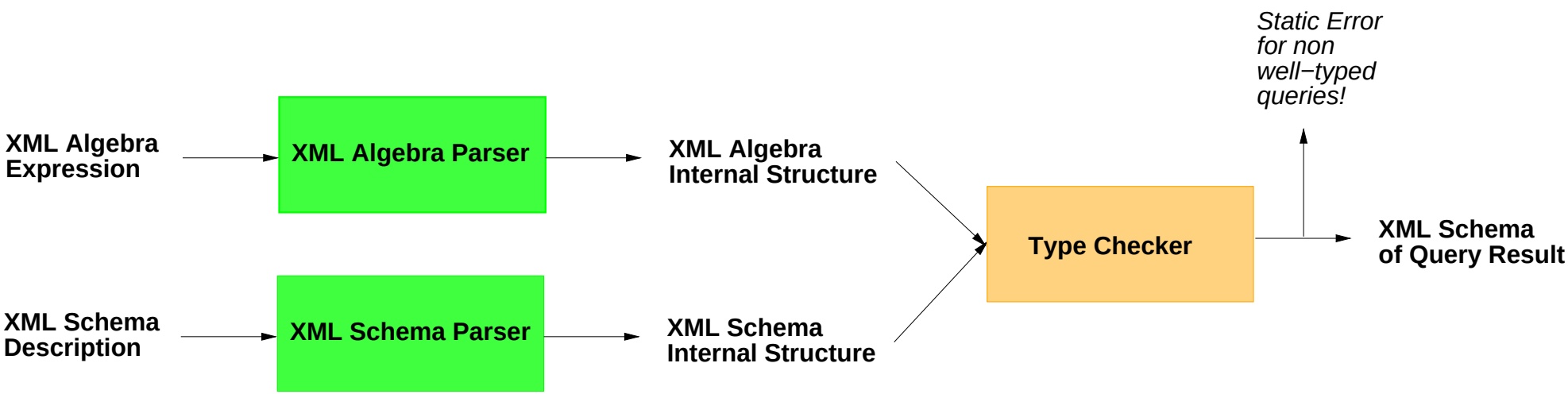
- Implements W3C Working drafts:
  - XML Query Data Model (almost complete)
  - XML Query Algebra (almost complete)
  - XQuery (minimal)
- In its second round of implementation
  - Written in Objective Caml and C
  - Lightweight, performant, portable (now Linux&Solaris)
- Designed to support various storage modules
  - Native XML Query data model (now)
  - Module for DataBlitz (soon)
  - Module for native XML storage?

Once there was a query...

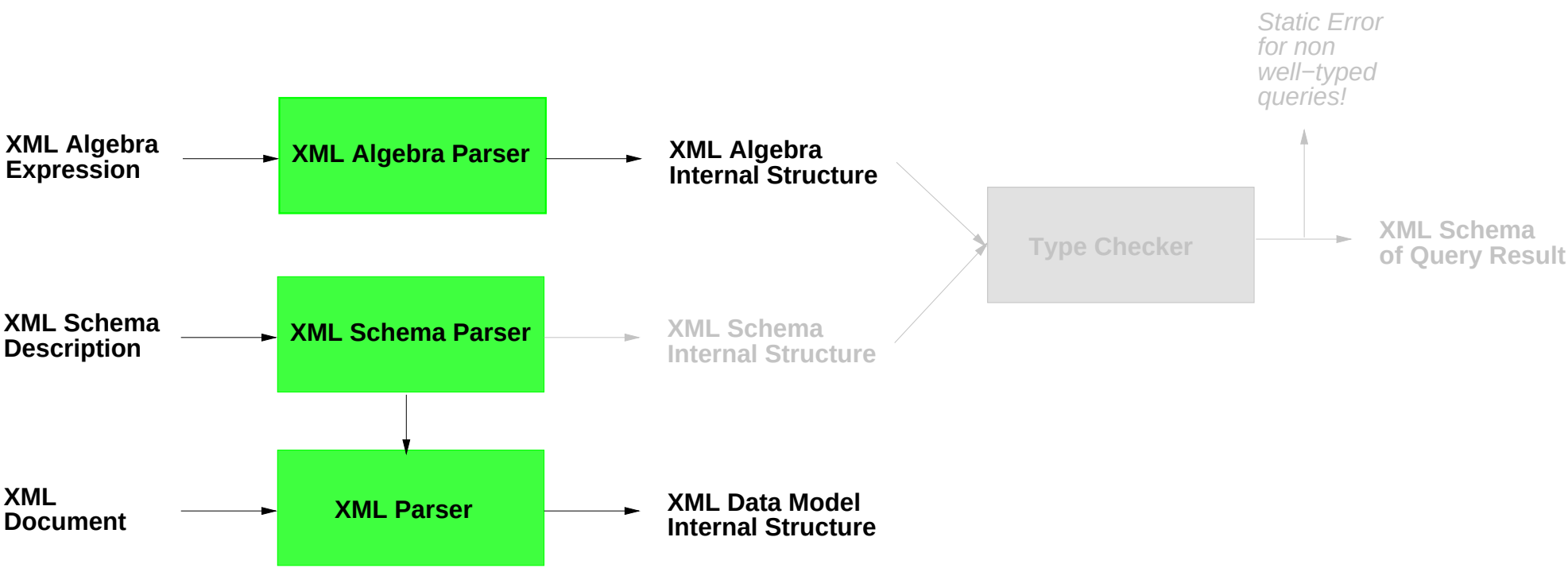
The query met a Schema



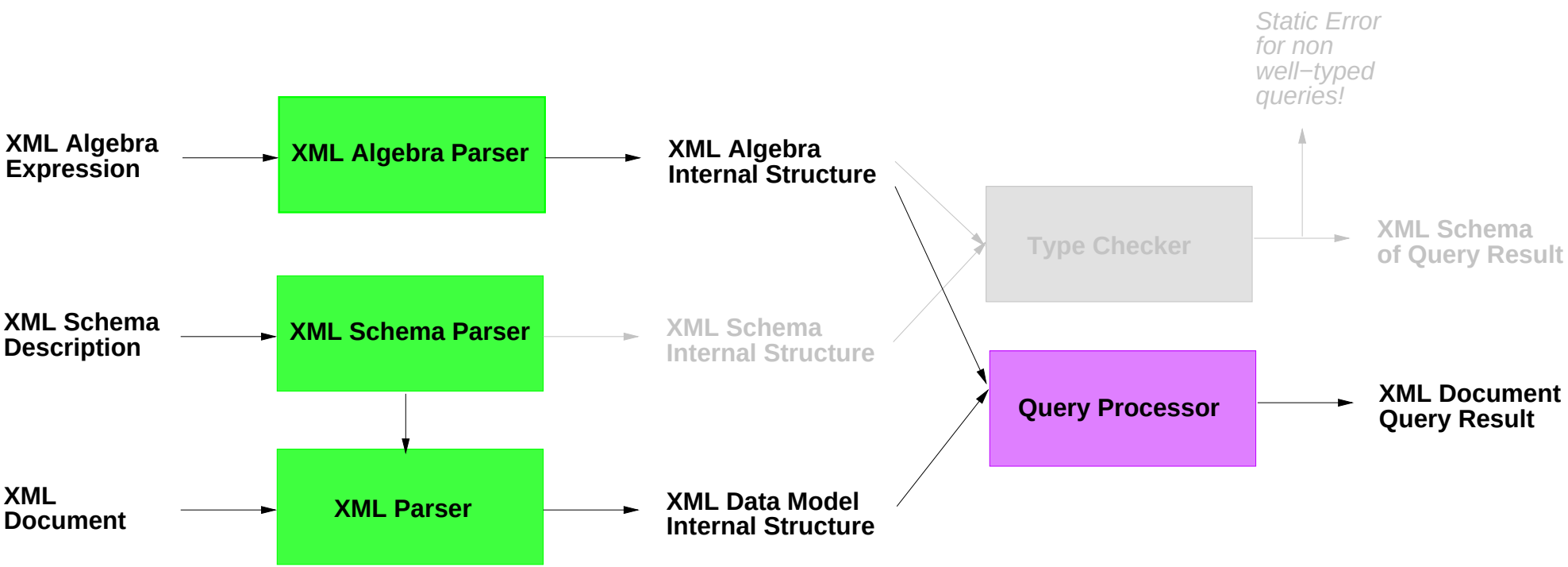
Going well, together they created a new Schema



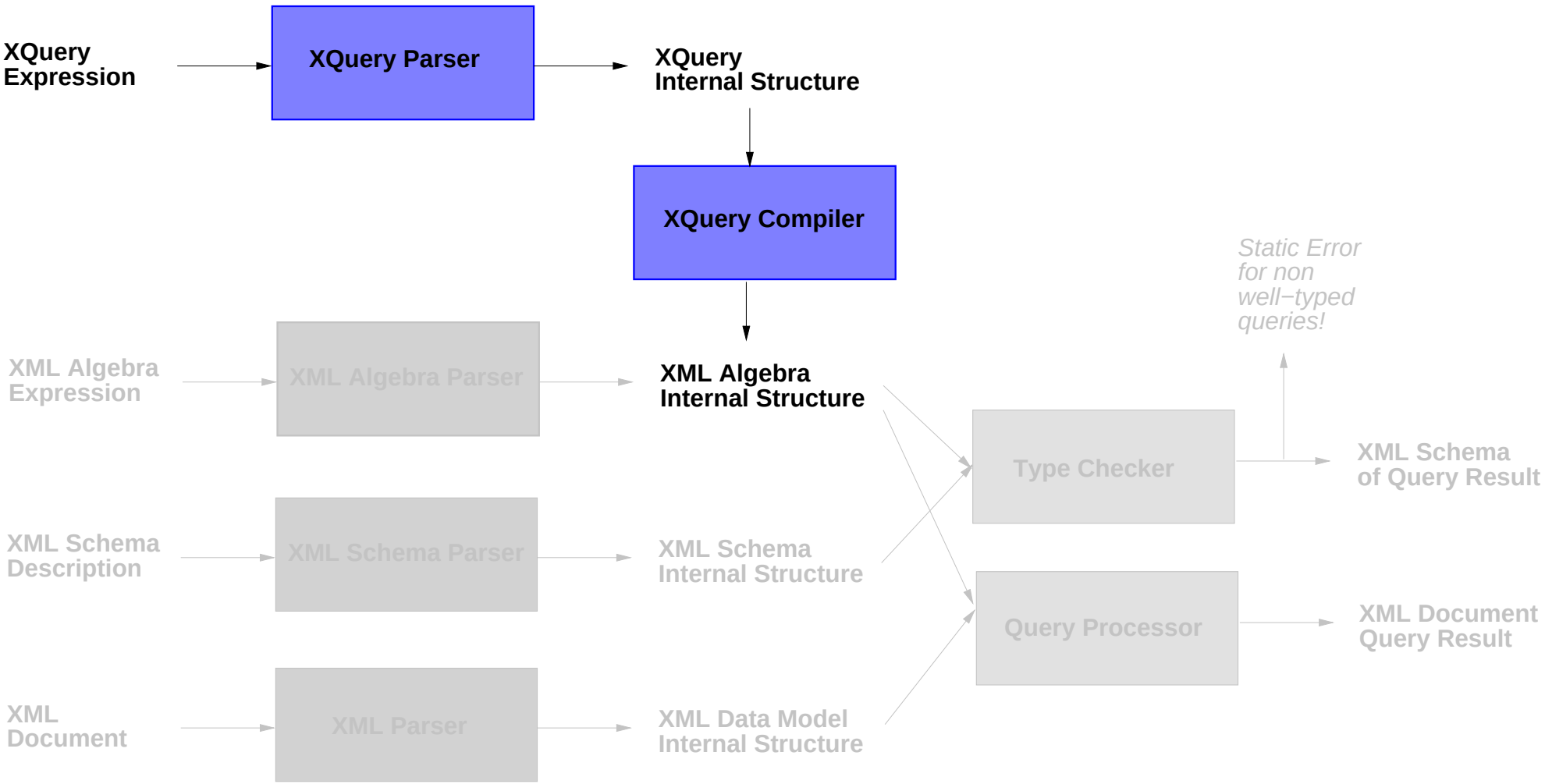
The query quickly forgot about the schema...



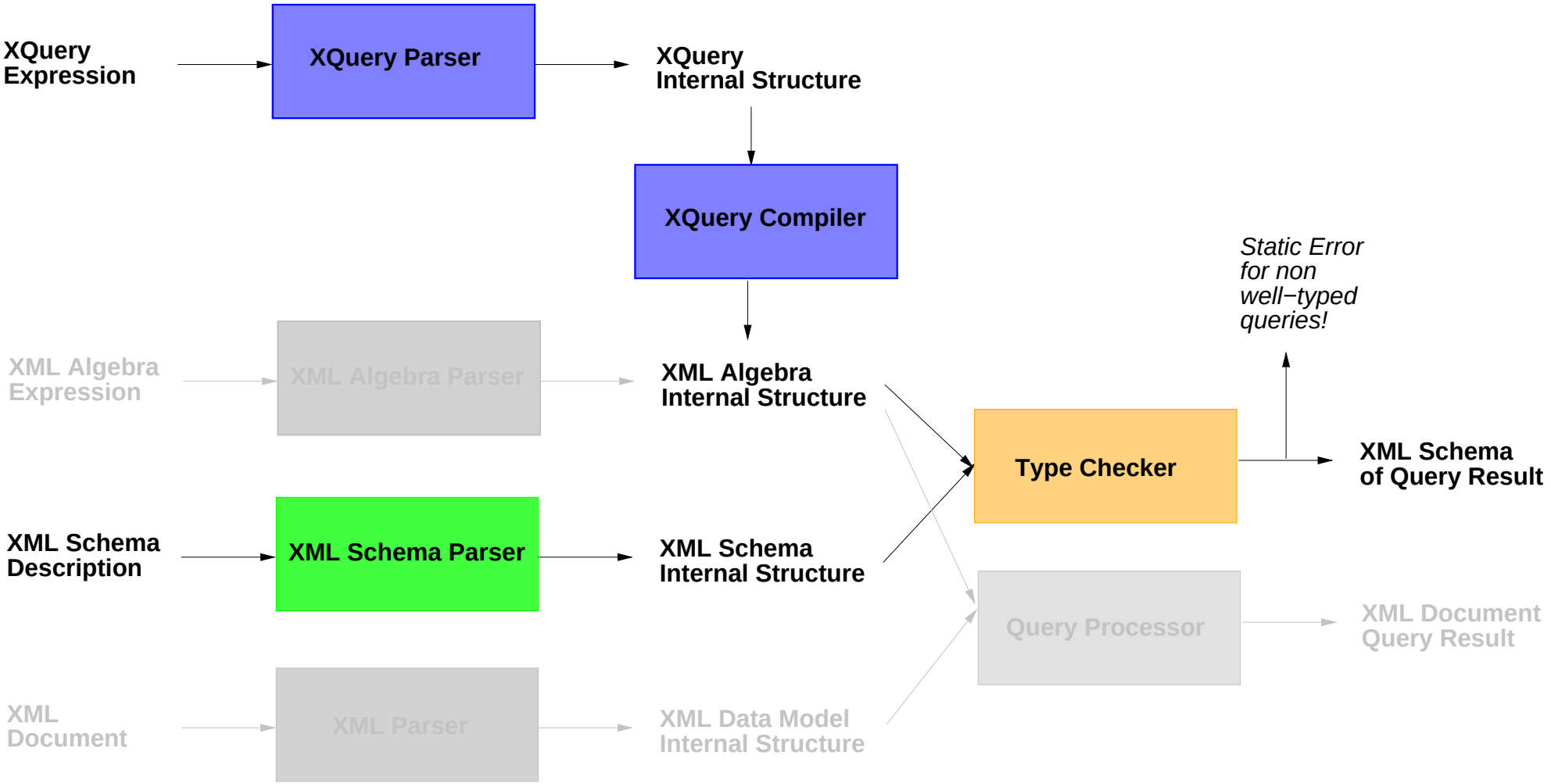
...and feeling safe, created a document



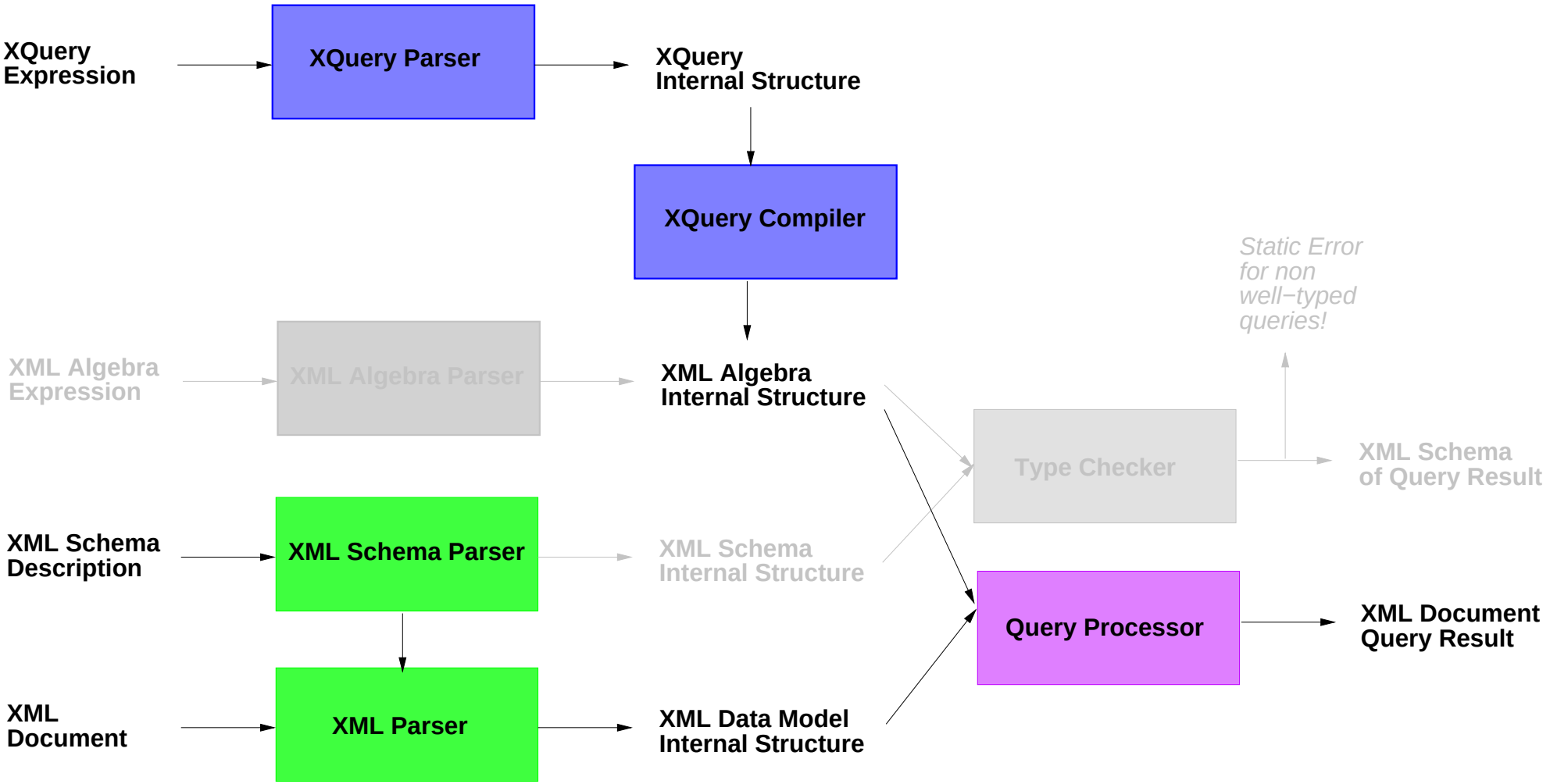
In the real world, the query compiles



The query type checks



And finally the query evaluates



Typing Use Case

- Detect errors before running queries on 10Gb data
  - Float artithmetics over dates ?
  - Mistakes in element names: result always empty
  - Query does not generate expected schema

    E.g., Some Lucent products generating VoiceXML
- XQuery must work with and without a Schema
  - Keep relational schema information in use case R
  - Generating some HTML for any well-formed XML

What's in the Demo

- Support for XML Algebra:
  - Static typing
  - Query evaluation
- Examples:
  - From XML Algebra document
  - Use cases: XMP and R (relational)

What's not in the Demo

- Support for XQuery:
  - Compilation to the XML Algebra

Some Influential Related Work

- XML Query languages
  - XML-QL (ATT)
  - Lorel (Stanford)
  - YATL (INRIA)
  - Quilt (Software AG, IBM)
- Typed 'query' languages
  - OQL
  - Kleisli (UPenn)
  - XDuce (Upenn)

Conclusion

- XQuery is on tracks
  - Concrete progress
  - Concrete contributions
  - On-going implementations
- Still very young
- Feedback is essential at this stage
- Stay tuned!

More about Galax

- Working towards full W3C compliance
- Complete set of use cases
- Optimization
- Physical storage
  - Datablitz (Lucent Main memory Database)
  - ODBC
  - Native XML storage
- Contact: Jérôme Siméon

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http://www-db.research.bell-labs.com/user/simeon/