XQuery Full Text Implementation in BaseX

XSym/VLDB 2009

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Motivation

XQuery/XPath Full Text 1.0

- upcoming W3C Recommendation for content-based XML queries
- brings DB and IR world together
- first implementations available (Qizx, MXQuery, xDB, BaseX)

Challenges

- large text corpora/XML instances
- complete embedding in XQuery language
- classical retrieval features: stemming, thesaurus, stop words

→ all features need to be supported, yet performance is essential

Queries

Document-based location path with predicate

```
//book[title ftcontains 'Crime and Punishment']
```

Optional filters and options

```
//book[section ftcontains ('heritage' ftand 'claim'
   window 10 words) language 'en' with stemming]/title
```

Queries without document reference

```
'a b c' ftcontains 'b'
```

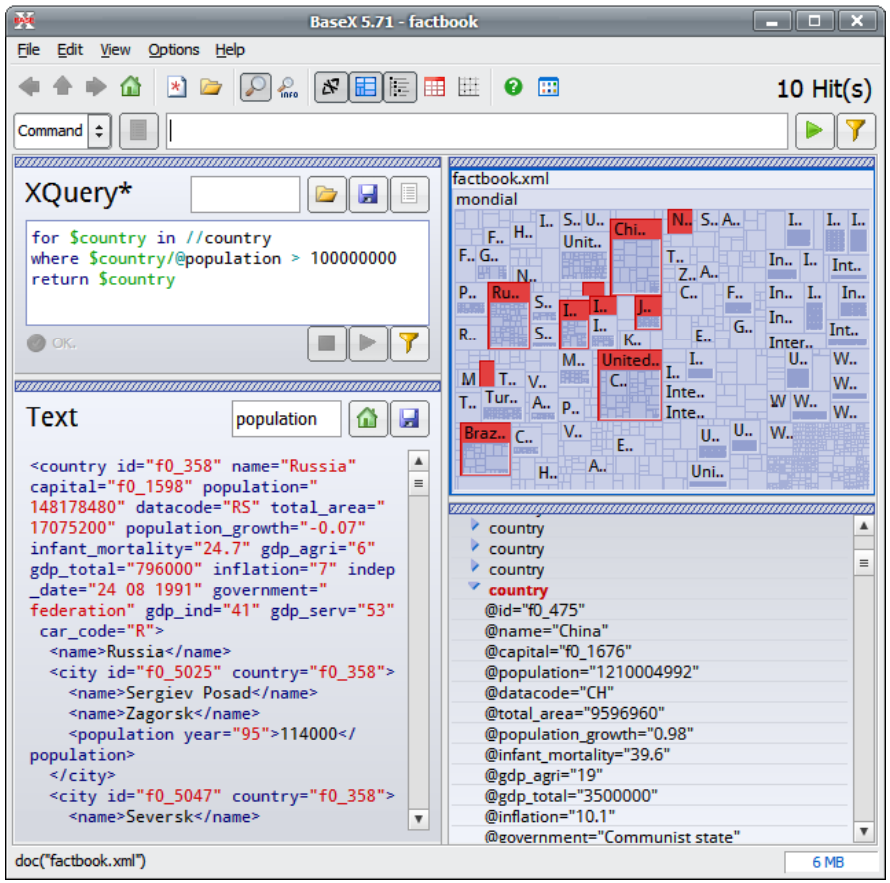
Dynamic item values

```
func:merge($a) ftcontains { func:stem($a), $b, $c }
```

BaseX

Native XML Database and XQuery Processor

- first complete XQuery Full Text implementation
- high XQuery conformance (99.9%)
- various index structures: names, paths, values, full text
- tight backend/frontend coupling, real-time querying
- open source (BSD) since 03/07

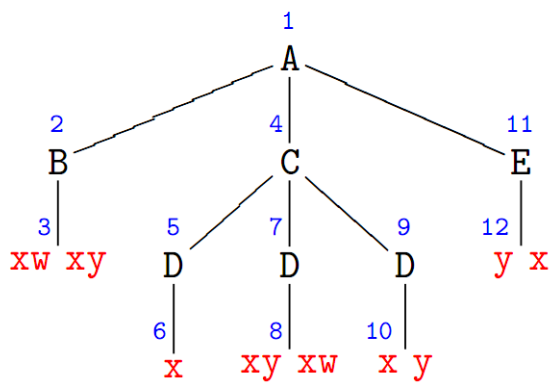


Storage

Document Storage

- inspired by XPath Accelerator[1] and MonetDB/XQuery
- flat, compressed table storage, using `pre/dist/size` encoding:

```
<A>
 <B>xw xy</B>
 <C>
  <D>x</D>
  <D>xy xw</D>
  <D>x y</D>
 </C>
 <E>y x</E>
</A>
```



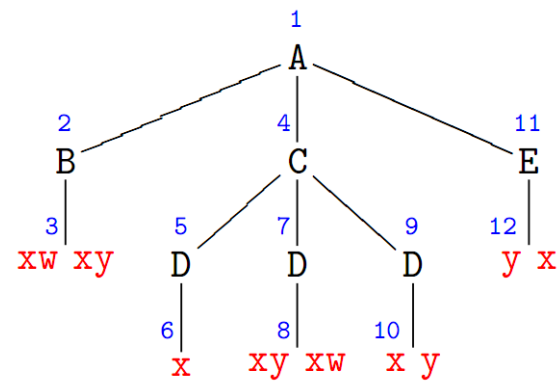
pre	dist	size	data
1	1	11	A
2	1	1	B
3	1	0	xw xy
4	3	6	C
5	1	1	D
6	1	0	x
7	3	1	D
8	1	0	xy xw
9	5	1	D
10	1	0	x y
11	10	1	E
12	1	0	y x

[1] Torsten Grust, Accelerating XPath Location Steps. SIGMOD 2002

Storage

Indexes

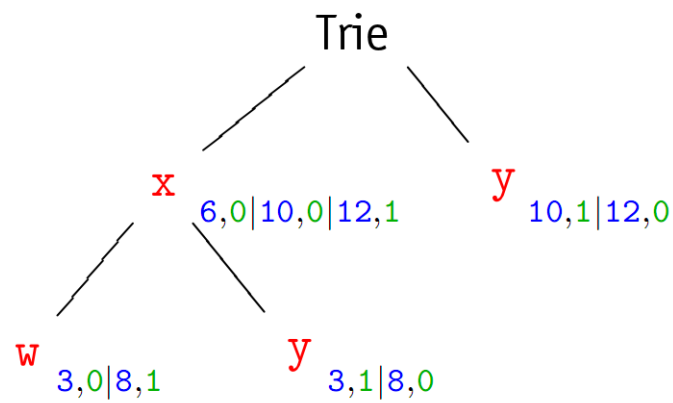
- names (tags, attribute names)
- paths (unique location paths)
- values (texts, attribute values)



Full Text Index

- Compressed Trie
- node: characters and `pre`, `pos` value pairs
- value pairs are sorted

→ essential for pipelined evaluation



Evaluation

Sequential Scan

```
/A/C[D/text() ftcontains "x"]
```

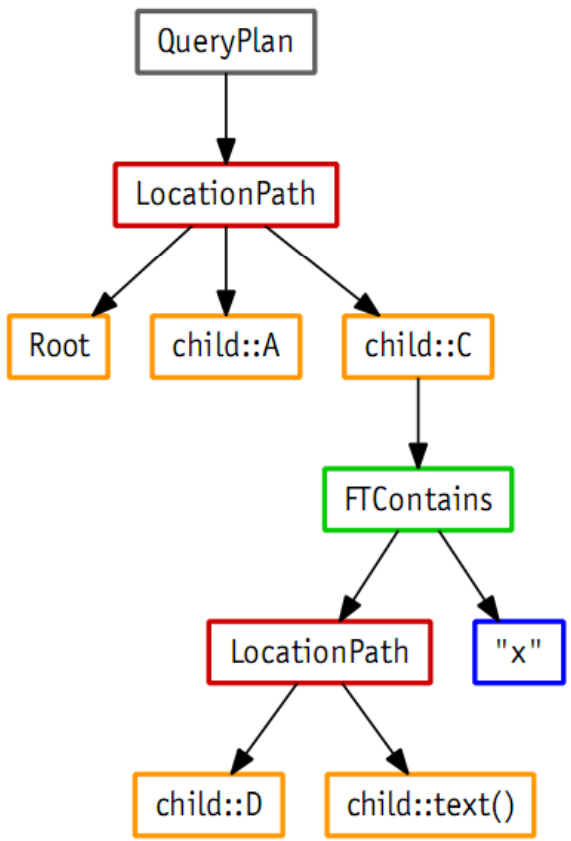
- performs the predicate test for each location path
- touches all addressed nodes at least once

Index-based processing

- performs the predicate test first
- traverses the inverted path for all index items

Hybrid Approach

- combination of sequential and index-based processing



Evaluation: Index-Based

Indexing on document level

- popular approach in relational databases
- no performance boost for large documents

Indexing of location paths

- simple queries with fixed path can be easily sped up
- does not work for nested/more complex queries

XQuery Index Functions

- allows for explicit index calls
- no benefit for internal query optimization

Evaluation: Index-Based

Dynamic Approach

- all text nodes are indexed
- predicates with `ftcontains` are analyzed for index access
- costs are estimated for each index access
- cheapest predicates are rewritten to index operators
- remaining location paths are inverted (utilizing the XPath Symmetries[2])

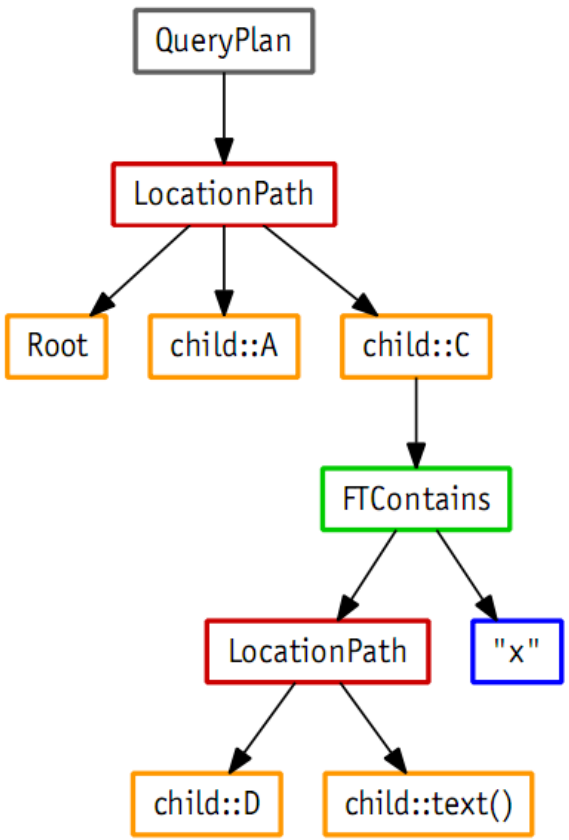
Advantages

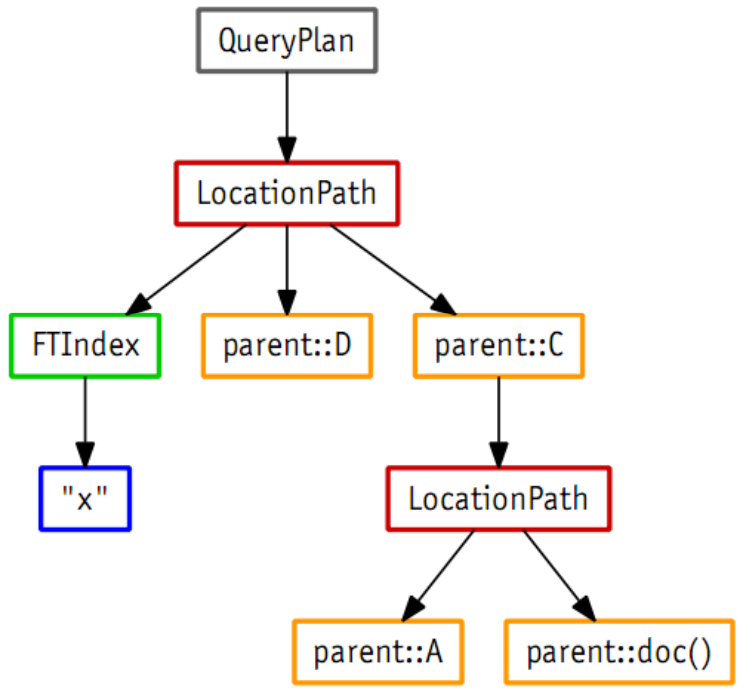
+ many queries with nested/complex location paths can be optimized
+ query writing and query optimization are uncoupled

[2] Dan Olteanu et al., XPath: Looking Forward. XMLDM Workshop 2002

Evaluation: Index-Based

```
/A/C[D/text() ftcontains "x"]
```

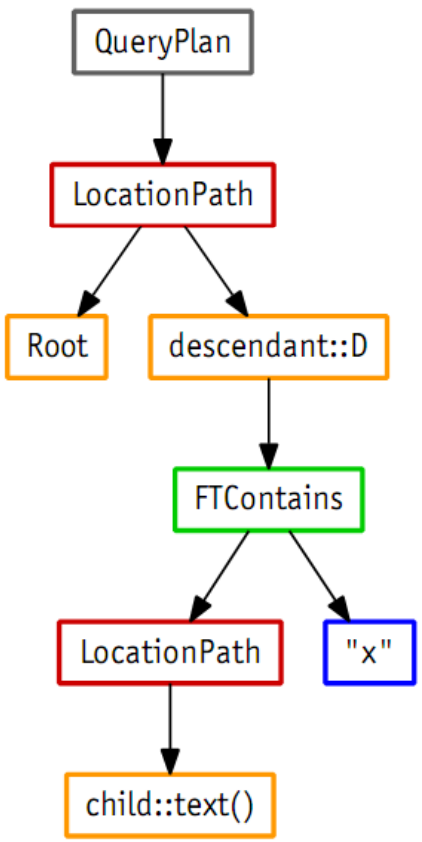


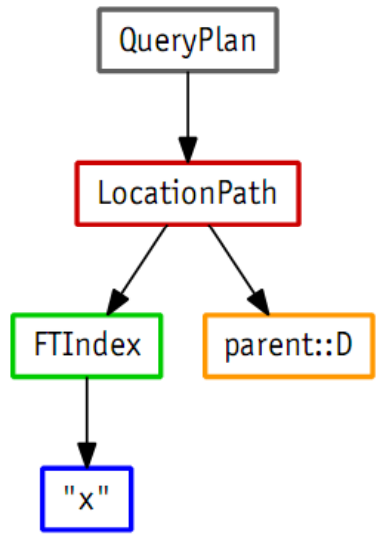



```
FTIndex("x")/parent::D/parent::C
            [parent::A/parent::doc()]
```

Evaluation: Index-Based

```
/descendant::D[text() ftcontains "x"]
```

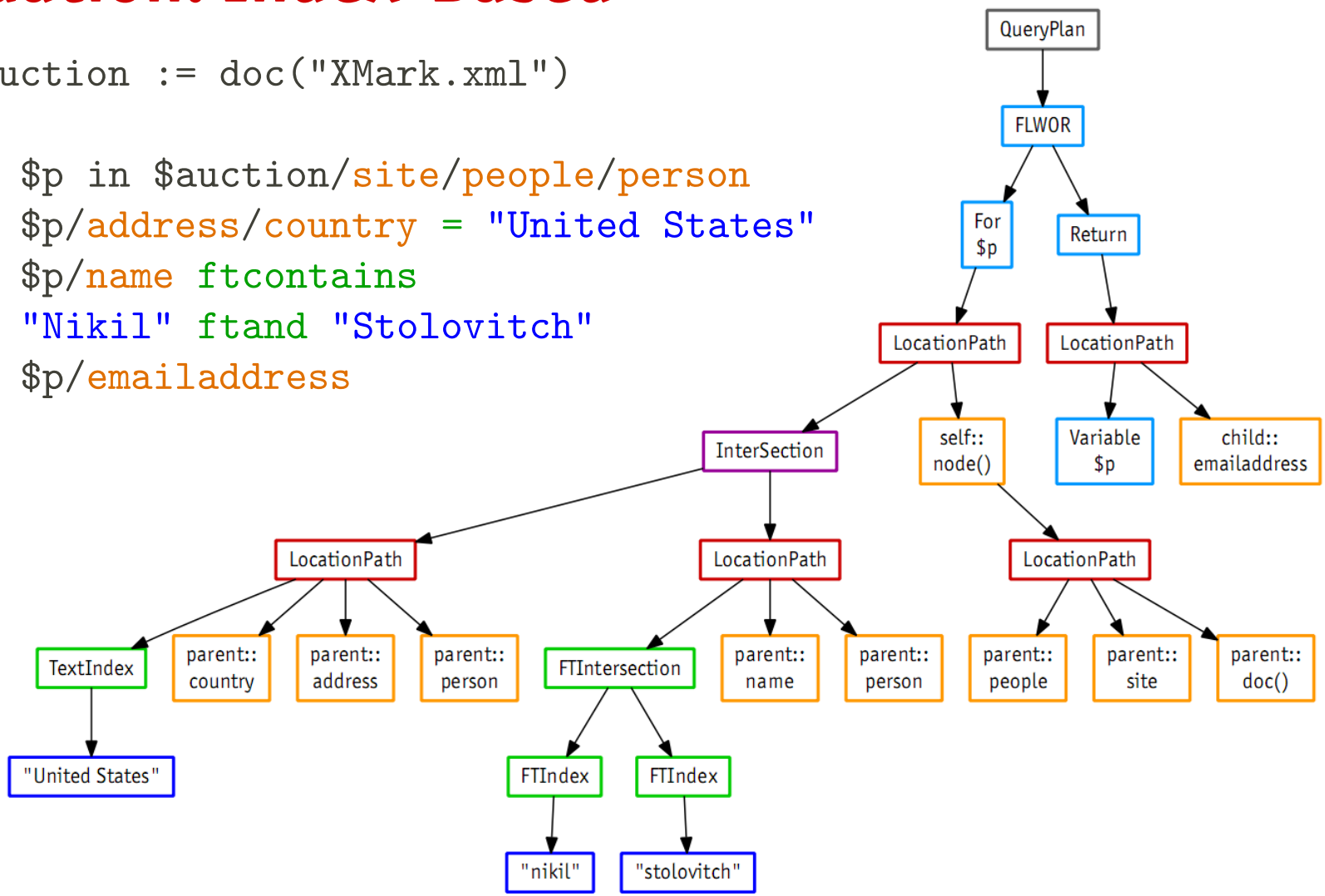





```
FTIndex("x")/parent::D
```

Evaluation: Index-Based

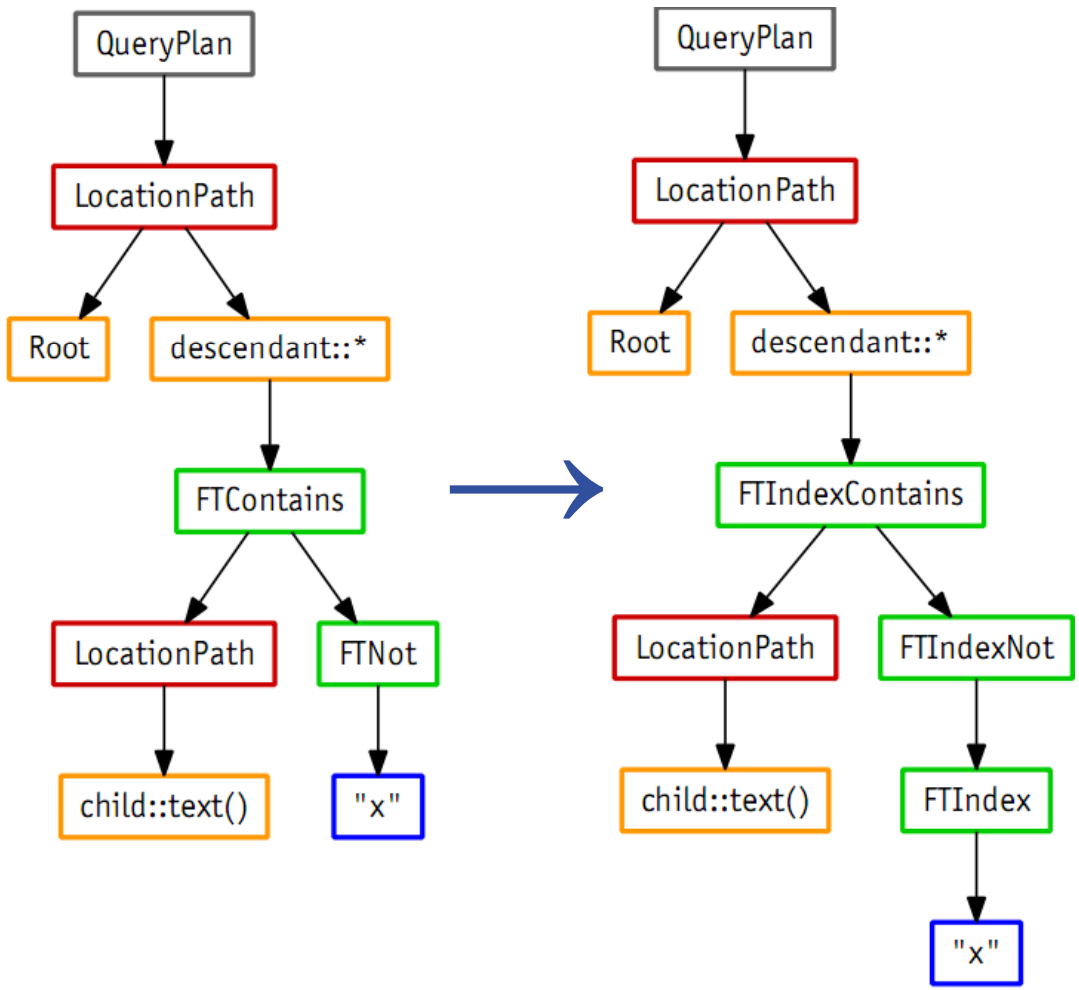
```
let $auction := doc("XMark.xml")
return
   for $p in $auction/site/people/person
 where $p/address/country = "United States"
   and $p/name ftcontains
       "Nikil" ftand "Stolovitch"
return $p/emailaddress
```



Evaluation: Hybrid

Hybrid Approach

- the `ftnot` operator cannot be processed by only using the index
- yet, index can be applied to avoid tokenization of all text nodes
- optimized plan combines seq. scan and index access
- sortedness of nodes and index results leads to linear costs



Evaluation: Pipelining

Iterative/pipelined Evaluation

- items are processed one-by-one
- constant memory consumption
- most efficient if large results are reduced to small, final result sets

Index Access

- all XQFT operators can be processed in an iterative manner
- a pipelined index operator returns single items

→ this way, the same full-text operators can be applied on both sequential and index-based processing

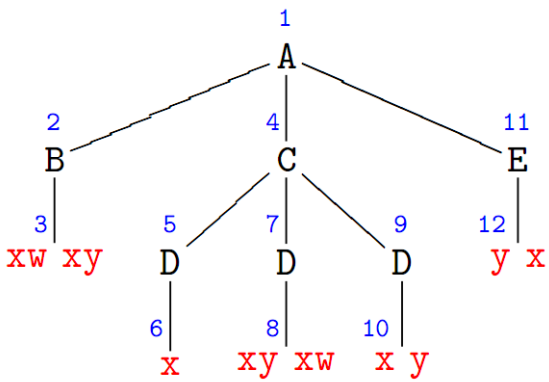
- again, the sortedness of index results avoids pipeline blocking

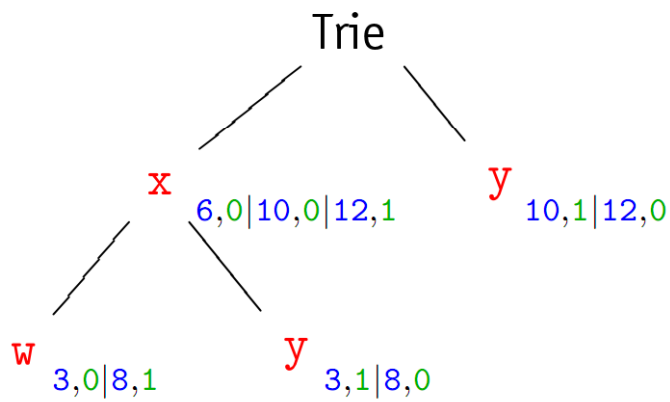
Evaluation: Pipelining

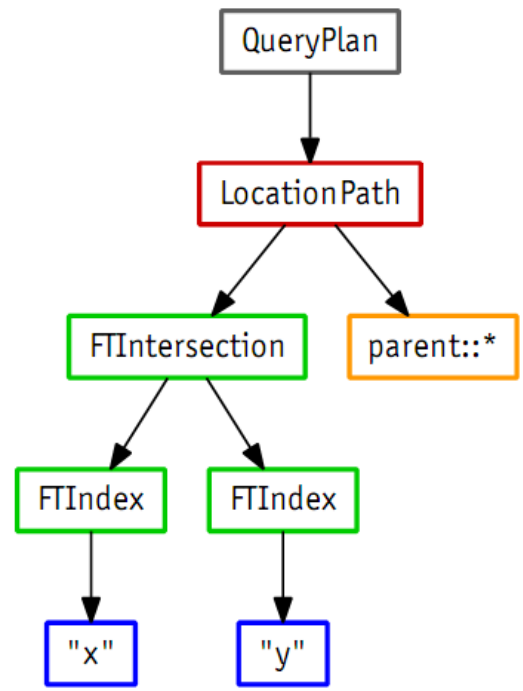
Index-based evaluation of `ftand`

```
//*[text() ftcontains
        "x" ftand "y"]
```

- FTIntersection operator merges index results:







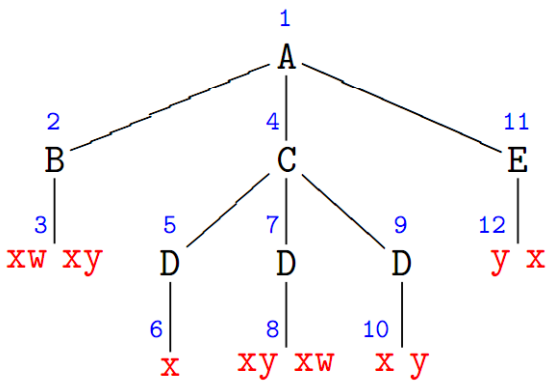
- first argument call delivers value pairs [6,0] and [10,1]
- [6,0] is skipped, [10,0] and [10,1] are merged & returned
- finally, [12,1] and [12,0] are merged & returned

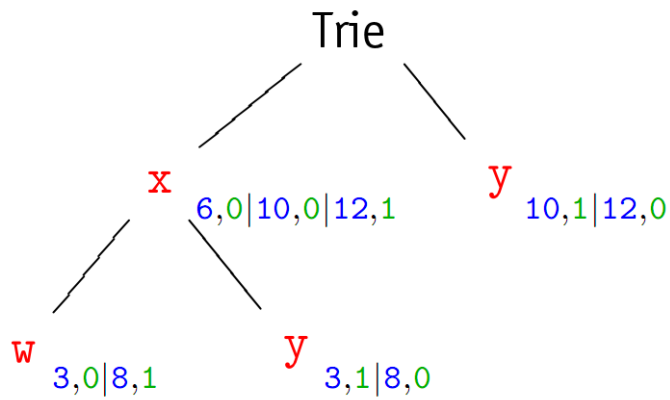
Evaluation: Pipelining

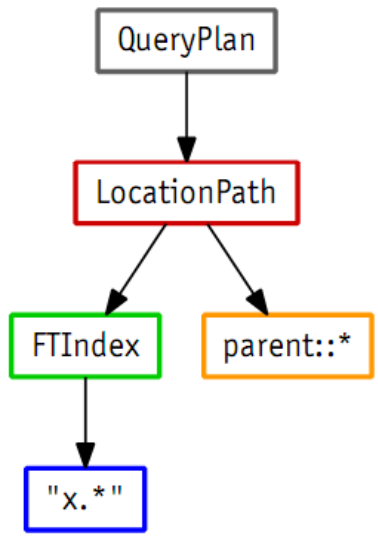
Index-based evaluation of wildcards

```
//*[text() ftcontains
 "x.*" with wildcards]
```

- Wildcards results are merged by FTIndex (`ftor` works similar):







- [3,0] and [3,1] are merged and returned
- next results are: [6,0], [8,0 | 8,1], [10,0], [12,1]

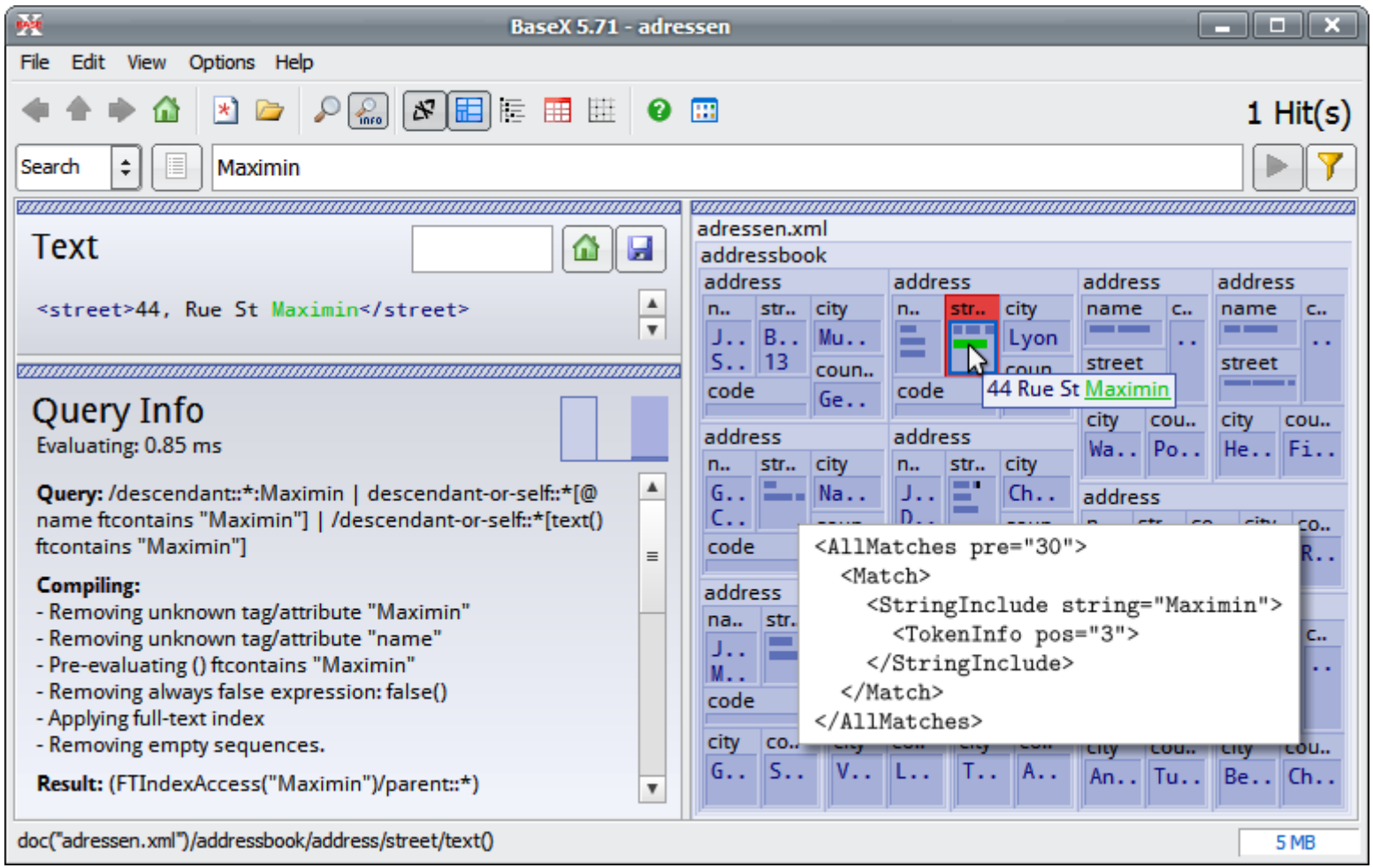
Performance

Q1:
```
doc("xmark")//keyword[text() ftcontains "barrel"]
```

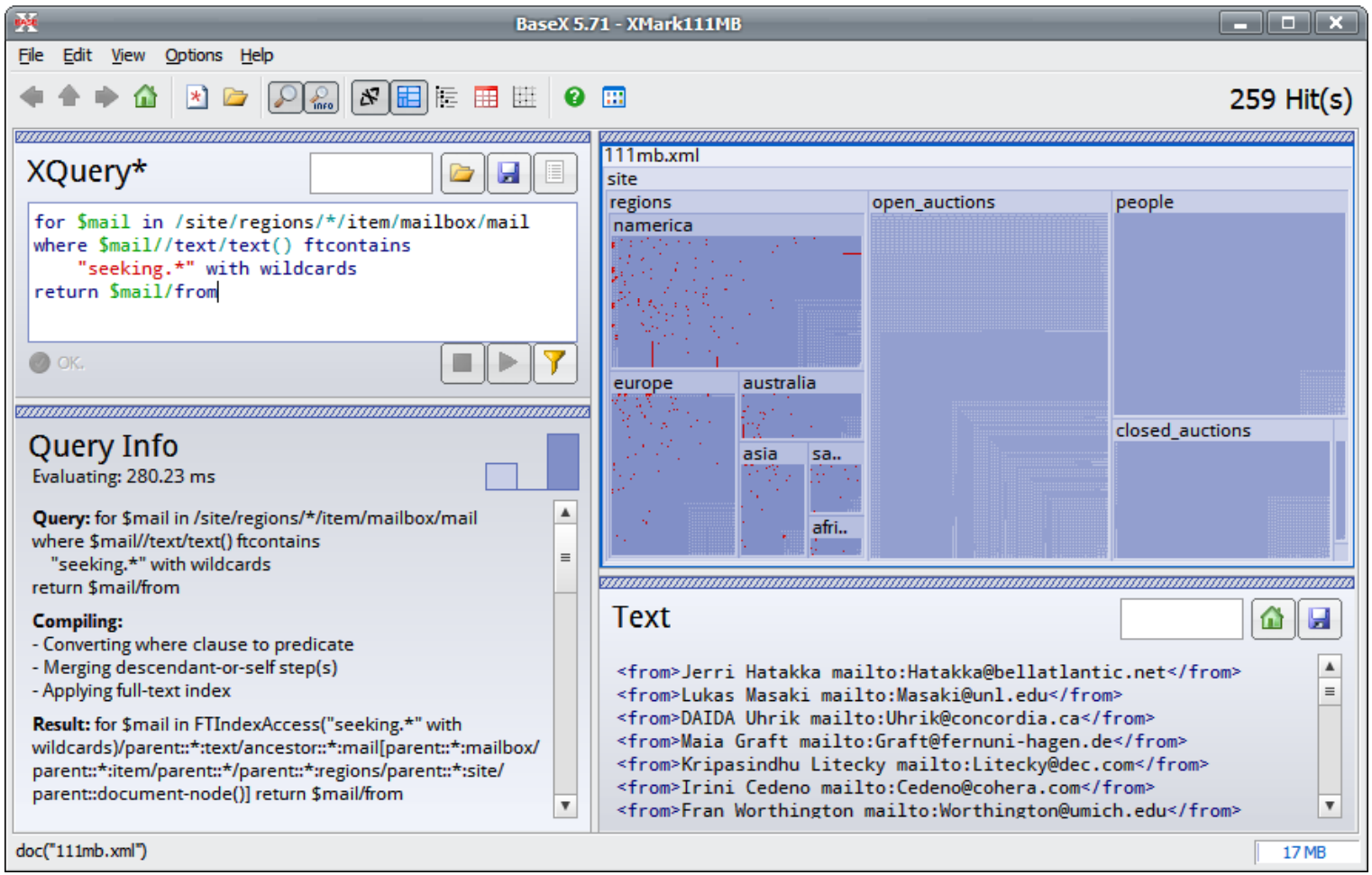
Q2:
```
for $mail in doc("xmark")/site/regions/*/item/mailbox/mail
where $mail//text/text() ftcontains "seeking.*" with wildcards
return $mail/from
```

Q3:
```
for $item in doc("xmark")/site/regions/*/item
where $item//listitem/text/text() ftcontains ftnot "preventions"
return <result>{ $item/location/text() }</result>
```

Frontend



Frontend



Conclusion

XQuery Full Text is getting popular!

- many of our users are already working with XQFT
- more and more implementations arise

Open Challenges

- suitable scoring algorithms for XML data (see INEX, SIGIR, ...)
- runtime optimizations to allow for index access of variable `ftcontains` strings

...thanks for listening!