COMP9319 Web Data Compression and Search

Semistructured / Tree Data,

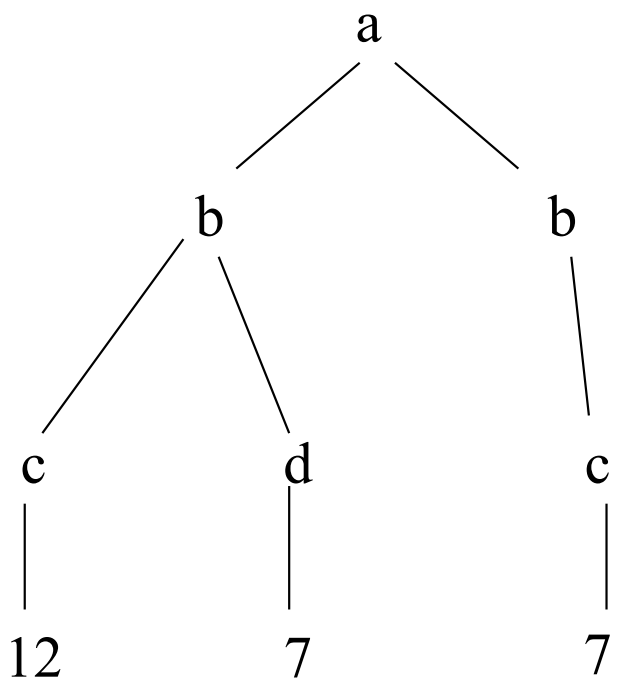
XML,

XML Compression

XPath evaluation

<a><c>12</c><d>7</d><c>7</c>

/ a / b [c = “12”]

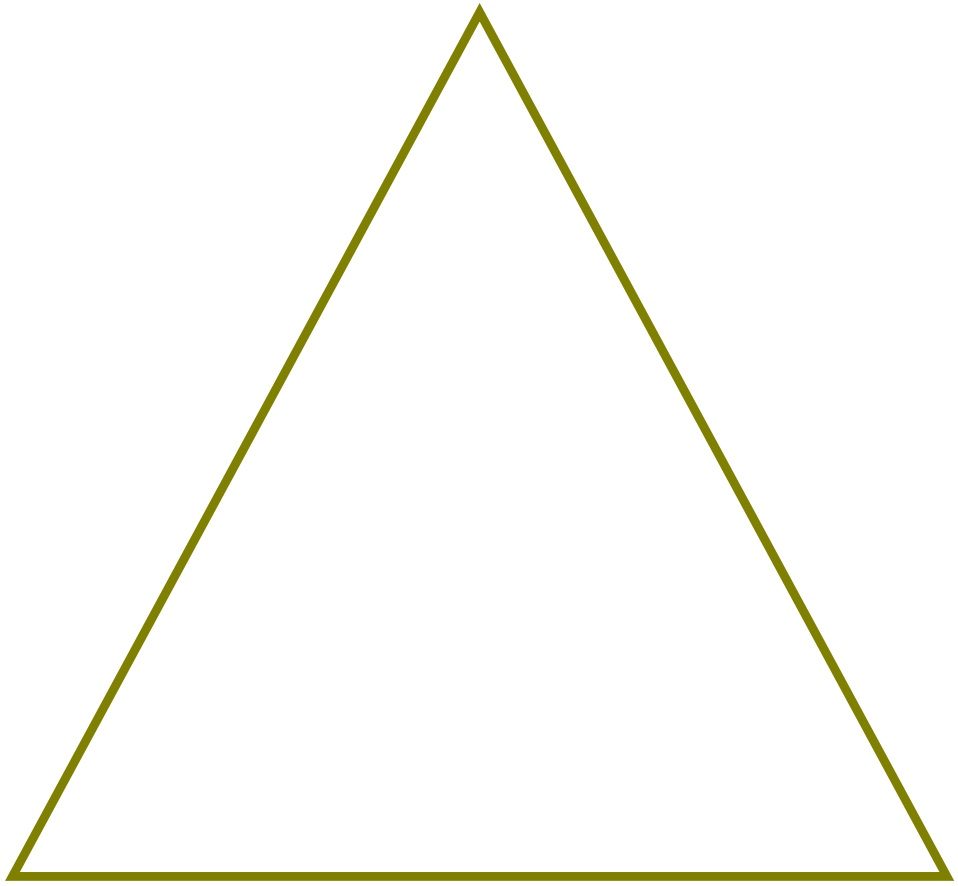


Query evaluation

Top-down

Bottom-up

Hybrid



XPath evaluation

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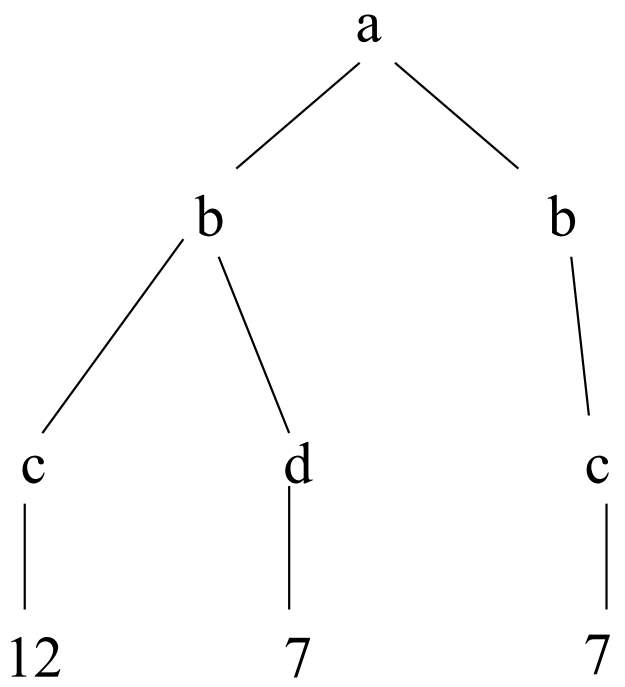

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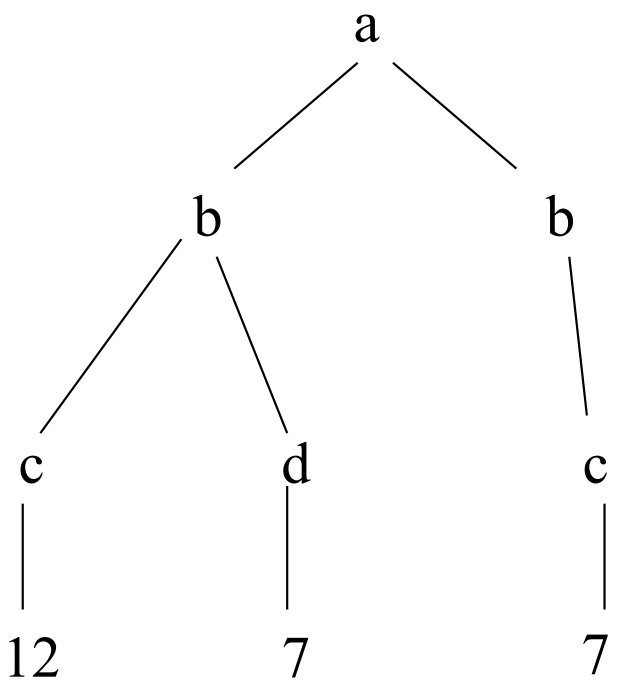


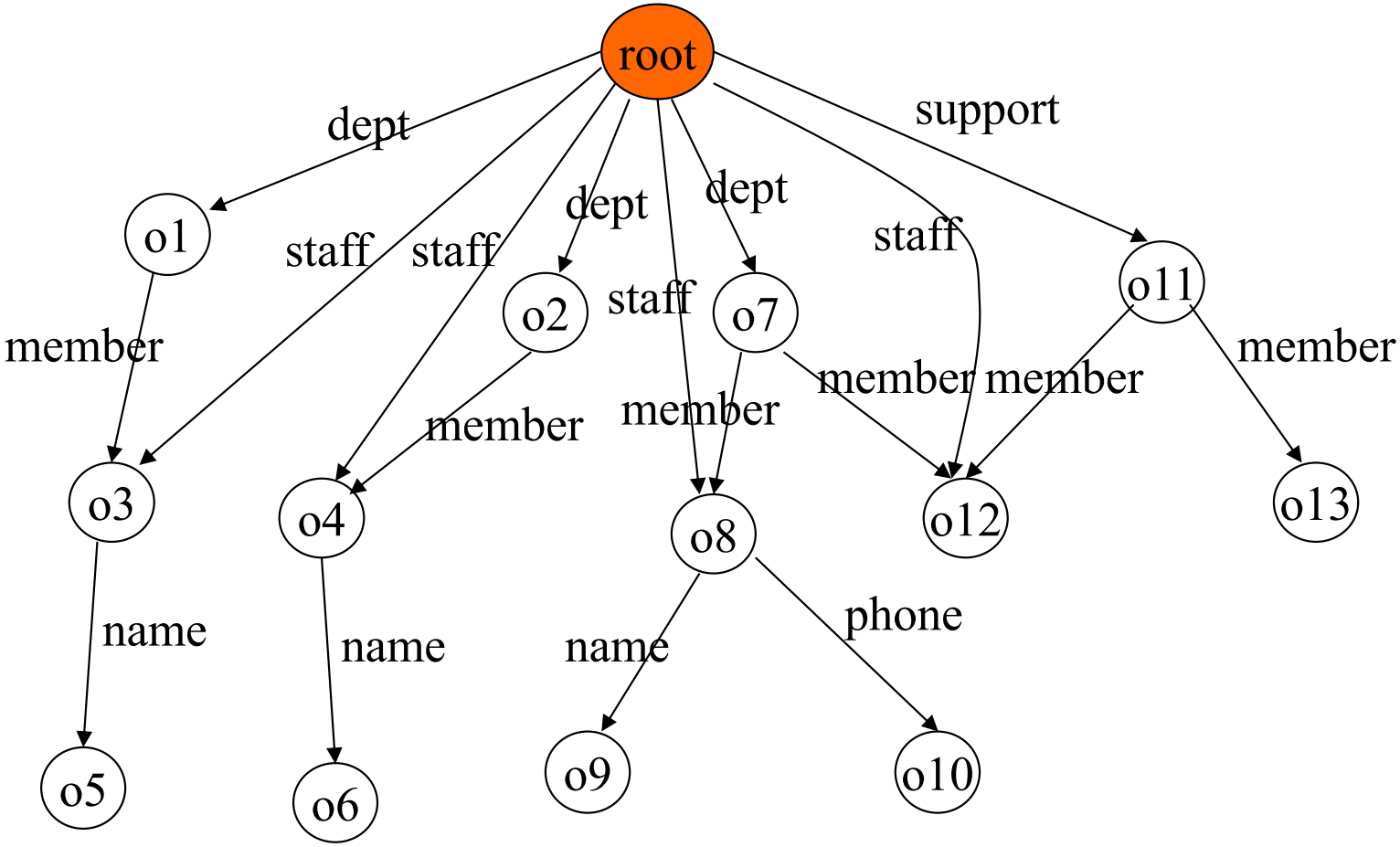
Path indexing

- Traversing graph/tree almost = query processing for semistructured / XML data
- Normally, it requires to traverse the data from the root and return all nodes X reachable by a path matching the given regular path expression
- Motivation: allows the system to answer regular path expressions without traversing the whole graph/tree

Major Criteria for indexing

- Speed up the search (by cutting the search space down)
- Relatively smaller size than the original data graph/tree
- Easy to maintain (during data loading during updates)

An Example of DAG Data



Index graph based on language-equivalence

- a reduced graph that summarizes all paths from the root in the data graph
- The paths from root to o12
  - staff
  - dept/member
  - support/member

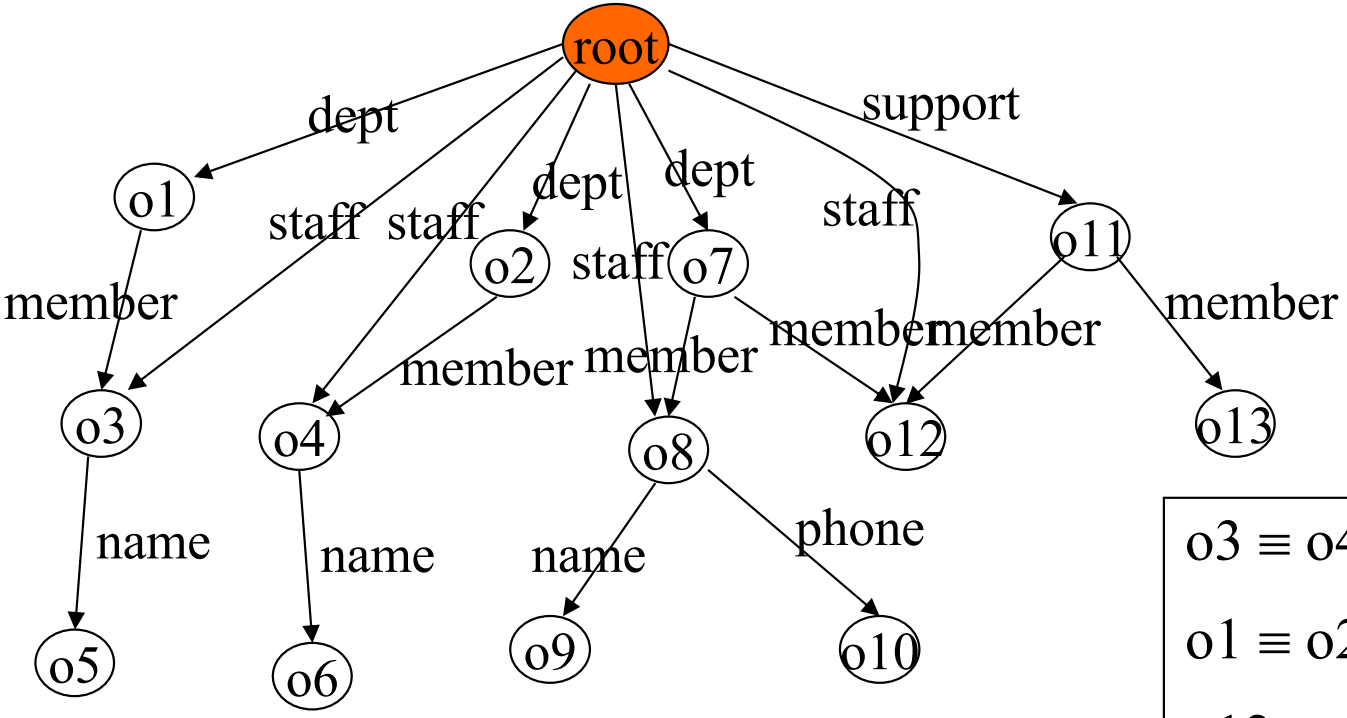
Language-equivalent nodes

- Let $L(x) := \{w \mid \exists$ a path from the root to x labeled w$\}$
- The set L(x) may be infinite when there are cycles
- Nodes x, y are language-equivalent ($x \equiv y$) if $L(x) = L(y)$
- We construct index I by taking the nodes to be the equivalent classes for $\equiv$

Language-equivalent

- The paths from root to o3
  - staff
  - dept/member
- Paths to o4 happen to be exactly the same 2 sequences
- Same for o8 and o12
- o3 ≡ o4 ≡ o8 ≡ o12

Equivalence classes



o3 ≡ o4 ≡ o8 ≡ o12

o1 ≡ o2 ≡ o7

o12 ≡ o13

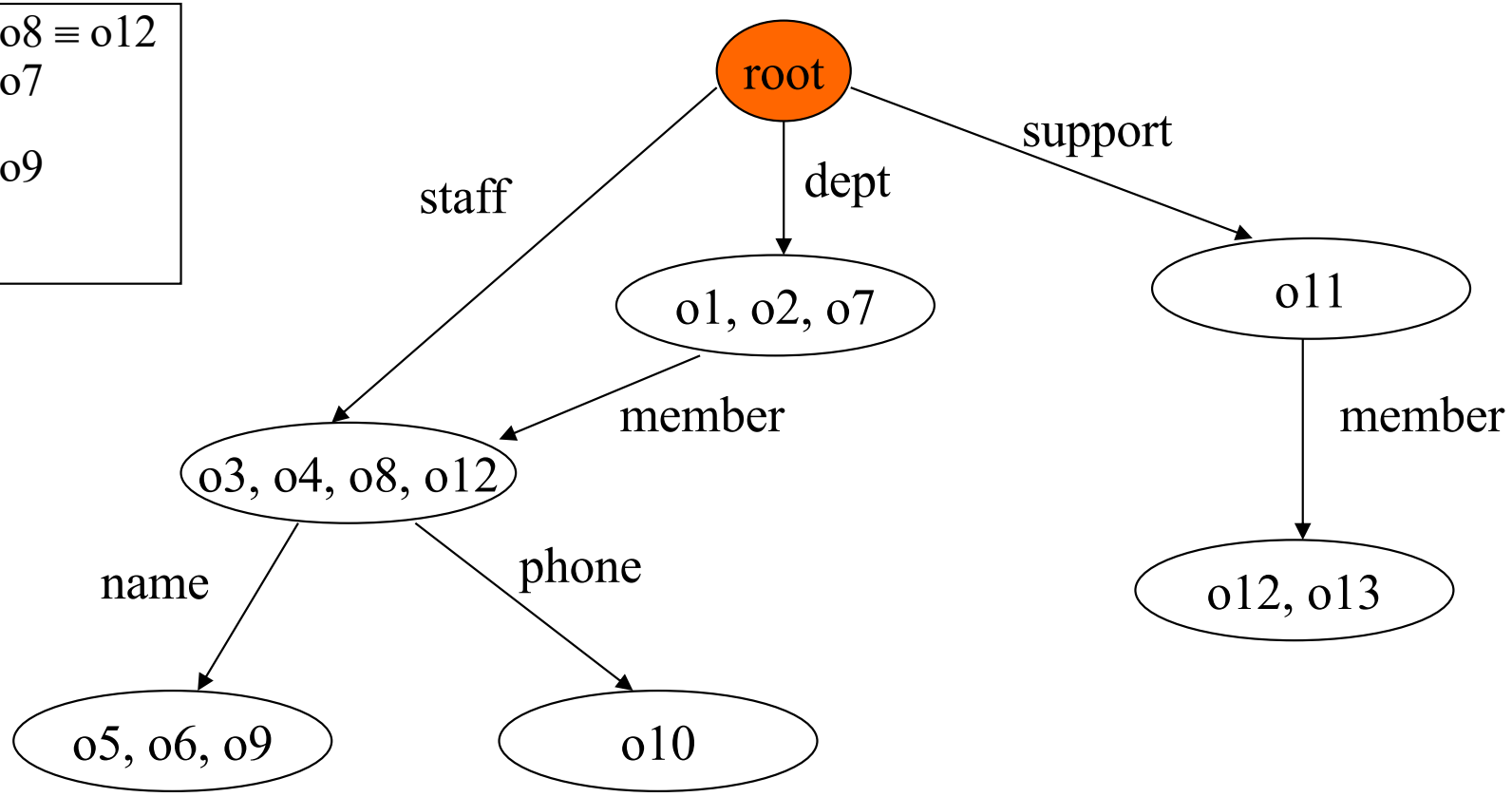
o5 ≡ o6 ≡ o9

o10

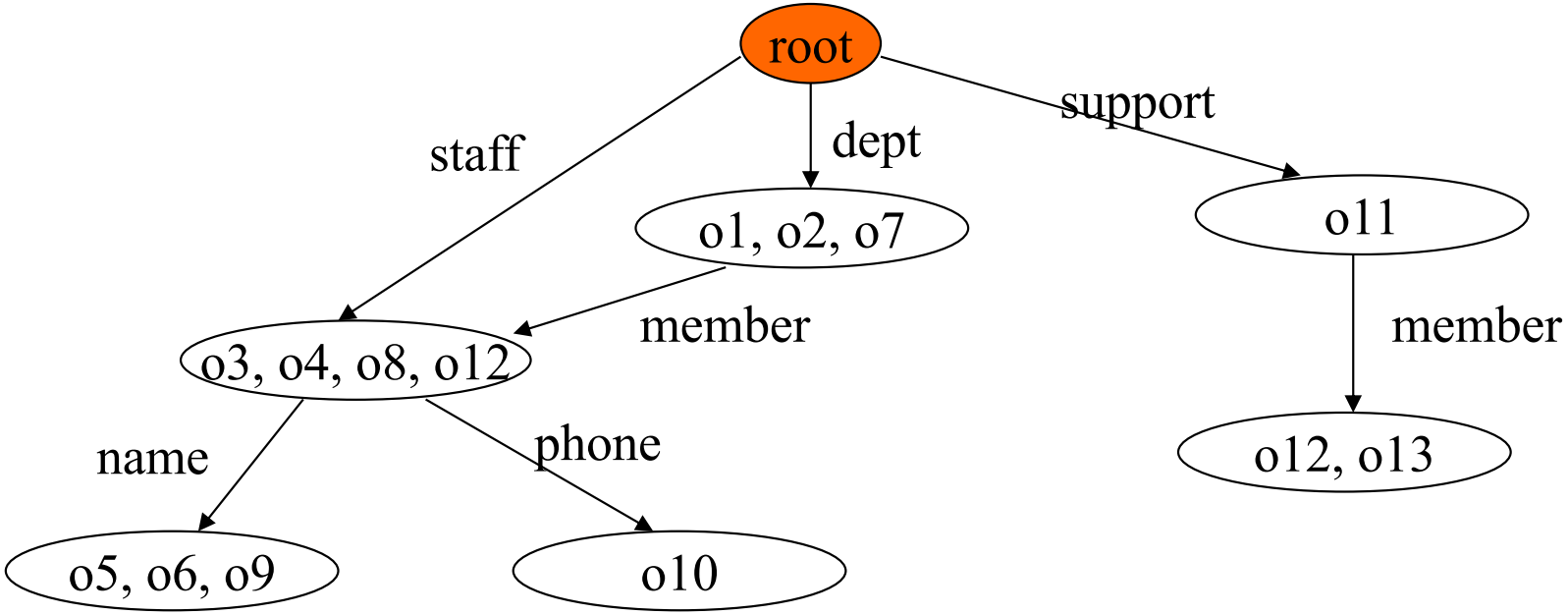
o11

The index graph

o3 ≡ o4 ≡ o8 ≡ o12
o1 ≡ o2 ≡ o7
o12 ≡ o13
o5 ≡ o6 ≡ o9
o10
o11



Query processing based on the index graph



dept/member/(name | phone)

-> dept/member/name UNION dept/member/phone

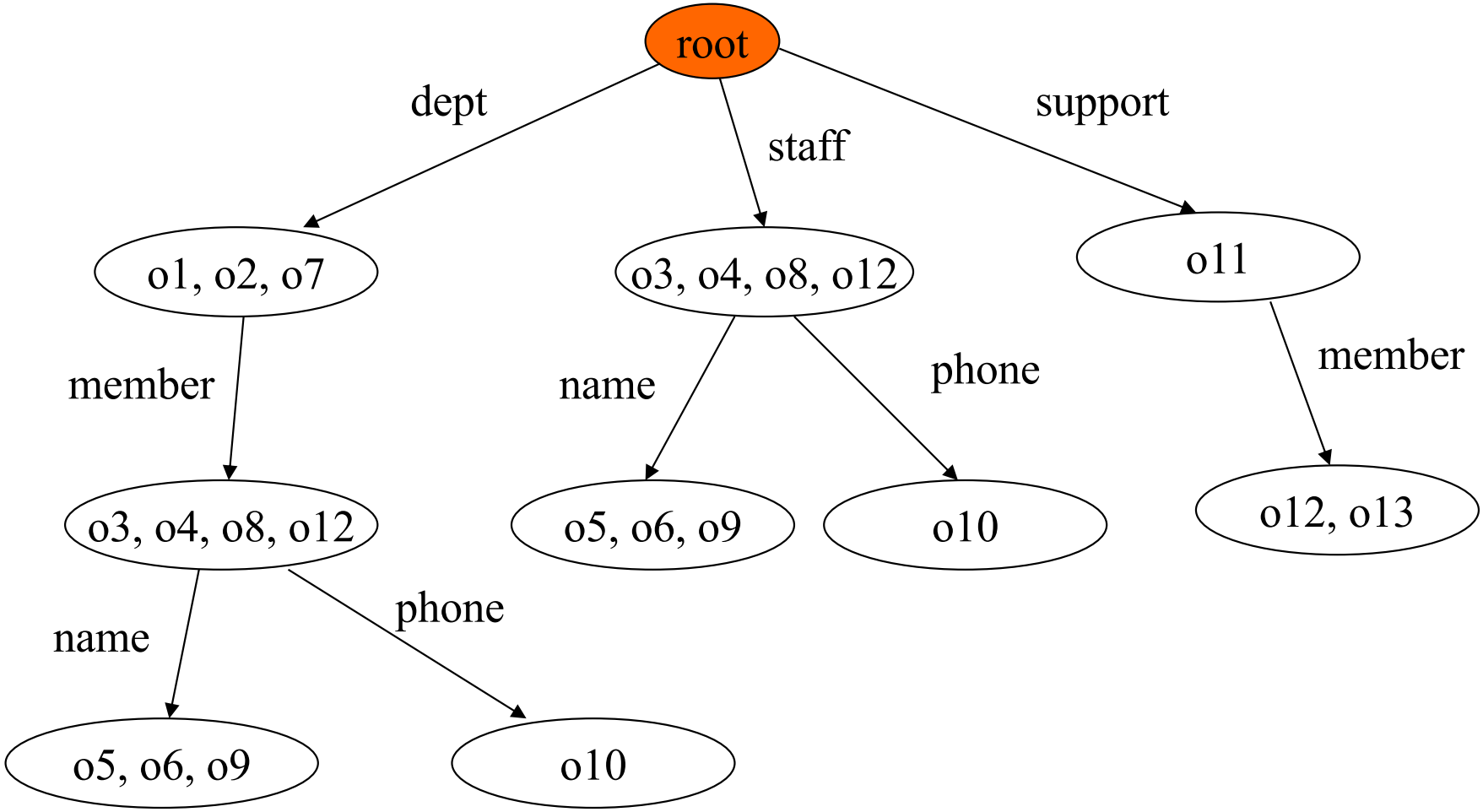
-> {o5, o6, o9} UNION {o10}

-> {o5, o6, o9, o10}

About this indexing scheme

- The index graph is never > the data
- In practice, the index graph is small enough to fit in memory
- Construct the index is however a problem
  - check two nodes are language-equivalent is very expensive (are PSPACE)
  - approximation based on bisimulation exists

A Data Guide


root
dept
staff
support
o1, o2, o7
o3, o4, o8, o12
o11
member
name
phone
member
o3, o4, o8, o12
o5, o6, o9
o10
o12, o13
name
phone
o5, o6, o9
o10

About Data Guide

- unique labels at each node
- (hence) extents are no longer disjoint
- query processing proceeds as before
- size of the index may >= data size
- good for data that is regular & has no cycles

XML-Specific Compressors

- Unqueriable Compression (e.g. XMill):
  - Full-chunked: data commonalities eliminated
  - Very good compression ratio
- Queriable Compression (e.g. XGrind, XPRESS):
  - Fine-grained: data commonalities ignored
  - Inadequate compression ratio and time
  - Support simple path queries with atomic predicate

XMill

- First specialized compressor for XML data
  - SAX parser (a fast, event-based parser) for parsing XML data
  - Still using gzip as its underlying compressor
  - Clever grouping of data into containers for compression
- Compress XML via three basic techniques
  - Compress the structure separately from the data
  - Group the data values according to their types
  - Apply semantic (specialized) compressors:

XMill Architecture:

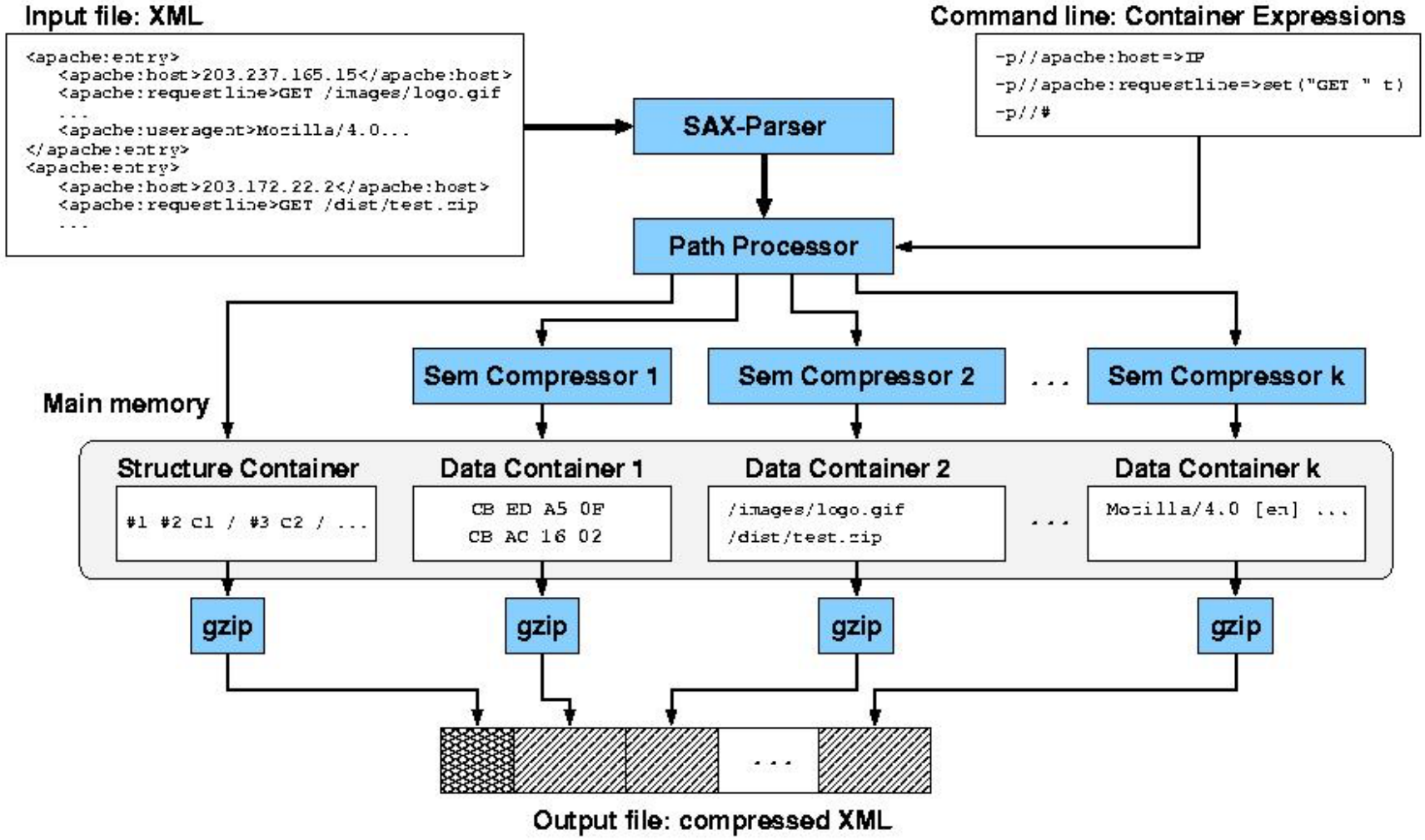


Figure 4: Architecture of the Compressor

An Example:Web Server Logs

ASCII File 15.9 MB (gzipped 1.6MB):

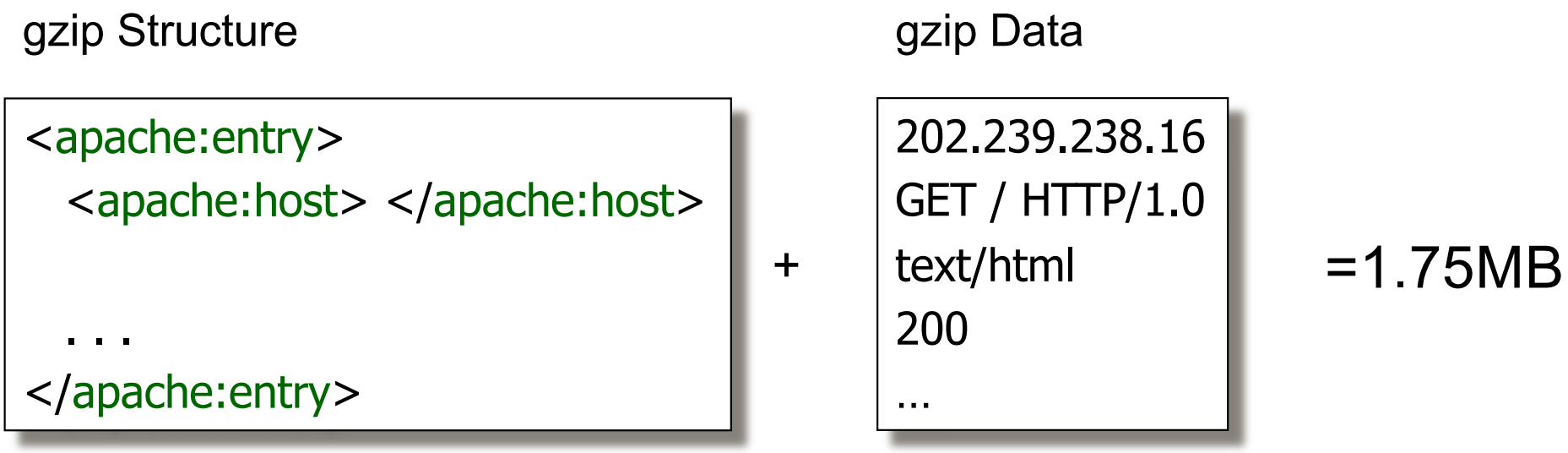
```
202.239.238.16|GET / HTTP/1.0|text/html|200|1997/10/01-00:00:02|-|4478|-|-|http://www.net.jp/|Mozilla/3.1[ja](I)
```

XML-ized apache web log inflates to 24.2 MB (gzipped 2.1MB):

```
<apache:entry>
  <apache:host> 202.239.238.16 </apache:host>
  <apache:requestLine> GET / HTTP/1.0 </apache:requestLine>
  <apache:contentType> text/html </apache:contentType>
  <apache:statusCode> 200</apache:statusCode>
  <apache:date> 1997/10/01-00:00:02</apache:date>
  <apache:byteCount> 4478</apache:byteCount>
  <apache:referer> http://www.net.jp/ </apache:referer>
  <apache:userAgent> Mozilla/3.1$[$ja$]$(I)</apache:userAgent>
</apache:entry>
```

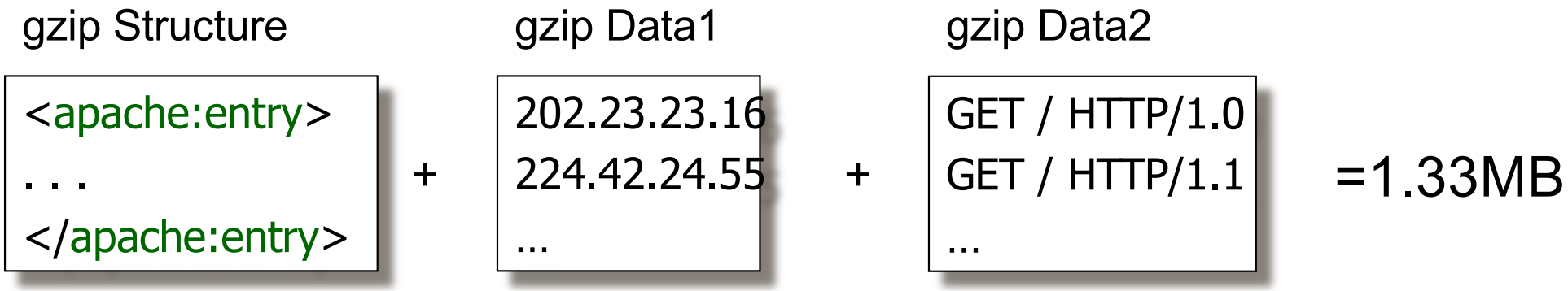
How Xmill Works: Three Ideas

Compress the structure separately from the data:



How Xmill Works: Three Ideas

Group the data values according to their types:



How Xmill Works: Three Ideas

Apply semantic (specialized) compressors:

gzip Structure + gzip c1(Data1) + gzip c2(Data2) + ... =0.82MB

Examples:

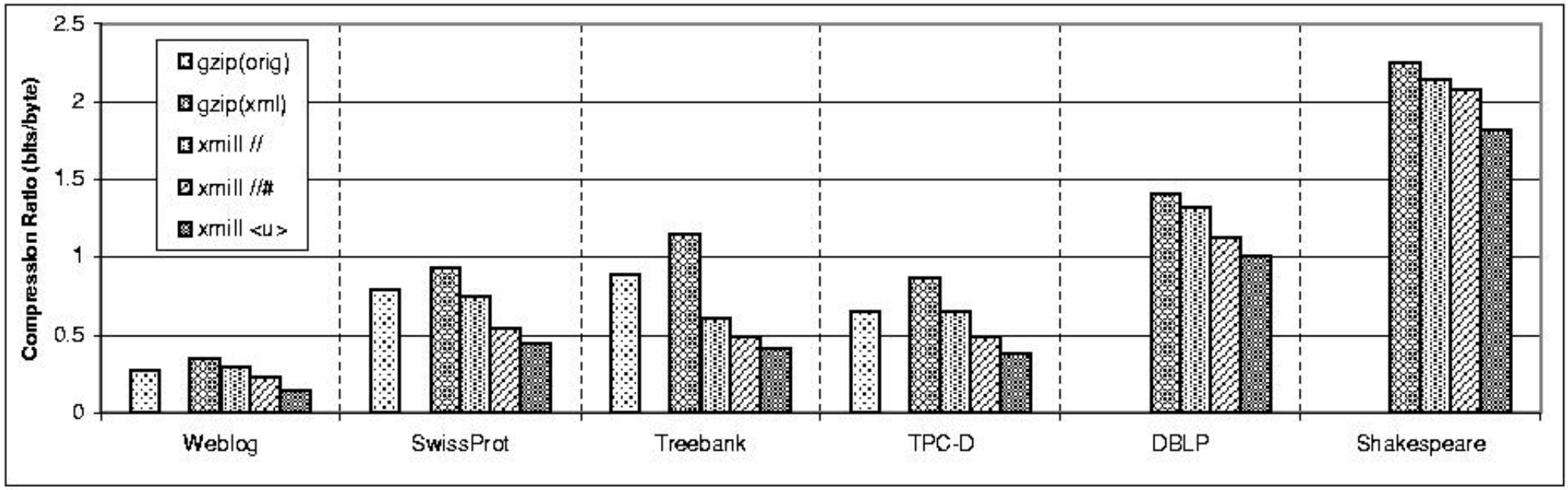
- 8, 16, 32-bit integer encoding (signed/unsigned)
- differential compressing (e.g. 1999, 1995, 2001, 2000, 1995, ...)
- compress lists, records (e.g. 104.32.23.1 → 4 bytes)

Need user input to select the semantic compressor

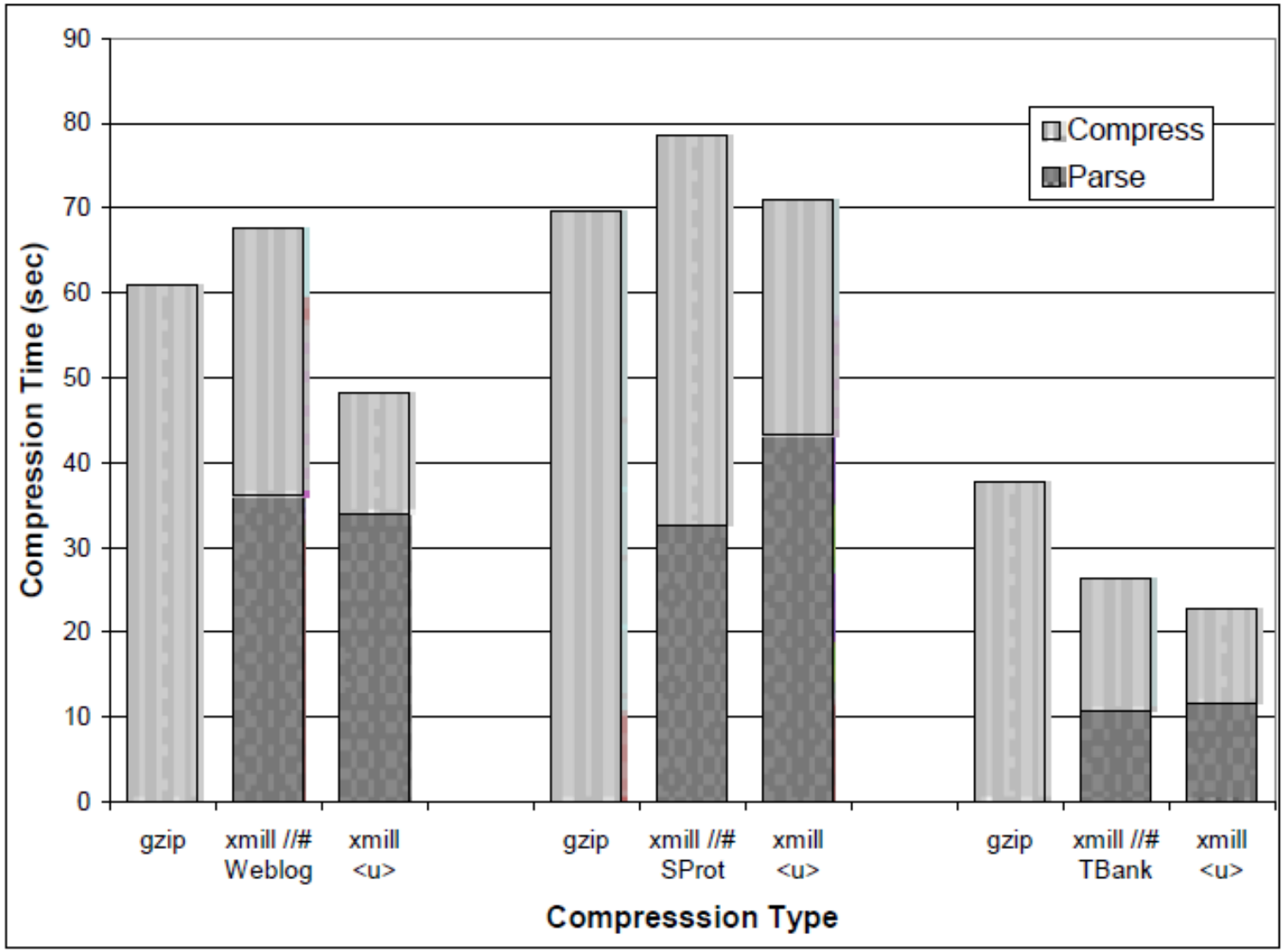
Experiments

Data Source	Original Size	Size in XML	Regular?	Depth	Tags	DataGuide Size
Weblog Data	57.7MB	172MB	yes	1	10	11
SwissProt	98.5MB	158MB	yes	3	92	58
Treebank	39.6MB	53.8MB	no	35	251	339920
TPC-D	34.6MB	119MB	yes	2	43	60
DBLP	-	47.2MB	yes	3	10	145
Shakespeare	-	7.3MB	no	5	21	58

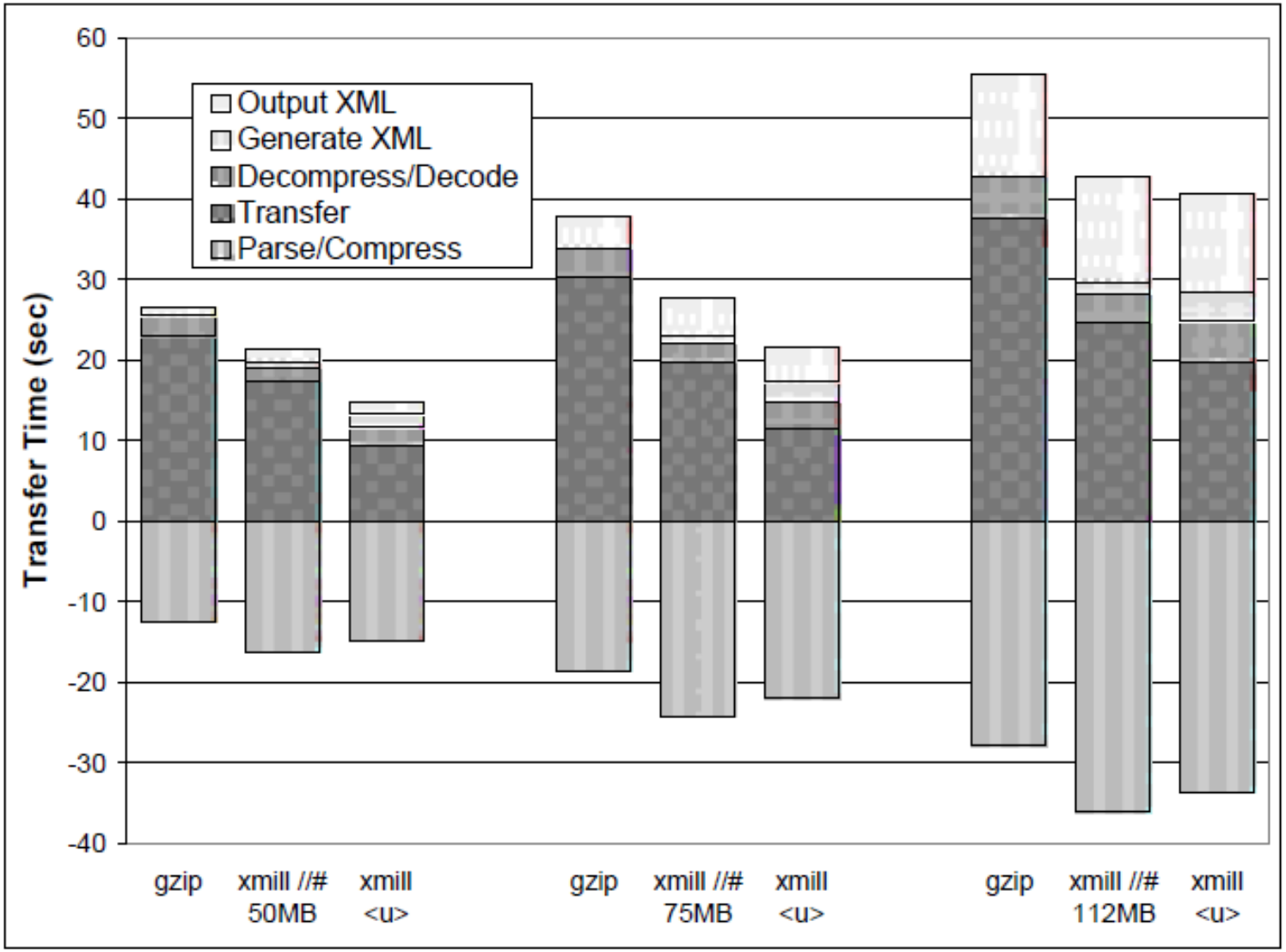
XML Compression



Compression Time



Transfer Time (& Decode)



XGRIND (Tolani & Haritsa, 2002)

- Encodes elements and attributes using XMill's approach
- **DTD-conscious:** enumerated attributes with *k* possible values are encoded using a $\log_2 k$-bit scheme
- Data values are encoded using non-adaptive Huffman coding
  - Requires two passes over the input document
  - Separate statistical model for each element/attribute
- Homomorphic compression: compressed document retains original structure

XGRIND

Original Fragment:

```
<student name="Alice">
        <a1>78</a1>
        <a2>86</a2>

    <midterm>91</midterm>

    <project>87</project>
</student>
```

Compressed Fragment:

```
T0 A0 nahuff(Alice)
    T1 nahuff(78) /
    T2 nahuff(86) /
    T3 nahuff(91) /
    T4 nahuff(87) /
/
```

XGRIND

- Many queries can be carried out entirely in compressed domain
  - Exact-match, prefix-match
- Some others require only decompression of relevant values
  - Range, substring
- Queryability comes at the expense of achievable compression ratio: typically within 65-75% that of XMill