XBird/D: Distributed and Parallel XQuery Processing using Remote Proxy

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Outline

- Background & Motivation
- Open Problems
- Our Solution to Open Problems
- XBird/D Implementation
- Experimental Evaluation
- Conclusion

Background

As XML spreads over networks, the need to integrate distributed and d[...]s is increasing

Biological databases receive frequent update/corrections

Examples include,

- Integration of (heterogeneous) biological databases by XML
  - e.g., Integrating Genbank and Uniprot by Blast search results
- Display on-the-fly information of Web from thousands of XML feeds for each user
  - e.g., aggregating t[...]est result of football games

Current XML-feed readers aggregate users' subscriptions at hourly intervals

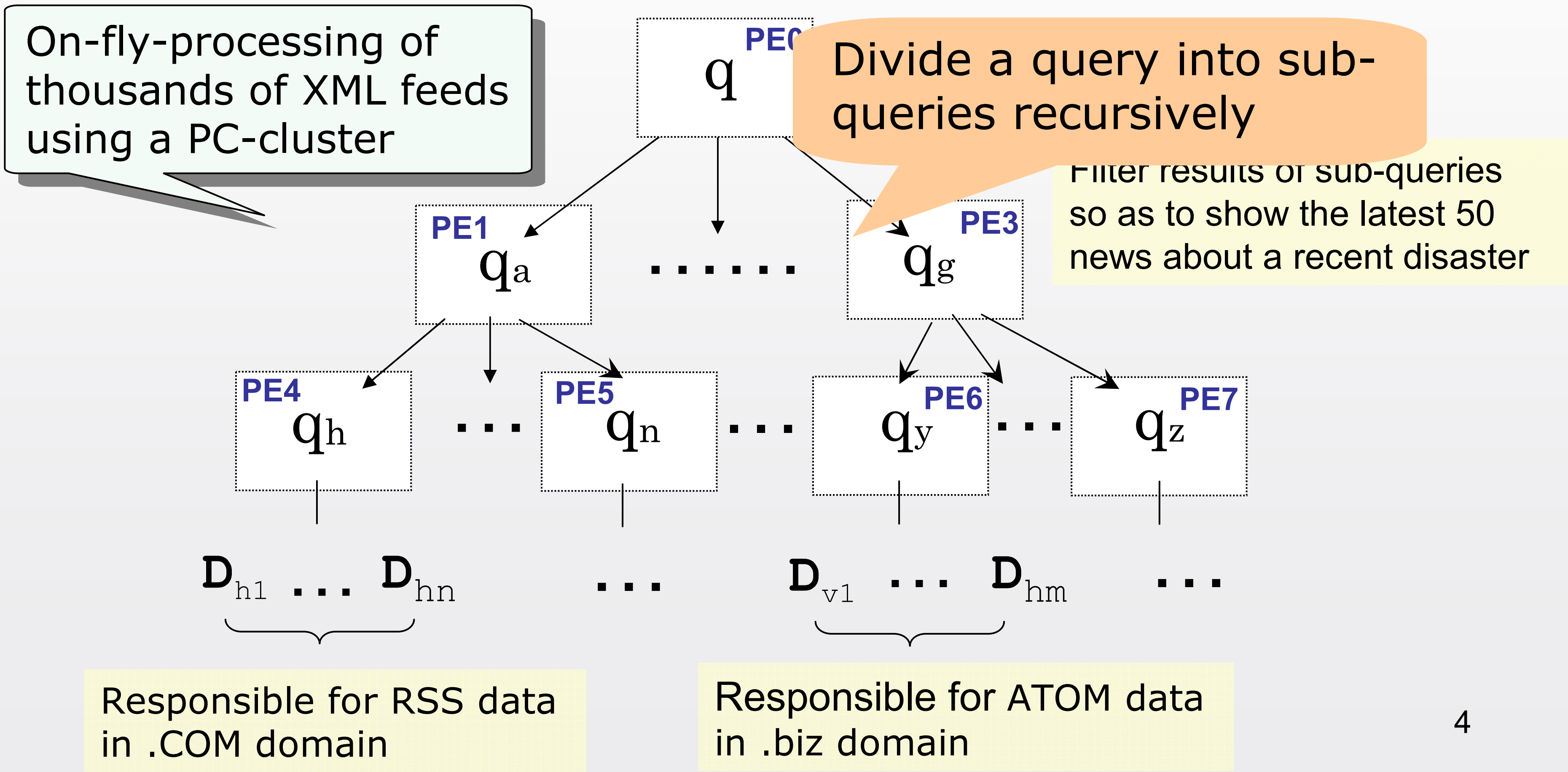
C[...]

- [...] data source
- Direct access to background databases is not allowed
- XML data is frequently changing

Motivation

To realize on-the-fly processing of thousands of distributed XML documents, we apply a divide-and-conquer design paradigm

Motivating example



Open Problems and Our Solution

The prior approaches [1][2][3] commonly used **pass-by-value** semantics

A) Limitation of inter-operator parallelism
due to lack support for pipelining

➡ Pipelining using pass-by-reference

B) Overhead of encoding/decoding

➡ Direct result forwarding to reduce the latency

C) Poor resource utilization

➡ Remote blocking-queue with which processing rates of operators are managed

[1] Re' C, Brinkley J, Hinshaw K, Suciu D: Distributed XQuery, In Proc. IIWEB (2004).
[2] Zhang Y, Boncz P: XRPC: Interoperable and Efficient Distributed XQuery, In Proc. VLDB (2007).
[3] Fernandez M, Jim T, Morton K, Onose N, Simeon J: Highly Distributed XQuery with DXQ, In Proc. XIME-P (2007).

Explore open problem (A)

- What was meant by the limitation of inter-operator parallelism?
- Why is pipelining indispensable?

Problems in Pass-by-Value Semantics

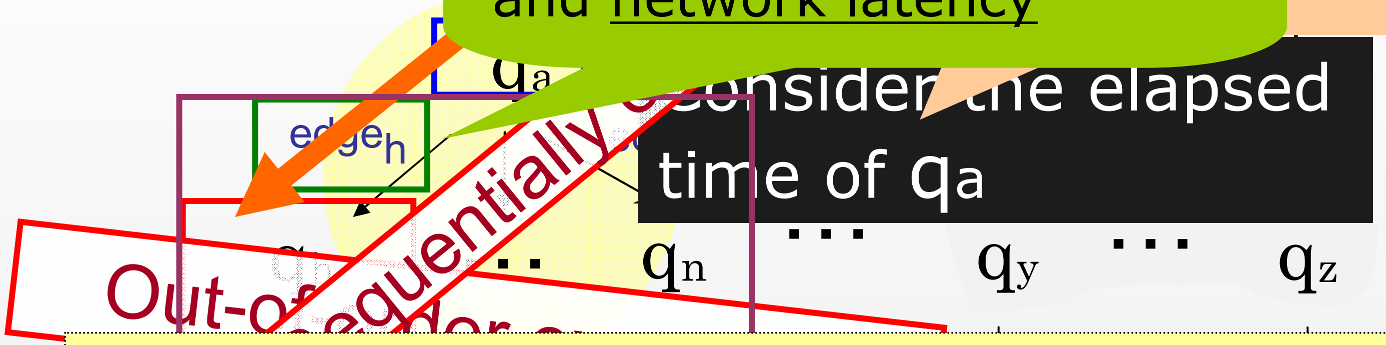
Pass-by-value sema
involves blocking

LT(q_a) represents
"Elapsed time of **local**

Edge involves latency
such as encoding/decoding
and network latency

ious

Query Invocation
Blocking edge
edge



Problems

- Inter-operator parallelism is limited
- Depends on the most time-consuming edge
- Non-parallelized portion of queries restricts the theoretical maximum speedups
  (according to Amdahl's law)

elapsed time of the most time-consuming edge

Recursively defined

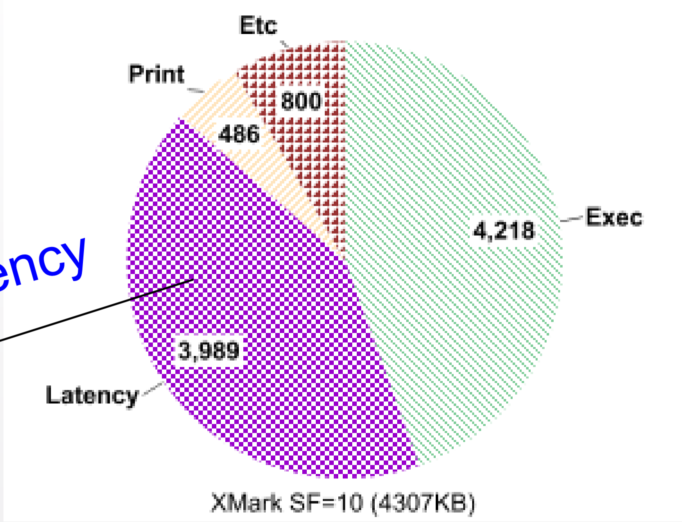
Explore open problem (B)

How critical is the overhead of encoding /decoding?

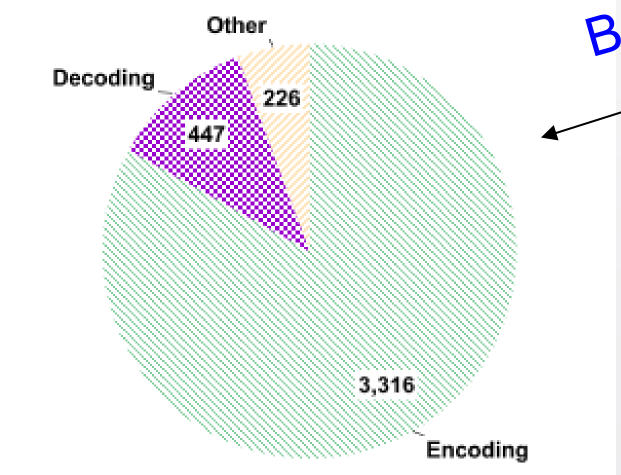
Costs involved in Remote Query Execution

We conducted a micro-benchmark, with using the following queries where $doc locates an XML document generated by XMark SF=10, to estimate the costs involved in remote query execution.

for $a in $doc/site/closed_auction/closed_auction
where $a/price/text() >= 40 return $a/price



Breakdown the latency



What this experiment showed is …

- The latency including **encoding/decoding** is as same as query execution time
- Thus, each **blocking** edge of operators can potentially be a bottleneck

Explore open problem (C)

What is the resource utilization problem?

Resource Utilization Problems

Intuitions

- selecting low degrees of an operator parallelism

  can lead to under-utilization of the system and reduce throughput

Efficient resource utilization scheme and processor allocation scheme are needed!

- … parallelism

  can spend "too many" resources to one query and lead to high resource contention

Further details can be obtained in our paper and the following paper,

Mehta M, Dewitt DJ: Managing Intra-operator Parallelism in Parallel Database Systems, VLDB (1995)

Our Solution for each Open Problem

A) Limitation of inter-operator parallelism due to lack support for pipelining

➡ Pipelining using pass-by-reference

B) Overhead of encoding/decoding

➡ Direct result forwarding to reduce the latency

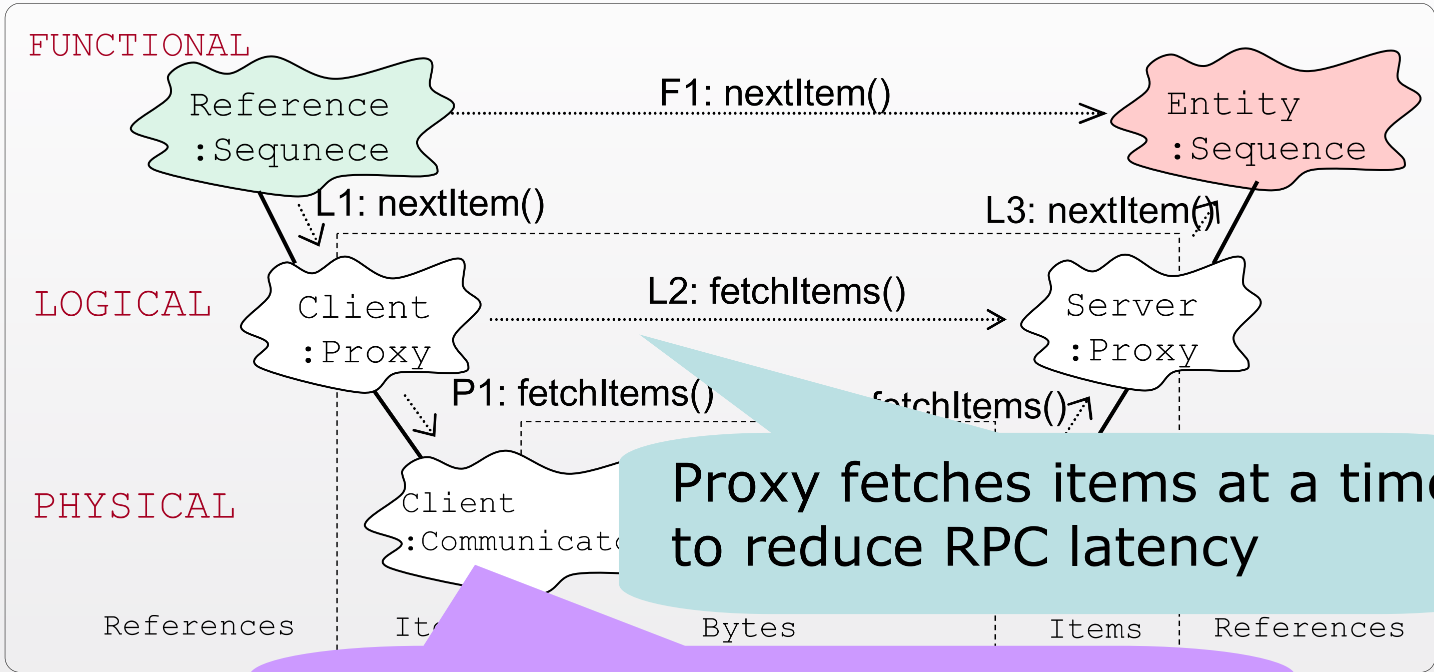
C) Poor resource utilization

➡ Remote blocking-queue with which processing rates of operators are managed

Our contribution consists of the above three techniques

A) Pass-by-Reference using a Remote Proxy

Handling a reference to a remote sequence as if it were on a local site



Proxy fetches items at a time to reduce RPC latency

Communicator encapsulates the underlying protocol (e.g., RMI)

G. Graefe. `Volcano-an extensible and parallel query evaluation system'. *Knowledge and Data Engineering, IEEE Transactions on* 6(1):120-135. 1994

Our Solution for the Problem (C)

✓A) **Limitation of inter-operator parallelism** due to lack support for pipelining

➡ Pipelining using pass-by-reference

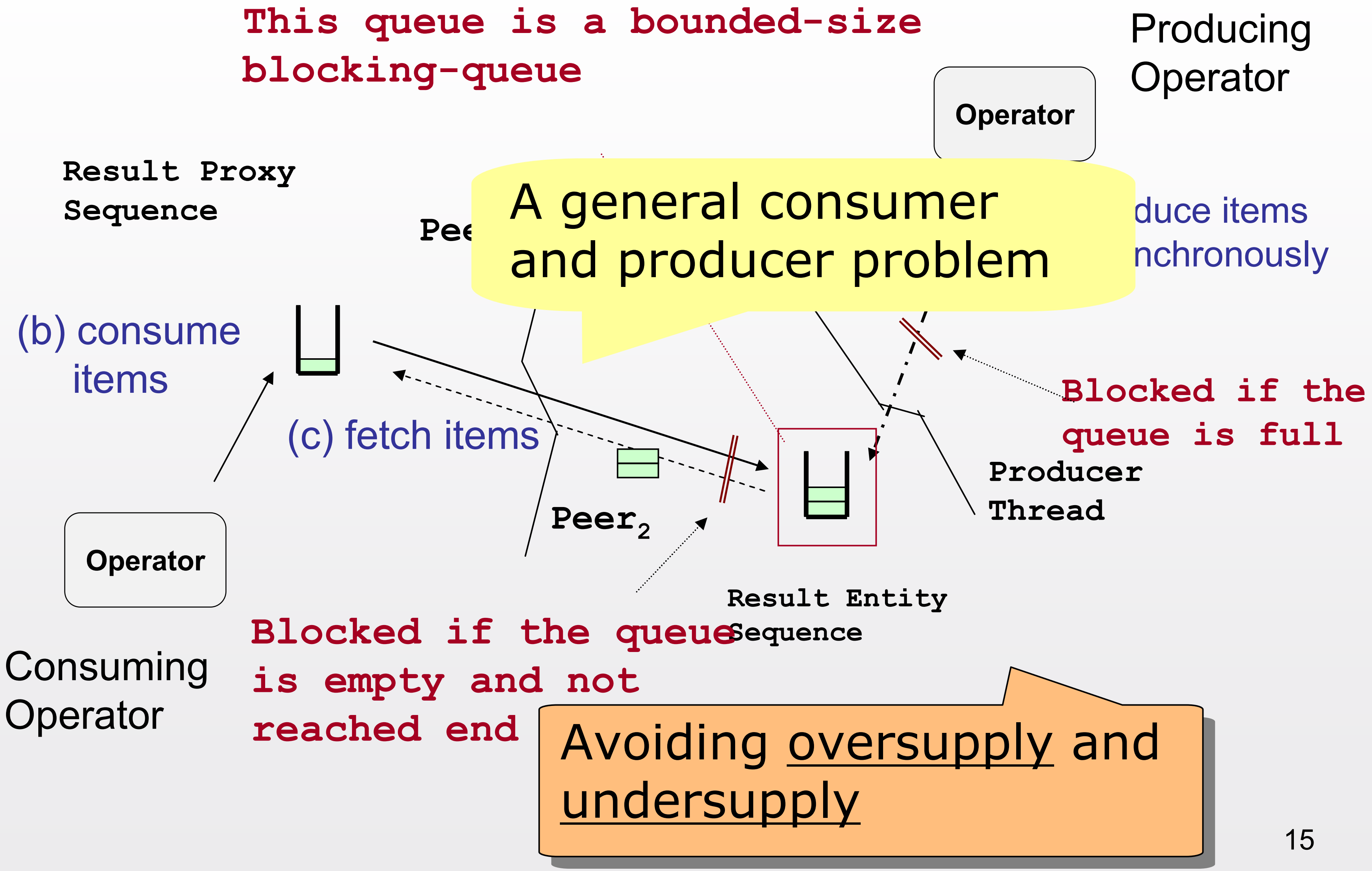
B) **Overhead of encoding/decoding**

➡ Direct result forwarding to reduce the latency

C) **Poor resource utilization**

➡ Remote blocking-queue with which processing rates of operators are managed

B) Asynchronous Production and Queue Management



Our Solution for the Problem (B)

✓A) **Limitation of inter-operator parallelism** due to lack support for pipelining

➡ Pipelining using pass-by-reference

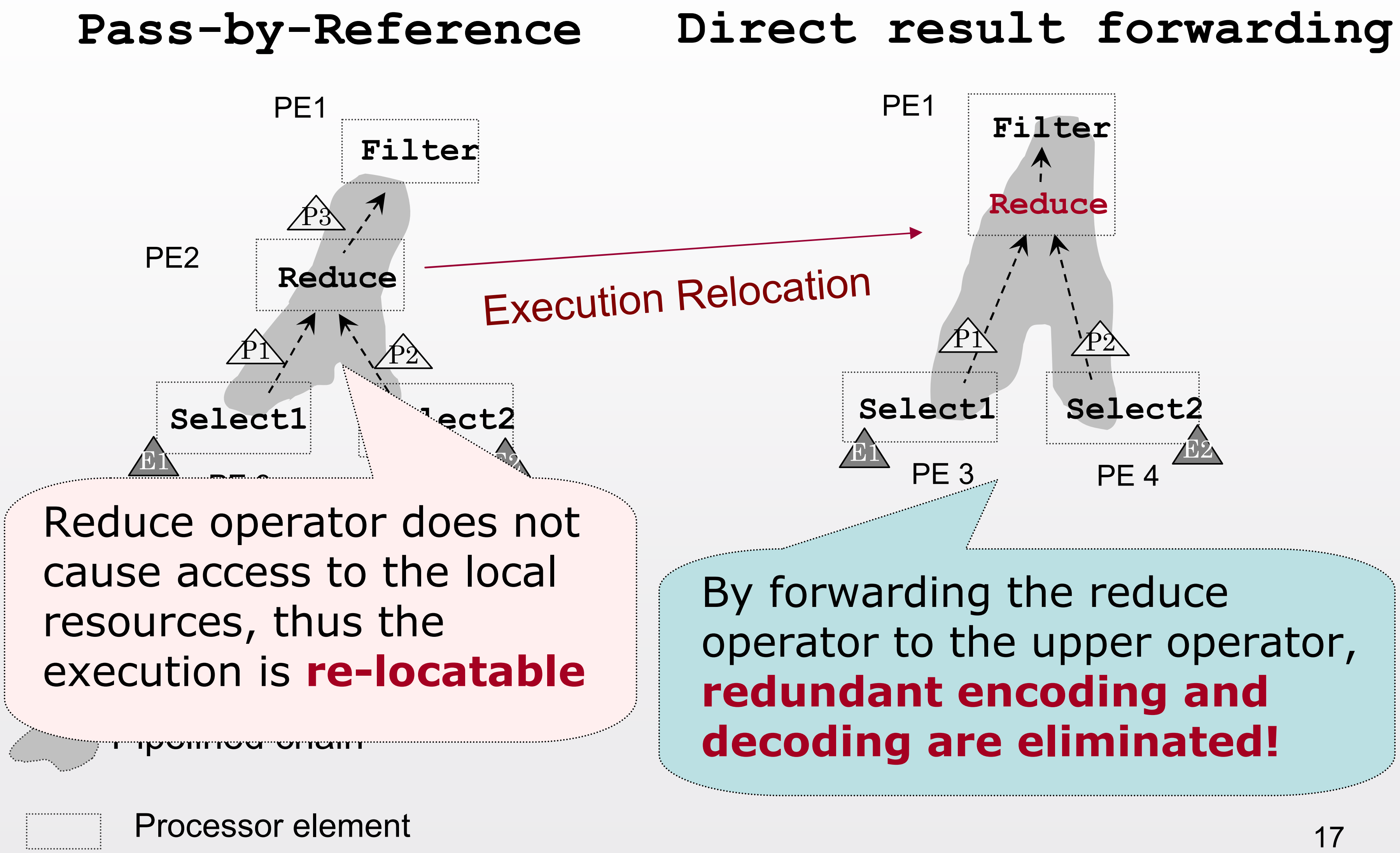
B) **Overhead of encoding/decoding**

➡ Direct result forwarding to reduce the latency

✓C) **Poor resource utilization**

➡ Remote blocking-queue with which processing rates of operators are managed

C) Direct Result Forwarding



Reduce operator does not cause access to the local resources, thus the execution is **re-locatable**

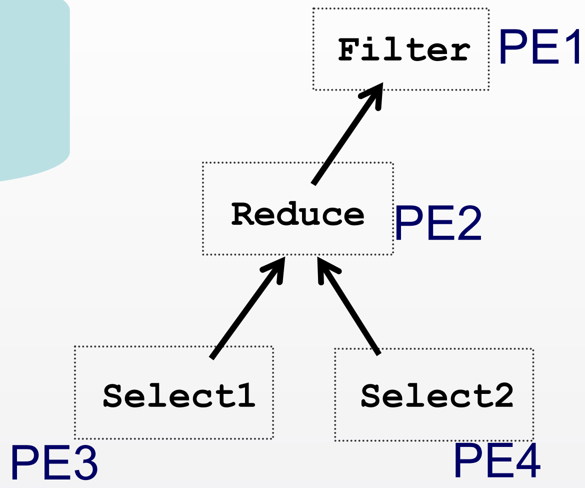
By forwarding the reduce operator to the upper operator, **redundant encoding and decoding are eliminated!**

Experimental Evaluation - Settings

In order to evaluate the effectiveness of our three enhancements, we conducted performance comparisons to MonetDB/XRPC.

one of the state-of-the-art distributed XQuery processors that represents pass-by-value semantics.

```
declare funct
  execute at
    fn:collec
  }
};
declare function bdq:select2() {
  execute at $PE4 {
    fn:collection($col)/site/open_auctions/open_auction
  }
};
declare function bdq:reduce() {
  execute at $PE2 {
    (  fn:subsequence(bdq:select1(), 1, 1000)
     | fn:subsequence(bdq:select2(), 1, 1000) )
  }
};
declare function local:filter() {
  for $a in bdq:reduce()
  where $a/seller/@person >= "person10000"
     or $a/buyer/@person >= "person10000"
  return $a
};
local:filter()  (: execute at PE1 :)
```



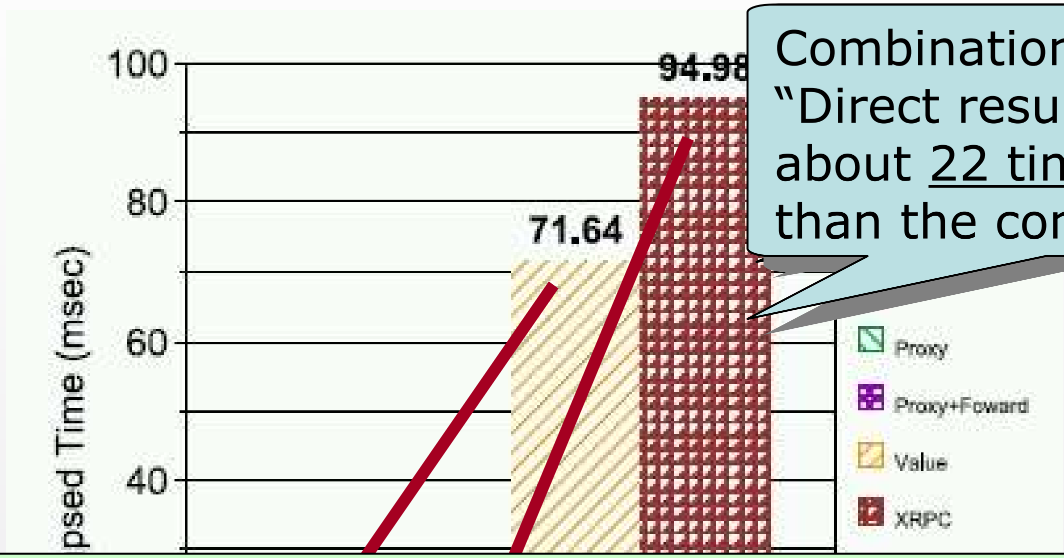
CPU: Pentium D 2.8GHz
(except that PE2 equips Athlon 64 X2 2.4 GHz)
Memory: 2GB
OS: SuSE Linux 10.2
Runtime: Sun JDK 1.6

Today's normal PC setting

Zhang Y, Boncz P: XRPC: Interoperable and Efficient Distributed XQuery, In Proc. VLDB (2007).

Experimental Evaluation - Results

Our pass-by-reference implementation using a remote proxy shows significant improvements on the elapsed time.



Combination of "Remote Proxy" and "Direct result forwarding" obtained about 22 times better performance than the competitive method (XRPC).

Moreover, **only our system using pass-by-reference** semantics could process 100 concurrent re

Pass-by-value semantics implementatio **from frequent swap-in/swap-out** due their poor resource utilization

Lazy evaluation effects!

Conclusion

We proposed an efficie
strategy using a remote

- Asynchronous item
- Direct result forwardi

We have tried other methods.
But the competitive system that is currently available and works properly is only MonetDB/XRPC.

Our experimental results showed up to 22x speedups compared with a competitive method in a certain situation, and demonstrated the importance for distributed XML database systems to take pass-by-reference semantics into consideration.

Future work

- Dynamic execution dispatching of remote query processors taking system resources and utilizations
- Development of a selection model of execution strategies

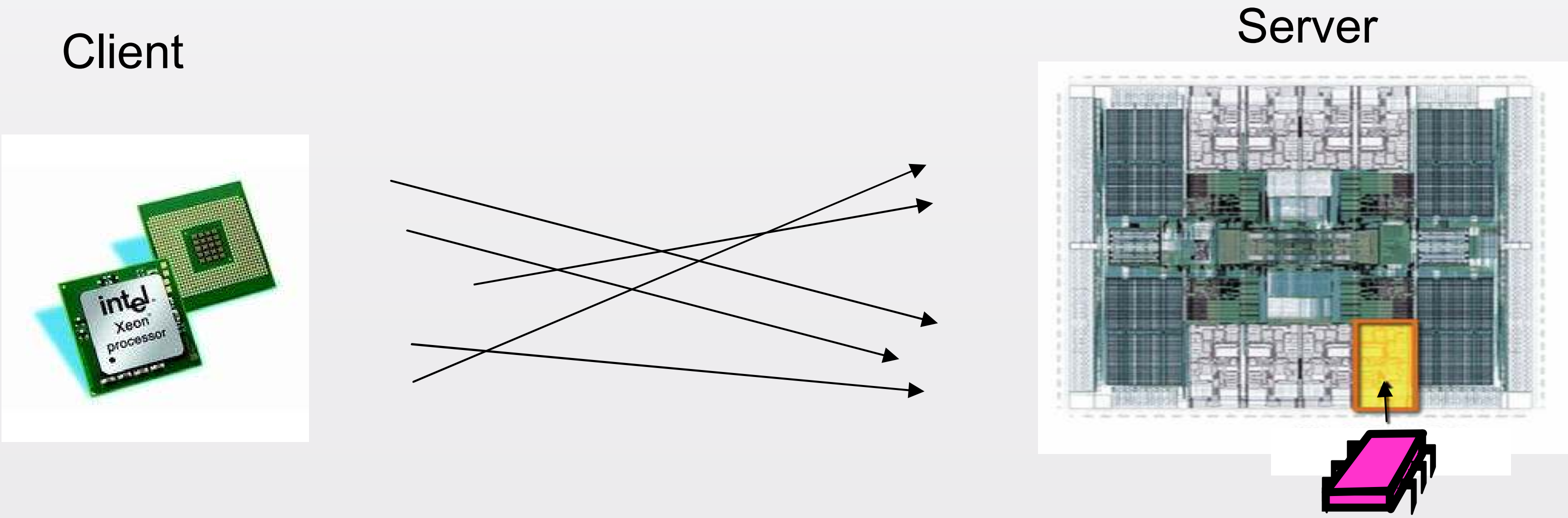
Thank you for your attention

XBird will be released as an open source software on
http://db-www.naist.jp/~makoto-y/proj/xbird

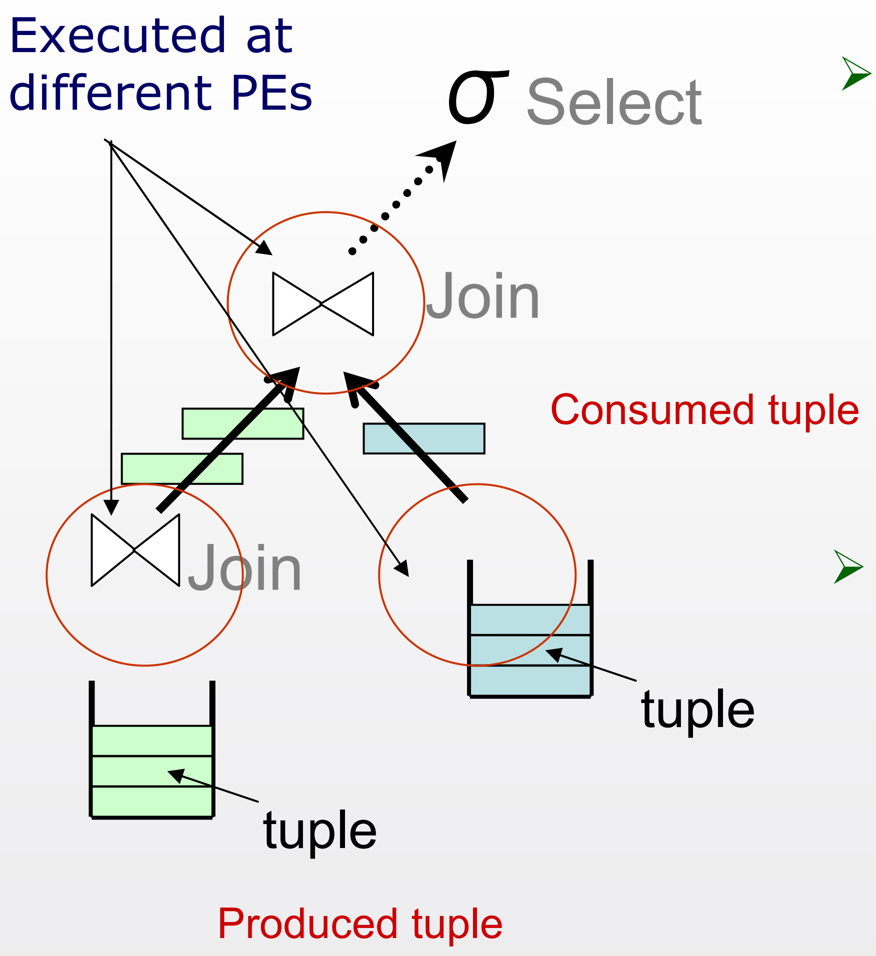
I have a demo-video in which XBird/D executed
180 remote queries on Niagara T2 in 5 seconds.
If you are interested in that, please contact me later.

Any questions or suggestions?

```
declare variable $colname := "/dews2008/xmark10.xml";
declare variable $remote-endpoint := "//niagara:1099/xbird/srv-01";
fn:subsequence(
    execute at $remote-endpoint
    {
        for $a in
    fn:collection($colname)/site/closed_auctions/closed_auction
        where $a/price/text() >= 40
        return $a/price
    }
,1,1000
)
```



Resource utilization problem



- Oversupply of tuples

  Too much production wastes system resources

- Undersupply of tuples

  Consumer tends to be idle

Mehta M, Dewitt DJ: Managing Intra-operator Parallelism in Parallel Database Systems, VLDB (1995)