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Managing a Fragmented XML Data Cube with Oracle and Timesten

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Outline

- Context and Motivation
- Timesten in-Memory Database
- XML Data Cube
- XML Cube Management Configurations
- Implementation and Testing
- Related Work
- Conclusion

Context and motivation

- Performance optimization of data warehouses (DW)
- Focus on a special type of DWs: XML warehouses
- Warehousing and analyzing complex data
  - Multidimensional model: conceptual, logical, physical level
  - Performance issues
  - Vertical fragmentation approach proposed
- Crossing two techniques
  - Vertical Fragmentation
  - Caching

Objectives and Contribution

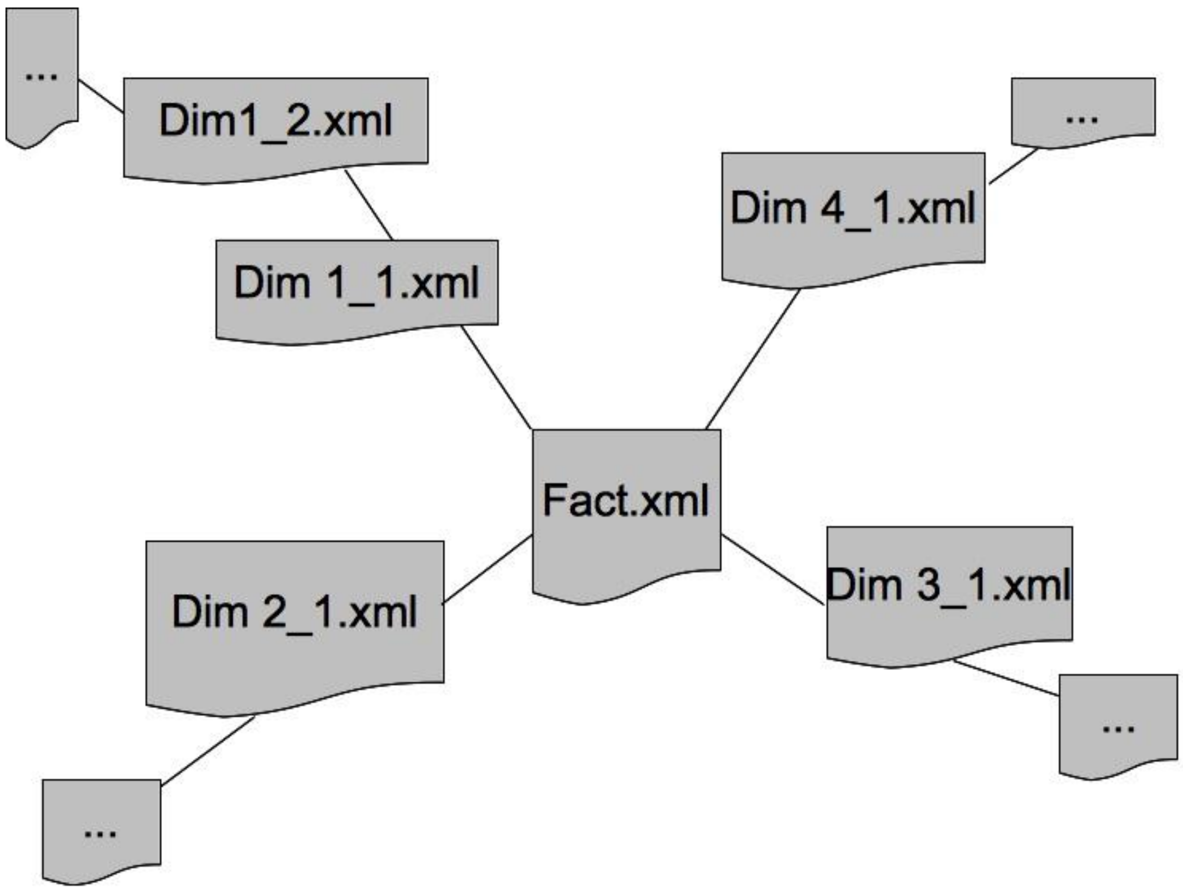
- **Objective:**
  - Analyze the impact of vertical fragmentation on caching and vice versa
  - A better cache management (data organization-aware)
  - Leverage the vertical fragmentation
- **Contributions**
  - A set of configurations to manage a fragmented XML cube
  - A comparision between the configurations

TimesTen In-Memory database

- Oracle's In-memory database solution
- Different uses of TimesTen
  - As a database cache for a disk resident database
    - Read-only transactions
    - Read-Write transactions
  - As a full-featured relational database
    - Persistence
    - Recovery
    - …

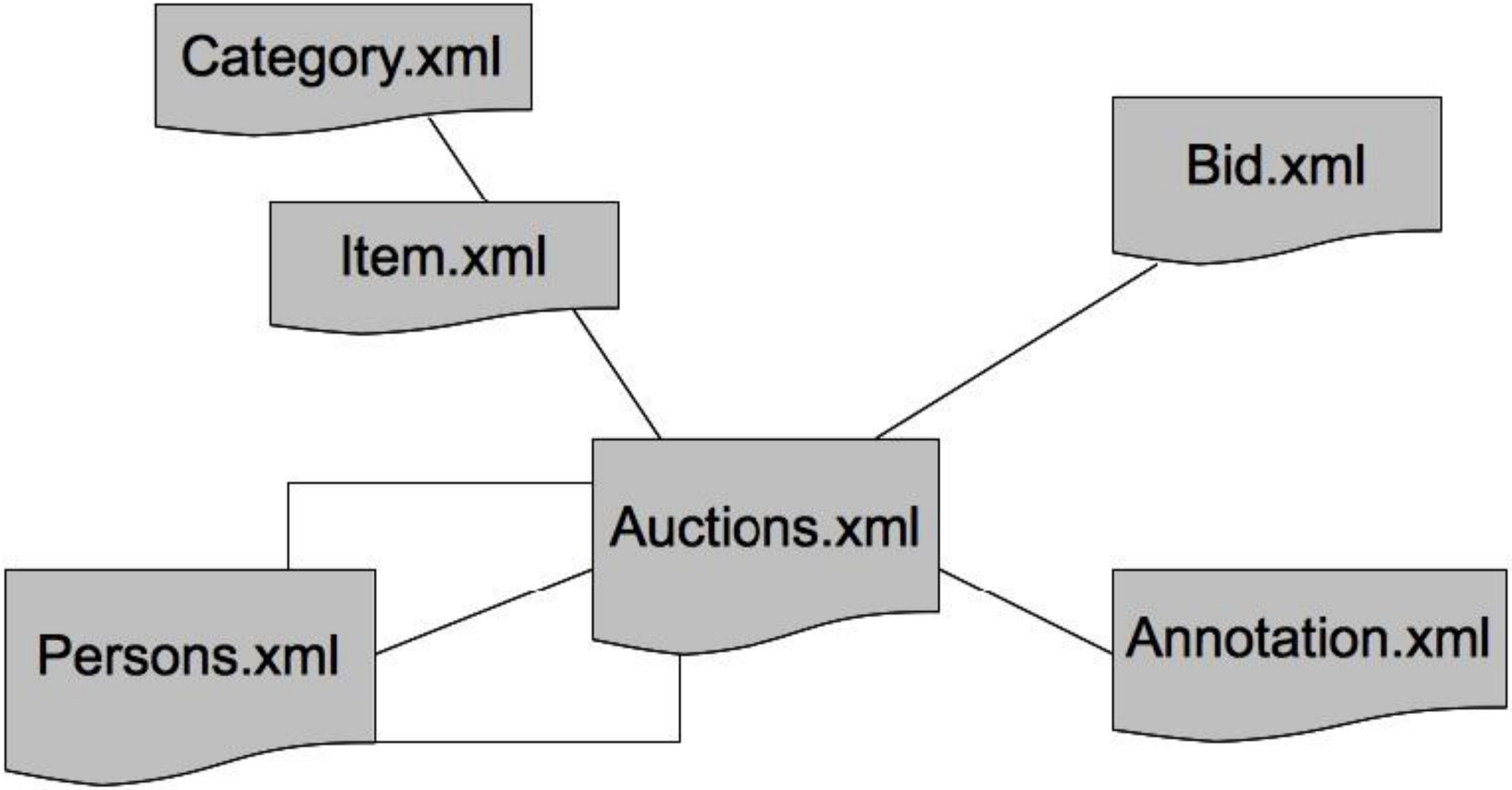
XML cubeModel

- General Cube Schema



XML Cube Model

- Instantiation: Auction cube

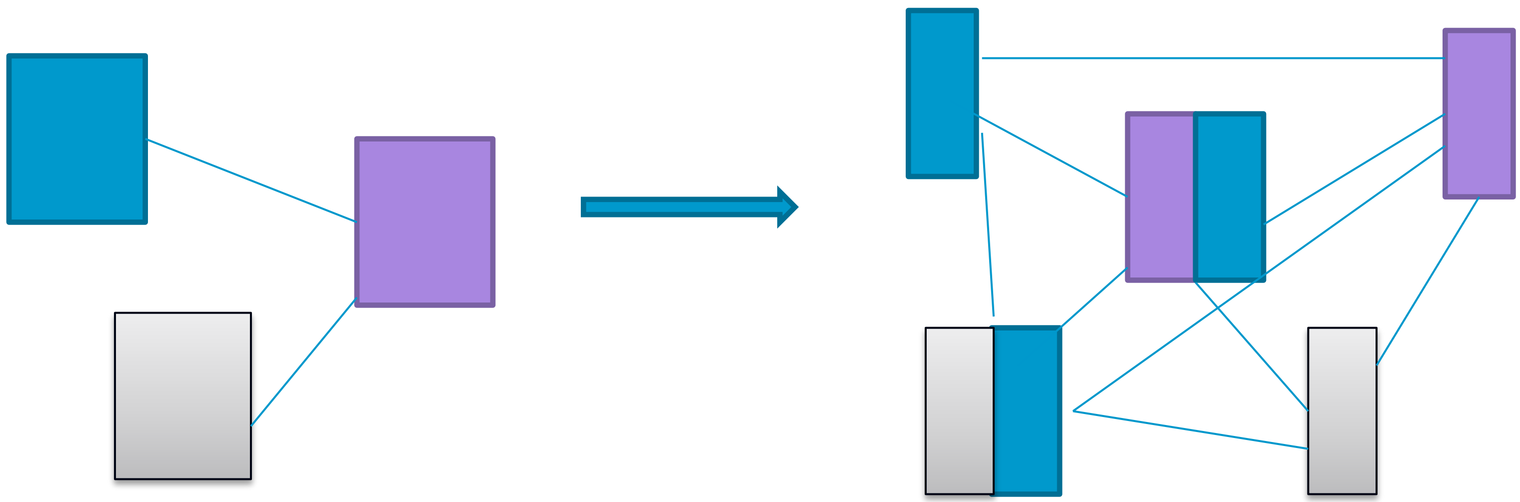


XML Cube Model

- Unfragmented XML cube
  - Basic configuration
  - Fact and each dimension member = one XML document
  - Formally:
    - UXCube = $\{D_i, i=1, \ldots\}$ set of XML documents
    - Di = $\{P^i_j, i=1, \ldots, j=1,\ldots\}$ set of XML properties accessed by XPath

XML Cube Model

- Fragmented XML cube
  - Vertical fragmentation approach for XML Cubes (Dawak'11)
  - Each document of the Cube split into fragments
    - Homogeneous fragments: properties ∈ same original document
    - Heteregenous fragments: properties



Before fragmentation After fragmentation

XML Cube Model

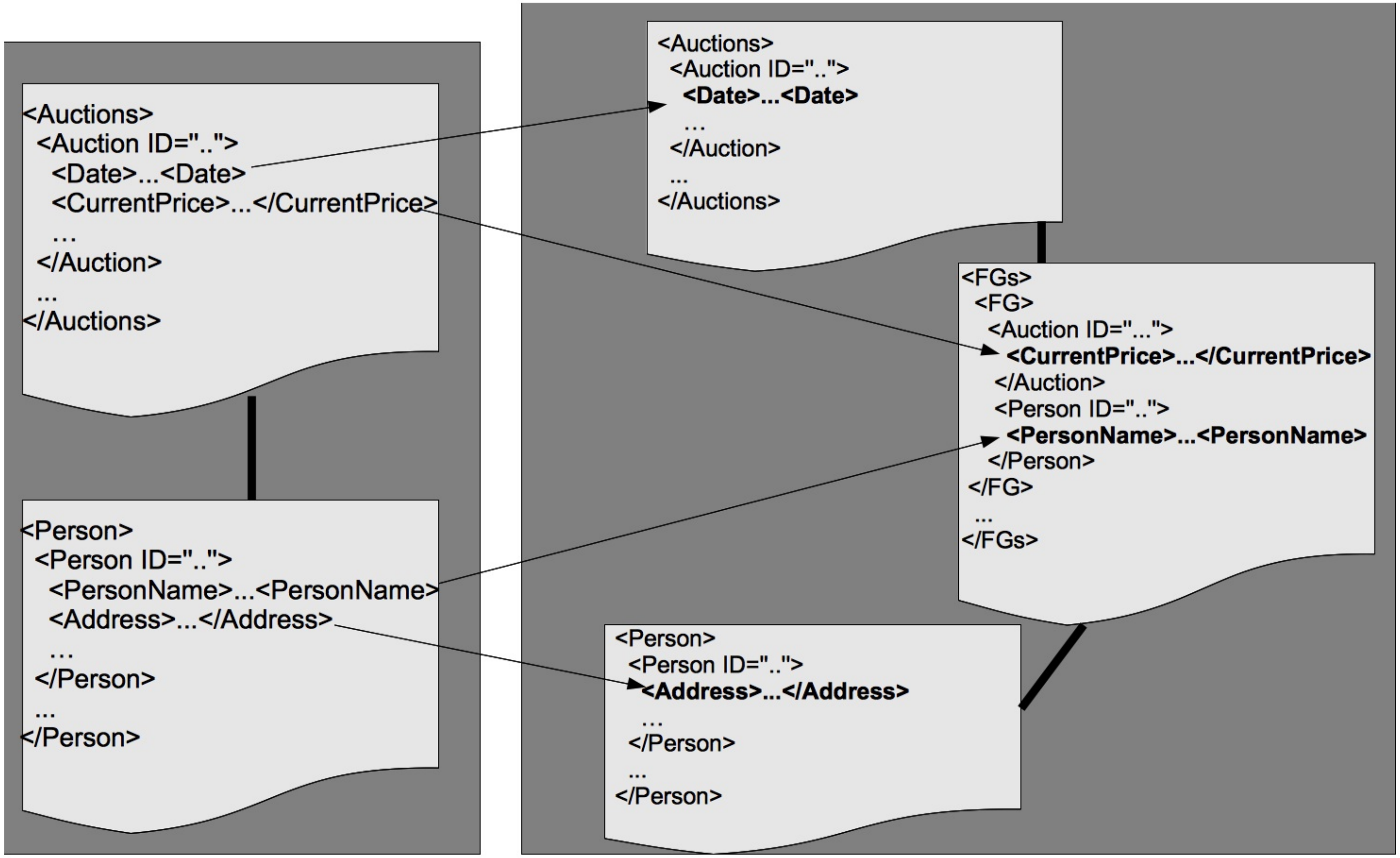
- Fragmented XML cube
  - Frequent Fragment: derived from a frequent property set (Association rules)
  - InFrequent Fragment: properties $\neg\in$ frequent property set

Formally

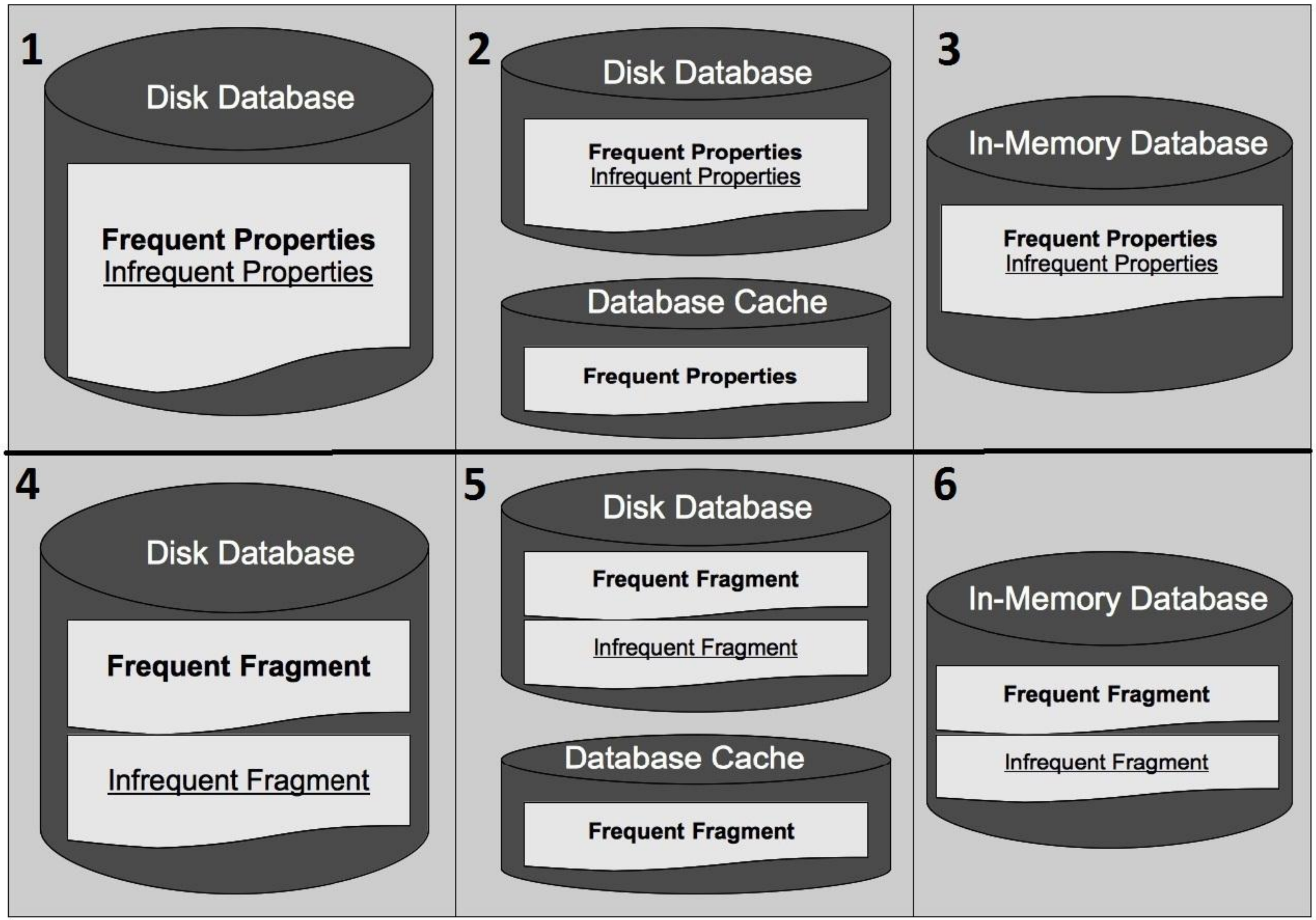
$$FXCube = \{FF_m, m=1, \ldots\} \cup \{IF_n, n=1, \ldots\}$$

XML Cube Model

- Fragmented XML cube: example

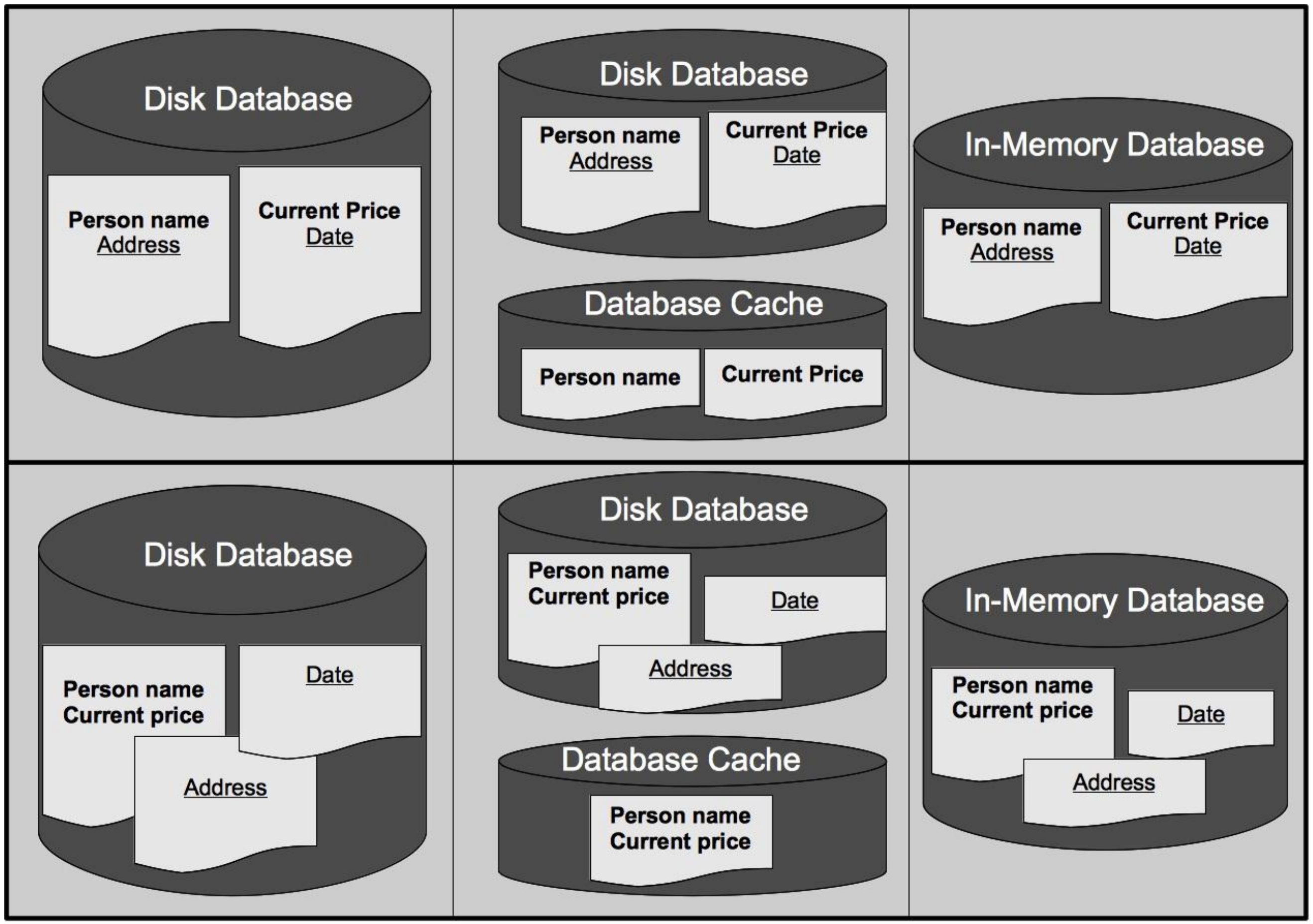


XML Cube Management Configurations



XML Cube Management Configurations

Instantiation: Auction cube configurations

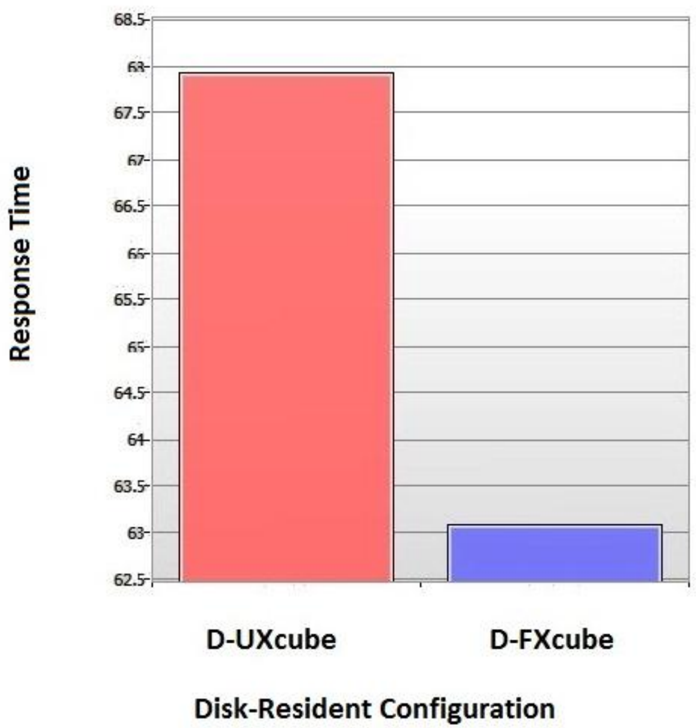


Implementation and Testing

- Disk Resident Database: Oracle 11g Rel. 2
- Database cache and in-Memory database: Oracle TimesTen 11.2.1
- Data Set:
  - XML Cube of auctions: 6 XML document types
  - Fragmented Cube: 28 XML fragment types
- Query load: 100 analytical queries targeting different aggregation levels of UXCube
- Queries rewritten against FXCube

Implementation and Testing

- First measure: average query response times
  - Unfragmented Vs Fragmented XML Cube



Implementation and Testing

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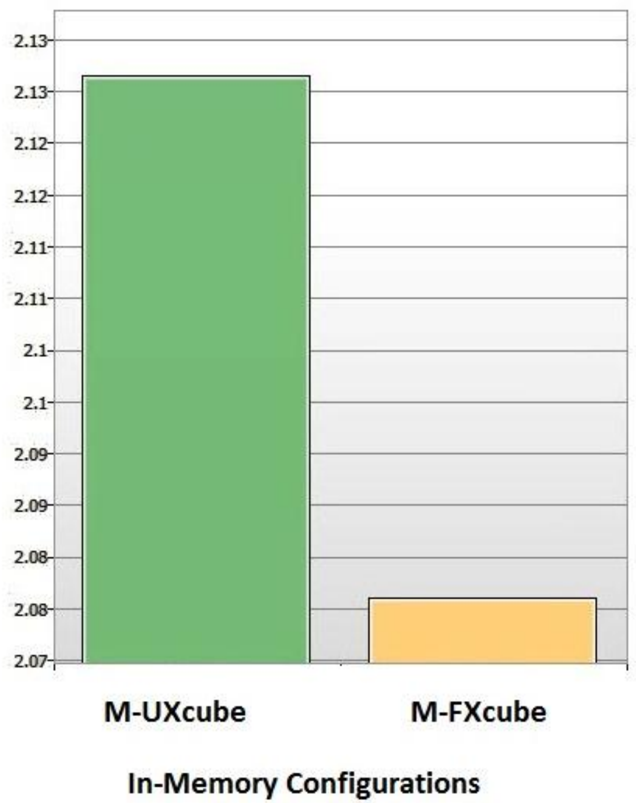

Implementation and Testing

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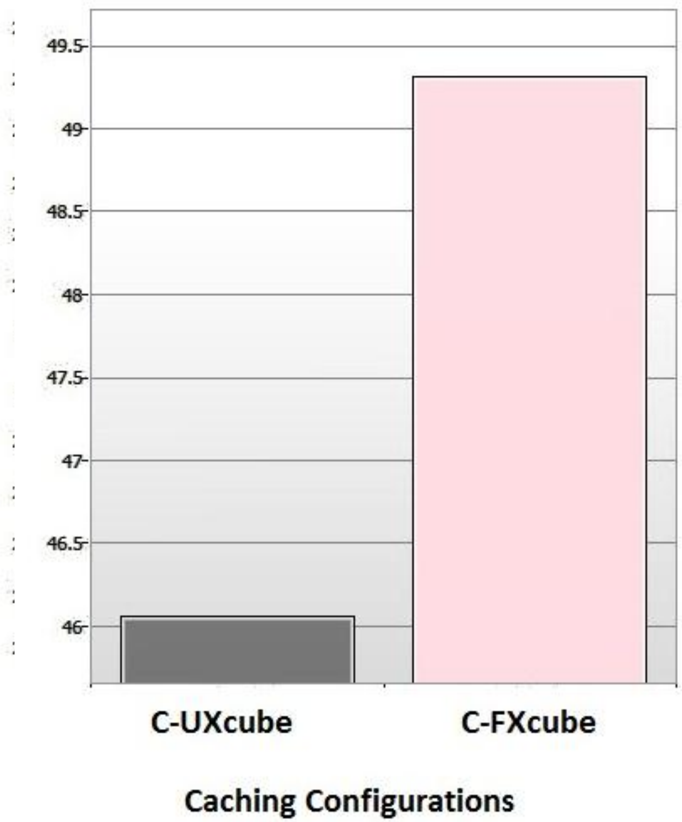
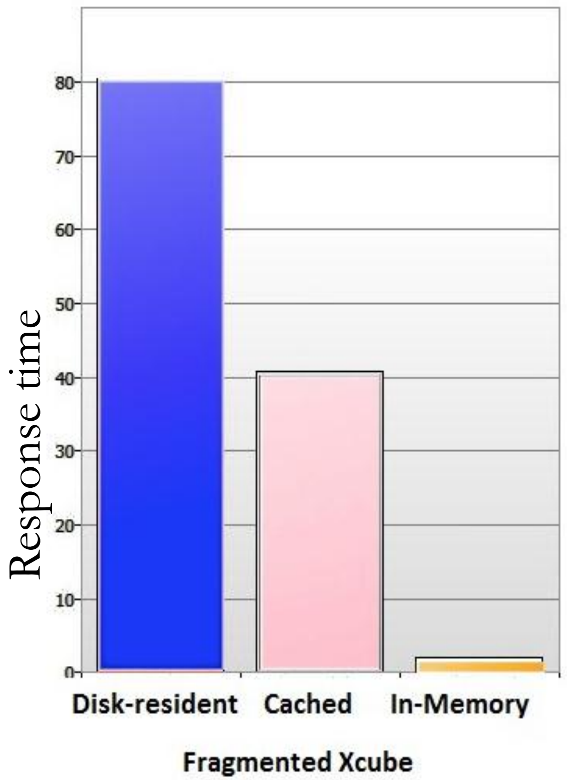


Implementation and Testing

- First measure: average query response times
  - Disk-resident Vs Cached Vs in-Memory XML Cube



Implementation and Testing

- First measure: average query response times
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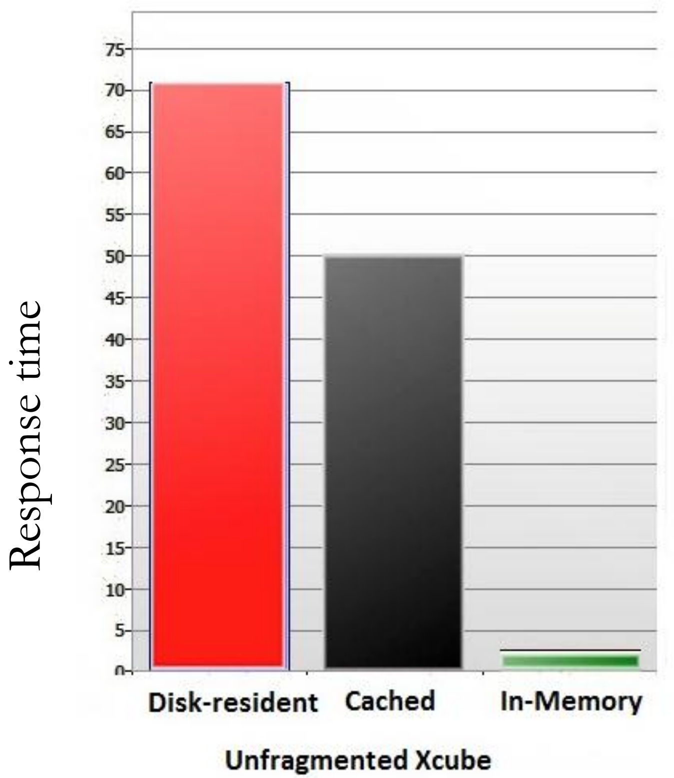
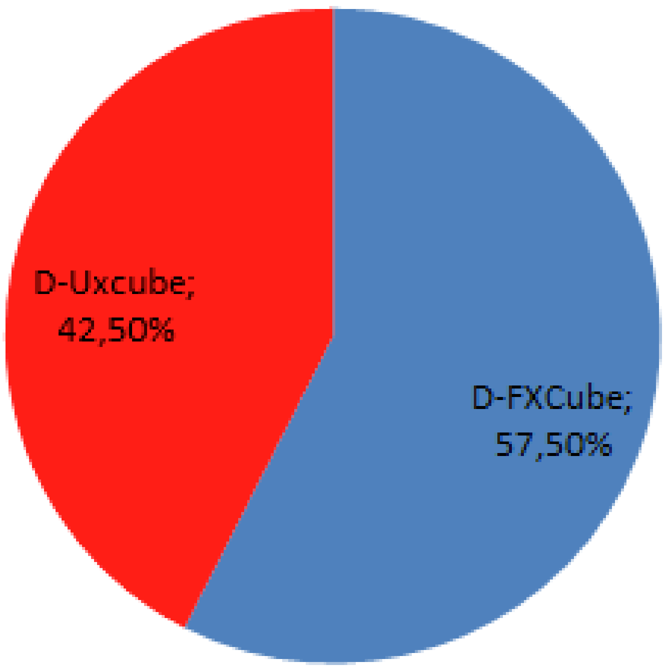


Implementation and Testing

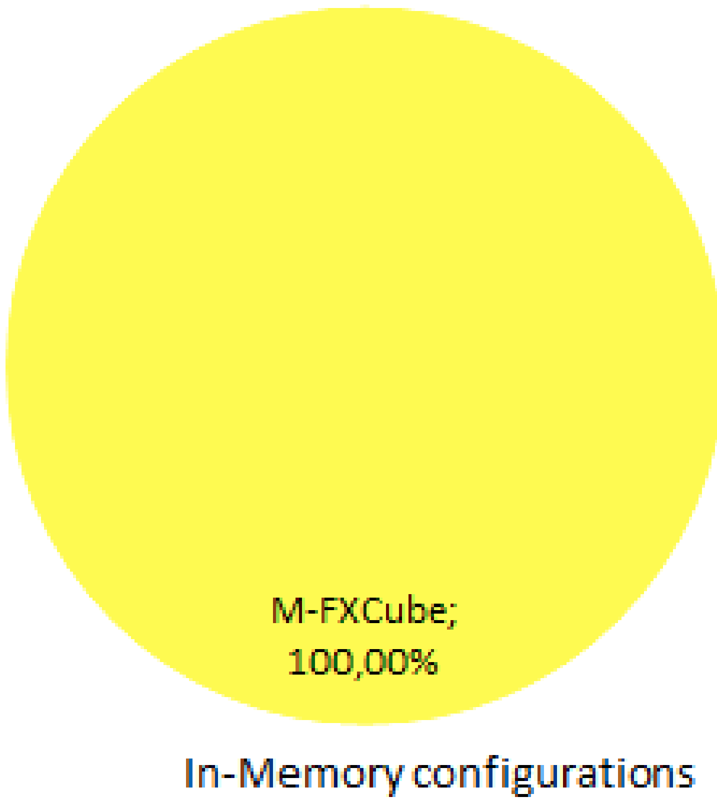
- Second measure: percentage of efficient queries
  - Unfragmented Vs Fragmented XML Cube



Disk resident configurations

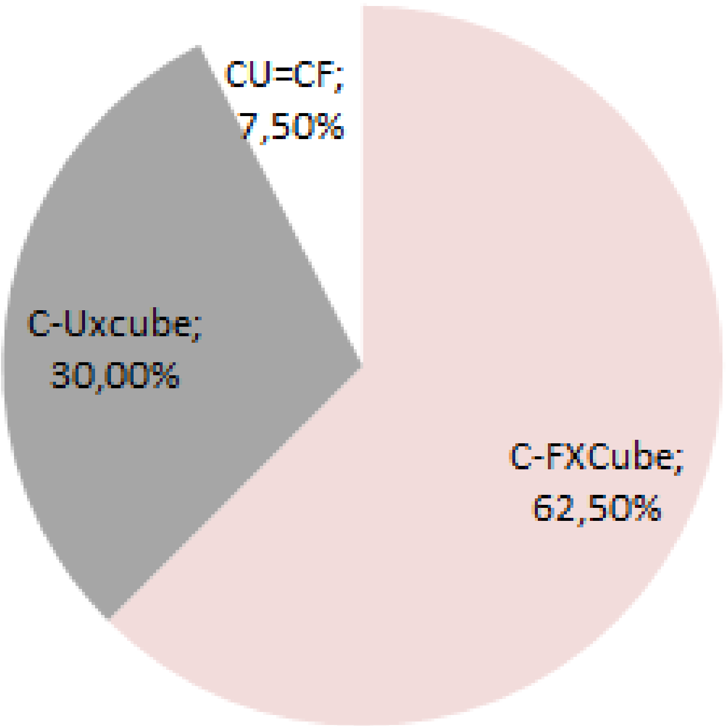
Implementation and Testing

- Second measure: percentage of efficient queries
  - Unfragmented Vs Fragmented XML Cube



Implementation and Testing

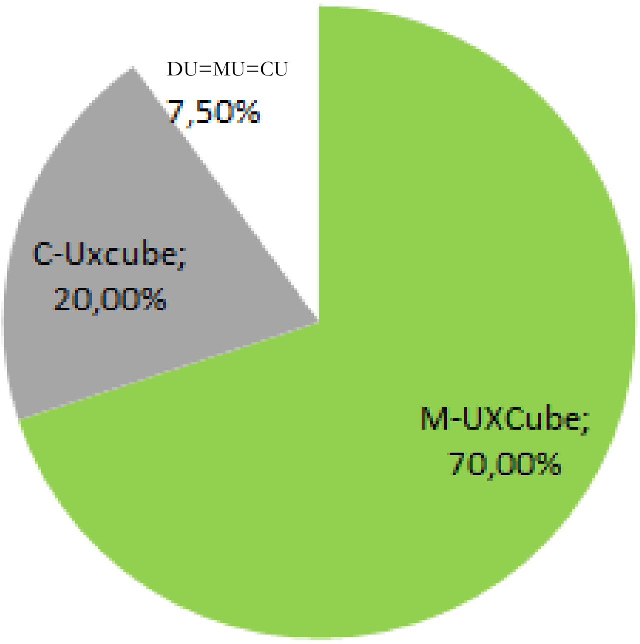
- Second measure: percentage of efficient queries
  - Unfragmented Vs Fragmented XML Cube



Caching configurations

Implementation and Testing

- Second measure: percentage of efficient queries
  - Disk-resident Vs Cached Vs in-Memory XML Cube



Unfragmented Cube

Implementation and Testing

- Second measure: percentage of efficient queries
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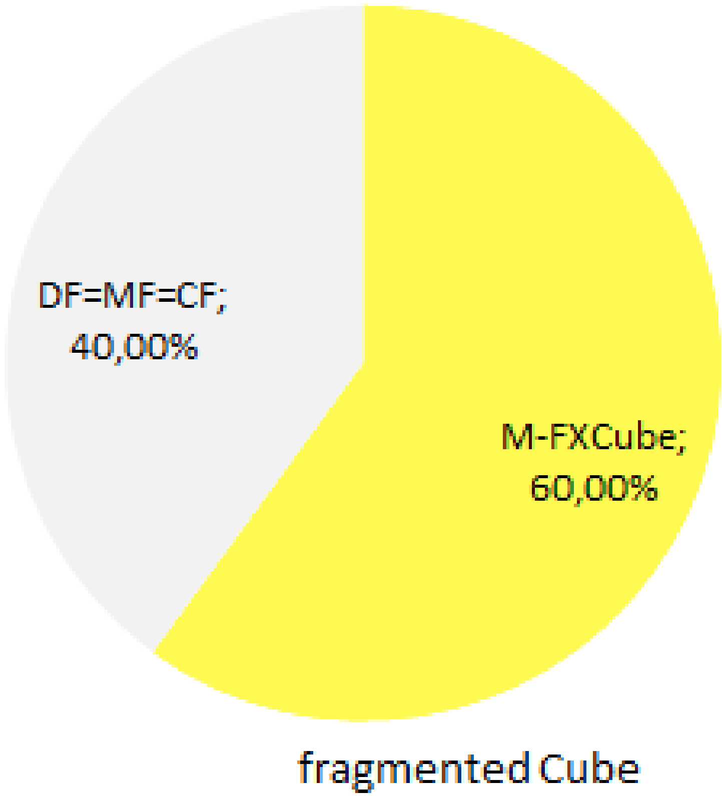

Related Work (1/2)

Category of work	Examples
Database & Web	• Altinel et al (2003): Static and dynamic caching • Manegold et al (2000): Optimizing main memory access • Dar et al. (1996): Semantic caching • Huang and Hsu (2008): Web document caching
Data Warehouses	• Andrade et al. (2007): Optimizing multiple data analysis queries • Deshpande et al. (1998) Cache small regions of a multidimensional space • Lehner et al. (2000): Dynamic caching for multidimensional data • Scheuermann et al. (1996): Caching small sets of query results • Muto & Kitsuregawa (1998) : Main memory for compressed cube management • Ross & Zaman (2000): Cache data cube subset materialization
XML	• Yang et al. (2003): Cache frequent XML patterns • Mandhani & Suciu (2005): Semantic cache of materialized Xpath queries • Obermeier and Bottcher (2008): XML splitting over mobile devices

Related Work (2/2)

- Discussion
  - Our work meets the same motivation of Obermeier and Bottcher (2008) but applied to XML cubes
  - Combination of Vertical fragmentation, main memory data management and caching not tackled before

Conclusion and Perspectives

- Conclusion
  - Crossed two optimization techniques of data warehouses: caching and vertical fragmentation

  - Benefits of fragmentation when the cube is managed in main memory
  - In-memory enhances both fragmented and unfragmented cube
  - Main memory increases the % of efficient queries

Conclusion and Perspectives

- Pespectives
  - Implement our proposals on an ad hoc network
  - Combine horizontal and vertical fragmentation with cache and in-memory management