Session V-A: Domain Specific Accelerators (Tuesday 1:30PM)

SMASH

Co-designing Software Compression and Hardware-Accelerated Indexing for Efficient Sparse Matrix Operations

Konstantinos Kanellopoulos, Nandita Vijaykumar, Christina Giannoula,
Roknoddin Azizi, Skanda Koppula, Nika Mansouri Ghiasi,
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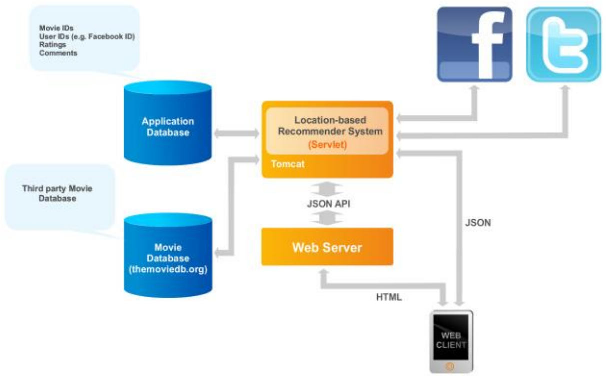
Sparse Matrix Operations are Widespread Today

Recommender Systems


Movie IDs
User IDs (e.g. Facebook ID)
Ratings
Comments
Application Database
Location-based Recommender System
(Servlet)
Tomcat
Third party Movie Database
JSON API
JSON
Movie Database (themoviedb.org)
Web Server
HTML
WEB CLIENT

- Collaborative Filtering

Graph Analytics

- PageRank
- Breadth-First Search
- Betweenness Centrality

Neural Networks

- Graph Neural Networks
- Sparse Deep Neural Networks

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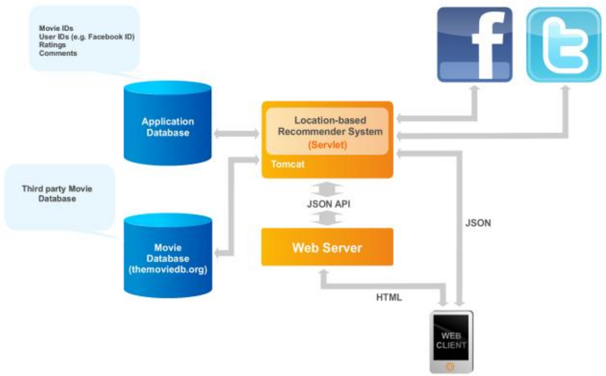
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Sparse matrix compression is essential to enable efficient storage and computation

Limitations of Existing Compression Formats

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❶

General formats optimize for storage → **Expensive discovery of the positions of non-zero elements**

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Specialized formats assume specific matrix structures and patterns (e.g., diagonals) → **Narrow applicability**

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Hardware/Software cooperative mechanism:

- Enables **highly-efficient** sparse matrix compression and computation
- **General** across a diverse set of sparse matrices and sparse matrix operations

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Efficient compression using a Hierarchy of Bitmaps

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Unit that scans bitmaps to accelerate indexing

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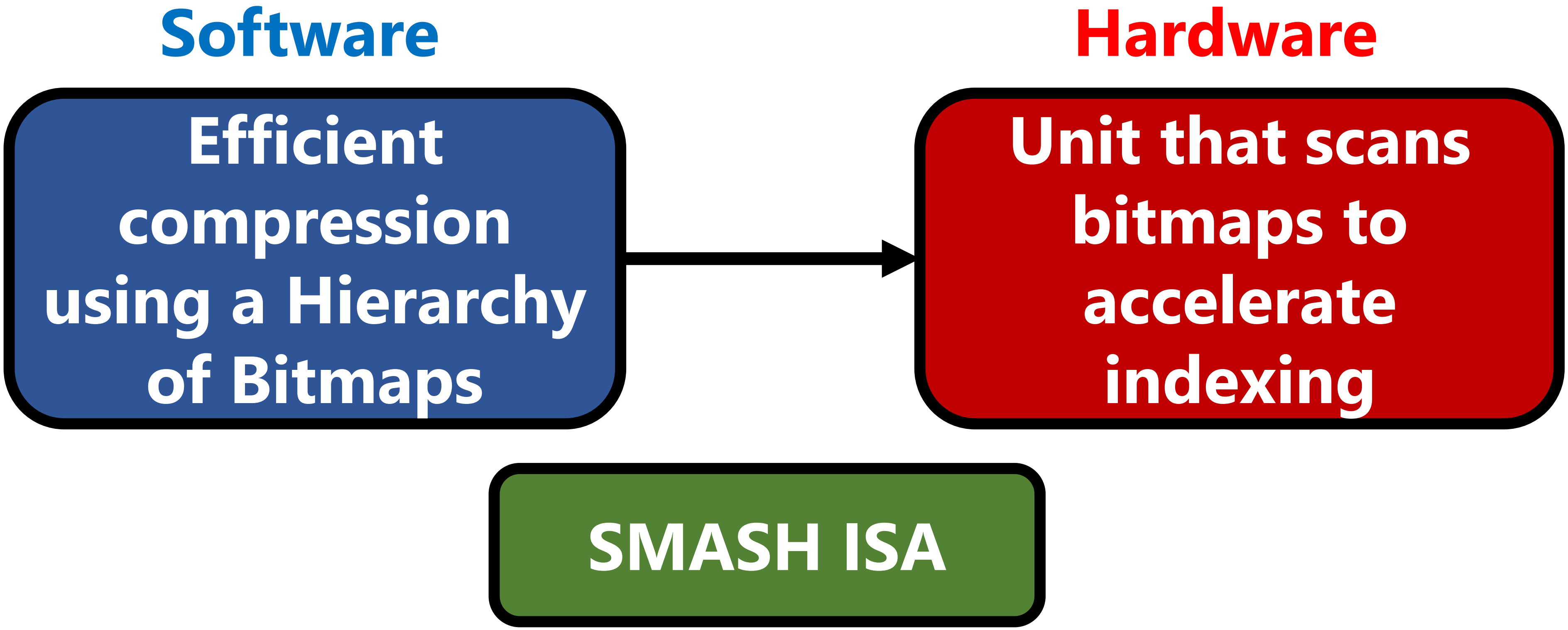

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Key Results

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- 38% and 44% speedup for SpMV and SpMM

Hardware Overhead

- 0.076% area overhead over an Intel Xeon CPU

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