**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,
Taha Shahroodi, Juan Gomez Luna, Onur Mutlu

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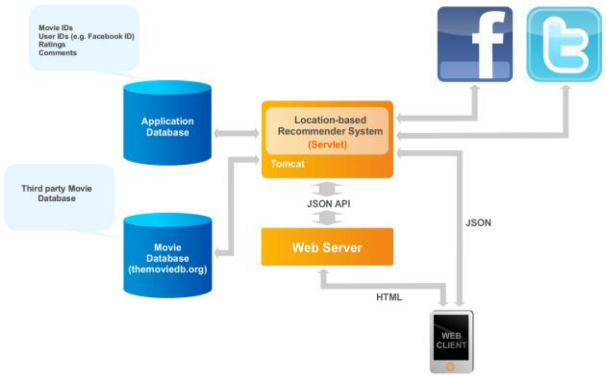
Carnegie Mellon University

# Sparse Matrix Operations are Widespread Today

### *Recommender Systems*


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

- Collaborative Filtering

### *Graph Analytics*

- PageRank
- Breadth-First Search
- Betweenness Centrality

### *Neural Networks*

- Graph Neural Networks
- Sparse Deep Neural Networks

**Sparse matrix compression is essential to enable efficient storage and computation**

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# Limitations of Existing Compression Formats

❶

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

❷

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

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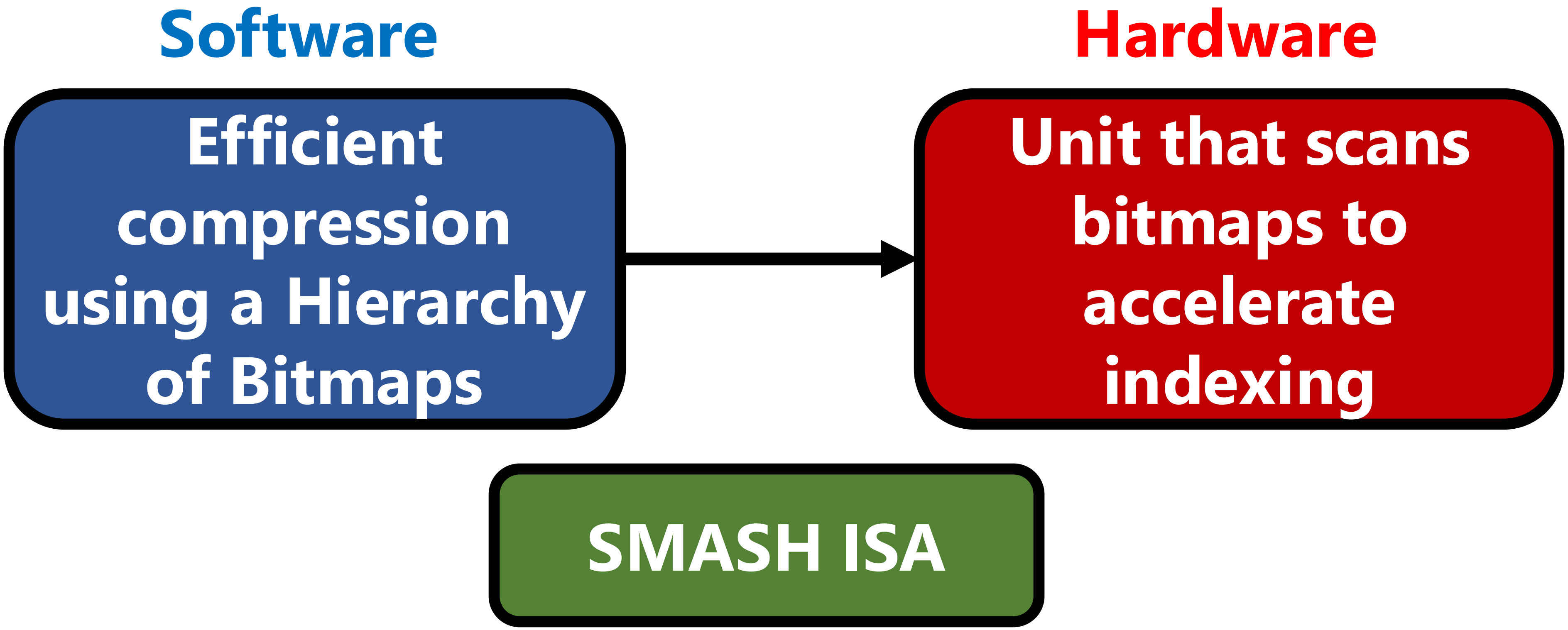
**Hardware/Software cooperative mechanism:**

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



Software

Efficient compression using a Hierarchy of Bitmaps

Hardware

Unit that scans bitmaps to accelerate indexing

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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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