Database Forensic Analysis Through Internal Structure Carving

By

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Database Forensic Analysis through Internal Structure Carving

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Roadmap

- Motivation
  - File carving (for databases)
  - Stochastic analysis
- Results
- Future work

Motivation

- A lot of data lives in databases
- Recovery
  - Rely on “safe” storage (or backups)
  - Inconsistent / commercial
- Monitoring
  - Logs and profiling
  - Inspect DB connections
    - e.g., IBM Guardium

Database Storage

Table Rows

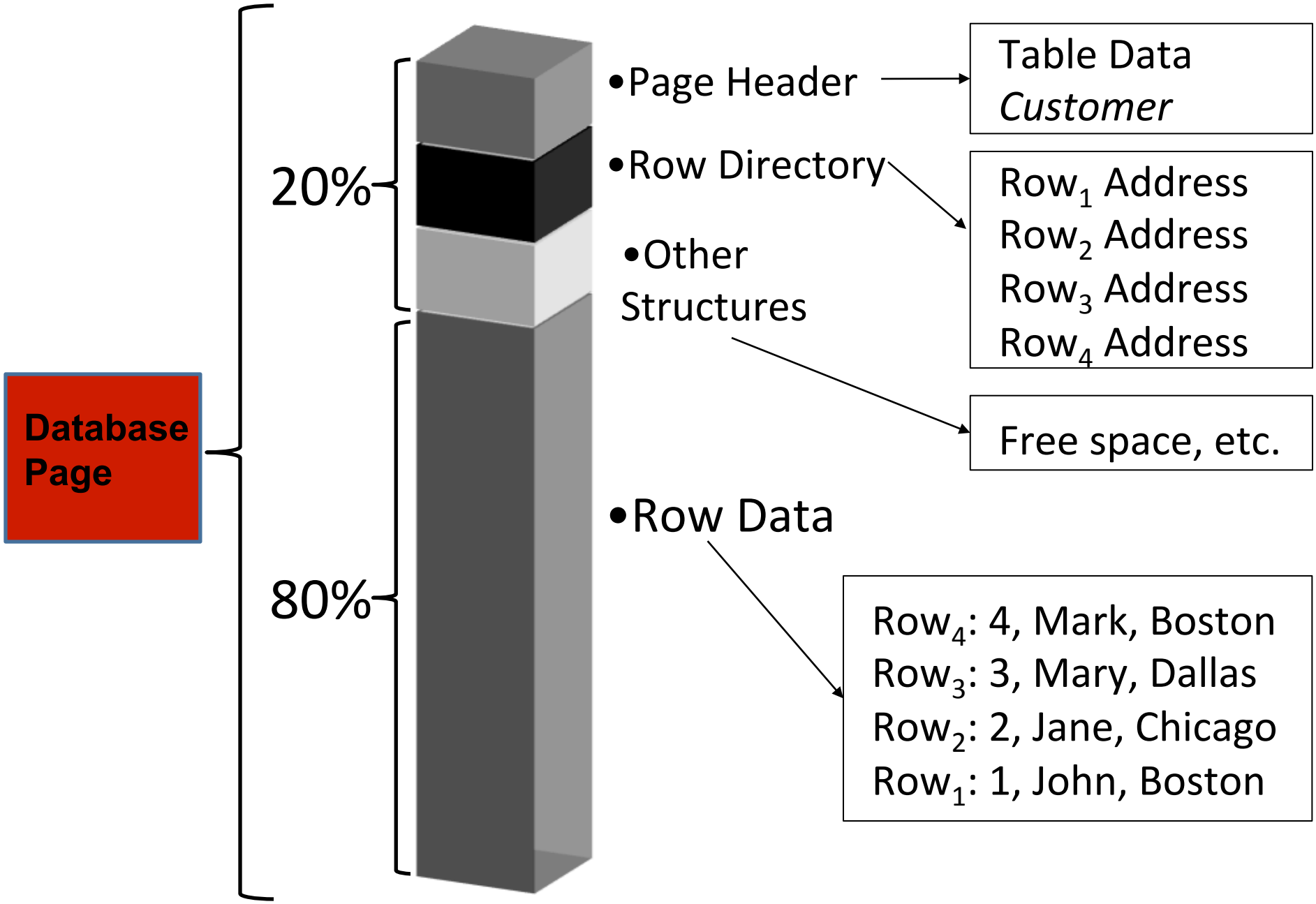
RID	Name	Position	FavoriteTown
1	Stan	Professor	Westwood
2	Ugur	Professor	Providence
3	Tom	Professor	Providence
4	Alex	Student	Providence
5	Stan	Professor	Cambridge
6	Andy	Student	Providence

Logical

Physical

Disk Pages

#1	1	Stan	Professor	Westwood
	2	Ugur	Professor	Providence
#2	3	Tom	Professor	Providence
	4	Alex	Student	Providence
#3	5	Stan	Professor	Cambridge
	6	Andy	Student	Providence


Database Page
20%
80%
•Page Header
•Row Directory
•Other Structures
•Row Data
Table Data
Customer
Row_1 Address
Row_2 Address
Row_3 Address
Row_4 Address
Free space, etc.
Row_4: 4, Mark, Boston
Row_3: 3, Mary, Dallas
Row_2: 2, Jane, Chicago
Row_1: 1, John, Boston

Indexes and other Structures

Index on Favorite Town

Cambridge	5
Providence	2
Providence	3
Providence	4
Providence	6
Westwood	1

RID	Name	Position	FavoriteTown
1	Stan	Professor	Westwood
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4	Alex	Student	Providence
5	Stan	Professor	Cambridge
6	Andy	Student	Providence

MV

Logical

Physical

#1	Cambridge	5	Providence
	2	Providence	3

#2	Providence	4	Providence
	6	Westwood	1

#1	1	Stan	Professor	Westwood
	2	Ugur	Professor	Providence

#2	3	Tom	Professor	Providence
	4	Alex	Student	Providence

#3	5	Stan	Professor	Cambridge
	6	Andy	Student	Providence

#1

#2

#3

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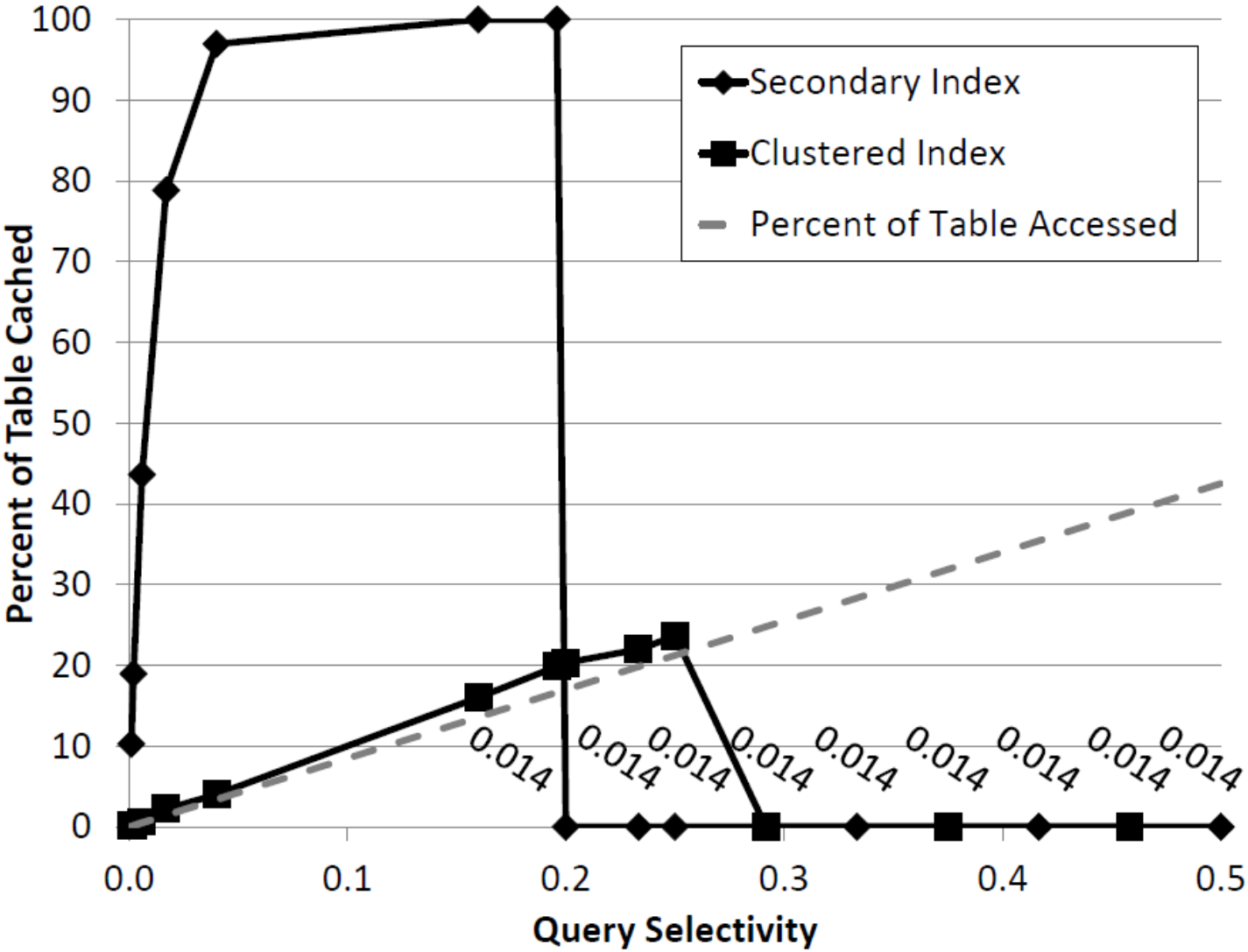
Database Caching Policies



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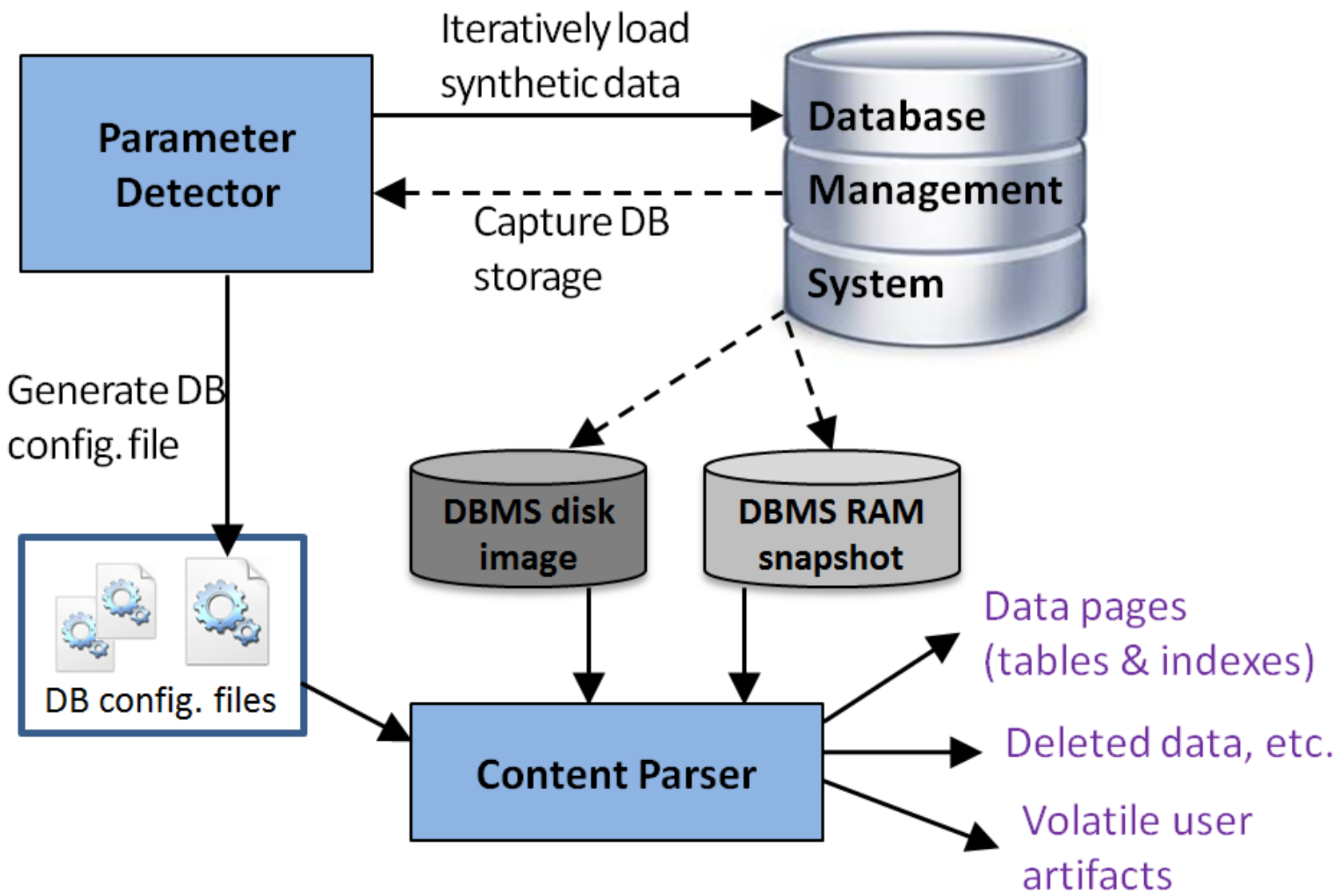
Architecture



<table>
<tr><th></th><th>Oracle</th><th>PostgreSQL</th><th>SQLite</th><th>Firebird</th><th>DB2</th><th>SQLServer</th><th>MySQL</th><th>Apache Derby</th></tr>
<tr><td>Structure Identifier</td><td>Yes</td><td>No</td><td colspan="5">Yes</td><td>No</td></tr>
<tr><td>Unique Page ID</td><td colspan="7">Yes</td><td>No</td></tr>
<tr><td>Row Dir. Sequence</td><td colspan="4">Top-to-bottom insertion</td><td colspan="4">Bottom-to-top insertion</td></tr>
<tr><td>Row Identifier</td><td>No</td><td colspan="2">Yes</td><td colspan="3">No</td><td colspan="2">Yes</td></tr>
<tr><td>Column Count</td><td colspan="3">Yes</td><td colspan="2">No</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Column Sizes</td><td colspan="4">Yes</td><td colspan="2">No</td><td colspan="2">Yes</td></tr>
<tr><td>Column Directory</td><td colspan="4">No</td><td colspan="2">Yes</td><td colspan="2">No</td></tr>
<tr><td>Numbers w/Strings</td><td colspan="4">Yes</td><td colspan="2">No</td><td colspan="2">Yes</td></tr>
</table>

DBMS Versions

Hard to get some older DB versions

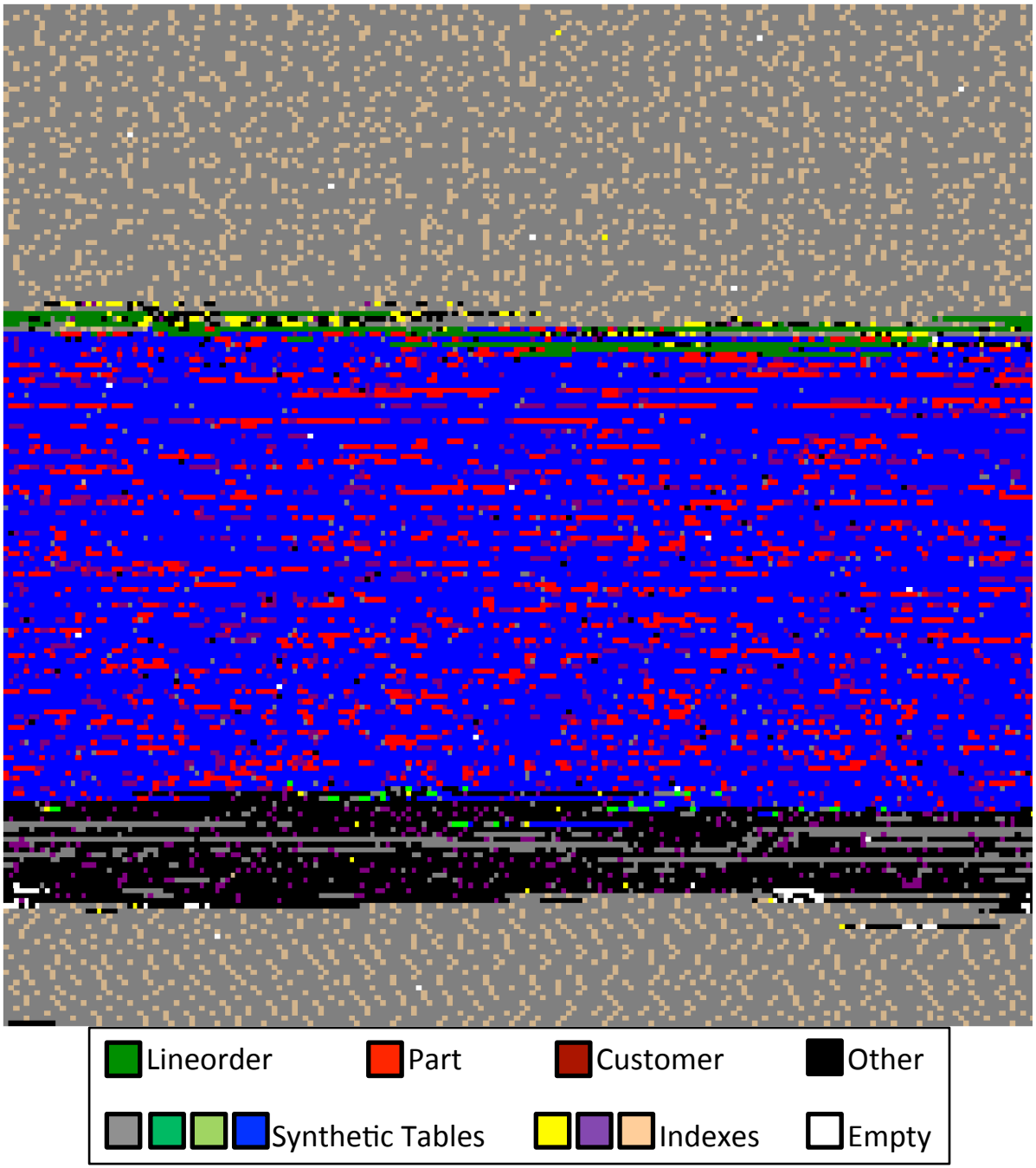
Different parameters

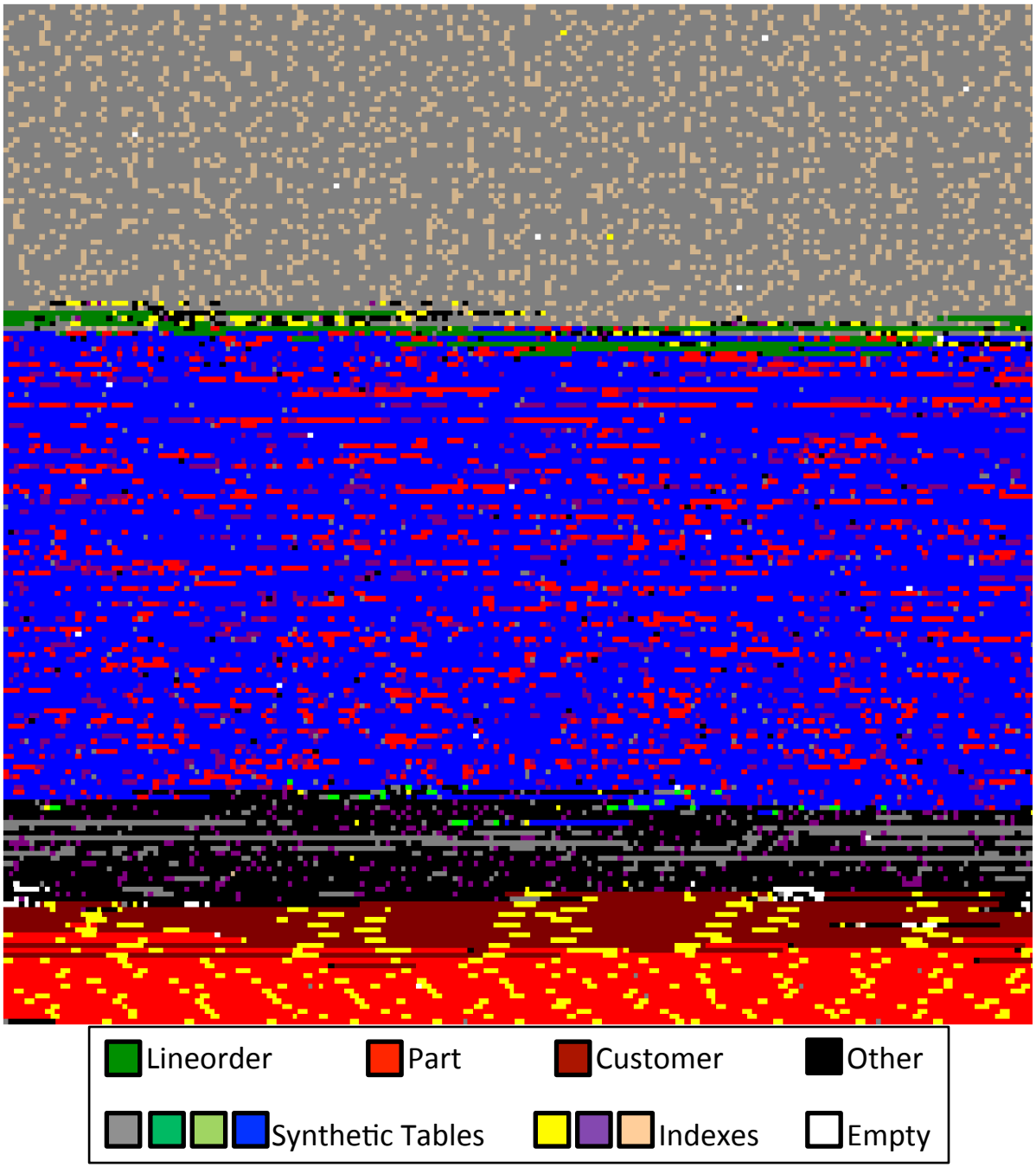
DBMS Version	Testing OS	Buffer Size(MB)	Page Size(KB)
Apache Derby 10.10	Linux	400	4
Apache Derby 10.5	Linux	400	4
DB2 Express-C 10.5	Linux	400	4
Firebird 2.5.1	Linux	400	8
Firebird 2.1.7	Windows	400	8
MySQL Server 5.1.73	Linux	800	16
MySQL Server 5.6.1	Windows	800	16
Oracle 11g R2	Windows	800	8
Oracle 12c R1	Windows	1200	8
PostgreSQL 7.3	Linux	400	8
PostgreSQL 8.4	Linux	400	8
PostgreSQL 9.3	Windows	800	8
SQLite 3.8.6	Linux	2	1
SQLite 3.8.7	Windows	2	1
SQLServer 2008 Enterprise	Windows (~~Linux~~)	800	8

Recovering Corrupted Data

- An AWS instance + PostgreSQL
  1. Load SSBM benchmark data
  2. Delete the rows, then **delete all Postgres files**

	Damage = 0%	Damage = 10%	Damage = 25%
Dwdate	**35** (100%)	**31** (88.6%)	**20** (57.1%)
Supplier	**565** (100%)	**455** (80.5%)	**326** (57.7%)
Customer	**1915** (100%)	**1559** (81.4%)	**1075** (56.1%)
Part	**8659** (100%)	**6969** (80.5%)	**4864** (56.2%)
Lineorder	**115 K** (100%)	**104 K** (89.9%)	**87 K** (75.2%)
TOTAL	**416 K** (100%)	**375 K** (89.9%)	**312 K** (74.9%)


Lineorder
Part
Customer
Other
Synthetic Tables
Indexes
Empty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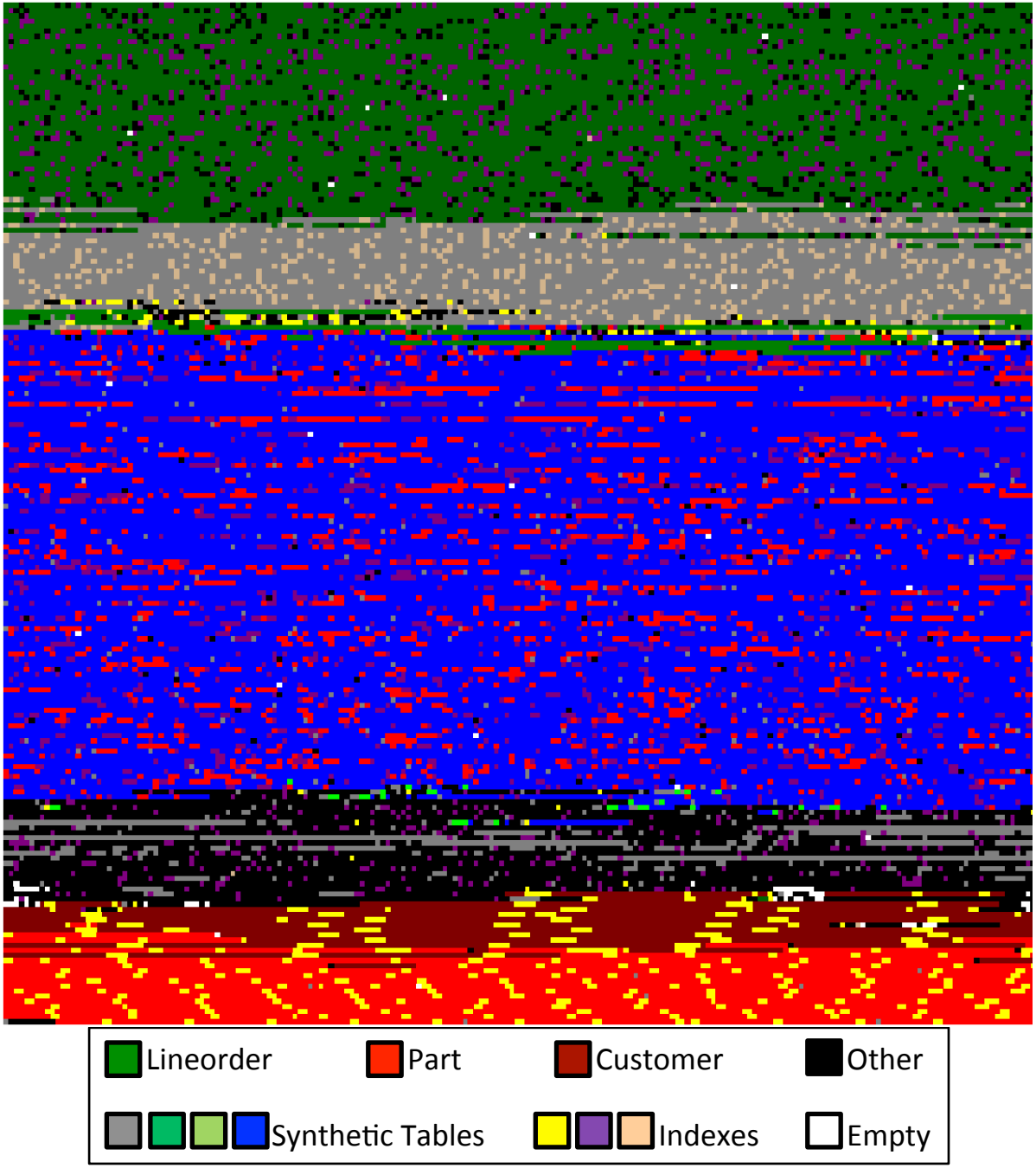
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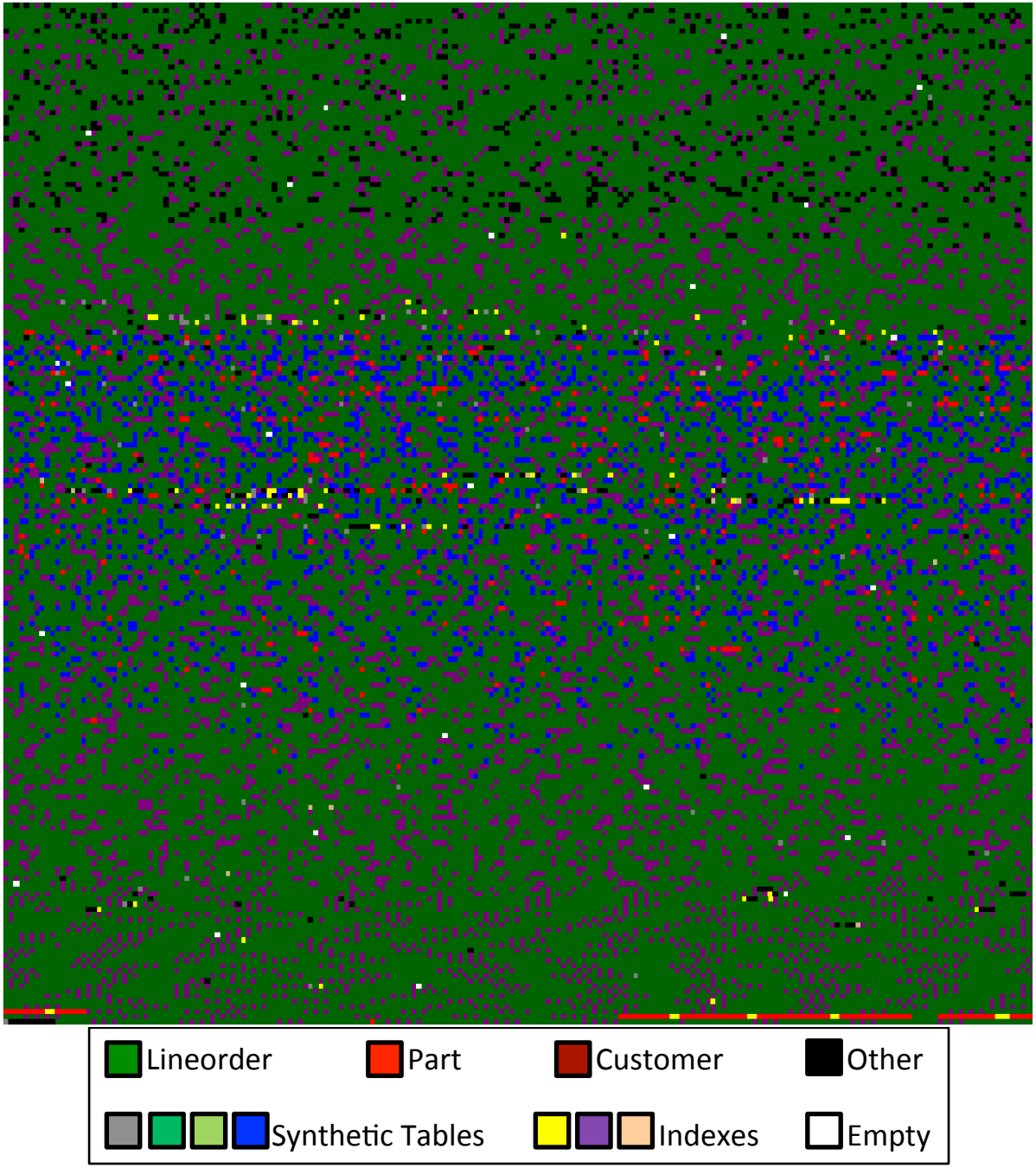
Lineorder
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Synthetic Tables
Indexes
Empty

Data Modification

- DELETE/UPDATE/INSERT
- When is a value **really** deleted?
- Example
  - Customer table (Phone# column)
  - Indexed Phone#

Row Deletion

Event	Table		Index	
	HDD	RAM	HDD	RAM
$Time_0$	☎		✓	
Delete a Phone #	✓	✗	✓	✓
Run a few of queries	✓	✗	✓	
Many more queries	✗		✓	
Rebuild the index	✗			
Rebuild the table				

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Future Work

- Column-stores and Key-value stores
- Automated database deconstruction
- Database performance tuning
- Monitoring user behavior (DB cache)
- Independent database audit/verification


time for questions