Session #03

Carnegie Mellon University

*Special Topics:*

# Self-Driving Database Management Systems

## Index Recommendation I

@Deepayan_Patra // 15-799 // Spring 2022

# TODAY'S AGENDA

Overview of AutoAdmin
Architecture Deep Dive
Summary Analysis
Reflection

# PHYSICAL DESIGN

| ID | name | animal | ... | net_worth |
|---|---|---|---|---|
| 0 | Terrier | Dog | … | $800 |
| 1 | Scout | Dog | … | $800 |
| … | … | … | … | |
| N | Kapi | Capybara | … | $1000 |

```
SELECT * FROM animals WHERE net_worth = $1000 LIMIT 1 -> O(N) to O(1)

SELECT * FROM animals WHERE animal = dog -> O(N) to O(LOG N)

SELECT name FROM animals ORDER BY name, animal LIMIT 100 -> O(N LOG N) to
O(1)
```

# PRIOR WORK

## State of the Art in 1997:

→ Stonebraker suggested views could simulate databases[0]

→ Index evaluation had a few approaches:

- Approaches based on query semantics and table statistics[1]
- Expert systems using rules for decision-making[2]
- Using internal components to compare different designs[3]

# AUTOADMIN

The first version of AutoAdmin was the precursor to modern autonomous database tuning tools.

→ Implemented a hypothetical action framework that considered system overhead

→ Implemented a tuner that interfaced directly with DBMS internals

→ First tuner in DBMS industry

# HYPOTHETICAL CONFIGURATION SIMULATION

1. **How can we estimate costs without executing queries?**

The optimizer is the actual component of the system which chooses query execution. We can rely on its internal costing mechanism.

2. **How do we create a hypothetical configuration?**

The simplest way would be to literally change the configuration to the hypothetical. This is costly/inefficient.

What we really need is what the optimizer will use from the index. Densities and histograms.

# OPTIMIZER ESTIMATES

SQL Server allows optimization of queries without executing them.

Using this mode and retrieving the query plan allows the system to determine the cost of a query.

**Using the optimizer in this fashion ensures costing is consistent with actual execution.**

# CREATING HYPOTHETICAL INDICES

In order to generate the index, the system samples pages of the dataset until convergence (or a specified fraction) and creates density estimates and histograms.

**5% sampling has < 4% error on query cost.**

Other details:

→ Can't put indexes in catalog
→ Handle in connection-specific manner
→ Allow rescaling

# HYPOTHETICAL CONFIGURATION SIMULATION

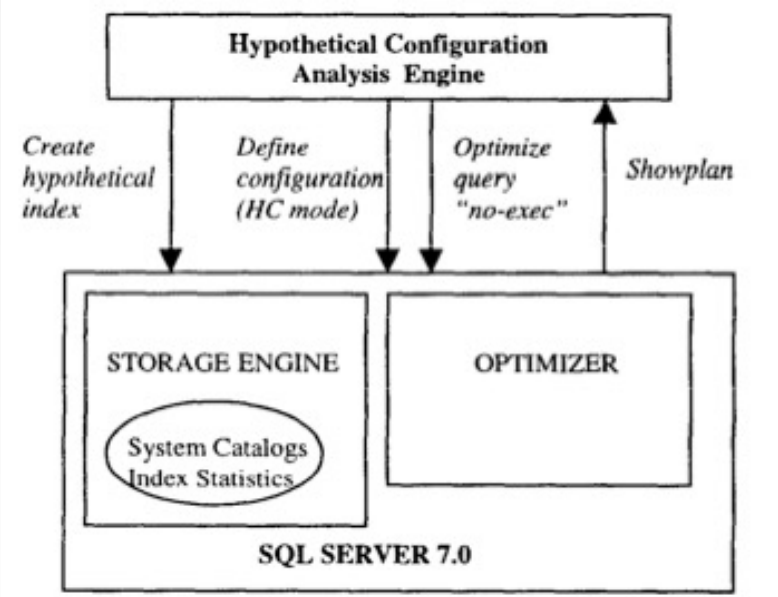



**Figure 2. Interfaces between HCA Engine and SQL Server**

# AUTOADMIN APIS

→ Hypothetical Configuration Simulation

```
DEFINE WORKLOAD <workload-name>
  [FROM <file> | AS (Q_1,f_1),...,(Q_n,f_n)]

DEFINE CONFIGURATION <configuration-name>
  AS (Table_1, column_list_1),..,(Table_i, column_list_i)

SET DATABASE SIZE OF <configuration-name>
  AS (Table_1, row_count_1) ,..., (Table_i, row_count_i)

ESTIMATE CONFIGURATION OF <workload-name>
  FOR <configuration-name>

REMOVE [WORKLOAD <workload_name> |
  CONFIGURATION <configuration_name> |
  COST-USAGE <configuration_name>]
```

# SUMMARY ANALYSIS

Instead of exposing the analysis data as part of the system catalog, they try to encapsulate what analysis might look like. They arrive at the following categories:

→ Workload Analysis

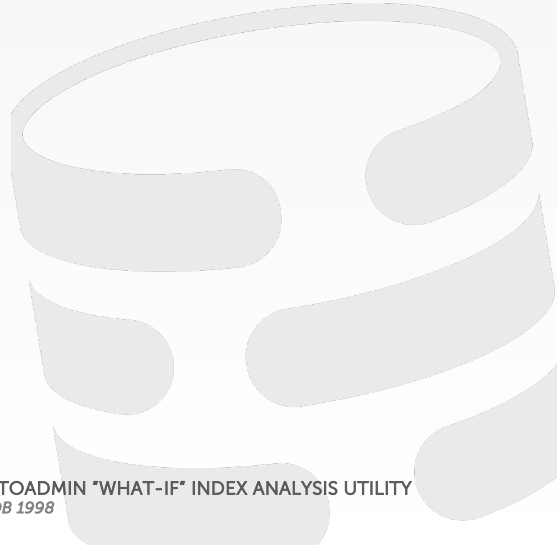
→ Configuration Analysis

→ Cost and Index Usage Analysis

# SUMMARY ANALYSIS API

→ Summary Analysis

```
ANALYZE [WORKLOAD | CONFIGURATION | COST-USAGE]
  WITH <parameter-list>
  [TOP <number> |
   SUMMARIZE USING <aggregation-function>]
  BY <measure>
  WHERE <filter-expression>
  [PARTITION BY <partition-parameter>
     IN <number> STEPS]
```





AUTOADMIN "WHAT-IF" INDEX ANALYSIS UTILITY
*VLDB 1998*

# AUTOADMIN INDEX SELECTION

AutoAdmin was introduced to SQL Server with an index selection tool, introduced first in VLDB 1997. This paper improved:

- → Pruning the input candidate index set based on the configuration for individual queries in a workload
- → Enumerating configurations through a "seed" micro exhaustive enumeration, followed by a greedy search for improvements
- → A multi-column index search framework that iteratively grows the search space



AN EFFICIENT, COST-DRIVEN INDEX SELECTION TOOL FOR MICROSOFT SQL SERVER
*VLDB 1997*

# 10 YEAR REFLECTION

A decade after this paper was released, it won VLDB 10-year Best Paper.

SQL Server continued to improve the tool.

→ Added new physical design structures (materialized views and partitioning)

→ Replacement of multi-column index generation procedure and introducing index merging

→ Multi-dimensional self-tuning histograms

→ Adding an alerting mechanism and online tuning

→ (Many more)

SELF-TUNING DATABASE SYSTEMS: A DECADE OF PROGRESS
*VLDB 2007*

# 10 YEAR REFLECTION

The authors of this paper also share a reflection. The ten years since their original publication inspired a lot of work across the database industry and academia. That said, they acknowledge that achieving true self-tuning will still be a long road.

Nevertheless, they are optimistic on:

- → Defining physical design structures in a more lightweight fashion
- → Looking into ways to compare automated solutions in a meaningful way
- → Applying machine learning for self-tuning tasks
- → Innovative ground-up database architectures that manage complexity in favor of configurability

# PARTING THOUGHTS

This tool is by no means "autonomous," it falls under the "assistant" classification of automatic tools.

Huge factors aren't considered – the cost of creating an index is large and the statistics collected are tied to a workload.

Capabilities of this tool are limited at best.

# PARTING THOUGHTS

Rome wasn't built in a day.

What does this paper provide?

→ What-if -> HypoPG

→ Implementing *inside* the database instead of using an external tool

# NEXT CLASS

Index Recommendation II

# REFERENCES

[0] Stonebraker M., Hypothetical Data Bases as Views. Proceedings of ACM SIGMOD 1981.

[1] Peter C., Gurry M., “ORACLE Performance Tuning”, O’Reilly & Associates, Inc. 1993

[2] Hobbs L., England K., “RdbNMS A Comprehensive Guide”, Digital Press, 1991.

[3] Finkelstein S, Schkolnick M, Tiberio P.“Physical Database Design for Relational Databases”, ACM TODS, Mar 1988.