databricks

Session memory footprint

Ways to reduce the memory footprint of connections

Matthias van de Meent
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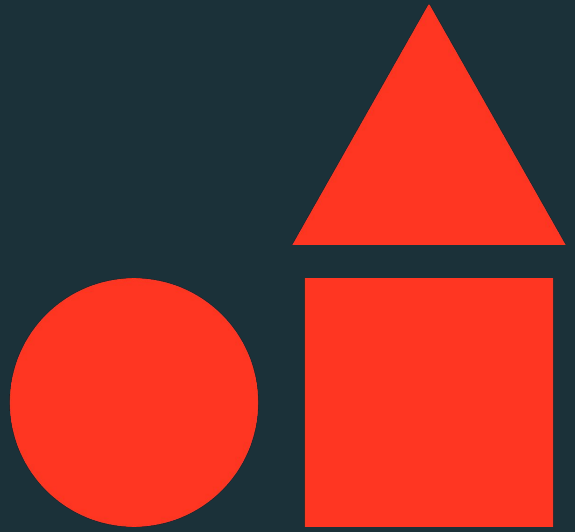

About me

Matthias van de Meent

Professional path

2017-'21: Cofano

FE → Full stack → Infra/DBA

2021-'25: Neon

PG hacker & software engineer

2025-now: Databricks

PG hacker & software engineer

PostgreSQL hacker of 5 years, mostly performance oriented

- Help out parallel index creation (BRIN, GIN)
- Heap page savings
- COPY progress reporting
- ANALYZE (SERIALIZE) option
- etc.

Agenda

Today

Relcache

- Contents
- Optimizations
- Deduplications

Memory context optimizations

Not today

Planner/executor memory usage

Shared memory (pgconf.dev 2025)

- Shared buffers, lock tables, etc.

On-disk data (pgconf.dev 2024)

- Layouts of pages, catalog tuples, etc.

Relcache contents

- Primary entrypoint for retrieving relation data
  - tables, views, indexes, etc.
- Various allocated data structures, both internal and external:
  - RelationData
  - ~~IndexAmRoutine~~ *(static const * as of PG19)*
  - TupleDesc
  - hashmaps for lookups
  - etc.
- *consumes over 50% of memctx-managed memory in an idle connection*

Relcache optimization

RelationData: Many relation types

- fields: shared vs. owned
  `TupleDesc rd_att` (any relation) vs. `IndexAmRoutine *rd_indam` (indexes)

Alias memory for owned data:

- Index-specific fields (128B)
- Fields never used by indexes (>128B)

Relcache optimization

RelationData: Many relation types

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Alias memory for owned data:

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… But won't save memory when allocated in ASET (488 → 360 bytes; both use 512 B bucket in ASET allocator)

Relcache deduplication

Frequent pattern: ~equivalent object definitions

Duplication can be caused by e.g.

- Partitioning
- Shared definitions (indexes)
  - *CREATE INDEX ON tableA USING btree (id int8_ops)*
  - *CREATE INDEX ON tableB USING btree ("count" int8_ops)*

Relcache deduplication

Deduplicate large/frequently duplicated structures

- RelationData's index opclass-related allocations
- TupleDesc's attribute data

Relcache deduplication

Deduplicate RelationData's fields populated from pg_index:

pg_index.indam

PG19's bc6374cd7 "Change IndexAmRoutines to be statically-alocated structs"

- `IndexAmRoutine *.rd_indam`

Relcache deduplication

Deduplicate RelationData's fields populated from pg_index:

pg_index.indnkeyatts + indclass + indoption

- `rd_opfamily`/`rd_opcintype`/`rd_support`/`rd_supportinfo`/`rd_opcoptions`
- None of these contain table/index references; only "shape" info
- Fields trivial to deduplicate

  WIP branch at https://github.com/MMeent/postgres/tree/relcache-dedup-shapes

Relcache deduplication

Deduplicate RelationData's fields populated from pg_index:

pg_index.indkey, .indexprs, .indpred

- rd_indexprs/rd_indpred
- Contain table references = more entropy & less duplicated definitions
- Partitioned workloads may still make this worthwhile, but I haven't spent time exploring this further

Relcache deduplication

Deduplicate TupleDesc

With partitions, the TupleDescs of the partitions are all the same, right?

(or at least, close enough)

Relcache deduplication

Deduplicate TupleDesc

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Relcache deduplication

Deduplicate TupleDesc – differences

- Different column numbers
  - Dropped columns
  - Columns added to partitions
  - Manually attached partitions with different column order
- Different column options
  - e.g. statistics targets may be configured differently

Relcache deduplication

Deduplicate TupleDesc - differences (cont.)

- TupleDesc contains pg_attribute verbatim
  - ***pg_attribute.attrelid is always different for each table***, and so can't be deduplicated across tables

Relcache deduplication

Deduplicate TupleDesc

Split TupleDesc definition:

- Shared/deduplicated shape:
  - atttype/attlen/attalign/attbyval/attisdropped/attnullability/etc
  - Generally useful for both indexes and normal partitioning schemes
  - C.F. CompactAttribute
- Shared/deduplicated column name list:
  - Saves N times NAME_DATA_LEN in case of normal partitioning patterns
- Private relid list
  - Relids are (presumably) needed for planner TupleDescs

Relcache deduplication

Deduplicate TupleDesc

Critically: **Removes FormData_pg_attribute[] from catcache memory**

- Decouples one more direct reliance on NAME_DATA_LEN for struct layouts
- (far future) Could enable longer attribute/column names

Memory context selection

using a better allocator for long-lived allocations

- catcache doesn't care as much about low-latency as it would about resource usage
- aset is not great for catcache:
  - Overallocates memory (up to 100%)
  - Oversized initial memctx allocation (1kB)

Memory context selection

A better allocator for long-lived allocations

Andres' suggestion: proxy.c allocator

- Proxies memory requests into malloc
- Tracks individual allocations in the memctx

Memory context selection

Pro

- No more overallocated memory for memctx blocks
- Better sized allocations

Contra

- Takes away some control on which memory is kept around to avoid OS (re)alloc overheads
- Assumes malloc is a better allocator than what we can do
  (probably correct for aset, but what about others?)

Memory context selection

A better allocator for long-lived allocations

Alternative approaches

- Proxy context, which proxies allocations into other contexts
  - Removes the need for memory blocks/allocator
- New context better optimized for long-lived allocations
  - Don't care about low-latency (de)allocation patterns (aset.c)
  - Instead care about reducing memory wastage
  - Implement jmalloc/glibc's malloc/etc. ideas in new MCTX implementations?
- CTA: there are 7 MCTX_UNUSED IDs. Try implementing one and see what works.


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