Performance improvements in PostgreSQL 9.5 (and beyond)

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PostgreSQL 9.5, 9.6, ...

- many improvements
  - many of them related to performance
  - many quite large
- release notes are good overview, but ...
  - many changes not mentioned explicitly
  - often difficult to get an idea of the impact
- many talks about new features in general
  - this talk is about changes affecting performance

What we'll look at?

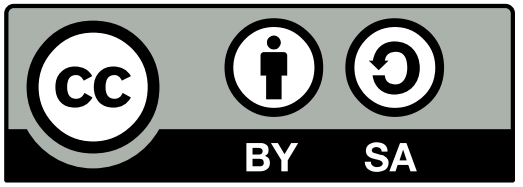
- PostgreSQL 9.5
- PostgreSQL 9.6+
  - committed
  - still being worked on (commitfests)
- only “main” improvements
  - complete “features” (multiple commits)
  - try to showcase them, show the impact
  - no particular order
- won't mention too many low-level optimizations

slides

http://www.slideshare.net/fuzzycz/performance-in-pg95

test scripts

https://github.com/2ndQuadrant/performance-in-pg95



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PostgreSQL 9.5

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Sorting

- allow sorting by inlined, non-SQL-callable functions
  - reduces per-call overhead
- use abbreviated keys for faster sorting
  - VARCHAR, TEXT, NUMERIC
  - Does not apply to CHAR values!
- stuff using “Sort Support” benefits from this
  - CREATE INDEX, REINDEX, CLUSTER
  - ORDER BY (when not executed using an index)

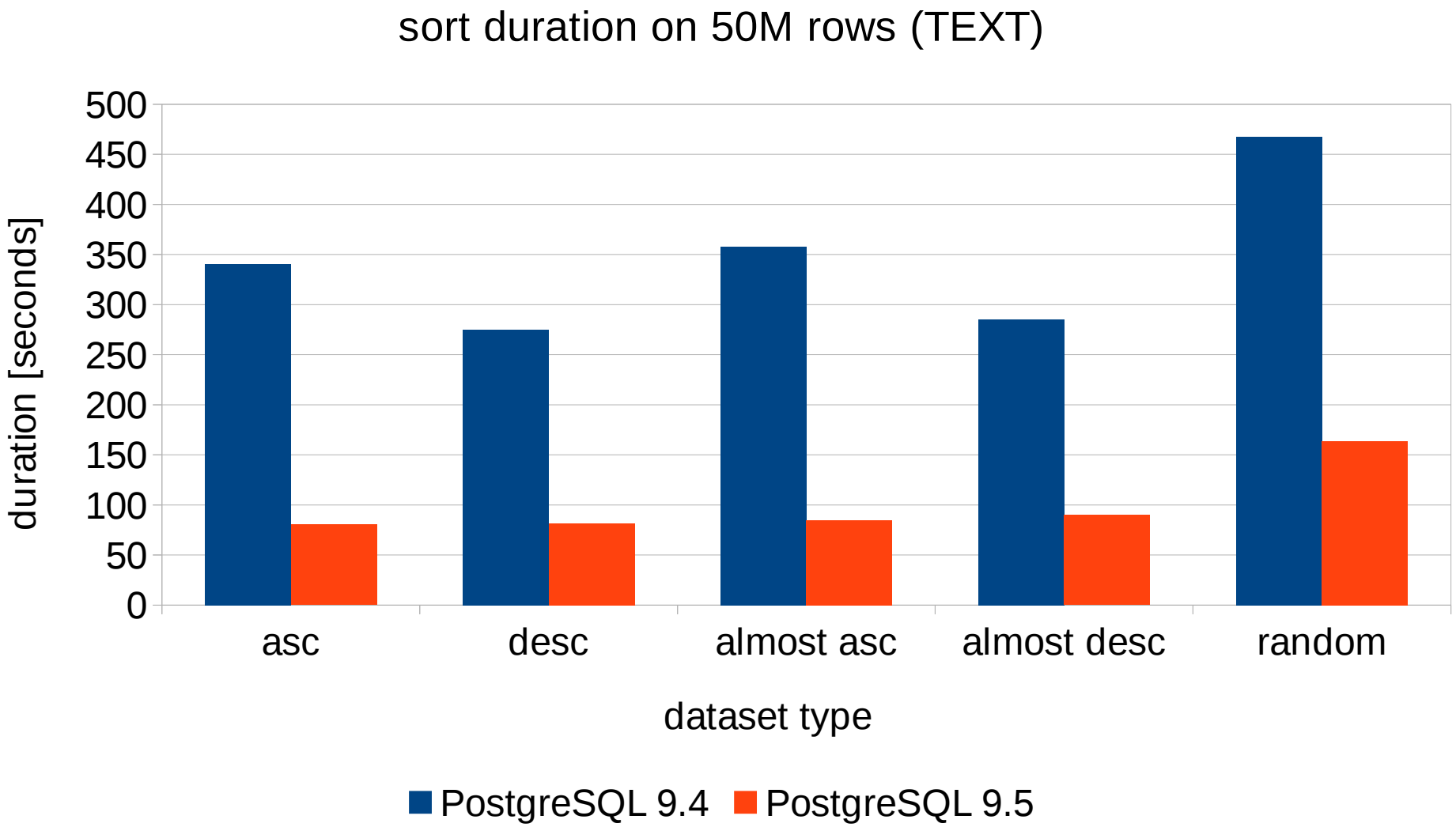
Sorting

```
CREATE TABLE test_text_random AS
SELECT md5(i::text) AS val
  FROM generate_series(1, 50.000.000) s(i);

CREATE TABLE test_text_asc AS
SELECT * from test_text_random
 ORDER BY 1;

SELECT COUNT(1) FROM (
   SELECT * FROM test_text_random ORDER BY 1
) foo;
```

Sorting improvements in PostgreSQL 9.5



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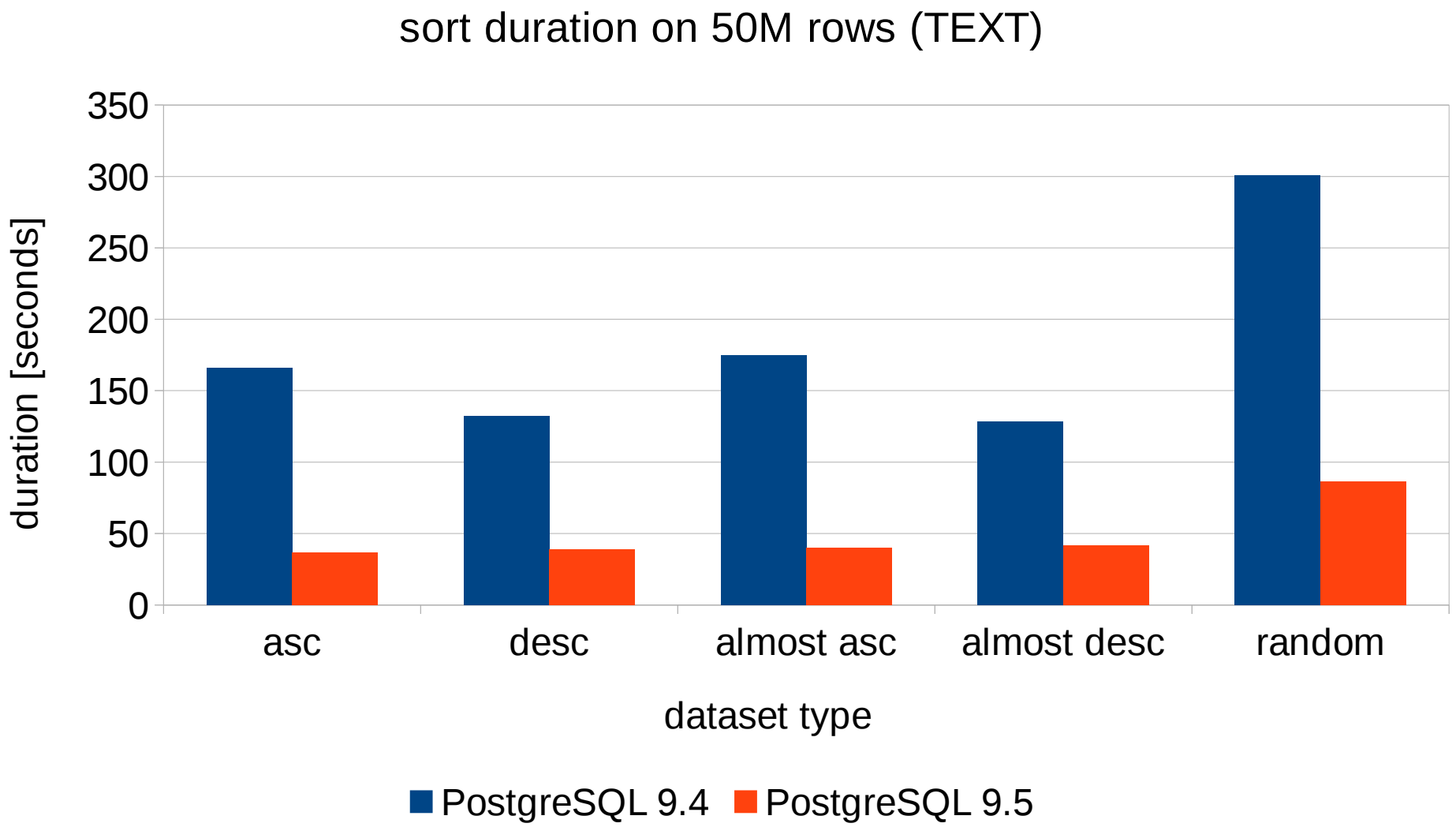
Sorting improvements in PostgreSQL 9.5



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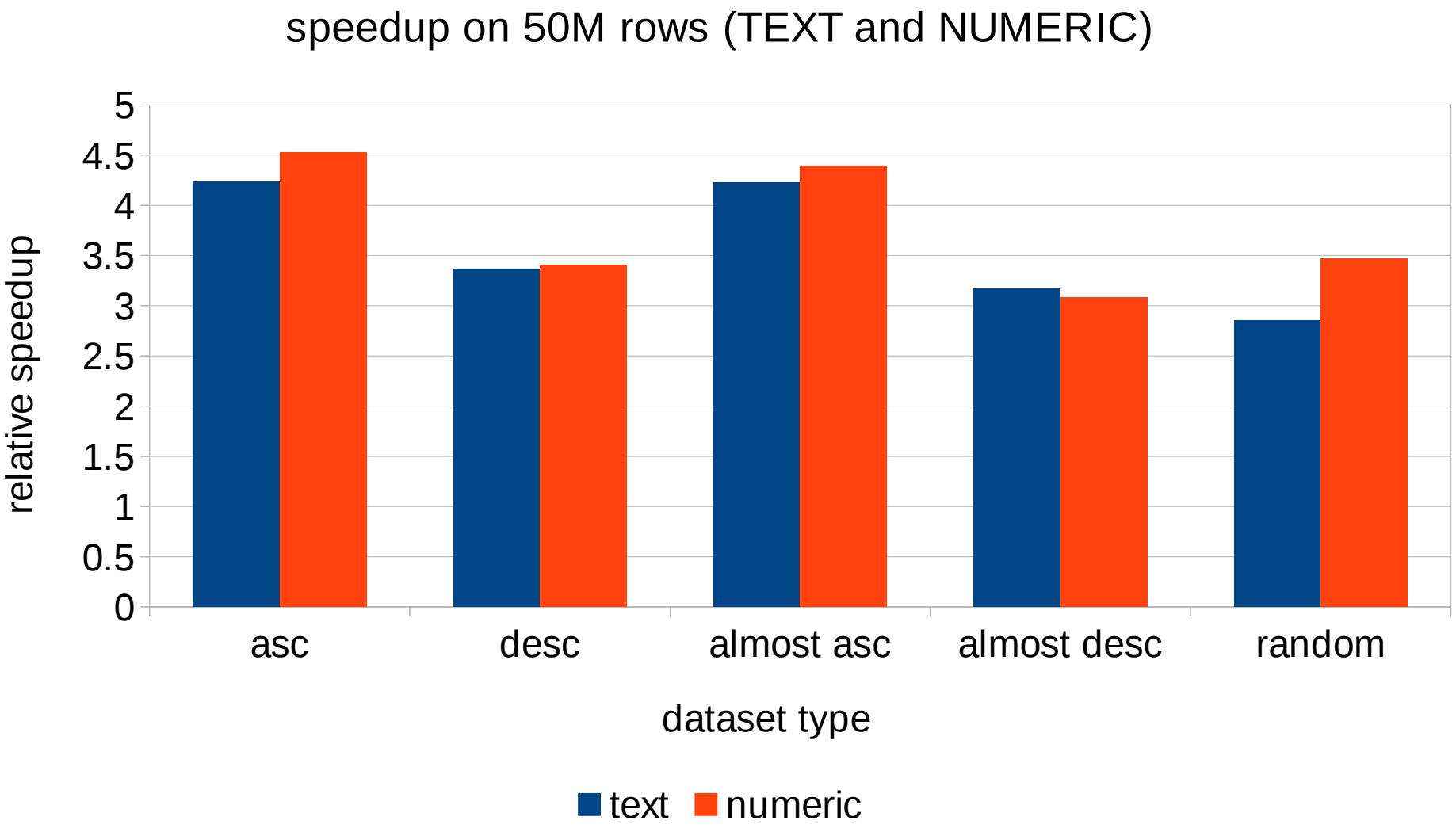
Sorting speedups on PostgreSQL 9.5



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Hash Joins

- reduce palloc overhead
  - dense packing of tuples (trivial local allocator, same life-span)
  - significant reduction of overhead (both space and time)
- reduce NTUP_PER_BUCKET to 1 (from 10)
  - goal is less that 1 tuple per bucket (on average)
  - significant speedup of lookups
- dynamically resize the hash table
  - handle under-estimates gracefully
  - otherwise easily 100s of tuples per bucket (linked list)

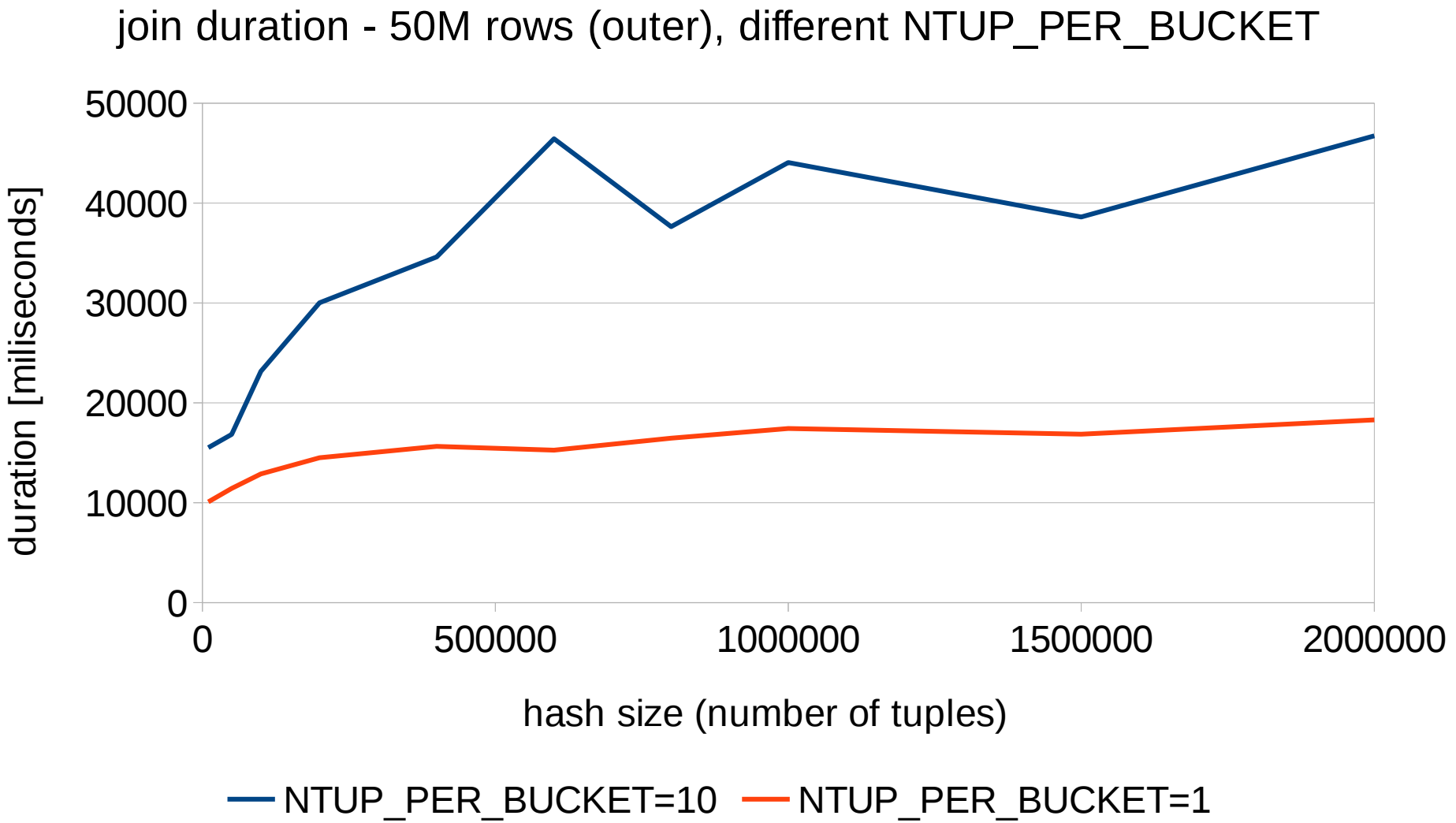
Hash Joins

```
CREATE TABLE test_dim AS
SELECT (i-1) AS id, md5(i::text) AS val
  FROM generate_series(1,100.000) s(i);

CREATE TABLE test_fact AS
SELECT mod(i,100.000) AS dim_id, md5(i::text) AS val
  FROM generate_series(1,50.000.000) s(i);

SELECT count(*) FROM test_fact
                JOIN test_dim ON (dim_id = id);
```

PostgreSQL 9.5 Hash Join Improvements



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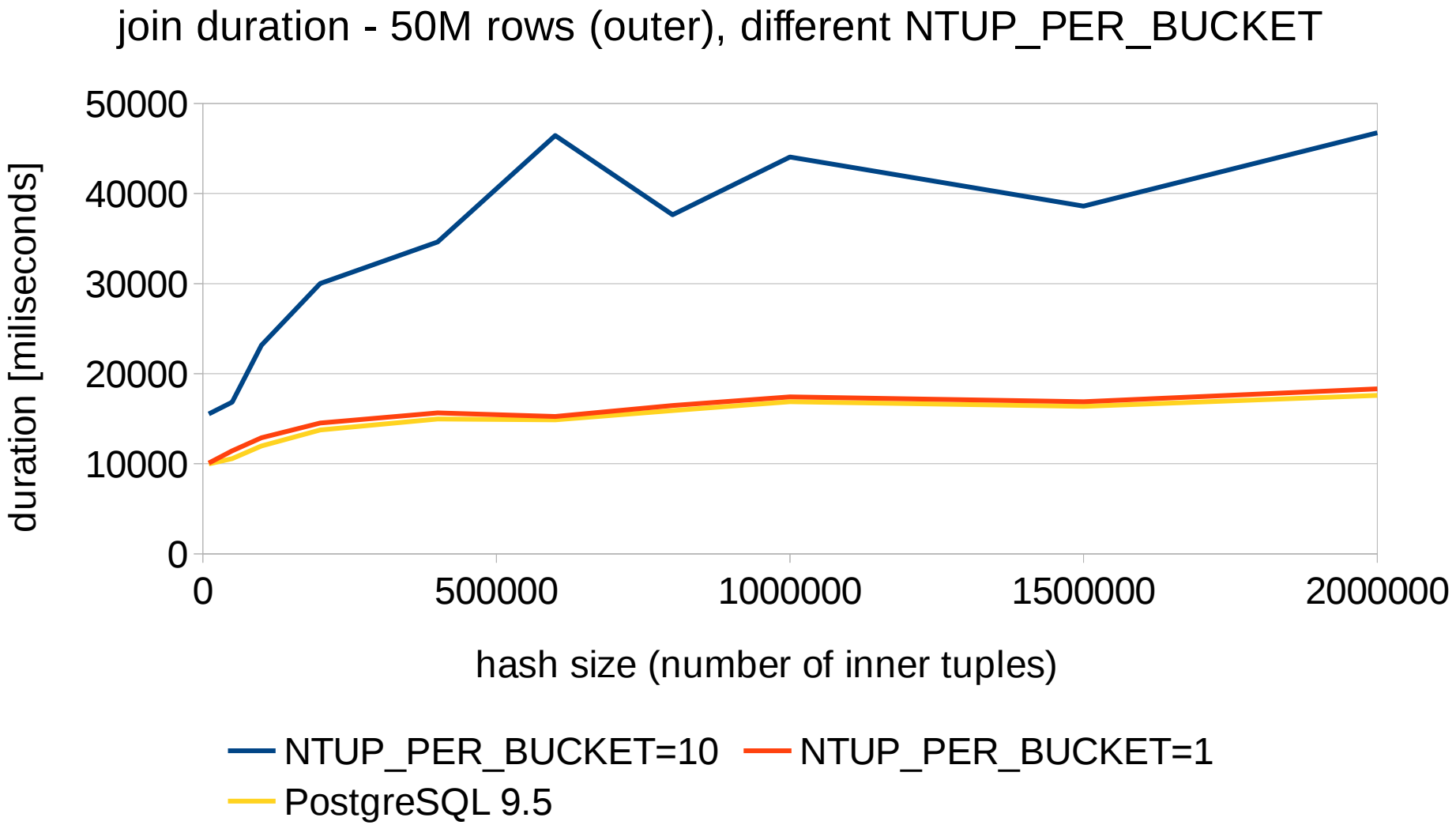
PostgreSQL 9.5 Hash Join Improvements



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Indexes

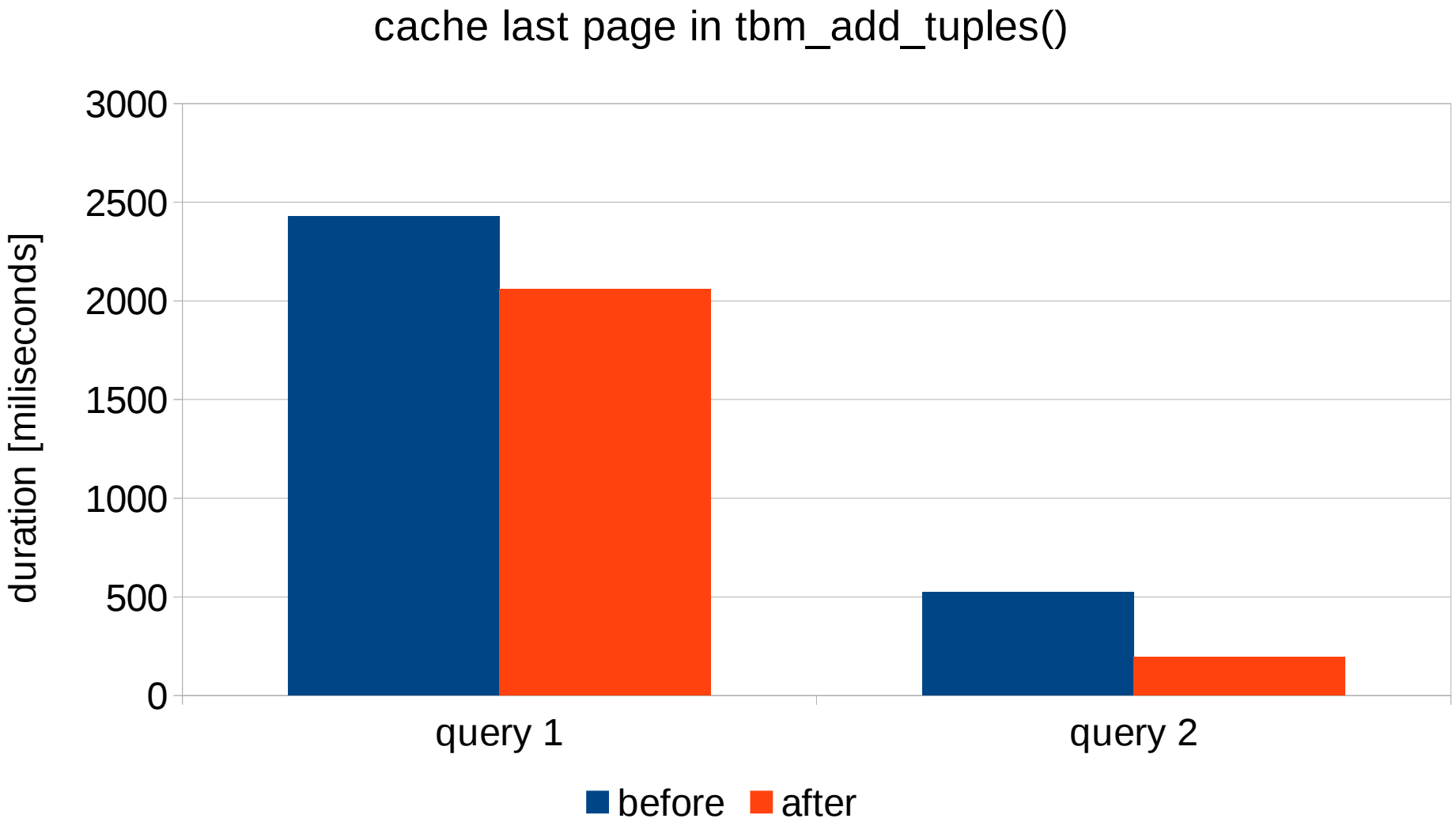
- CREATE INDEX
  - avoid copying index tuples when building an index (palloc overhead)
- Index-only scans with GiST
  - support to range type, inet GiST opclass and btree_gist
- Bitmap Index Scan
  - in some cases up to 50% was spent in tbm_add_tuples
  - cache the last accessed page in tbm_add_tuples
- BRIN
  - block range indexes, tracking min/max per block
  - only bitmap index scans (equality and range queries)

Bitmap build speedup

```
CREATE EXTENSION btree_gin;
CREATE TABLE t AS
SELECT (v / 10)::int4 AS i
  FROM generate_series(1, 5.000.000) AS v;
CREATE INDEX idx ON t USING gin (i);

SET enable_seqscan  = off;
SELECT * FROM t WHERE i >= 0;
SELECT * FROM t WHERE i >= 100 AND i<= 100;
```

Bitmap build speedup



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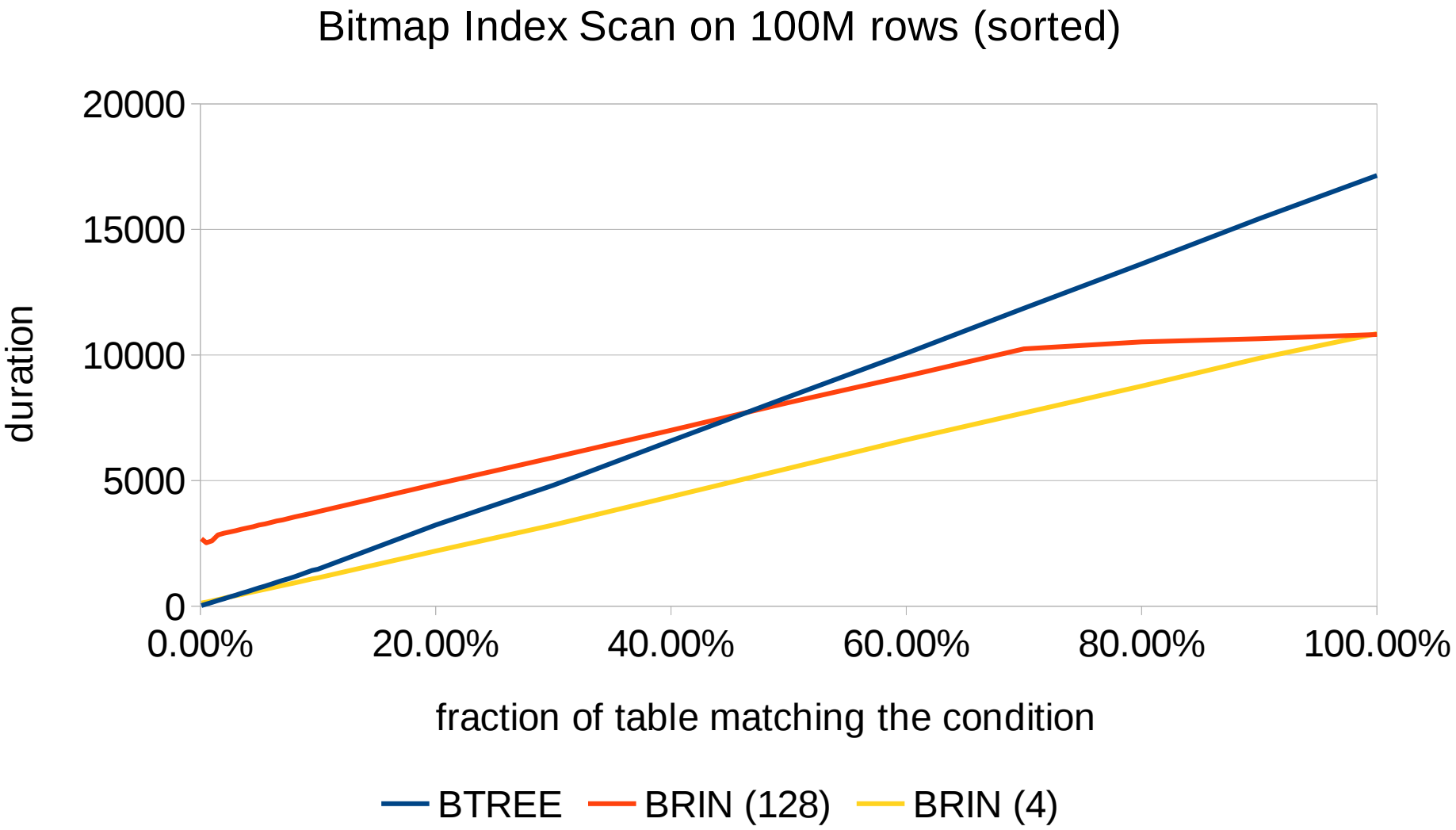
BRIN Indexes

```
-- data preparation

CREATE TABLE test_bitmap AS
SELECT mod(i, 100.000) AS val
  FROM generate_series(1, 100.000.000) s(i);

CREATE INDEX test_btree_idx ON test_bitmap(val);
CREATE INDEX test_brin_idx ON test_bitmap USING brin(val);

-- benchmark

SET enable_seqscan = off;
SET enable_indexscan = off;

SELECT COUNT(*) FROM test_bitmap WHERE val <= $1;
```

BRIN vs. BTREE



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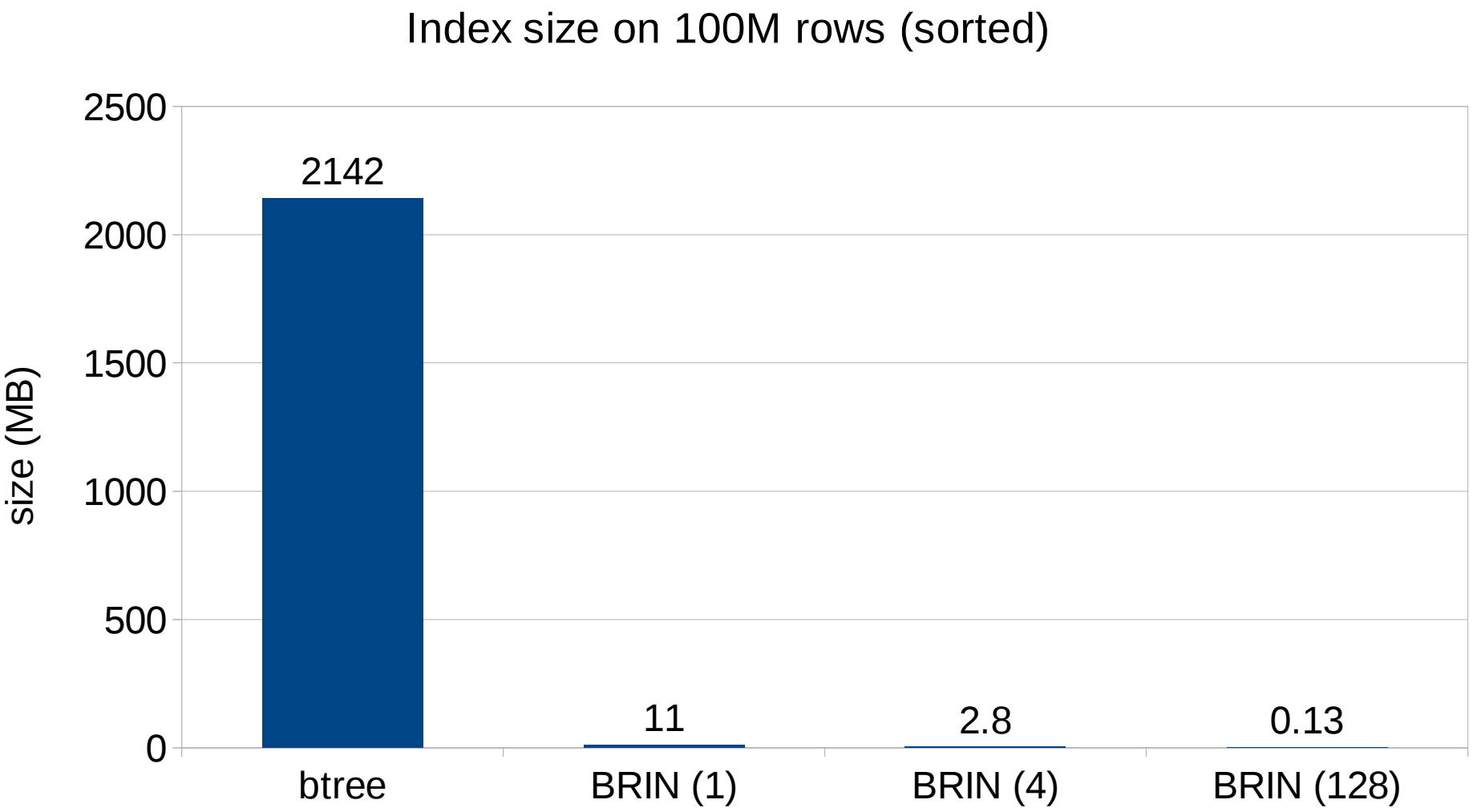
BRIN vs. BTREE



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Aggregate functions

- Use 128-bit math to accelerate some aggregation functions.
  - some INT aggregate functions used NUMERIC for internal state
  - requires support for 128-bit integers (if provided by compiler).
- impacted aggregates
  - sum(int8)
  - avg(int8)
  - var_*(int2)
  - var_*(int4)
  - stdev_*(int2)
  - stdev_*(int4)

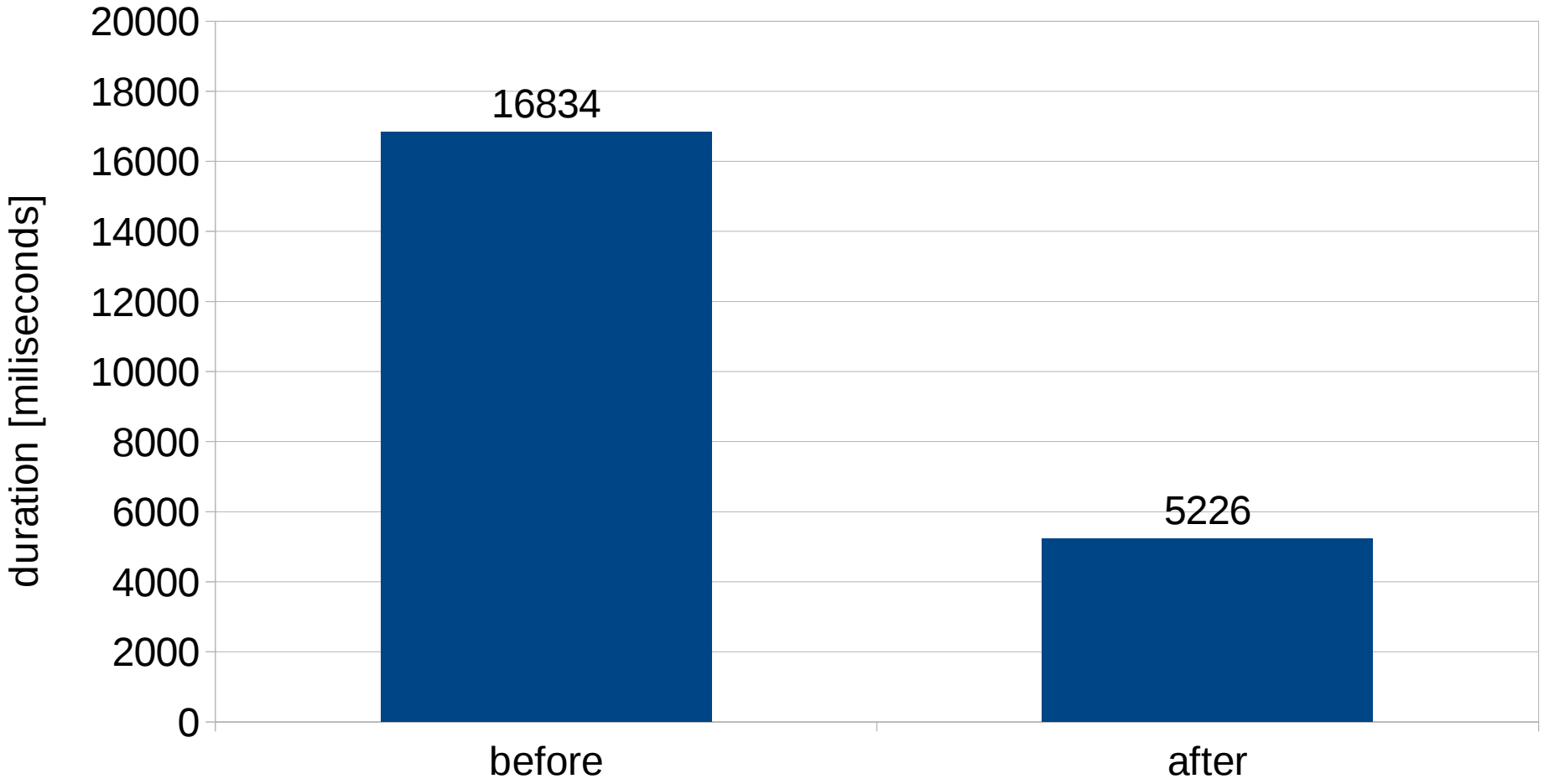
Aggregate functions

```
CREATE TABLE test_aggregates AS
SELECT i AS a, i AS b
  FROM generate_series(1, 50.000.000) s(i);

SELECT SUM(a), AVG(b) FROM test_aggregates;
```

Aggregate functions / 128-bit state

using 128-bit integers for state (instead of NUMERIC)



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PL/pgSQL

- Support "expanded" objects, particularly arrays, for better performance.
- Allocate ParamListInfo once per plpgsql function, not once per expression.
- Use standard casting mechanism to convert types in plpgsql, when possible.
- Use fast path in plpgsql's RETURN/RETURN NEXT in more cases.

Planner and optimizer

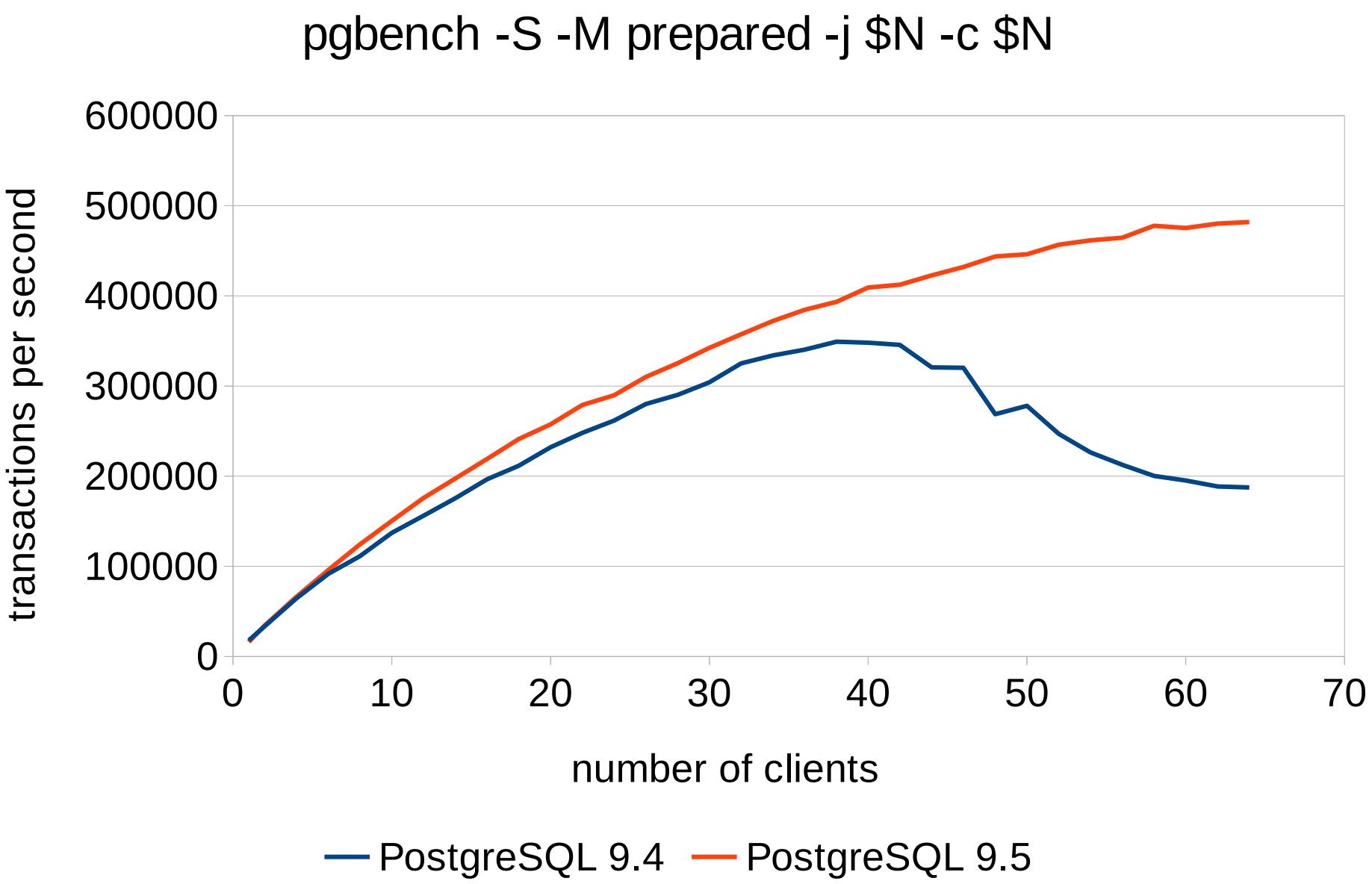
- remove unnecessary references to left outer join subqueries
- pushdown of query restrictions into window functions
- simplification of EXISTS() subqueries containing LIMIT
- teach predtest.c that "foo" implies "foo IS NOT NULL"
- improve predtest.c's ability to reason about operator expressions

Locking and concurrency

- checksum improvements
  - Speed up CRC calculation using slicing-by-8 algorithm.
  - Use Intel SSE 4.2 CRC instructions where available.
  - Optimize pg_comp_crc32c_sse42 routine slightly, and also use it on x86.
- add a basic atomic ops API abstracting away platform/architecture details.
- reduce lock levels of some trigger DDL and add FKs

Locking and concurrency

- Improve LWLock scalability.
- various shared buffer improvements
  - Improve concurrency of shared buffer replacement
  - Increase the number of buffer mapping partitions to 128.
  - Lockless StrategyGetBuffer clock sweep hot path.
  - Align buffer descriptors to cache line boundaries.
  - Make backend local tracking of buffer pins memory efficient
  - Reduce the number of page locks and pins during index scans
  - Optimize locking a tuple already locked by another subxact



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PostgreSQL 9.6+

Parallel Seq Scan

```
SET max_parallel_degree = 4;
SELECT COUNT(*) FROM test_parallel WHERE test_func(a, 1);

                                QUERY PLAN
-----------------------------------------------------------------------
 Aggregate  (cost=15411721.93..15411721.94 rows=1 width=0)
   ->  Gather  (cost=1000.00..15328388.60 rows=33333330 width=0)
         Number of Workers: 4
         ->  Partial Seq Scan on test_parallel
                     (cost=0.00..5327388.60 rows=33333330 width=0)
               Filter: test_func(a, 1)
```

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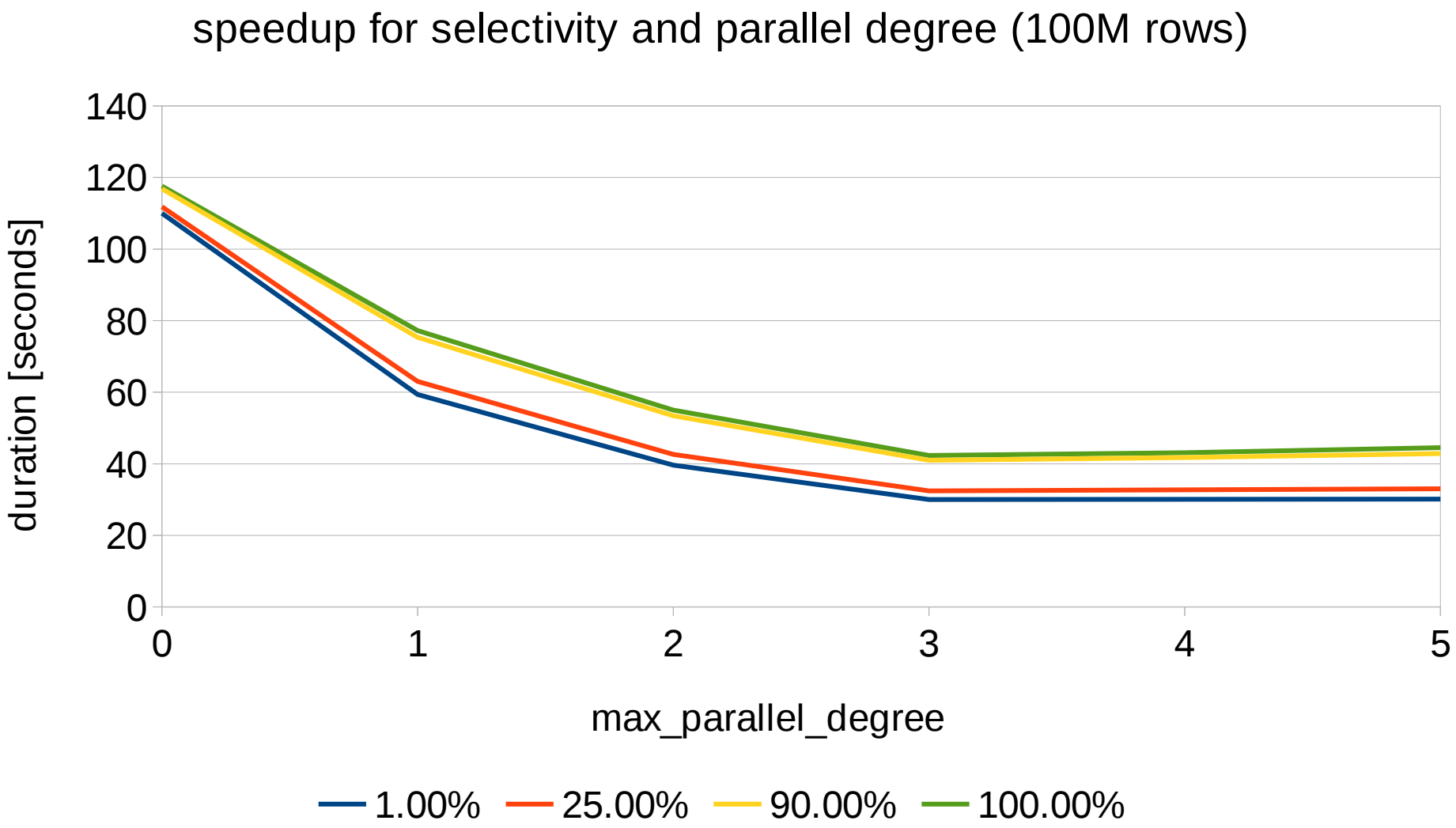
Parallel Seq Scan



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TABLESAMPLE

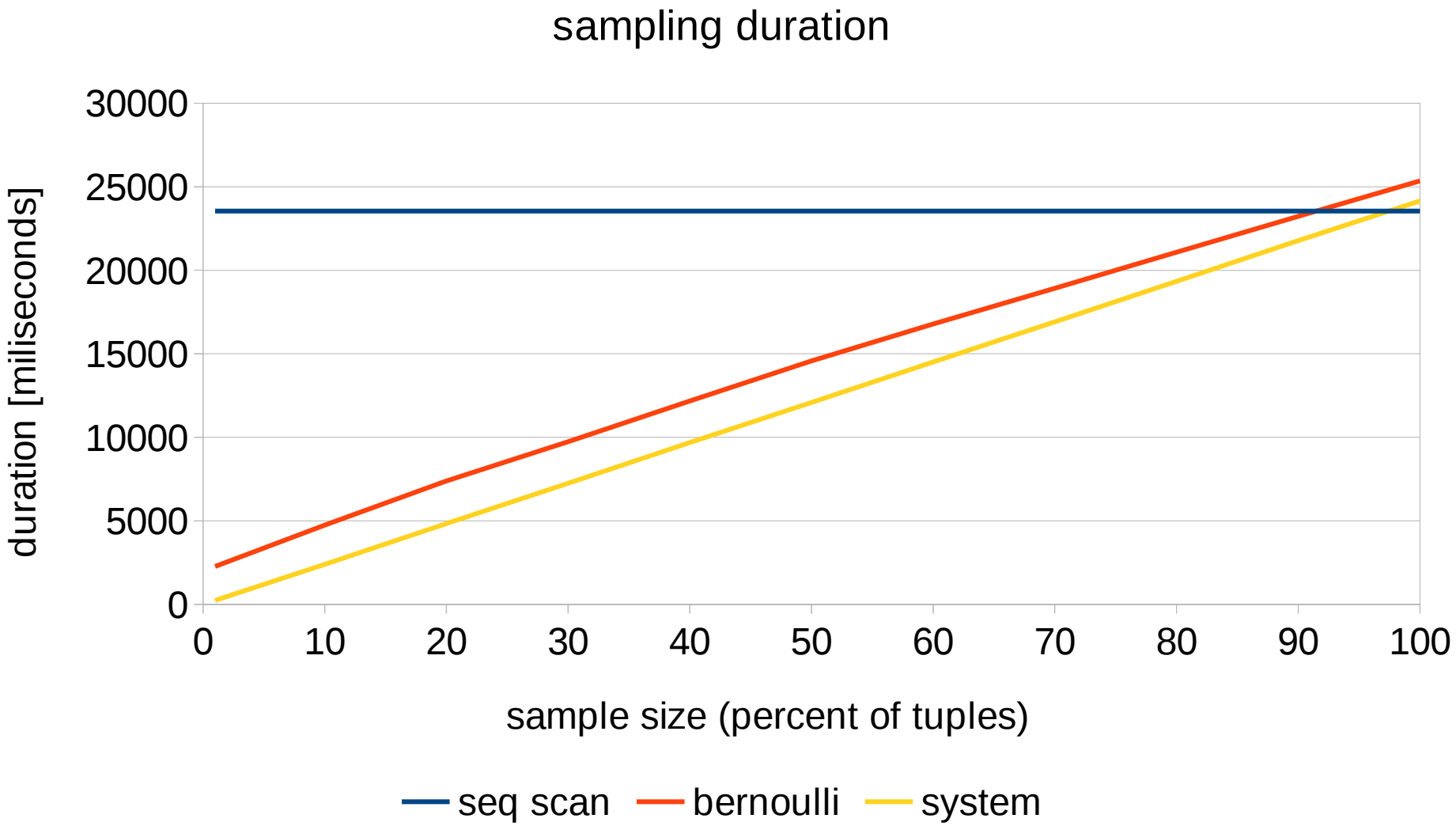
```
SELECT * FROM t TABLESAMPLE sampling_method (args)
                [REPEATABLE (seed)]

SELECT * FROM t TABLESAMPLE BERNOULLI (33.3);
SELECT * FROM t TABLESAMPLE SYSTEM (33.3);

-- tsm_system_rows
SELECT * FROM t TABLESAMPLE SYSTEM_ROWS (1000);

-- tsm_system_time
SELECT * FROM t TABLESAMPLE SYSTEM_TIME (1000);
```

TABLESAMPLE



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Aggregate functions

- some aggregates use the same state
  - AVG, SUM, …
  - we’re keeping it separate and updating it twice
  - but only the final function is actually different
- so …

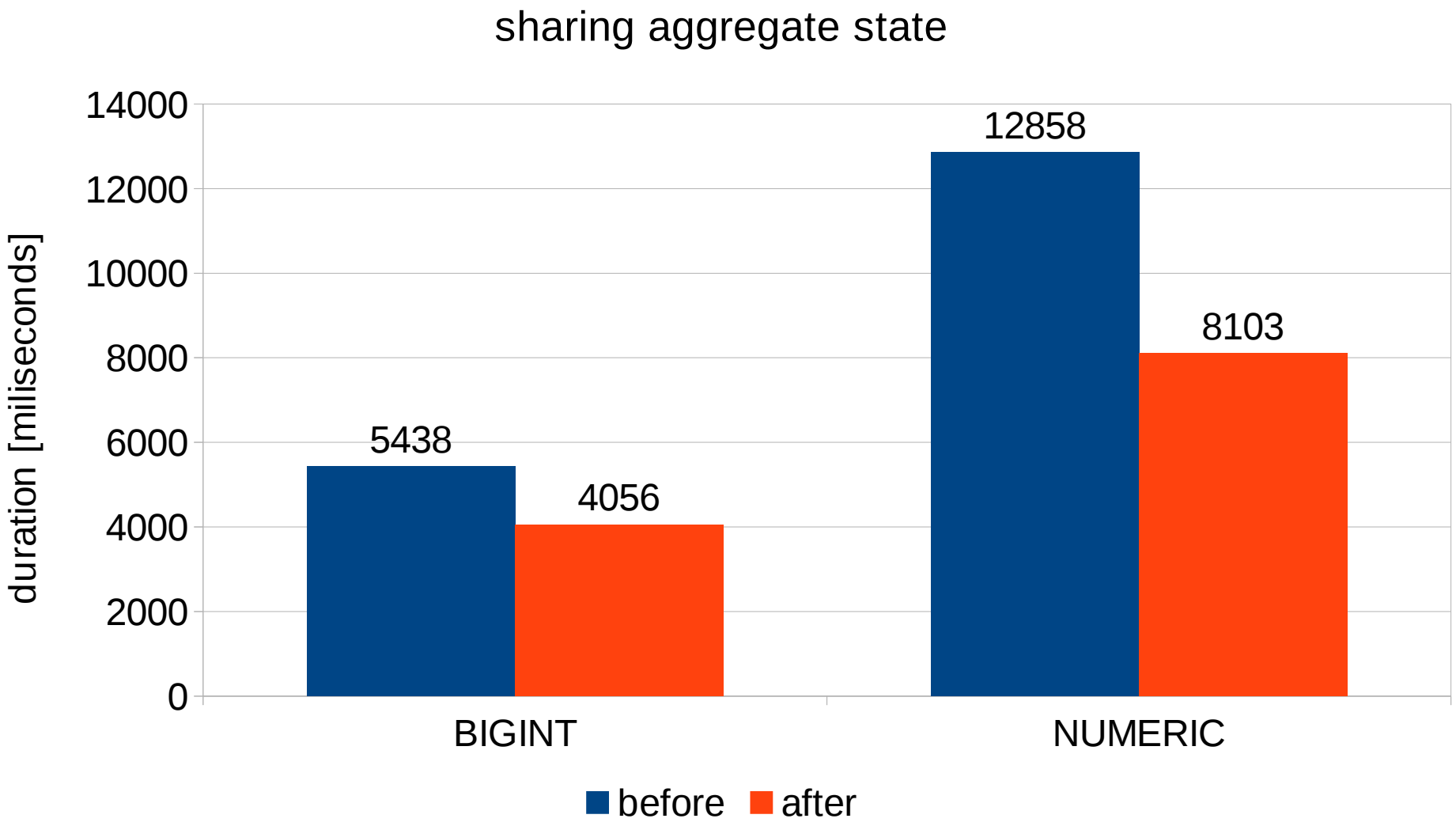
Share transition state between different aggregates when possible.

Aggregate functions

```
CREATE TABLE test_aggregates AS
SELECT i AS a
  FROM generate_series(1, 50.000.000) s(i);

SELECT SUM(a), AVG(a) FROM test_aggregates;
```

Aggregate functions



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Disabling HOT cleanup

- HOT allows UPDATEs without bloating indexes
  - a page may have and many “previous” tuple versions
  - the dead versions are cleaned by VACUUM or by queries reading the block
  - single query may be forced to cleanup the whole table (e.g. after a batch update)
  - clear impact on performance, a bit unpredictable
- the patch attempts to somehow limit the impact
  - query only fixes limited number of pages, etc.

Checkpoints

- continuous flushing (and sorting writes)
  - more about variance than about throughput
  - eliminate latency stalls / spikes due to checkpoints
  - effect depends on I/O scheduler, storage, ...
- compensate for full_page_writes
  - spread checkpoints assume constant WAL rate
  - not really true due to initial rush to write full pages
  - scheduling gets confused by this difference
  - patch tries to compensate for this effect

Freezing large tables

- every time we “run out of XIDs” we need to freeze tuples
  - we have to scan all the tables to freeze all pages
  - even if many of the pages are already “fully frozen”
  - serious problem on large databases
  - users often postpone the freezing (and then DB shuts down)
- add “all tuples frozen” into visibility map
  - allows skipping already frozen pages
- patch seems mostly ready
  - mostly discussions about renaming (vm or vfm?)

Additional 9.6+ changes

- Locking and concurrency
  - Reduce ProcArrayLock contention by removing backends in batches.
- PL/pgSQL
  - Further reduce overhead for passing plpgsql variables to the executor.
- Planner / Optimizer
  - Unique Joins
  - Index-only scans with partial indexes
  - FK join estimates
  - Selectivity estimation for intarray
  - Table Partition + Join Pushdown
  - FDW join pushdown

Additional 9.6+ changes

- Declarative partitioning
  - easier maintenance (huge improvement)
  - allows advanced planning (insight into partitioning rules)
- Sorting
  - Reusing abbreviated keys during second pass of ordered [set] aggregates
  - SortSupport for text - strcoll() and strxfrm() caching
  - Memory prefetching while sequentially fetching from SortTuple array, tuplestore
  - Using quicksort and a merge step to significantly improve on tuplesort's single run "external sort"

http://pgconf.de/feedback