Tuning parameters in Postgres vs. Tuning your queries

Hettie Dombrovskaya

Database Architect

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DRW

Who Am I

Database Architect at DRW
Local Organizer of Chicago PostgreSQL User Group

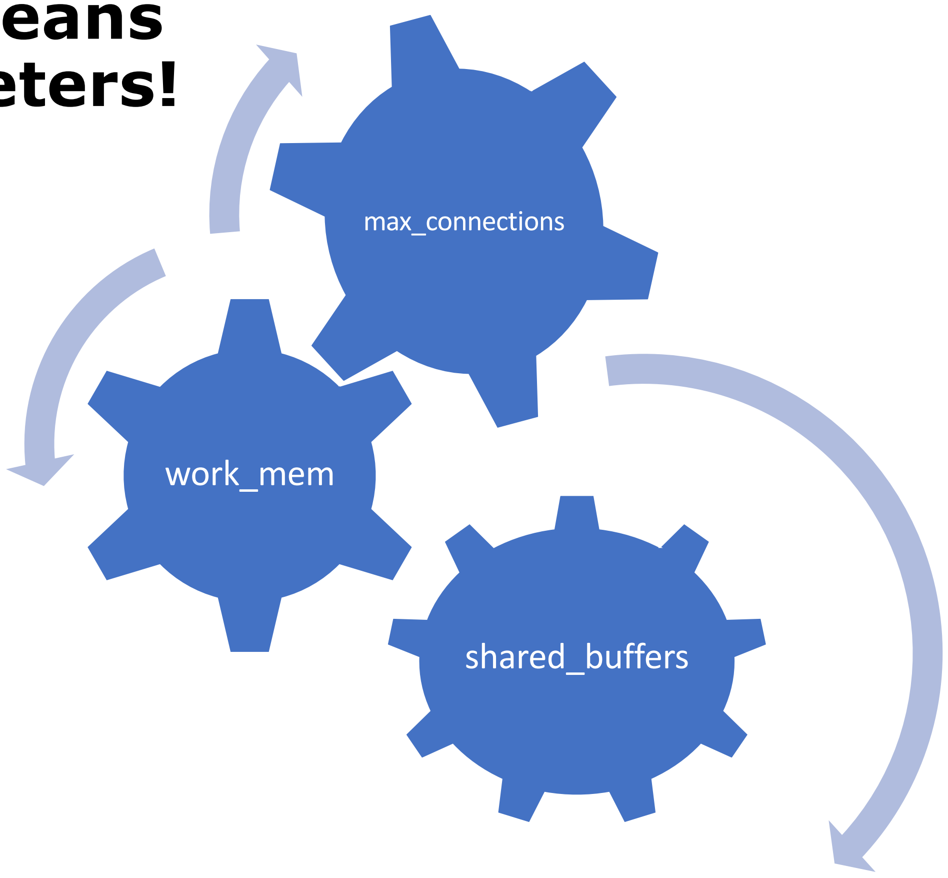
I never presented any talk about tuning parameters -why now?!

Tuning your database – what does it mean?

I thought I knew...

Until I started working for EDB!

And then it turned out that *tuning* means tuning parameters!



Why I never did it before?

Why people believe in the magic of parameters?

My goal today is to show
Why it ~~almost~~ does not matter

Why it is difficult to show?

- Tuning individual queries performance vs improving throughput
- It’s difficult to model a real-life workload
- It’s difficult to model a real-life concurrency

Facts

Tuning parameters can improve performance 10%, 20%, in some cases 50%

Tuning queries can improve performance several (tens) times

Tuning application can improve performance up to hundreds of time!

Query example

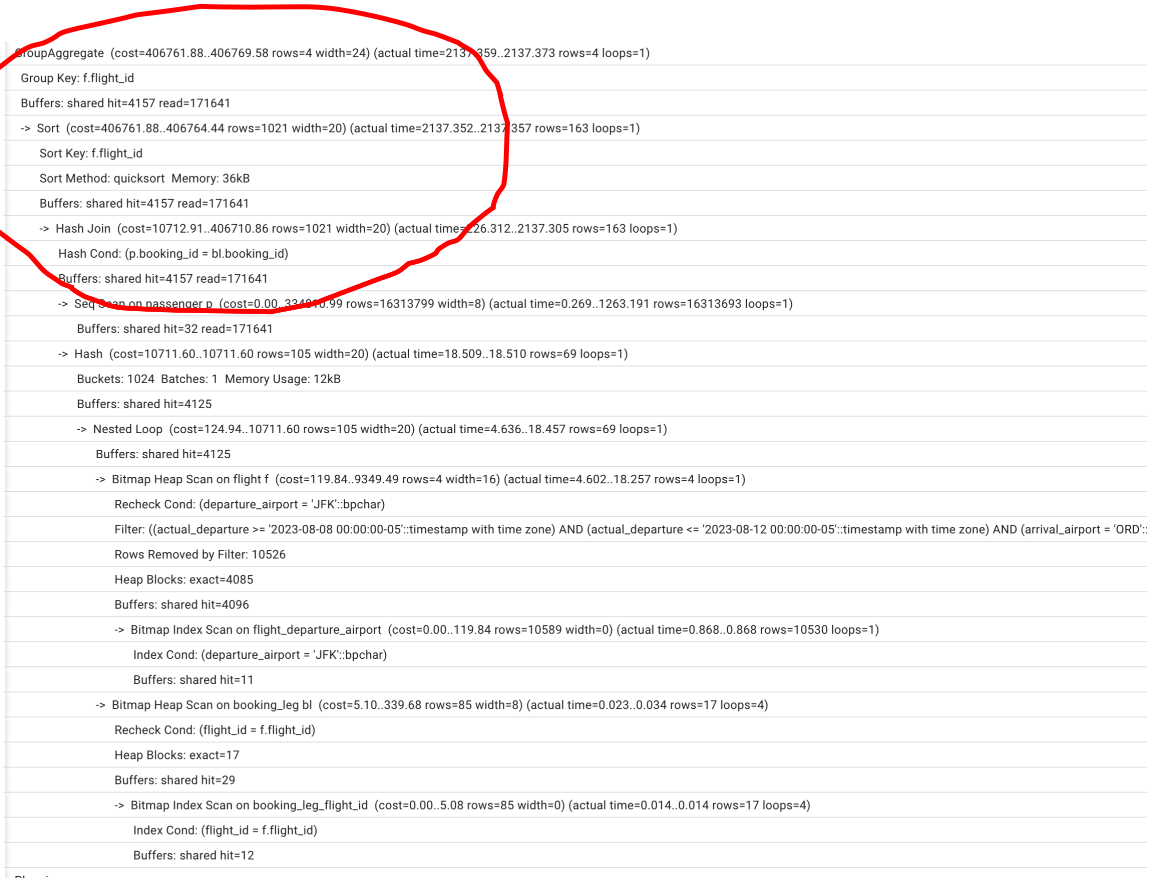
https://github.com/hettie-d/postgres_air

```
SELECT f.flight_no,
       f.actual_departure,
       count(passenger_id) passengers
  FROM flight f
       JOIN booking_leg bl ON bl.flight_id = f.flight_id
       JOIN passenger p ON p.booking_id=bl.booking_id
 WHERE f.departure_airport = 'JFK'
   AND f.arrival_airport = 'ORD'
   AND f.actual_departure BETWEEN
        '2023-08-08' and '2023-08-12'
GROUP BY f.flight_id, f.actual_departure;
```

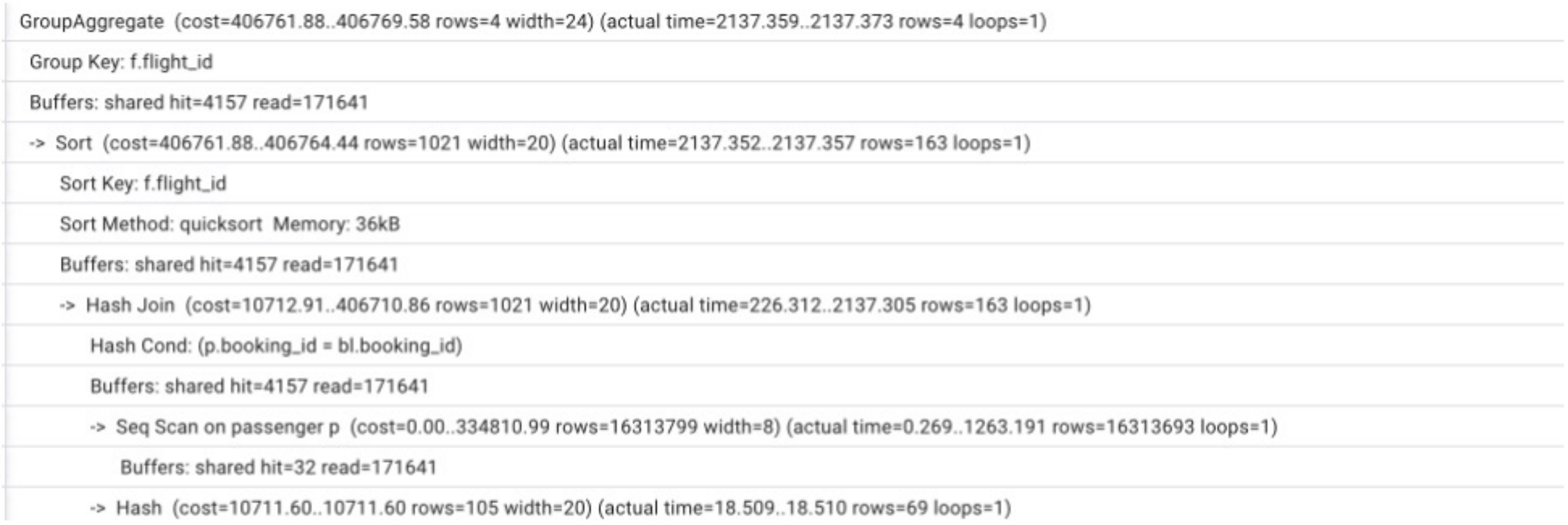
Execution plan with default memory allocation

```
shared_buffers=128MB

work_mem=4MB

max_parallel_workers_per_gather=0
```

Execution time: 2.4 s



```
GroupAggregate  (cost=406761.88..406769.58 rows=4 width=24) (actual time=2137.359..2137.373 rows=4 loops=1)
 Group Key: f.flight_id
 Buffers: shared hit=4157 read=171641
 ->  Sort  (cost=406761.88..406764.44 rows=1021 width=20) (actual time=2137.352..2137.357 rows=163 loops=1)
       Sort Key: f.flight_id
       Sort Method: quicksort  Memory: 36kB
       Buffers: shared hit=4157 read=171641
       ->  Hash Join  (cost=10712.91..406710.86 rows=1021 width=20) (actual time=226.312..2137.305 rows=163 loops=1)
             Hash Cond: (p.booking_id = bl.booking_id)
             Buffers: shared hit=4157 read=171641
             ->  Seq Scan on passenger p  (cost=0.00..334810.99 rows=16313799 width=8) (actual time=0.269..1263.191 rows=16313693 loops=1)
                   Buffers: shared hit=32 read=171641
             ->  Hash  (cost=10711.60..10711.60 rows=105 width=20) (actual time=18.509..18.510 rows=69 loops=1)
                   Buckets: 1024  Batches: 1  Memory Usage: 12kB
                   Buffers: shared hit=4125
                   ->  Nested Loop  (cost=124.94..10711.60 rows=105 width=20) (actual time=4.636..18.457 rows=69 loops=1)
                         Buffers: shared hit=4125
                         ->  Bitmap Heap Scan on flight f  (cost=119.84..9349.49 rows=4 width=16) (actual time=4.602..18.257 rows=4 loops=1)
                               Recheck Cond: (departure_airport = 'JFK'::bpchar)
                               Filter: ((actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::timestamp with time zone) AND (arrival_airport = 'ORD'::
                               Rows Removed by Filter: 10526
                               Heap Blocks: exact=4085
                               Buffers: shared hit=4096
                               ->  Bitmap Index Scan on flight_departure_airport  (cost=0.00..119.84 rows=10589 width=0) (actual time=0.868..0.868 rows=10530 loops=1)
                                     Index Cond: (departure_airport = 'JFK'::bpchar)
                                     Buffers: shared hit=11
                         ->  Bitmap Heap Scan on booking_leg bl  (cost=5.10..339.68 rows=85 width=8) (actual time=0.023..0.034 rows=17 loops=4)
                               Recheck Cond: (flight_id = f.flight_id)
                               Heap Blocks: exact=17
                               Buffers: shared hit=29
                               ->  Bitmap Index Scan on booking_leg_flight_id  (cost=0.00..5.08 rows=85 width=0) (actual time=0.014..0.014 rows=17 loops=4)
                                     Index Cond: (flight_id = f.flight_id)
                                     Buffers: shared hit=12
```



```
GroupAggregate  (cost=406761.88..406769.58 rows=4 width=24) (actual time=2137.359..2137.373 rows=4 loops=1)
  Group Key: f.flight_id
  Buffers: shared hit=4157 read=171641
  ->  Sort  (cost=406761.88..406764.44 rows=1021 width=20) (actual time=2137.352..2137.357 rows=163 loops=1)
        Sort Key: f.flight_id
        Sort Method: quicksort  Memory: 36kB
        Buffers: shared hit=4157 read=171641
        ->  Hash Join  (cost=10712.91..406710.86 rows=1021 width=20) (actual time=226.312..2137.305 rows=163 loops=1)
              Hash Cond: (p.booking_id = bl.booking_id)
              Buffers: shared hit=4157 read=171641
              ->  Seq Scan on passenger p  (cost=0.00..334810.99 rows=16313799 width=8) (actual time=0.269..1263.191 rows=16313693 loops=1)
                    Buffers: shared hit=32 read=171641
              ->  Hash  (cost=10711.60..10711.60 rows=105 width=20) (actual time=18.509..18.510 rows=69 loops=1)
```

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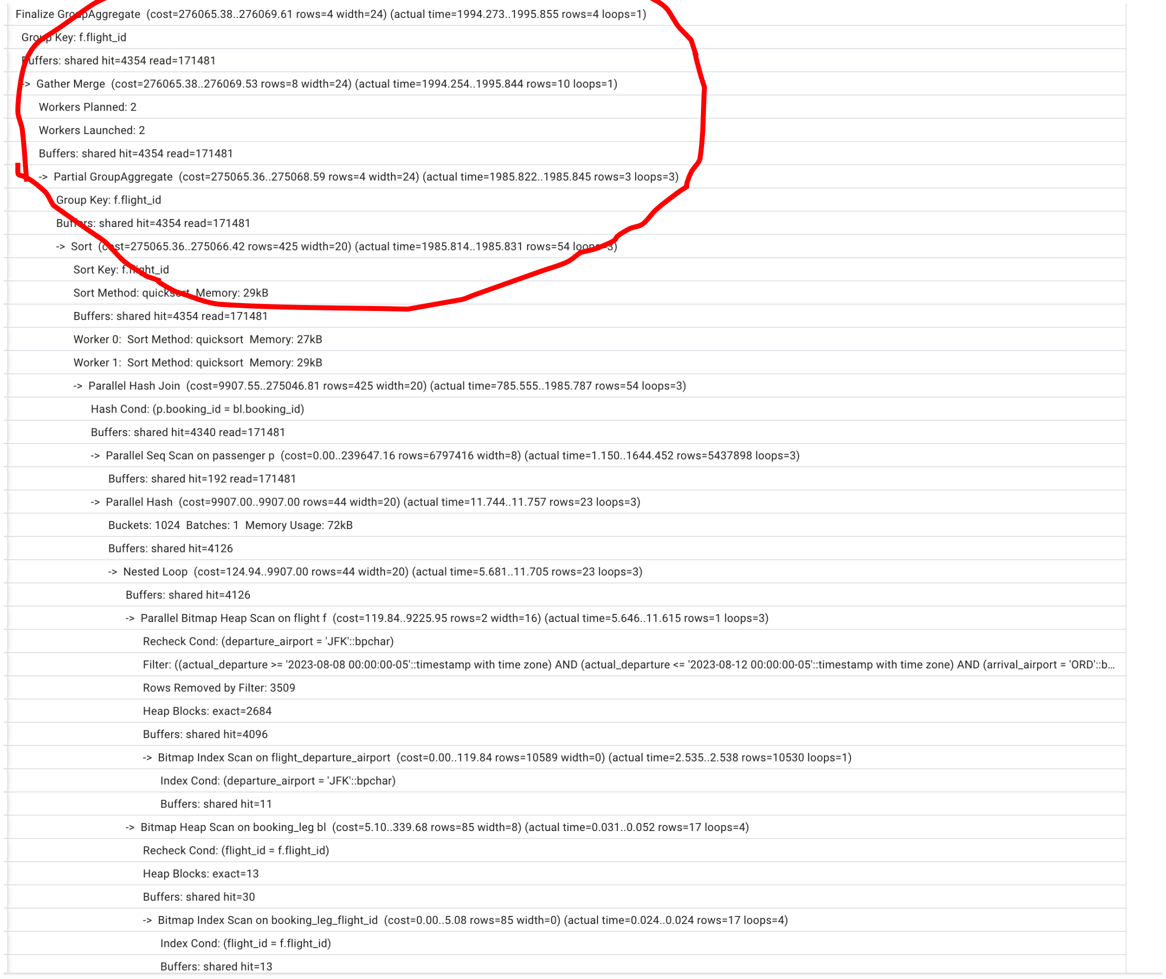
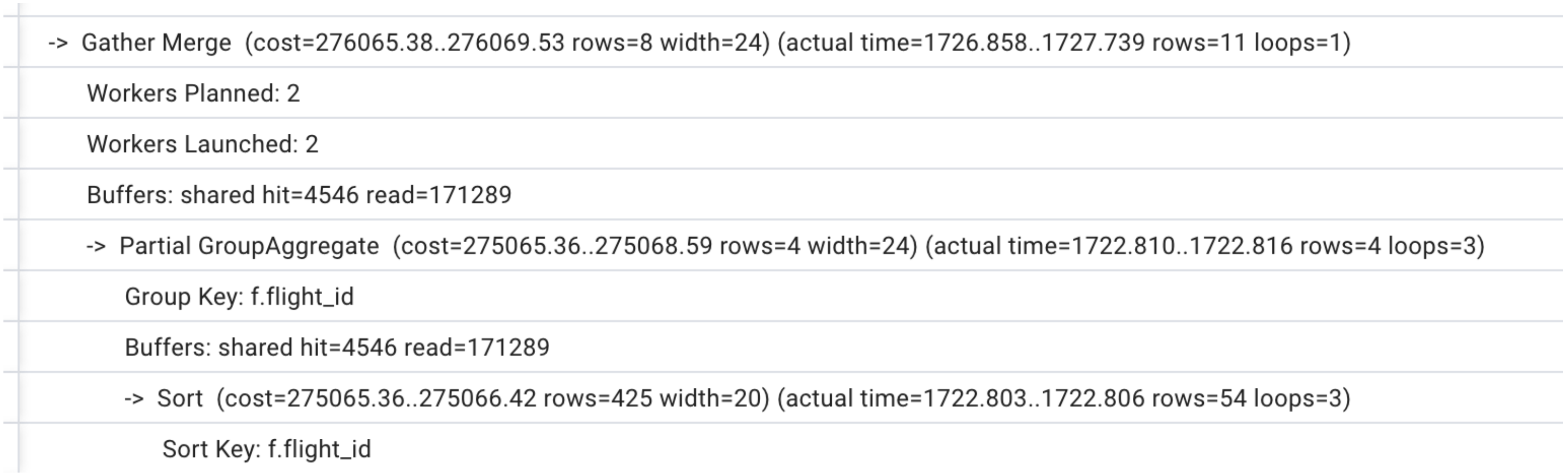
Execution plan with default memory allocation

```
shared_buffers=128MB

work_mem=4MB

max_parallel_workers_per_gather=2
```

Execution time 2.1 s



```
Finalize GroupAggregate  (cost=276065.38..276069.61 rows=4 width=24) (actual time=1994.273..1995.855 rows=4 loops=1)
  Group Key: f.flight_id
  Buffers: shared hit=4354 read=171481
  ->  Gather Merge  (cost=276065.38..276069.53 rows=8 width=24) (actual time=1994.254..1995.844 rows=10 loops=1)
        Workers Planned: 2
        Workers Launched: 2
        Buffers: shared hit=4354 read=171481
        ->  Partial GroupAggregate  (cost=275065.36..275068.59 rows=4 width=24) (actual time=1985.822..1985.845 rows=3 loops=3)
              Group Key: f.flight_id
              Buffers: shared hit=4354 read=171481
              ->  Sort  (cost=275065.36..275066.42 rows=425 width=20) (actual time=1985.814..1985.831 rows=54 loops=3)
                    Sort Key: f.flight_id
                    Sort Method: quicksort  Memory: 29kB
                    Buffers: shared hit=4354 read=171481
                    Worker 0:  Sort Method: quicksort  Memory: 27kB
                    Worker 1:  Sort Method: quicksort  Memory: 29kB
                    ->  Parallel Hash Join  (cost=9907.55..275046.81 rows=425 width=20) (actual time=785.555..1985.787 rows=54 loops=3)
                          Hash Cond: (p.booking_id = bl.booking_id)
                          Buffers: shared hit=4340 read=171481
                          ->  Parallel Seq Scan on passenger p  (cost=0.00..239647.16 rows=6797416 width=8) (actual time=1.150..1644.452 rows=5437898 loops=3)
                                Buffers: shared hit=192 read=171481
                          ->  Parallel Hash  (cost=9907.00..9907.00 rows=44 width=20) (actual time=11.744..11.757 rows=23 loops=3)
                                Buckets: 1024  Batches: 1  Memory Usage: 72kB
                                Buffers: shared hit=4126
                                ->  Nested Loop  (cost=124.94..9907.00 rows=44 width=20) (actual time=5.681..11.705 rows=23 loops=3)
                                      Buffers: shared hit=4126
                                      ->  Parallel Bitmap Heap Scan on flight f  (cost=119.84..9225.95 rows=2 width=16) (actual time=5.646..11.615 rows=1 loops=3)
                                            Recheck Cond: (departure_airport = 'JFK'::bpchar)
                                            Filter: ((actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::timestamp with time zone) AND (arrival_airport = 'ORD'::b...
                                            Rows Removed by Filter: 3509
                                            Heap Blocks: exact=2684
                                            Buffers: shared hit=4096
                                            ->  Bitmap Index Scan on flight_departure_airport  (cost=0.00..119.84 rows=10589 width=0) (actual time=2.535..2.538 rows=10530 loops=1)
                                                  Index Cond: (departure_airport = 'JFK'::bpchar)
                                                  Buffers: shared hit=11
                                      ->  Bitmap Heap Scan on booking_leg bl  (cost=5.10..339.68 rows=85 width=8) (actual time=0.031..0.052 rows=17 loops=4)
                                            Recheck Cond: (flight_id = f.flight_id)
                                            Heap Blocks: exact=13
                                            Buffers: shared hit=30
                                            ->  Bitmap Index Scan on booking_leg_flight_id  (cost=0.00..5.08 rows=85 width=0) (actual time=0.024..0.024 rows=17 loops=4)
                                                  Index Cond: (flight_id = f.flight_id)
                                                  Buffers: shared hit=13
```



```
-> Gather Merge  (cost=276065.38..276069.53 rows=8 width=24) (actual time=1726.858..1727.739 rows=11 loops=1)
     Workers Planned: 2
     Workers Launched: 2
     Buffers: shared hit=4546 read=171289
     -> Partial GroupAggregate  (cost=275065.36..275068.59 rows=4 width=24) (actual time=1722.810..1722.816 rows=4 loops=3)
          Group Key: f.flight_id
          Buffers: shared hit=4546 read=171289
          -> Sort  (cost=275065.36..275066.42 rows=425 width=20) (actual time=1722.803..1722.806 rows=54 loops=3)
               Sort Key: f.flight_id
```

Increasing work_mem

```
shared_buffers=128MB

max_parallel_workers_per_gather=2
```

work_mem =500MB

1.8 sec

work_mem =1GB

1.8 sec

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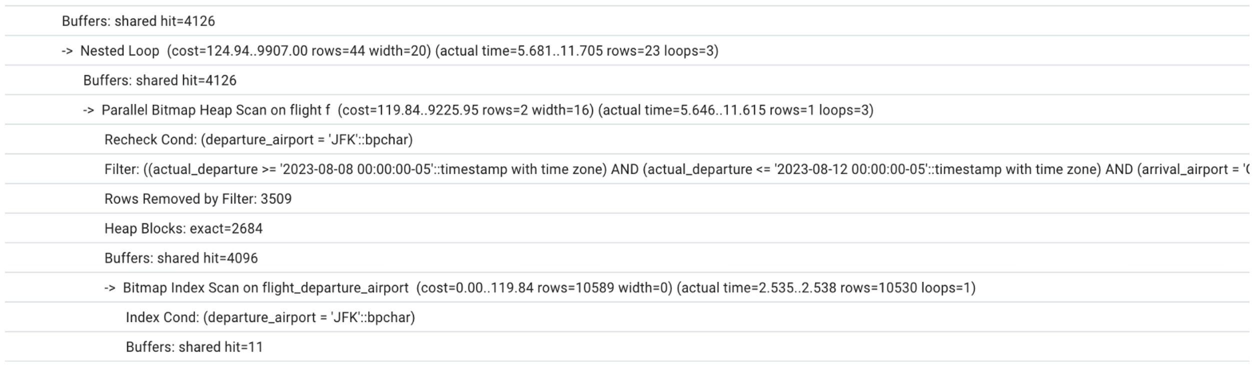
Increasing shared buffers (requires restart)

```
shared_buffers=1GB
Work_mem=4MB/100MB/500MB

1s


shared_buffers=2GB
Work_mem=500MB

1.1s
```

Let’s try something different!

Let’s take a closer look at the execution plans we have so far

Heap scan when looking for the departure dates between August 8 and 12.

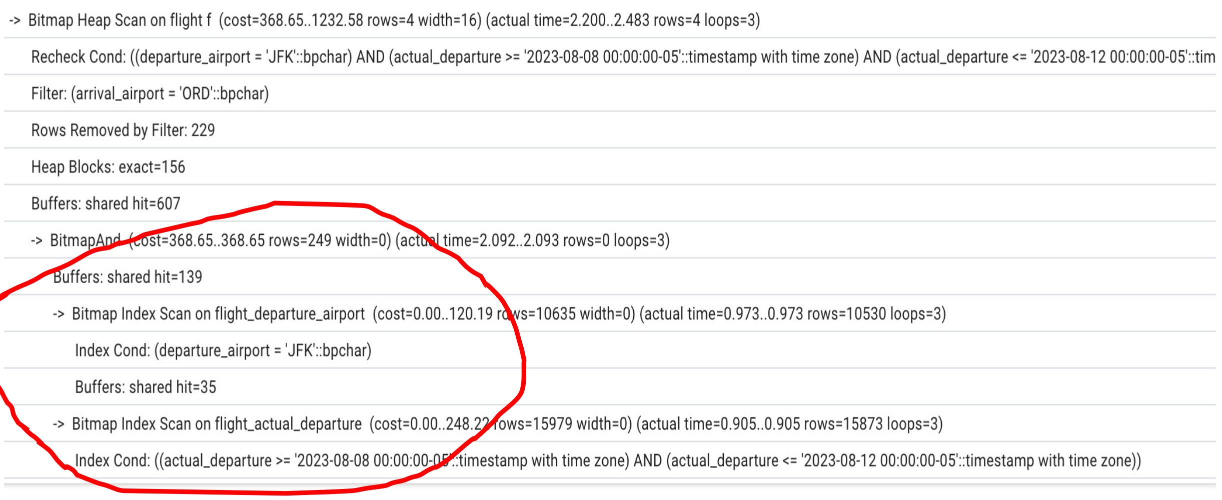


```
Buffers: shared hit=4126
-> Nested Loop  (cost=124.94..9907.00 rows=44 width=20) (actual time=5.681..11.705 rows=23 loops=3)
     Buffers: shared hit=4126
     -> Parallel Bitmap Heap Scan on flight f  (cost=119.84..9225.95 rows=2 width=16) (actual time=5.646..11.615 rows=1 loops=3)
          Recheck Cond: (departure_airport = 'JFK'::bpchar)
          Filter: ((actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::timestamp with time zone) AND (arrival_airport = '
          Rows Removed by Filter: 3509
          Heap Blocks: exact=2684
          Buffers: shared hit=4096
          -> Bitmap Index Scan on flight_departure_airport  (cost=0.00..119.84 rows=10589 width=0) (actual time=2.535..2.538 rows=10530 loops=1)
               Index Cond: (departure_airport = 'JFK'::bpchar)
               Buffers: shared hit=11
```

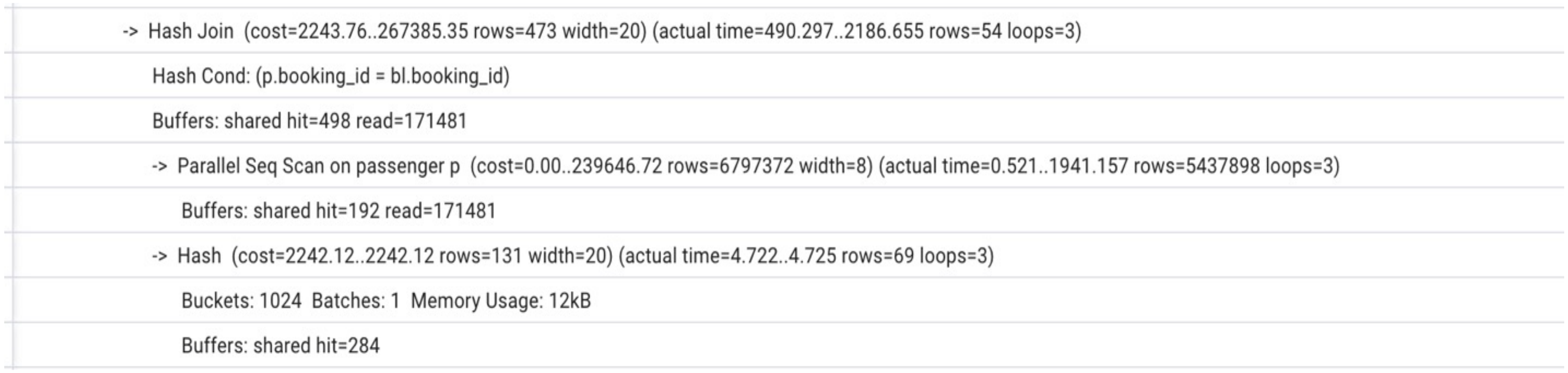
Build the index

```
CREATE INDEX
flight_actual_departure
    ON postgres_air.flight
    (actual_departure);
```

Execution time: 0.7 s



```
-> Bitmap Heap Scan on flight f  (cost=368.65..1232.58 rows=4 width=16) (actual time=2.200..2.483 rows=4 loops=3)
   Recheck Cond: ((departure_airport = 'JFK'::bpchar) AND (actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::tim
   Filter: (arrival_airport = 'ORD'::bpchar)
   Rows Removed by Filter: 229
   Heap Blocks: exact=156
   Buffers: shared hit=607
   -> BitmapAnd  (cost=368.65..368.65 rows=249 width=0) (actual time=2.092..2.093 rows=0 loops=3)
      Buffers: shared hit=139
      -> Bitmap Index Scan on flight_departure_airport  (cost=0.00..120.19 rows=10635 width=0) (actual time=0.973..0.973 rows=10530 loops=3)
         Index Cond: (departure_airport = 'JFK'::bpchar)
         Buffers: shared hit=35
      -> Bitmap Index Scan on flight_actual_departure  (cost=0.00..248.22 rows=15979 width=0) (actual time=0.905..0.905 rows=15873 loops=3)
         Index Cond: ((actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::timestamp with time zone))
```



```
-> Hash Join  (cost=2243.76..267385.35 rows=473 width=20) (actual time=490.297..2186.655 rows=54 loops=3)
     Hash Cond: (p.booking_id = bl.booking_id)
     Buffers: shared hit=498 read=171481
     -> Parallel Seq Scan on passenger p  (cost=0.00..239646.72 rows=6797372 width=8) (actual time=0.521..1941.157 rows=5437898 loops=3)
          Buffers: shared hit=192 read=171481
     -> Hash  (cost=2242.12..2242.12 rows=131 width=20) (actual time=4.722..4.725 rows=69 loops=3)
          Buckets: 1024  Batches: 1  Memory Usage: 12kB
          Buffers: shared hit=284
```

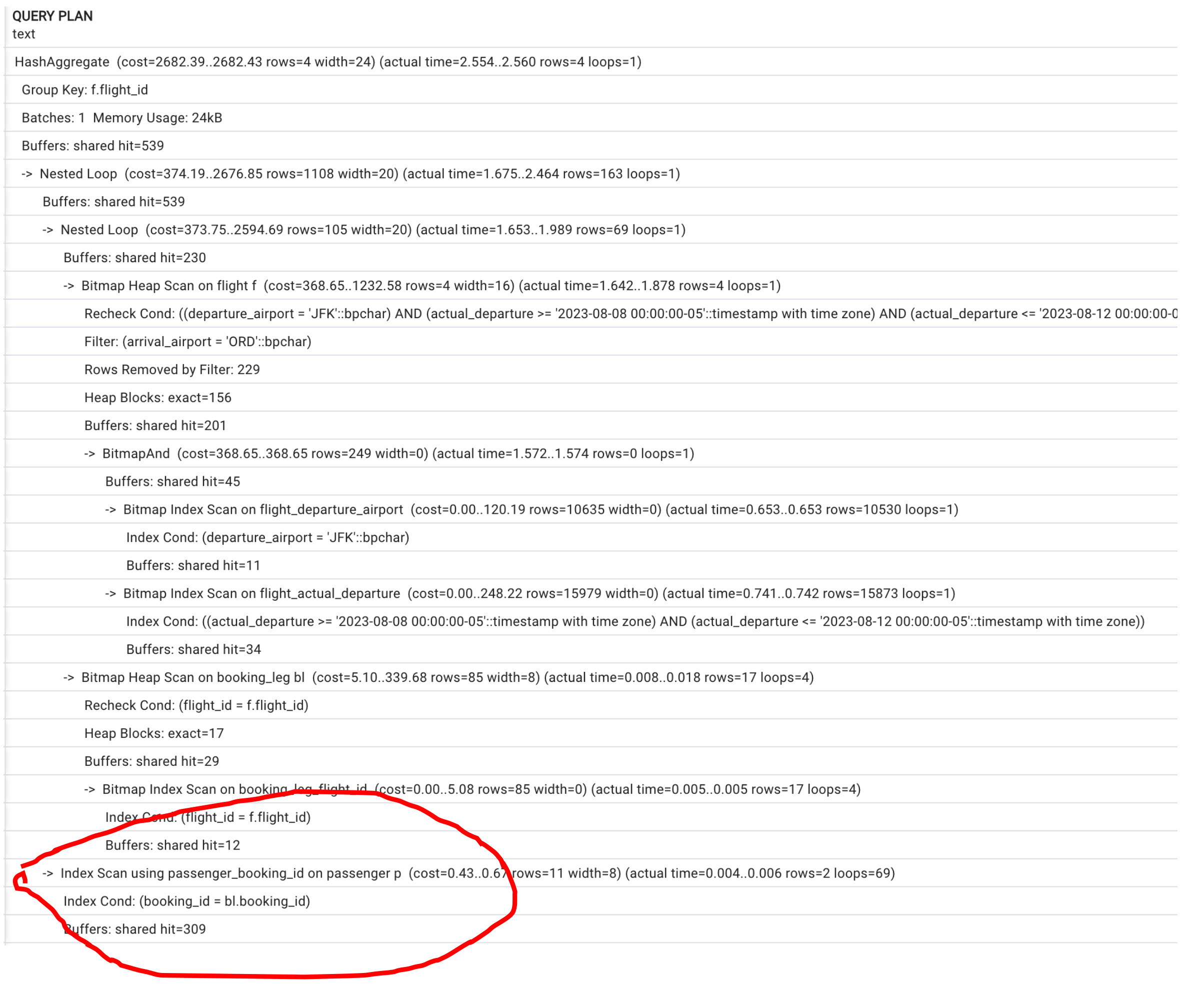
Build another index!

CREATE INDEX passenger_booking_id

    ON postgres_air.passenger

    (booking_id);

Execution time: 60 ms



```
QUERY PLAN
text
HashAggregate  (cost=2682.39..2682.43 rows=4 width=24) (actual time=2.554..2.560 rows=4 loops=1)
  Group Key: f.flight_id
  Batches: 1  Memory Usage: 24kB
  Buffers: shared hit=539
  ->  Nested Loop  (cost=374.19..2676.85 rows=1108 width=20) (actual time=1.675..2.464 rows=163 loops=1)
        Buffers: shared hit=539
        ->  Nested Loop  (cost=373.75..2594.69 rows=105 width=20) (actual time=1.653..1.989 rows=69 loops=1)
              Buffers: shared hit=230
              ->  Bitmap Heap Scan on flight f  (cost=368.65..1232.58 rows=4 width=16) (actual time=1.642..1.878 rows=4 loops=1)
                    Recheck Cond: ((departure_airport = 'JFK'::bpchar) AND (actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-0
                    Filter: (arrival_airport = 'ORD'::bpchar)
                    Rows Removed by Filter: 229
                    Heap Blocks: exact=156
                    Buffers: shared hit=201
                    ->  BitmapAnd  (cost=368.65..368.65 rows=249 width=0) (actual time=1.572..1.574 rows=0 loops=1)
                          Buffers: shared hit=45
                          ->  Bitmap Index Scan on flight_departure_airport  (cost=0.00..120.19 rows=10635 width=0) (actual time=0.653..0.653 rows=10530 loops=1)
                                Index Cond: (departure_airport = 'JFK'::bpchar)
                                Buffers: shared hit=11
                          ->  Bitmap Index Scan on flight_actual_departure  (cost=0.00..248.22 rows=15979 width=0) (actual time=0.741..0.742 rows=15873 loops=1)
                                Index Cond: ((actual_departure >= '2023-08-08 00:00:00-05'::timestamp with time zone) AND (actual_departure <= '2023-08-12 00:00:00-05'::timestamp with time zone))
                                Buffers: shared hit=34
              ->  Bitmap Heap Scan on booking_leg bl  (cost=5.10..339.68 rows=85 width=8) (actual time=0.008..0.018 rows=17 loops=4)
                    Recheck Cond: (flight_id = f.flight_id)
                    Heap Blocks: exact=17
                    Buffers: shared hit=29
                    ->  Bitmap Index Scan on booking_leg_flight_id  (cost=0.00..5.08 rows=85 width=0) (actual time=0.005..0.005 rows=17 loops=4)
                          Index Cond: (flight_id = f.flight_id)
                          Buffers: shared hit=12
        ->  Index Scan using passenger_booking_id on passenger p  (cost=0.43..0.67 rows=11 width=8) (actual time=0.004..0.006 rows=2 loops=69)
              Index Cond: (booking_id = bl.booking_id)
              Buffers: shared hit=309
```

What will happen if we return parameters back to default?

The execution plan will remain the same (and the execution speed as well!)

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Understanding the role of parameters

Communicating the hardware characteristics to PostgreSQL

Examples:

- RAM 16 GB/ shared_buffers 128MB
- RAM 16 GB/shared_buffers 4 GB/ work_mem 200MB/max_connections 1000
- random_page_cost 4

Application changes

Not necessarily NORM!

Examples:

- Using ‘=‘ instead of ‘~’
- Column transform: trunc(created_dt)=CURRENT_DATE
- Committing each record
- Not committing until the batch end

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Q&A

Hettie Dombrovskaya
Database Architect DRW

hdombrovska@drwholdings.com

www.drw.com