



 zalando

# NOSQL FOR POSTGRESQL

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## BEST PRACTICES



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→ Jsonb internals and performance-related factors

- Jsonb internals and performance-related factors
- Benchmarks

- Jsonb internals and performance-related factors
- Benchmarks
- How to shoot yourself in the foot

# Internals

# Performance-related factors



## **Performance-related factors**

→ On-disk representation

## Performance-related factors

- On-disk representation
- In-memory representation

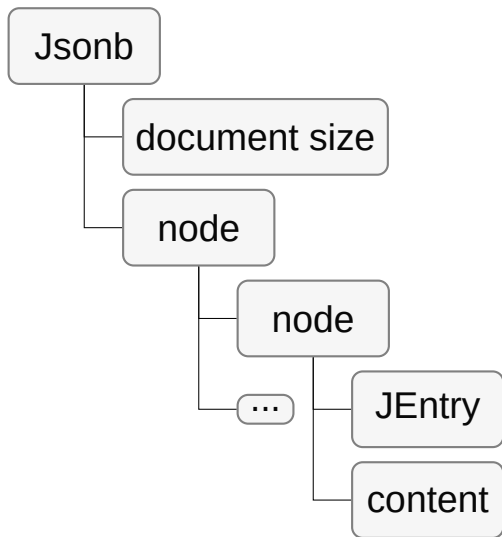
## Performance-related factors

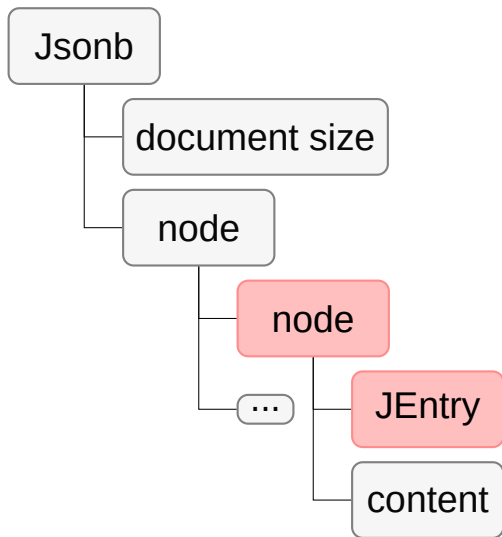
- On-disk representation
- In-memory representation
- Indexing support

**HOW MUCH INFO CAN I PUT  
TO A JSON DOCUMENT**



**TO WORK EFFICIENTLY WITH IT?**





Jsonb Header

type

number of items

JEntry

length or offset?

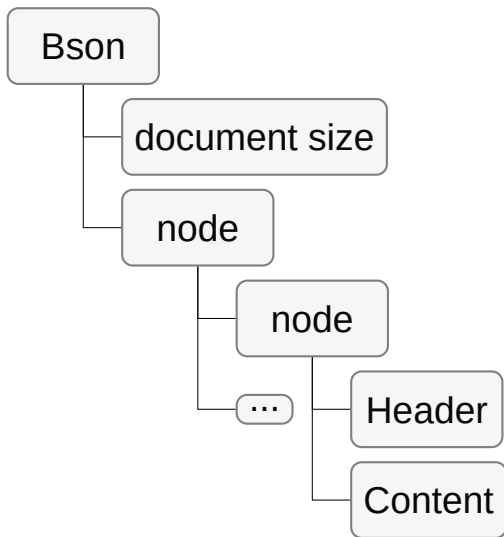
value type

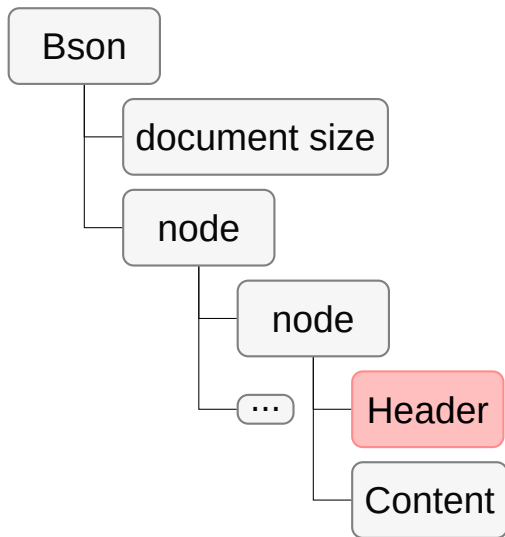
value length or offset

## JB\_OFFSET\_STRIDE

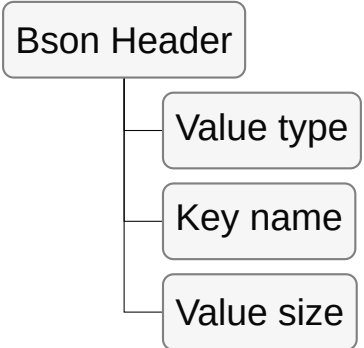
- JEntry may contains a value lenght or offset
- Offset = access speed
- Length = compressibility
- Every **JB\_OFFSET\_STRIDE**'th JEntry contains an offset
- Rest of them contain length







Bson Header



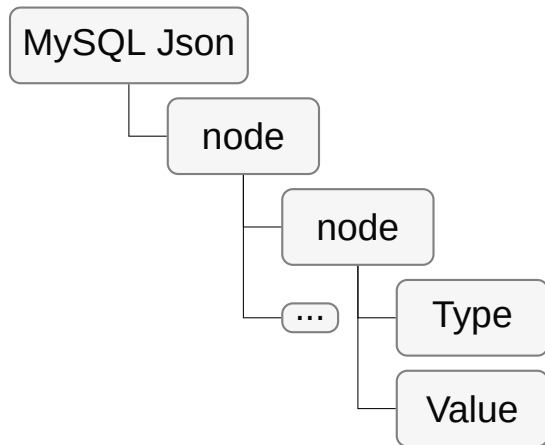
```
graph TD; A[Bson Header] --- B[Value type]; A --- C[Key name]; A --- D[Value size];
```

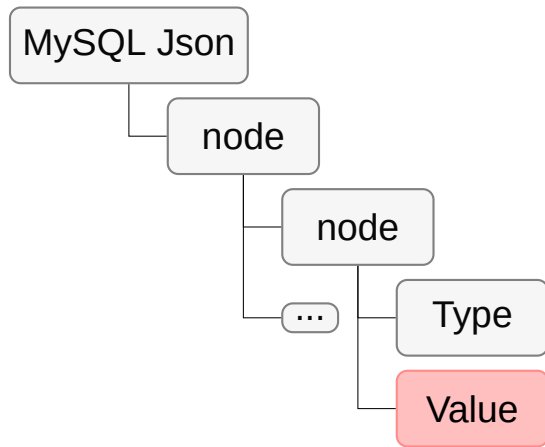
The diagram illustrates the structure of a Bson Header. It consists of a main box labeled 'Bson Header' which is connected by a vertical line to three stacked boxes on the right: 'Value type', 'Key name', and 'Value size'. Each of these three boxes is connected to the main vertical line by a horizontal line.

Value type

Key name

Value size





## MySQL Json Object

Count of elements

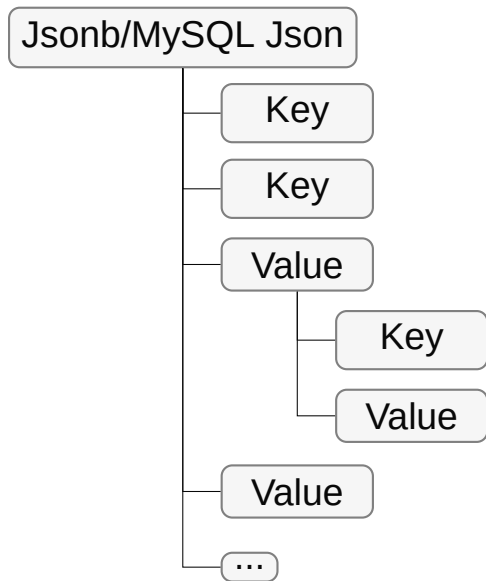
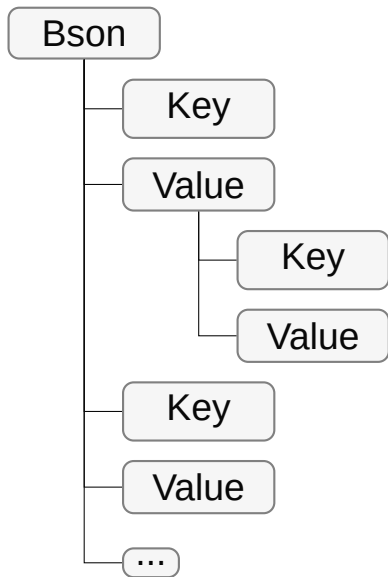
Size

Pointers to keys

Pointers to values

Keys

Values



```
{"a": 3, "b": "xyz"}
```





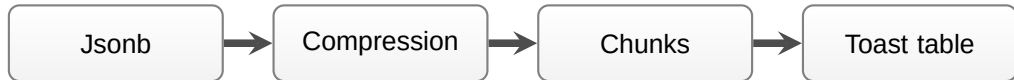
```
bson.dumps({"a": 3, "b": u"xyz"})
```

```
\x17\x00\x00\x00\x10a\x00\x03\x00\x00\x00\x02b\x00\x04\x00\x00\x00xyz\x00\x00
```

```
$ hexdump -C database/table.ibd
```

```
\x00\x02\x00\x18\x00\x12\x00\x01\x00\x13\x00\x01\x00\x05\x03\x00\x0c\x14\x00ab\x03xyz\x00
```

## TOAST



- TOAST\_TUPLE\_THRESHOLD bytes (normally 2 kB)
- PostgreSQL and MySQL use LZ variation
- MongoDB uses snappy block compression

## Alignment

Variable-length portion is aligned to a 4-byte

```
insert into test  
values('{"a": "aa", "b": 1}');
```

```
abaa\x20\x00\x00\x00\x00\x80\x01\x00
```

```
insert into test  
values('{"a": 1, "b": "aa"}');
```

```
\x00\x00ab\x00\x00\x20\x00\x00\x00\x00\x80\x01\x00aa
```

## In-memory representation

- Tree-like representation (JsonbValue, Document, Json\_dom)
- Little bit more expensive but more convenient to work with
- Mostly in use to modify data (except MySQL)
- Most of the read operations use on-disk representation

## Indexing support

- Postgresql – single field, multiple fields, entire document
- MongoDB – single field, multiple fields
- MySQL – virtual columns, single field, multiple fields

## PG indexing details

- JGIN\_MAXLENGTH
- jsonb\_path
- jsonb\_path\_ops



# Queries

## Pitfalls

- Queries with an array somewhere in the middle
- Iterating through document
- Update inside document

```
{  
  "items": [  
    {"id": 1, "value": "aaa"},  
    {"id": 2, "value": "bbb"}  
  ],  
  "items": [  
    {"id": 3, "value": "aaa"},  
    {"id": 4, "value": "bbb"}  
  ]  
}
```

```
WITH items AS (  
    SELECT jsonb_array_elements(data->'items')  
    AS item FROM test  
)  
SELECT * FROM items  
WHERE item->'value' = 'aaa';
```

item

---

```
{ "id": 1, "value": "aaa" }  
{ "id": 3, "value": "aaa" }  
(2 rows)
```

```
{  
  "items": {  
    "item1": {"status": true},  
    "item2": {"status": true},  
    "item3": {"status": false}  
  }  
}
```

```
WITH items AS (  
    SELECT jsonb_each(data->'items')  
    AS item FROM test  
)  
SELECT (item).key FROM items  
WHERE (item).value->'status' = 'true';  
  
key  
--  
item1  
item2  
(2 rows)
```

```
{  
  "items": [  
    {"id": 3, "value": "ccc"},  
    {"id": 4, "value": "ddd"}  
  ],  
  "items": [  
    {"id": 1, "value": "aaa"},  
    {"id": 2, "value": "bbb"}  
  ]  
}
```

```
UPDATE test
SET data = jsonb_set(data, '{items}',
(SELECT
    jsonb_agg(
        CASE WHEN item->'value' = 'aaa'
        THEN jsonb_set(item, '{value}', '"NEW"')
        ELSE item END
    )
FROM (SELECT
    jsonb_array_elements(data->'items')
    AS item) q));
```



# Benchmarks



**GREAT PERFORMANCE**

## AWS EC2

m4.xlarge instance

separate instance (database and generator)

16GB memory, 4 core 2.3GHz

Ubuntu 16.04

Same VPC and placement group

AMI that supports HVM virtualization type

at least 4 rounds of benchmark

PostgreSQL 9.6.3

MySQL 5.7.9/8.0

MongoDB 3.4.4

YCSB 0.13

$10^6$  rows and operations

AWS EC2

# Configuration

shared\_buffers

effective\_cache\_size

max\_wal\_size

innodb\_buffer\_pool\_size

innodb\_log\_file\_size

write concern level (journalled or transaction\_sync)

checkpoint

eviction

## Document types

“simple” document

10 key/value pairs (100 characters)

“large” document

100 key/value pairs (200 characters)

“complex” document

100 keys, 3 nesting levels (100 characters)

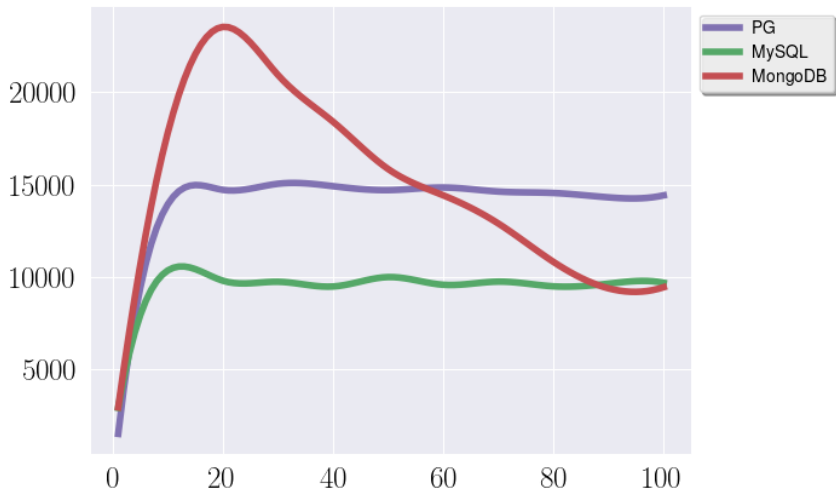
## Select, GIN

"simple" document

jsonb\_path\_ops

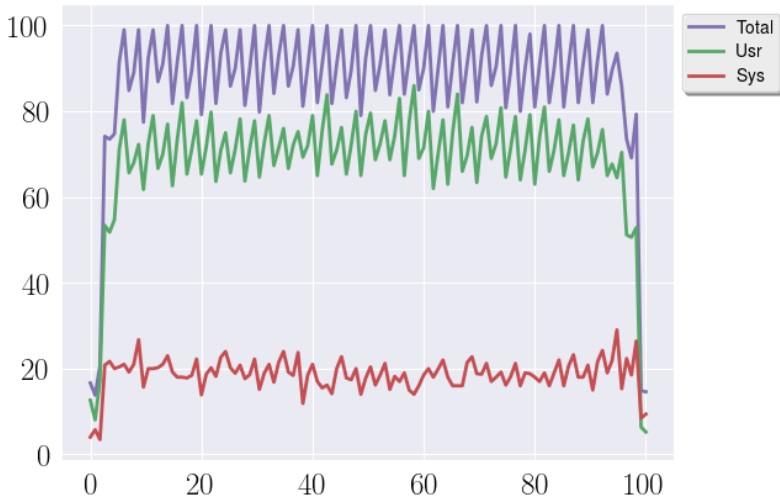
where data @> '{"key": "value"}'::jsonb

# Throughput (ops/sec)

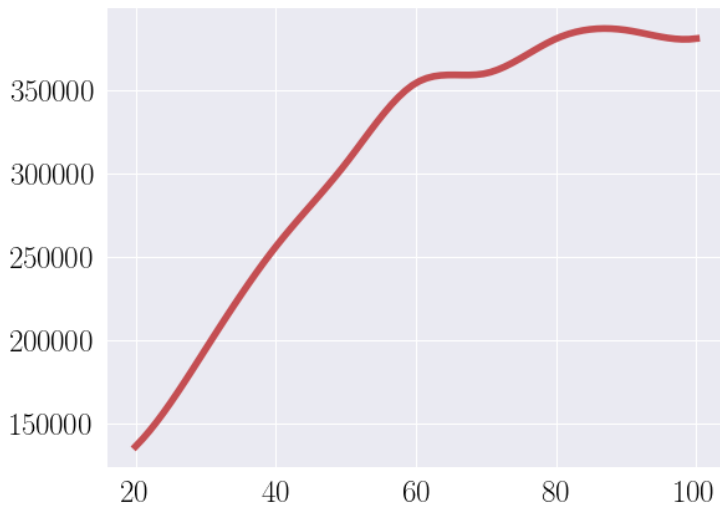




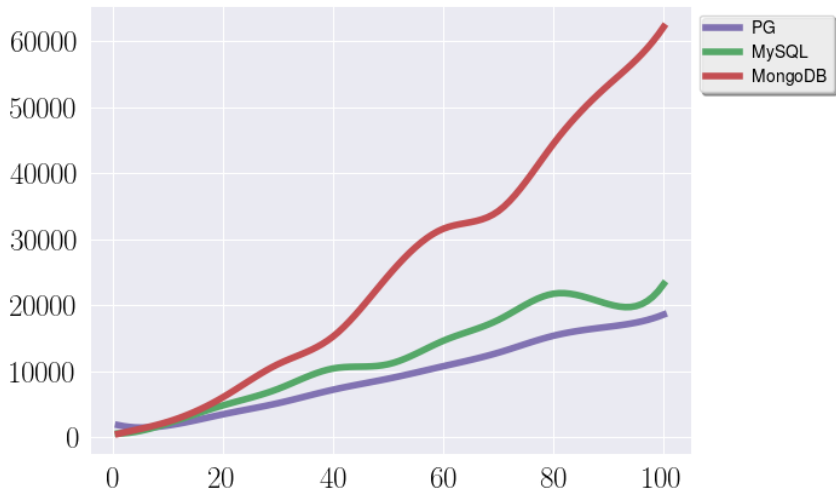
# CPU%



# CPU migrations (MongoDB)



## Latency 99% ( $\mu s$ )

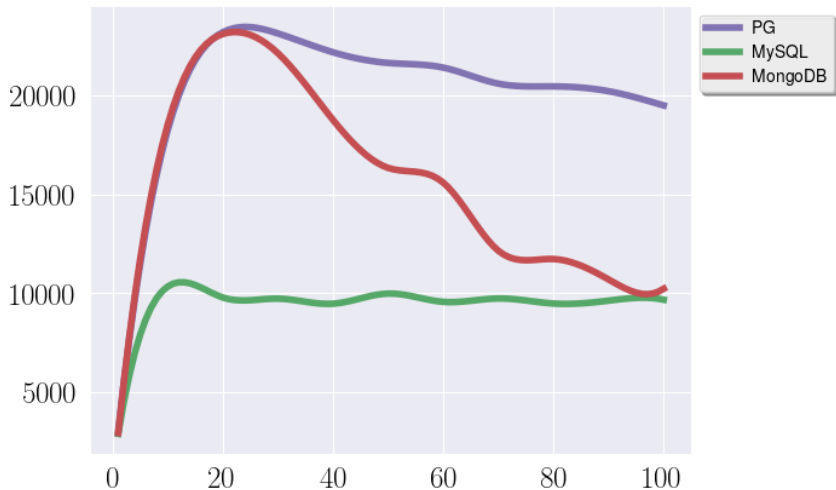


## Select, BTree

"simple" document

btree

# Throughput (ops/sec)

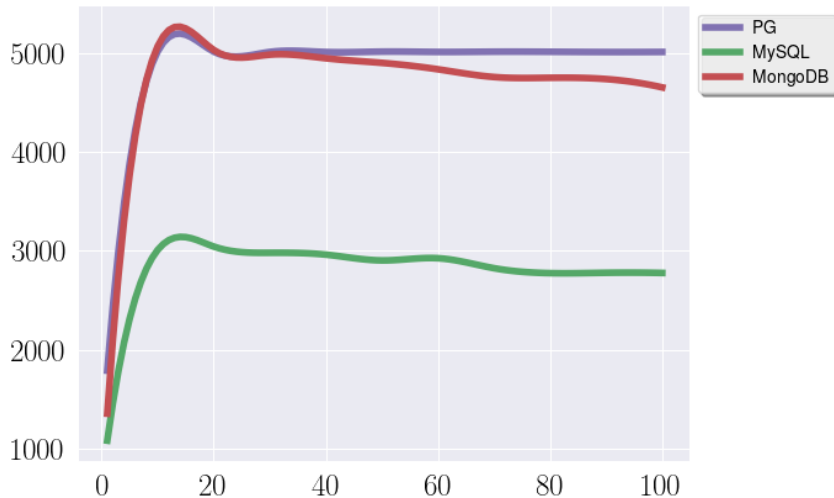


## Select, BTree

"complex" document

btree

# Throughput (ops/sec)



## Scalability

"simple" document

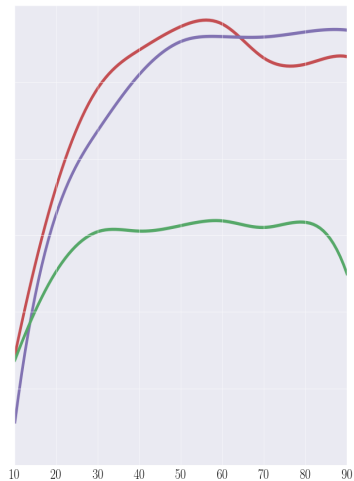
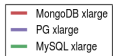
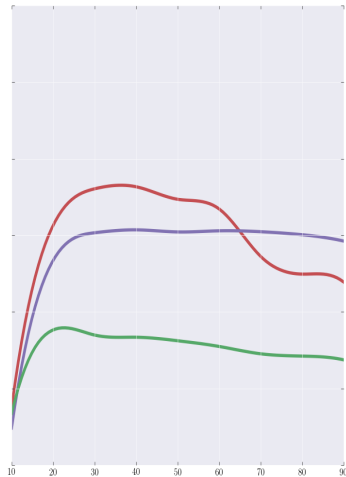
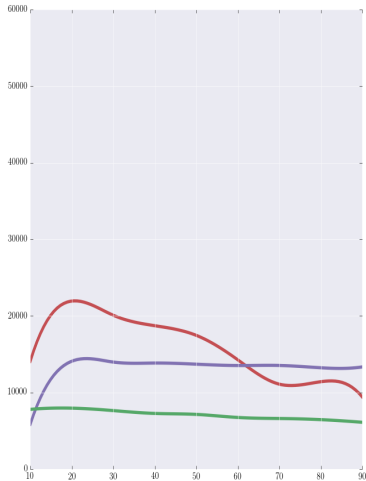
m4.large

m4.xlarge

m4.2xlarge



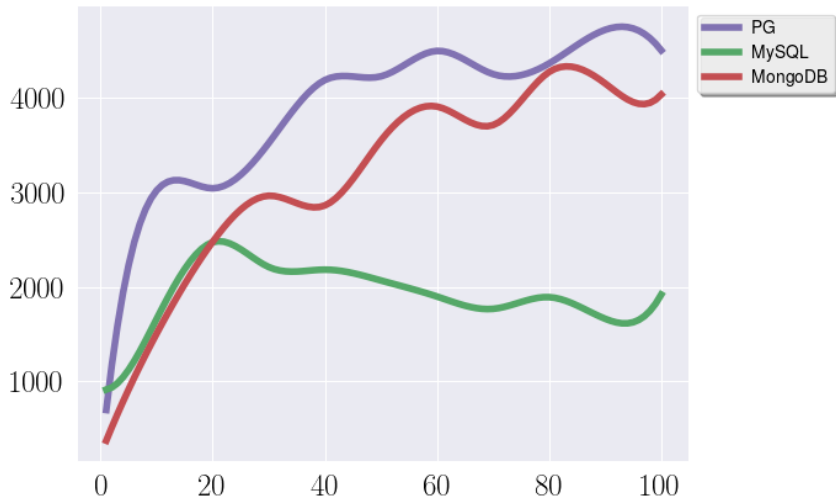
## Throughput (ops/sec)



## Insert

"simple" document  
journalized

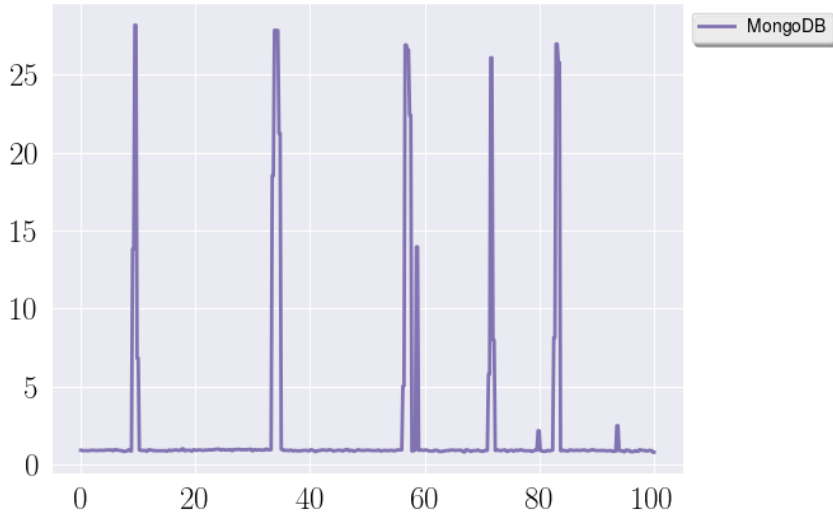
# Throughput (ops/sec)



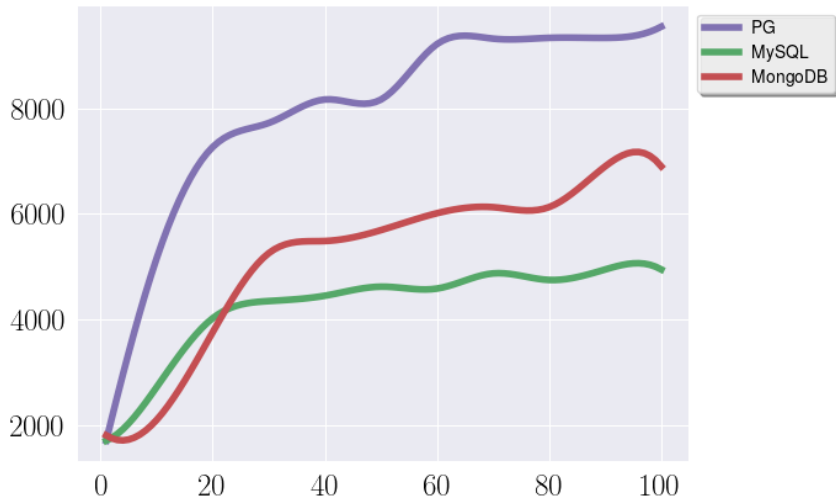
# CPU%



# IO queue size



# Throughput (ops/sec)



## **Update 50%, Select 50%**

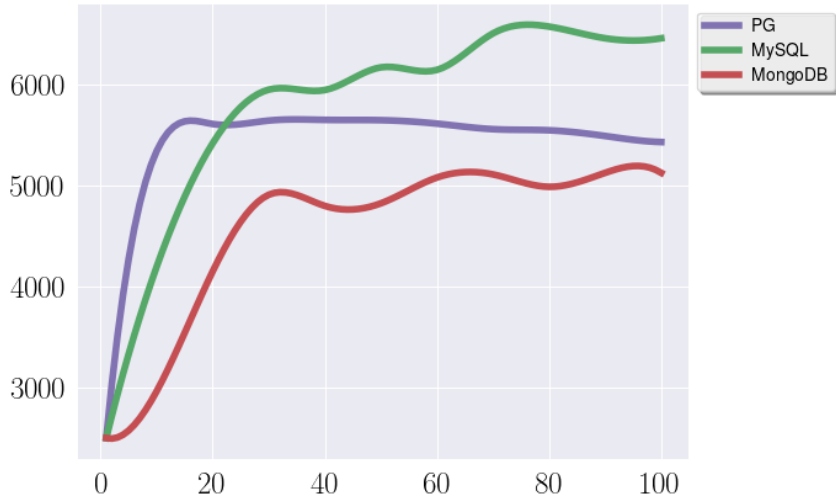
"simple" document

Update one field

journalled

max wal size 1GB

# Throughput (ops/sec)





## **Update 50%, Select 50%**

"large" document

Update one field

# Throughput (ops/sec)



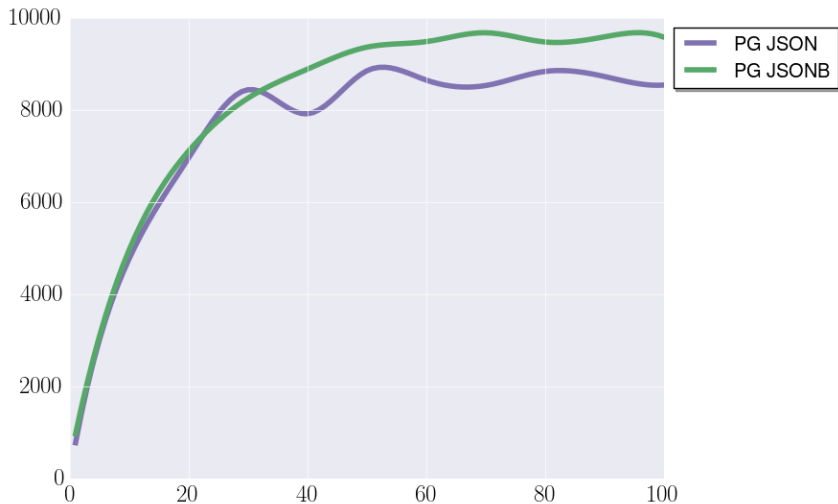
## JSON vs JSONB

"simple" document

btree

insert

## Throughput (ops/sec)



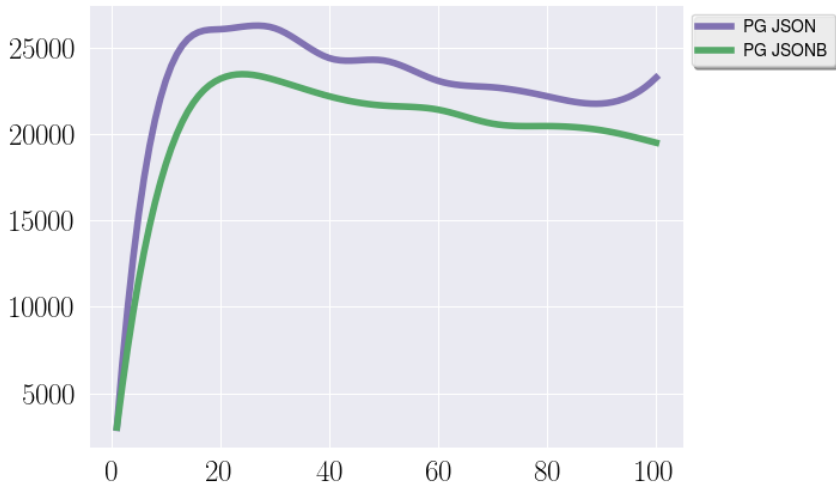
## JSON vs JSONB

"simple" document

btree

select

# Throughput (ops/sec)



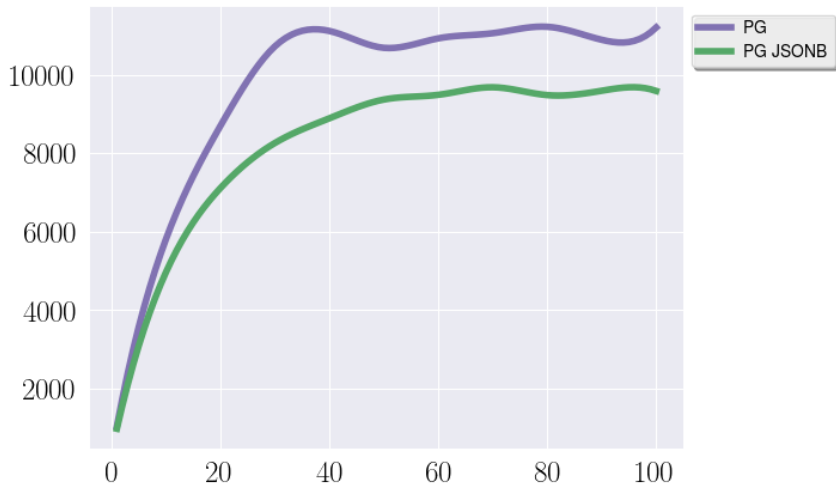
## SQL vs JSONB

"simple" document

btree

insert

# Throughput (ops/sec)





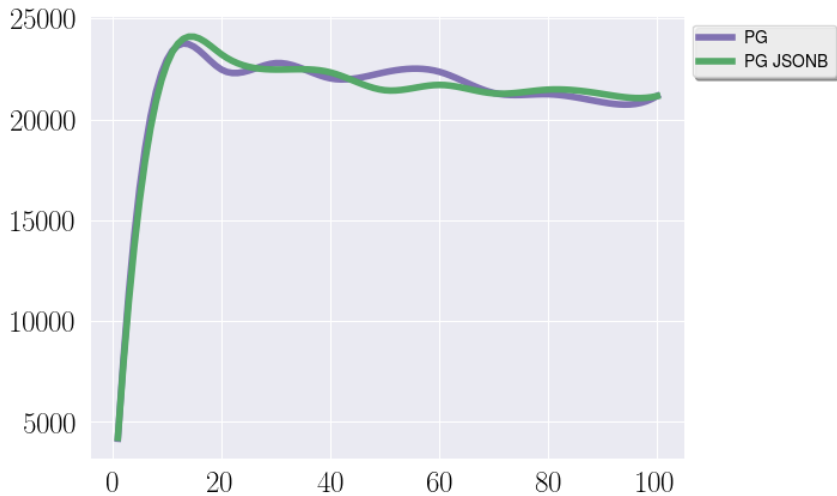
## SQL vs JSONB

"simple" document

btree

select

# Throughput (ops/sec)





How to bring it down accidentally?

**WHAT COULD POSSIBLY GO WRONG?**



- Update one field of a document
- DETOAST of a document  
(select, constraints, procedures etc.)
- Reindex of an entire document

## Document slice

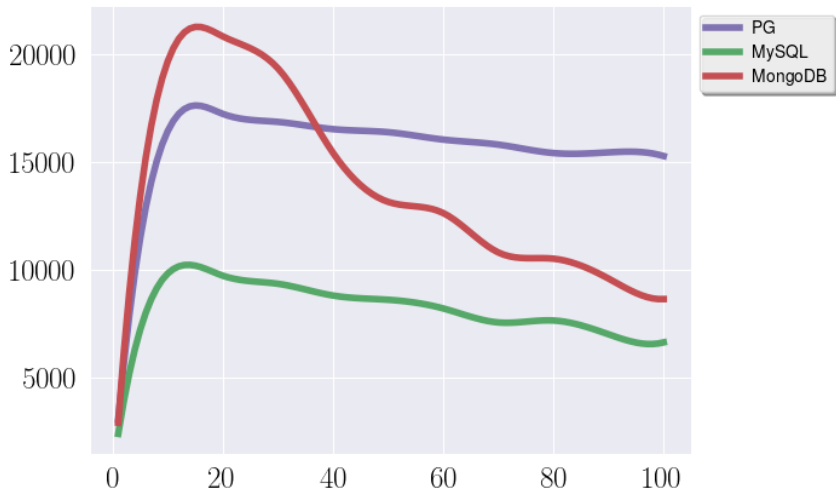
"large" document

One field from a document

```
select data→'key1'→'key2' from table;
```

```
select data→'key1', data→'key2' from table;
```

# Throughput (ops/sec)



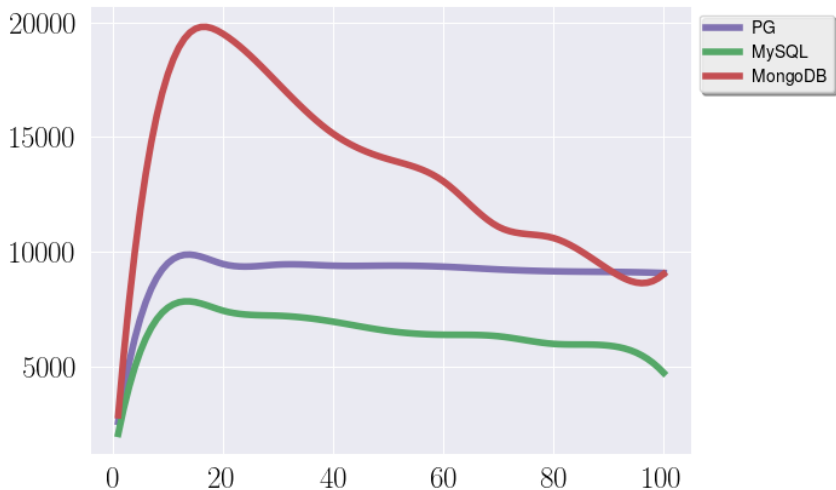


## Document slice

"large" document

10 fields from a document

# Throughput (ops/sec)



## Document slice

```
create type test as ("a" text, "b" text);
insert into test_jsonb
values('{"a": 1, "b": 2, "c": 3}');
select q.* from test_jsonb,
jsonb_populate_record(NULL::test, data) as q;
```

a	b
---	---

—+—

1	2
---	---

(1 row)

A person wearing a black hoodie and a backpack stands with their arms crossed on a glowing blue grid floor that recedes into the distance. The background is a dark space filled with stars and nebulae. The text "SET STORAGE EXTERNAL" is overlaid in large white letters across the lower half of the image.

**SET STORAGE EXTERNAL**

## TOAST\_TUPLE\_THRESHOLD

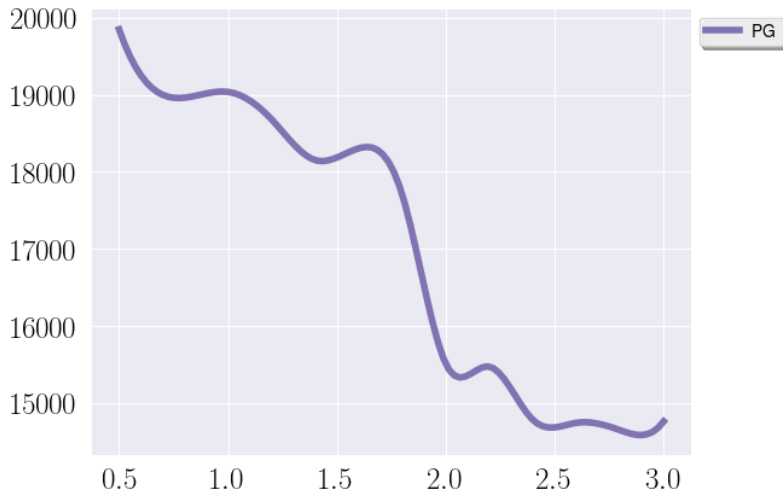
"simple" document

40 threads

different document size

select

## Throughput, 40 clients



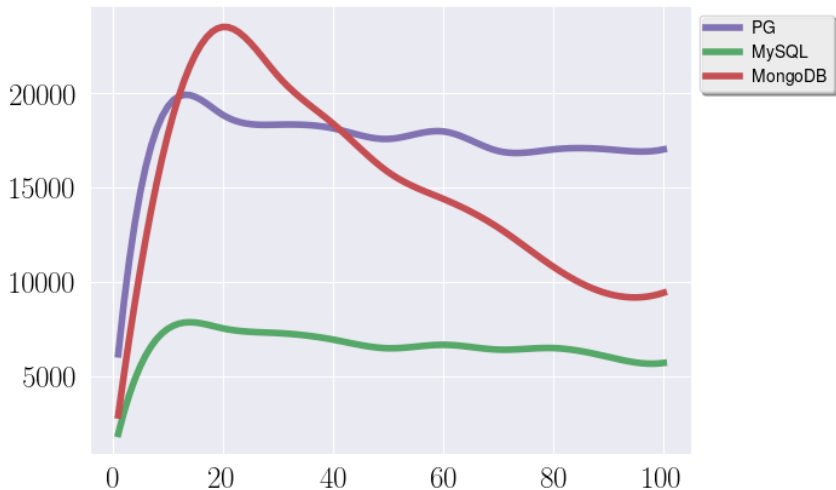
## Select, GIN

"simple" document

jsonb\_path\_ops

where data @> jsonb\_build\_object('key', 'value')

# Throughput (ops/sec)





→ Jsonb is more than good for many use cases


- Jsonb is more than good for many use cases
- Benchmarks above are only "hints"

- Jsonb is more than good for many use cases
- Benchmarks above are only "hints"
- You need your own tests

## Questions?

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