



# NOSQL FOR POSTGRESQL

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BEST PRACTICES

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→ Jsonb internals and performance-related factors

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- Tricky queries

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- Benchmarks

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

Live Long,  
and Prosper

- Han Solo





## AWS EC2

m4.large 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 9.6.3/10

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)

# Performance-related factors

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→ On-disk representation

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- On-disk representation
- In-memory representation

## Performance-related factors

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



## Indexing support

- PostgreSQL – single path, multiple paths, entire document
- MongoDB – single path, multiple paths
- MySQL – virtual columns, single path, multiple paths

## PG indexing details

→ jsonb\_path

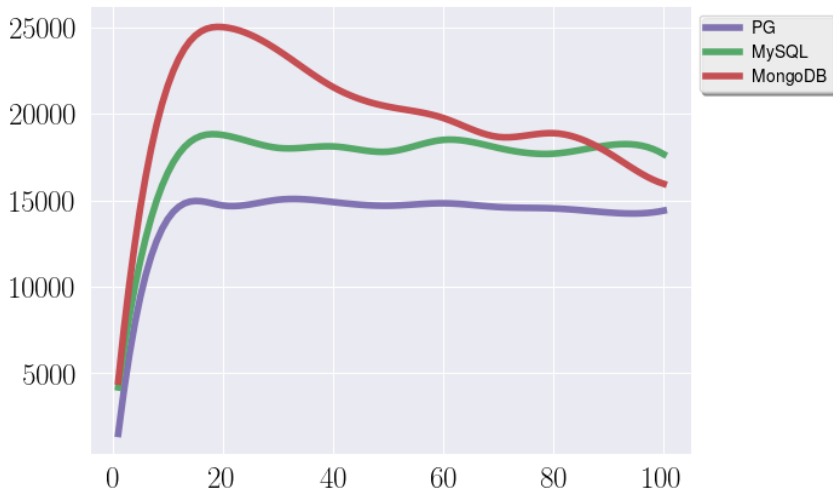
→ jsonb\_path\_ops

## Select, GIN

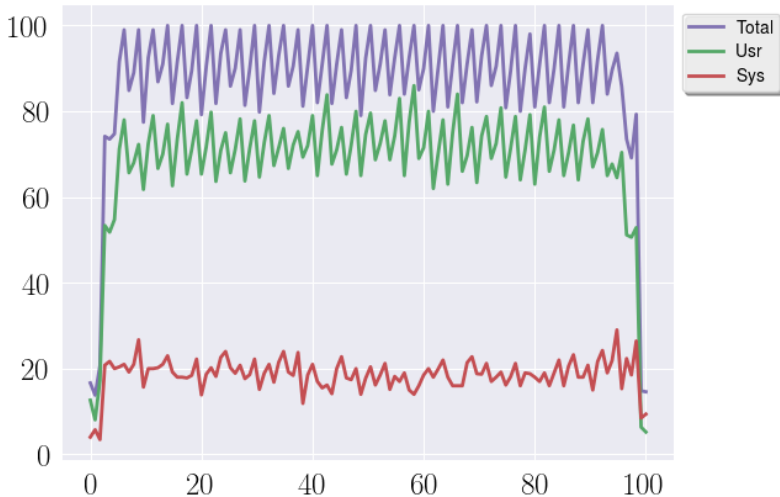
"simple" document

jsonb\_path\_ops

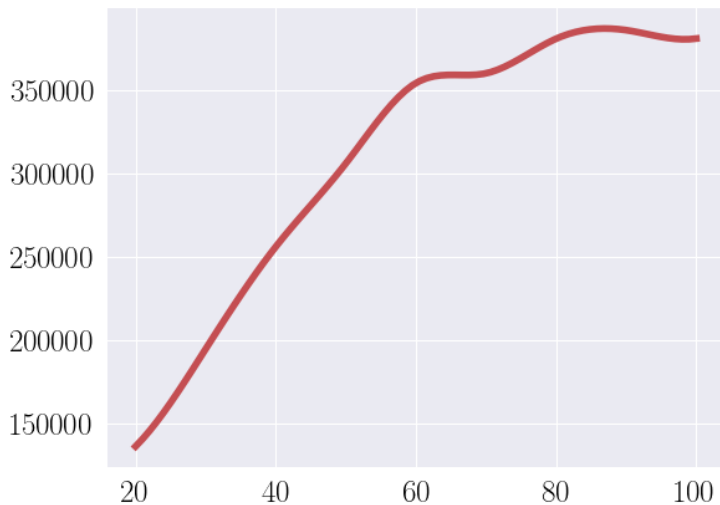
# Throughput (ops/sec)



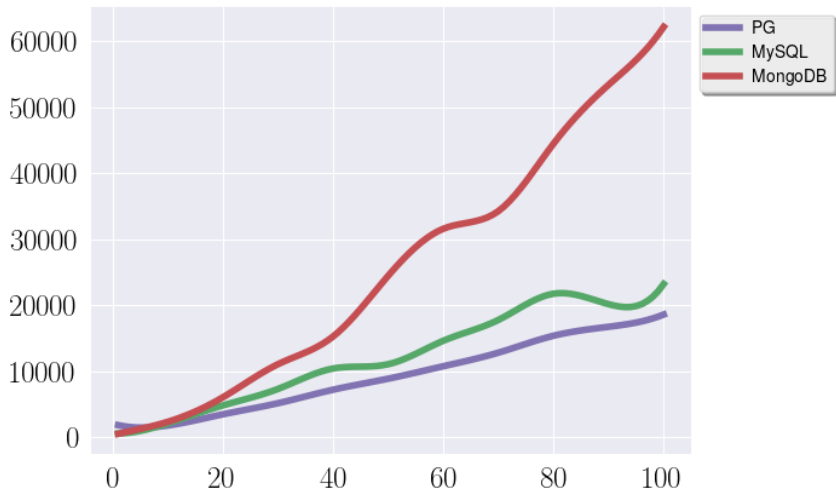
# CPU%



# CPU migrations (MongoDB)



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



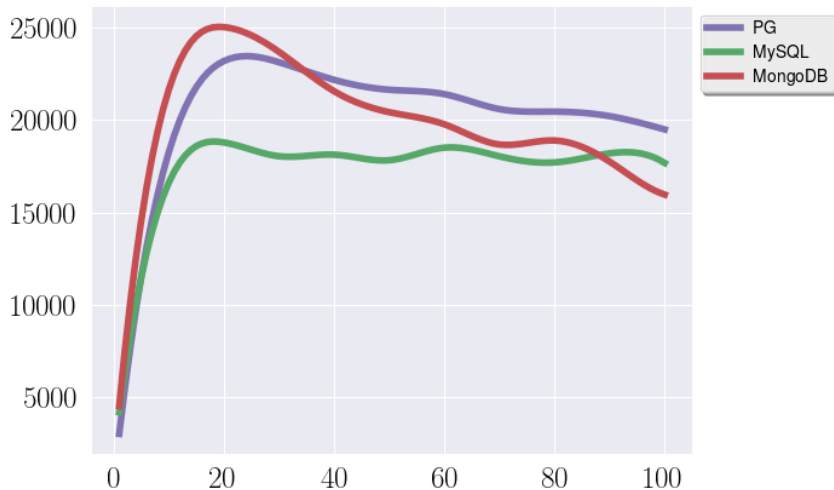
## Select, BTree

"simple" document

btree



# Throughput (ops/sec)

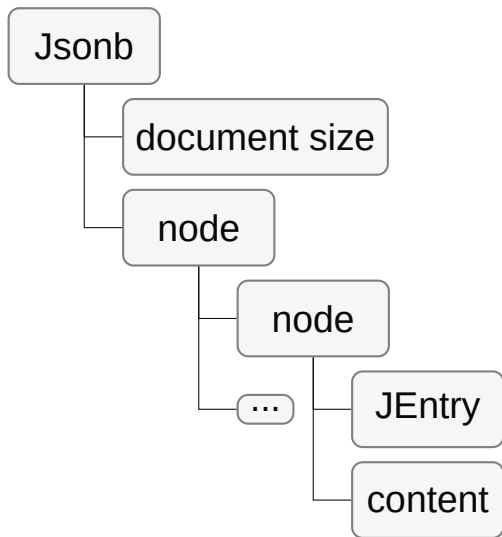


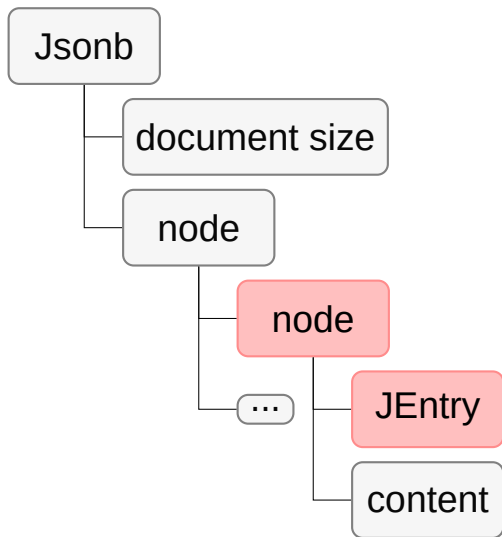
# Internals

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



**TO WORK EFFICIENTLY WITH IT?**





Jsonb Header

type

number of items

JEntry

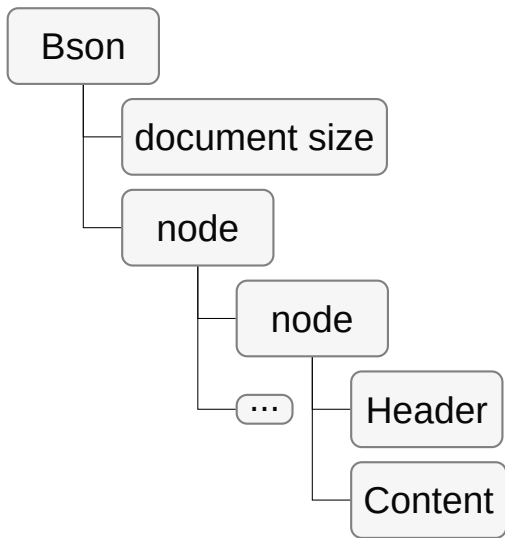
length or offset?

value type

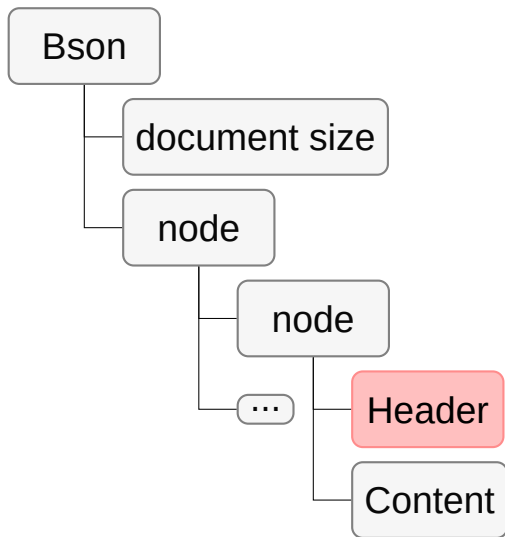
value length or offset

## JB\_OFFSET\_STRIDE

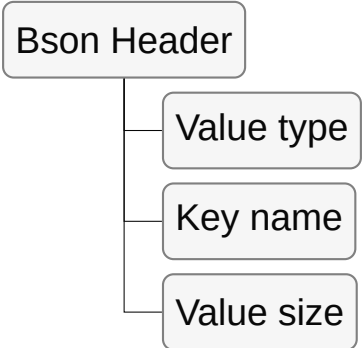
- JEntry may contains a value lenght or offset
- Offset = access speed
- Length = compressibility
- Every **JB\_OFFSET\_STRIDE**'th JEntry contains an offset
- Rest of them contain length







Bson Header



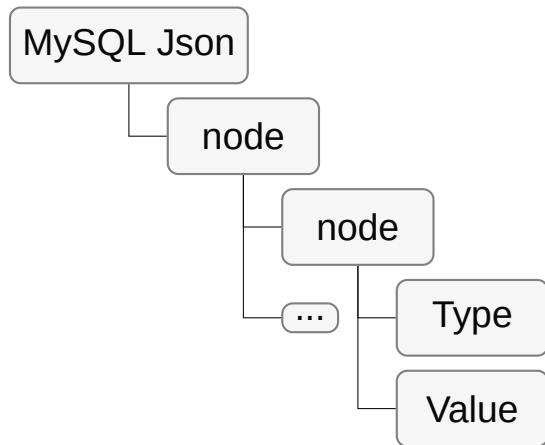
```
graph TD; A[Bson Header] --- B[Value type]; A --- C[Key name]; A --- D[Value size];
```

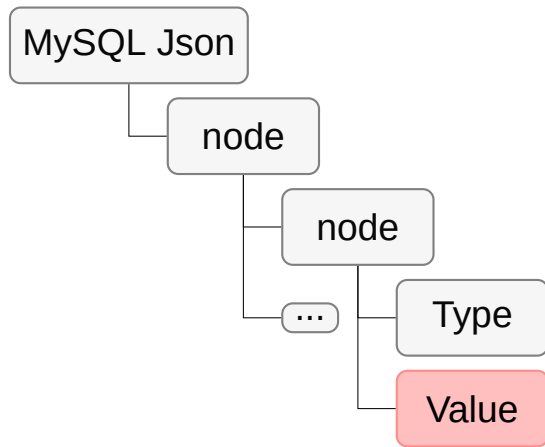
The diagram illustrates the structure of a Bson Header. It consists of a main box labeled 'Bson Header' which is connected by a vertical line to three stacked boxes on the right: 'Value type', 'Key name', and 'Value size'. Each of these three boxes is connected to the main vertical line by a horizontal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

Value type

Key name

Value size





## MySQL Json Object

Count of elements

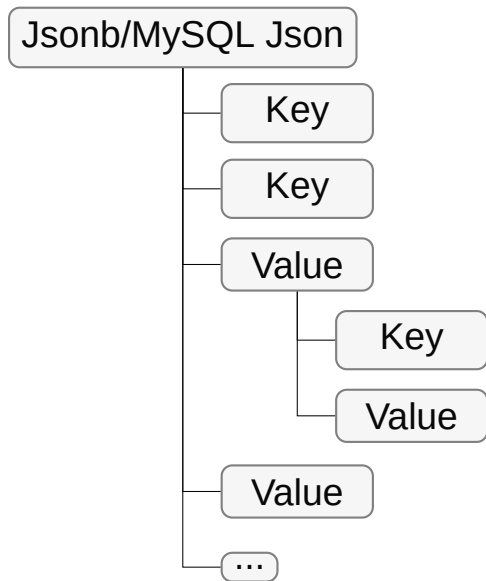
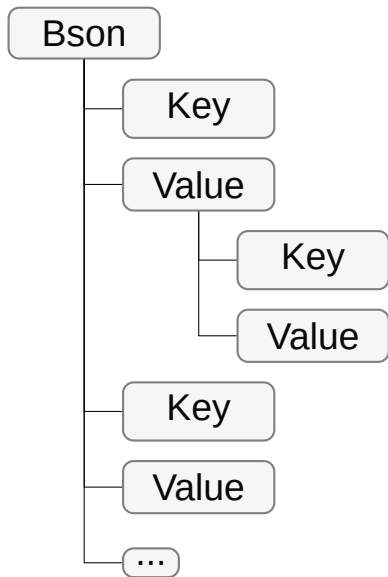
Size

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
```

# 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"}');
```

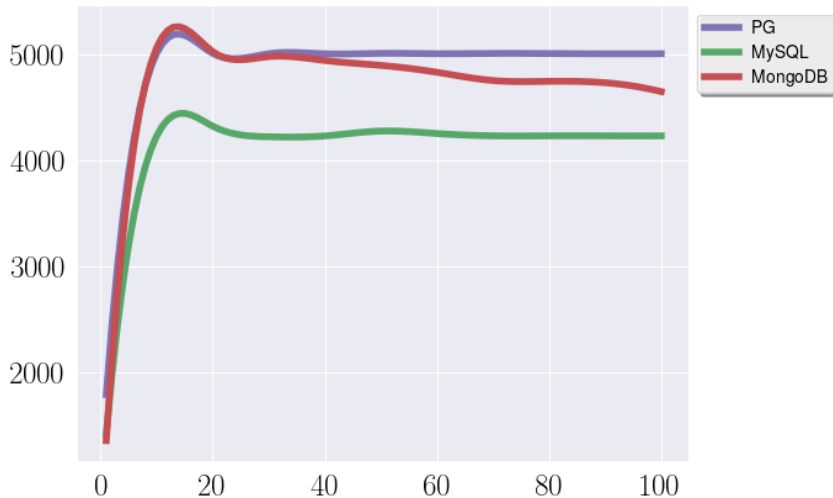
```
\x00\x00ab\x00\x00\x20\x00\x00\x00\x00\x80\x01\x00aa
```

## Select, BTree

"complex" document

btree

# Throughput (ops/sec)



## TOAST\_TUPLE\_THRESHOLD

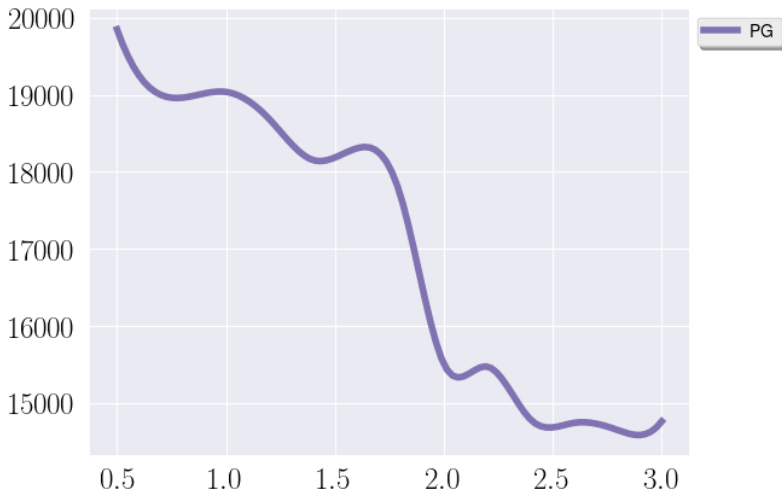
"simple" document

40 threads

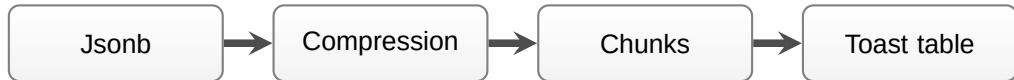
different document size

select

## Throughput, 40 clients



## TOAST



- `TOAST_TUPLE_THRESHOLD` bytes (normally 2 kB)
- PostgreSQL and MySQL use LZ variation
- MongoDB uses snappy block compression



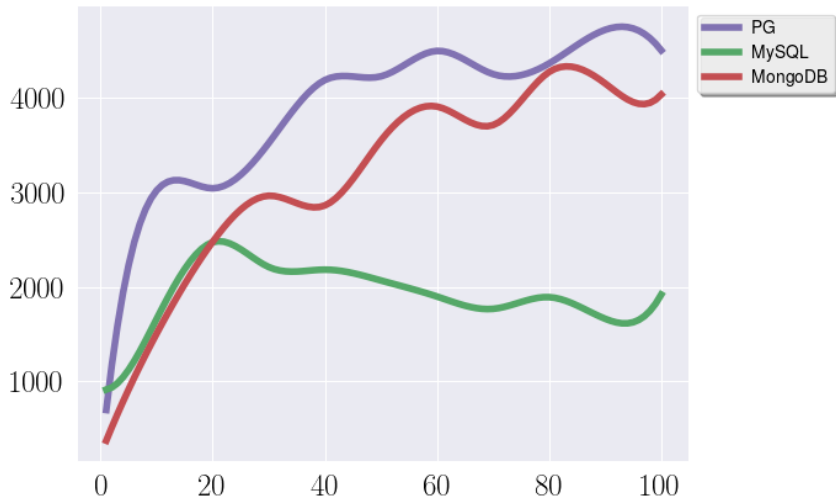
## In-memory representation

- 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

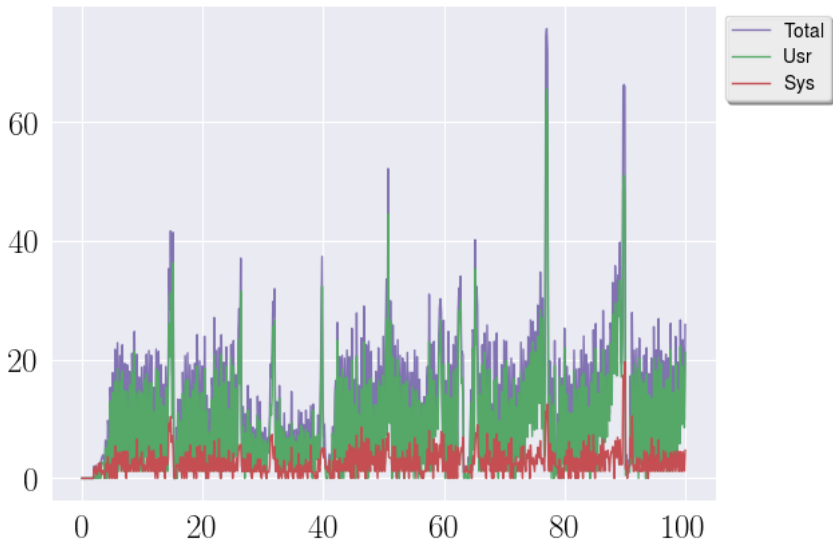
## Insert

"simple" document  
journalled

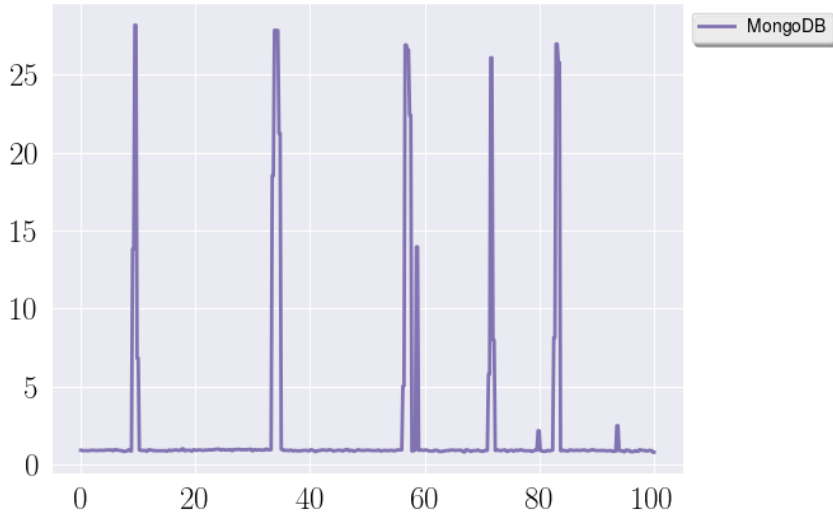
# Throughput (ops/sec)



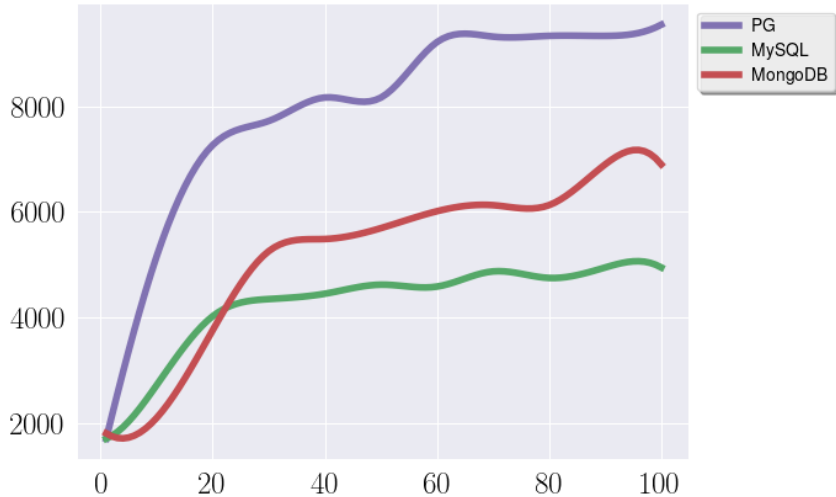
# CPU%



# IO queue size



# Throughput (ops/sec)



**WHAT COULD POSSIBLY GO WRONG?**



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

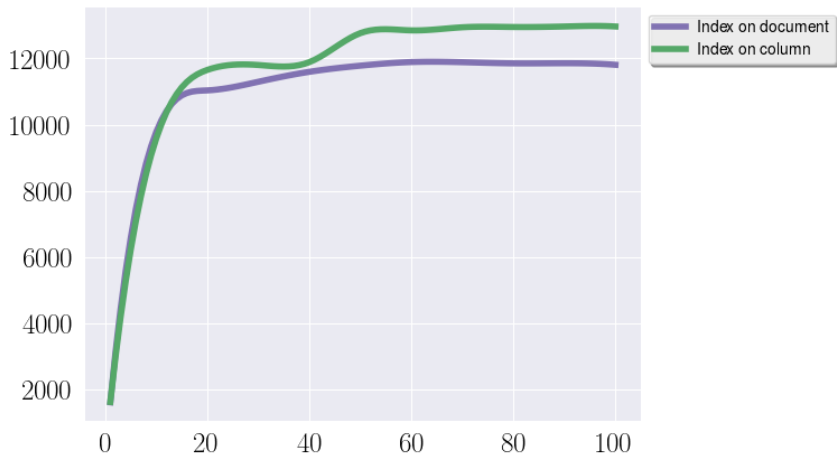


## Index update

"simple" document

Update one field

## PG, Throughput (ops/sec)



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

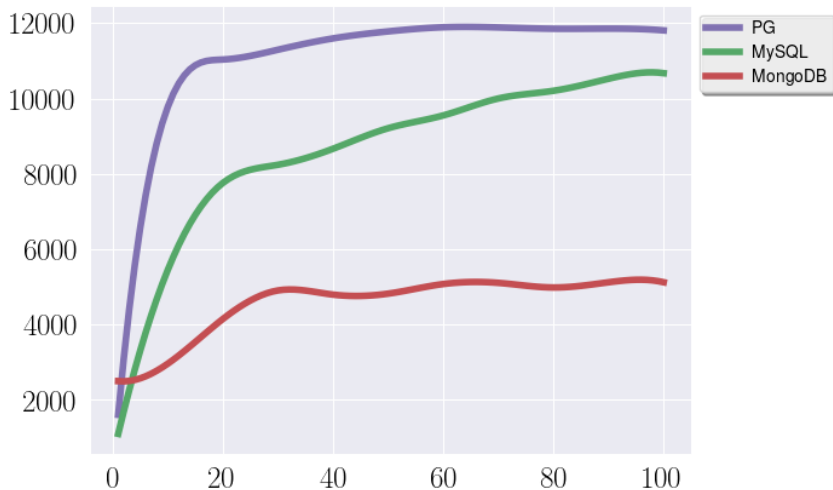
"simple" document

Update one field

journalled

max wal size 5GB

# Throughput (ops/sec)

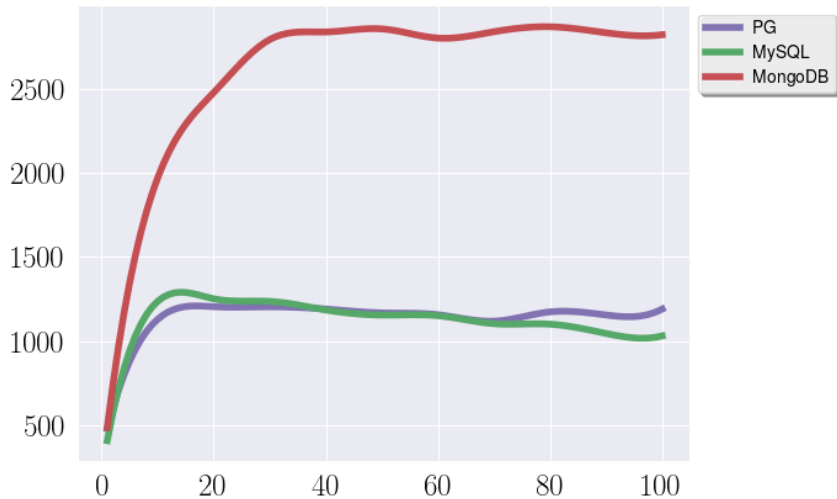


## **Update 50%, Select 50%**

"large" document

Update one field

# Throughput (ops/sec)



## Journal

```
{  
  "aaa": "aaa",  
  "bbb": "bbb",  
  "ccc": "ccc"  
}
```

```
{  
  "aaa": "ddd",  
  "bbb": "bbb",  
  "ccc": "ccc"  
}
```

# Postgresql

```
\x00\x00\xaaabbbcccdddbbaaa\x00\x00\x00\x0000\x02\x00\x00
```

# Mysql

```
\x0c\x2a\x00aaabbbccc\x03ddd\x03bbb\x03ccc7\x18\x00\x00\x10
```

# MongoDB

```
\x8a4\x02aaa\x00\x04\x00\x00\x00ddd\x00\x00
```



## Document slice

"large" document

One field from a document

```
select data->'key1'->'key2' from table;
```

```
select data->'key1', data->'key2' from table;
```

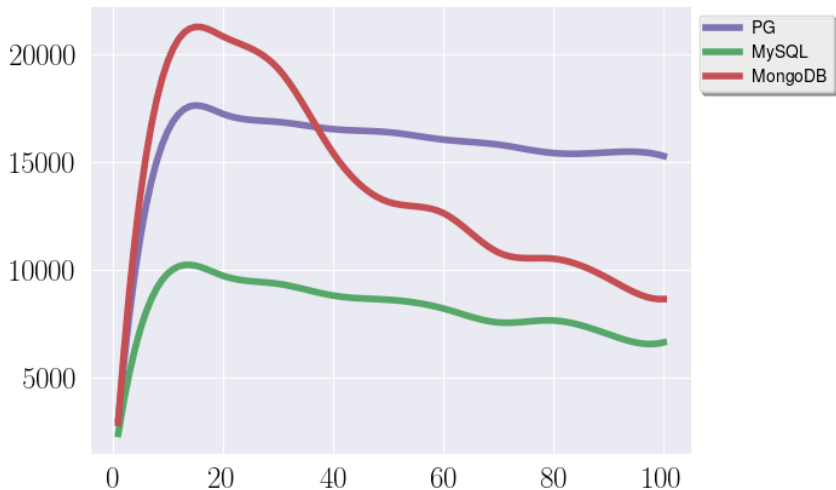
```
select data->'key1' -> 'key2' from table;
```

```
select data->'key1', data->'key2' from table;
```

```
select data->'key1'->'key2' from table;
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```
select data->'key1', data->'key2' from table;
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# Throughput (ops/sec)

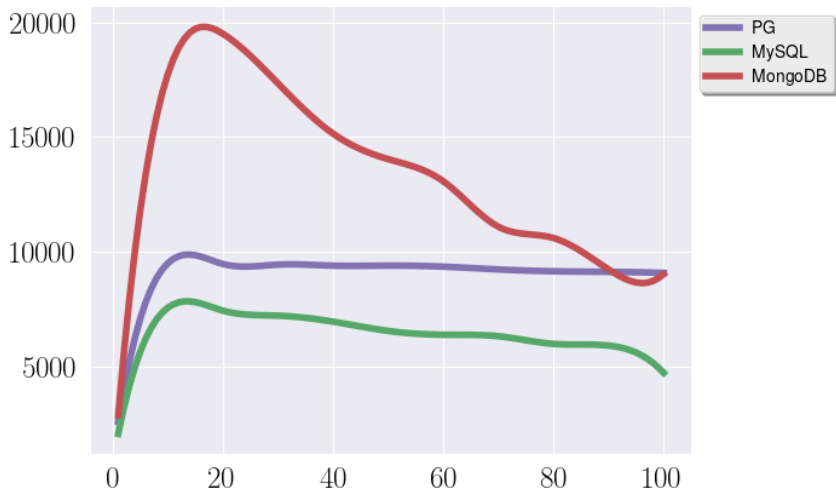


## Document slice

"large" document

10 fields from a document

# Throughput (ops/sec)



## Solutions?

- set storage external
- different query



## 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)

## Document slice

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

a	b
1	2

(1 row)

# Queries

## Pitfalls

- No Json path out of the box (jquery, SQL/JSON)
- 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)
```

```
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)
```

```
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)
```



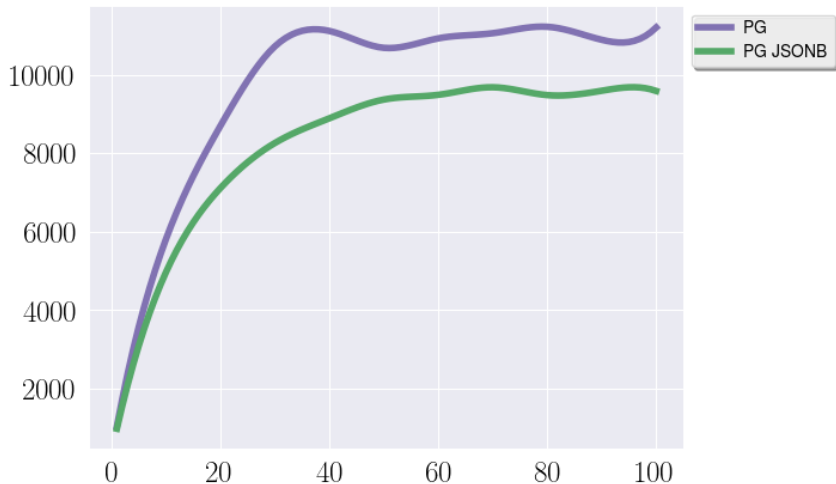
## SQL vs JSONB

"simple" document

btree

insert

# Throughput (ops/sec)



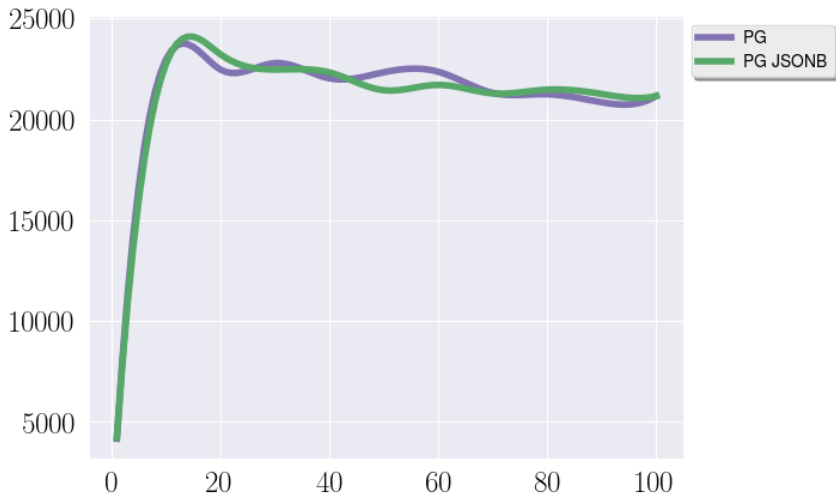
## SQL vs JSONB

"simple" document

btree

select

# Throughput (ops/sec)



## JSON vs JSONB

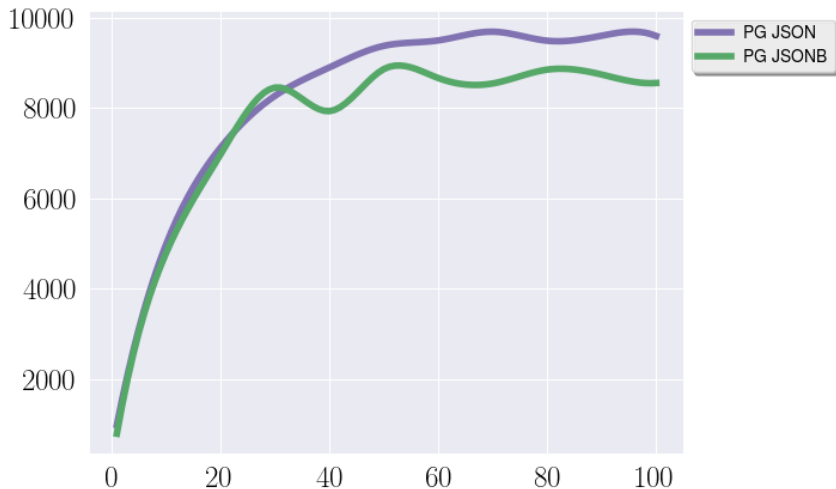
"simple" document

btree

insert



# Throughput (ops/sec)



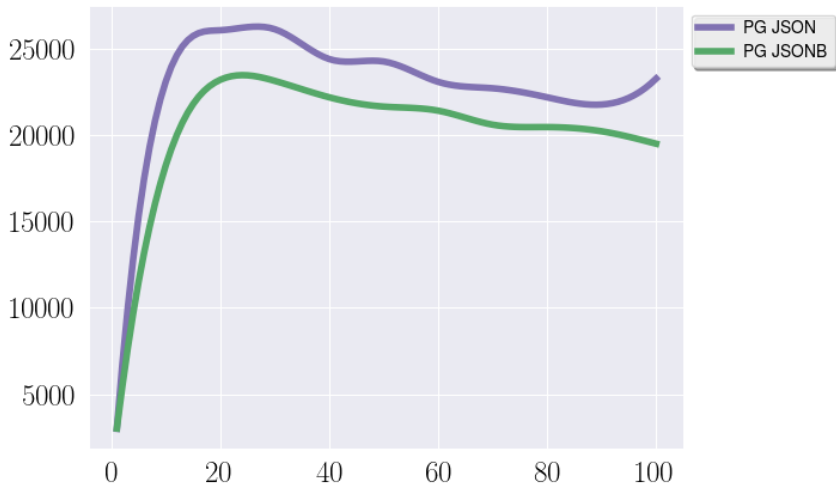
## JSON vs JSONB

"simple" document

btree

select

# Throughput (ops/sec)



→ Jsonb is more than good for many use cases

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- Reasons for performance difference is mostly database itself


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- Benchmarks above are only "hints"

- Jsonb is more than good for many use cases
- Reasons for performance difference is mostly database itself
- Benchmarks above are only "hints"
- You need your own tests

## Questions?

 [github.com/erthalion](https://github.com/erthalion)

 @erthalion

 9erthalion6 at gmail dot com