# Lessons Learned from OpenTSDB

Or why OpenTSDB is the way it is
and how it changed iteratively to
correct some of the mistakes made


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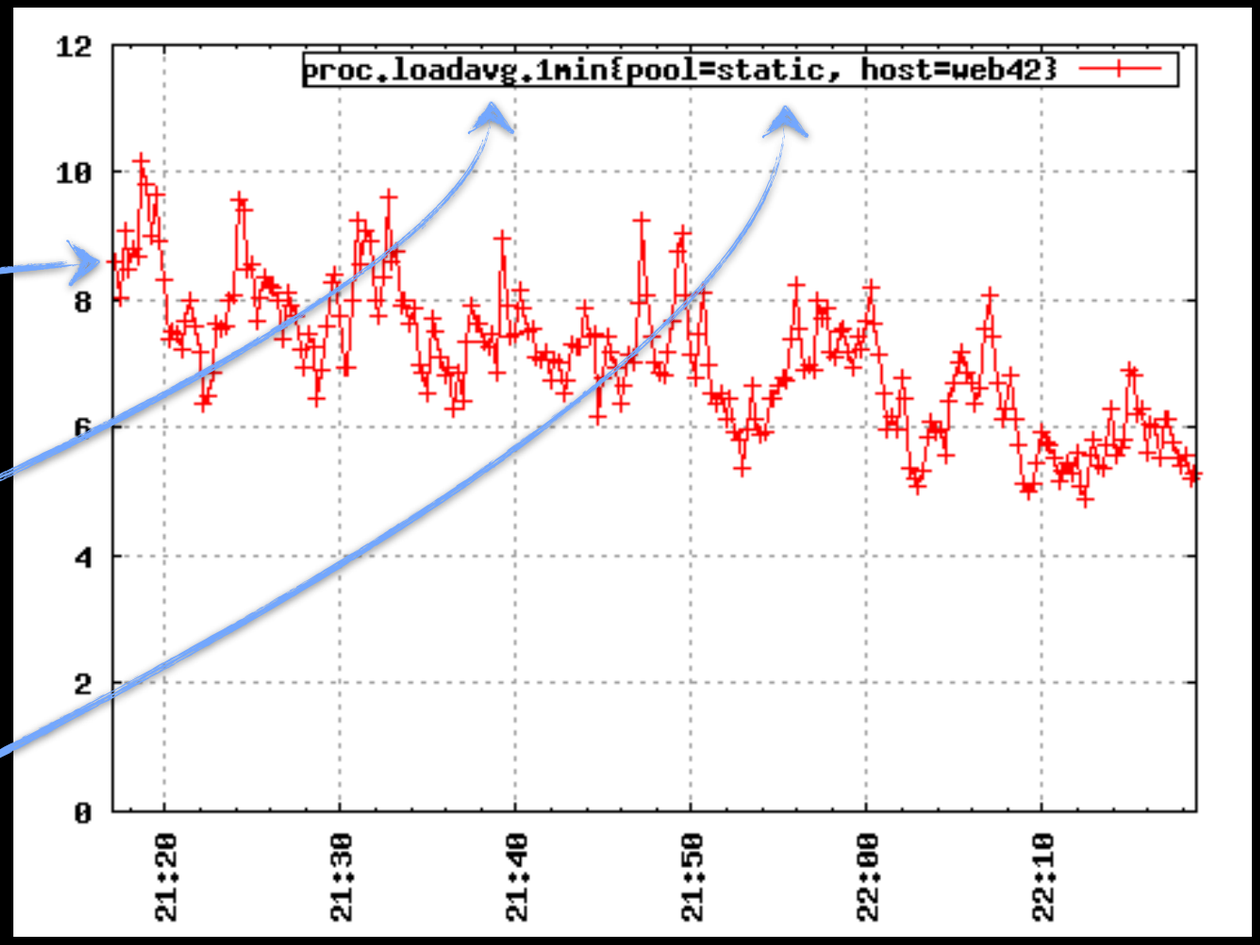
# Key concepts

- Data Points
  `(time, value)`
- Metrics
  `proc.loadavg.1m`
- Tags
  `host=web42  pool=static`
- `Metric + Tags = Time Series`
- Order of magnitude: $>10^6$ time series, $>10^{12}$ data points




```
put proc.loadavg.1m 1234567890 0.42 host=web42 pool=static
```

# OpenTSDB @ StumbleUpon

- Main production monitoring system for ~2 years
- Storing hundreds of billions of data points
- Adding over 1 billion data points per day
- 13000 data points/s → 130 QPS on HBase
- If you had a 5 node cluster, this load would hardly make it sweat

# Do's

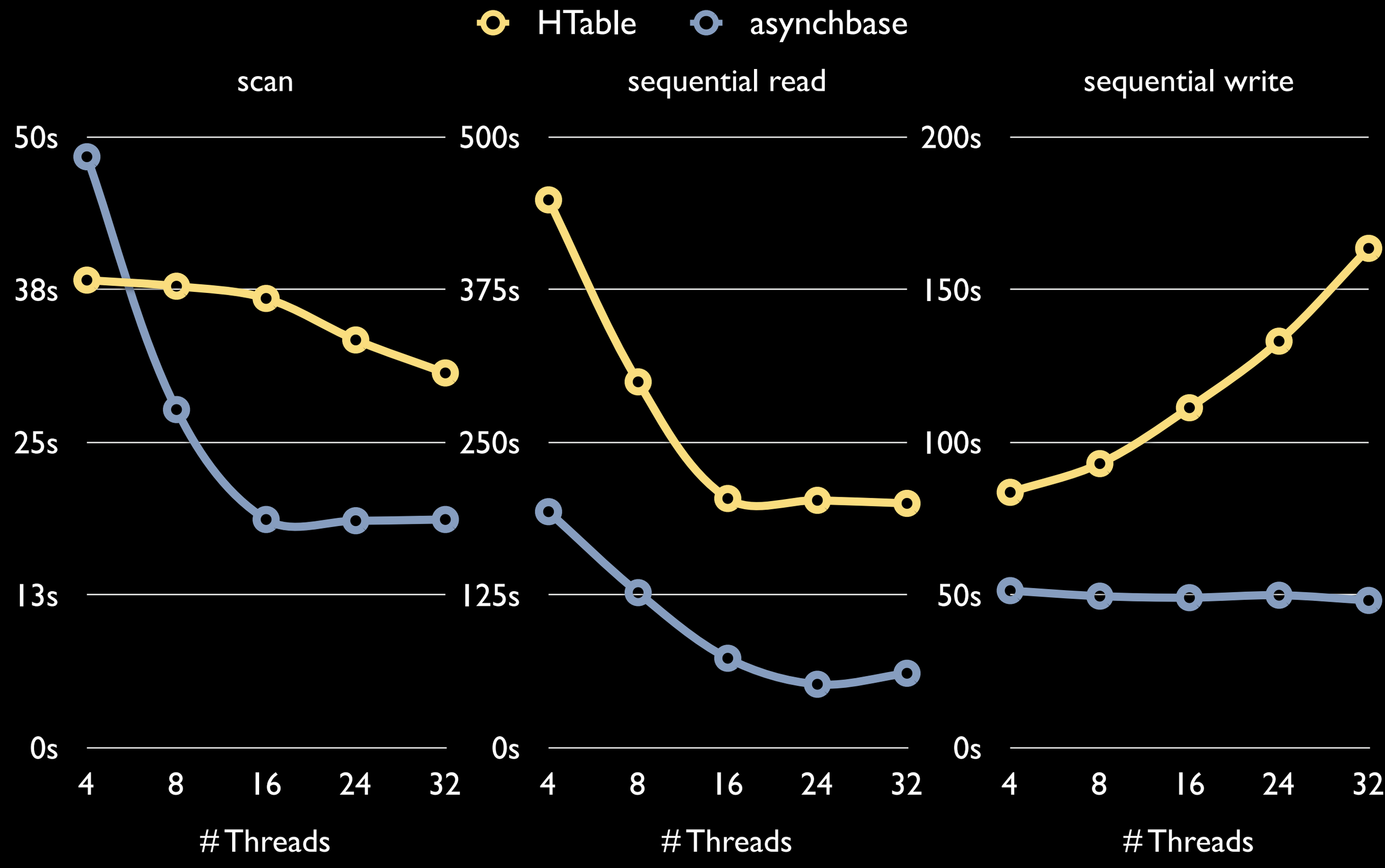
- **Wider** rows to seek faster
  before: ~4KB/row, after: ~20KB
- Make writes **idempotent** and **independent**
  before: start rows at arbitrary points in time
  after: align rows on 10m (then 1h) boundaries
- Store **more data per KeyValue**
  Remember you pay for the key along *each* value in a row, so large keys are *really* expensive

# Don’ts

- Use `HTable` / `HTablePool` in app servers
  asynchbase + Netty or Finagle = performance++
- Put variable-length fields in composite keys
  They’re hard to scan
- Exceed a few hundred regions per RegionServer
  “Oversharding” introduces overhead and makes recovering from failures more expensive

See detailed benchmark at goo.gl/8at5V

# Use asynchbase



# How OpenTSDB came to be the way it is

Questions:

- How to store time series data efficiently in HBase?
- How to enable concurrent writes without synchronization between the writers?
- How to save space/memory when storing hundreds of billions of data items in HBase?

# Time Series Data in HBase

Take 1

| Key \ Column | |
|---|---|
| 1234567890 | 1 |
| 1234567892 | 2 |
| 1234567894 | 3 |

don't care

values

timestamps

Simplest design: only 1 time series, 1 row with a single KeyValue per data point.
Supports time-range scans.

# Time Series Data in HBase

Take 2

| Key \ Column | |
|---|---|
| foo 1234567890 | 1 |
| foo 1234567892 | 3 |
| fool 1234567890 | 2 |

metric name

Metric name first in row key for data locality.
Problem: can't store the metric as text in row key due to space concerns

# Time Series Data in HBase

Take 3

| Key \ Column | |
|---|---|
| 0x1 1234567890 | 1 |
| 0x1 1234567892 | 3 |
| 0x2 1234567890 | 2 |

metric ID

Separate Lookup Table:

| Key | Value |
|---|---|
| 0x1 | foo |
| 0x2 | fool |
| foo | 0x1 |
| fool | 0x2 |

Use a separate table to assign unique IDs to metric names (and tags, not shown here). IDs give us a predictable length and achieve desired data locality.

# Time Series Data in HBase

Take 4

| Key \ Column | +0 | +2 |
|---|---|---|
| 0x1 1234567890 | 1 | 3 |
| 0x1 1234567892 | 3 | |
| 0x2 1234567890 | 2 | |

Reduce the number of rows by storing multiple consecutive data points in the same row.
Fewer rows = faster to seek to a specific row.

# Time Series Data in HBase

Take 4

Misleading table representation

| Key \ Column | +0 | +2 |
|---|---|---|
| 0x1 1234567890 | 1 | 3 |
| 0x1 1234567892 | 3 | |
| 0x2 1234567890 | 2 | |

## Gotcha #1: wider rows don't save any space*

Actual table stored

| Key | Colum | Value |
|---|---|---|
| 0x1 1234567890 | +0 | 1 |
| 0x1 1234567890 | +2 | 3 |
| 0x2 1234567890 | +0 | 2 |

* Until magic prefix compression happens in upcoming HBase 0.94

# Time Series Data in HBase

Take 4

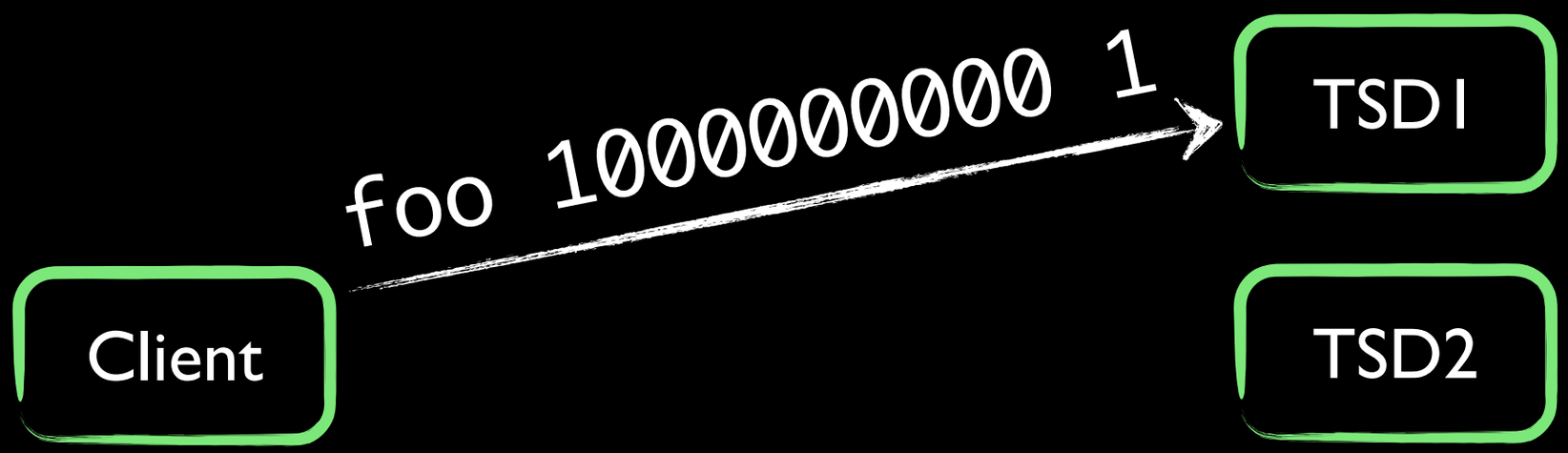
| Key \ Column | +0 | +2 |
|---|---|---|
| 0x1 1234567890 | 1 | 3 |
| 0x1 1234567892 | 3 | |
| 0x2 1234567890 | 2 | |

Devil is in the details: when to start new rows?
Naive answer: start on first data point, after some time start a new row.

# Time Series Data in HBase

Take 4

| Key \ Column | +0 | |
|---|---|---|
| 0x1 1000000000 | 1 | |

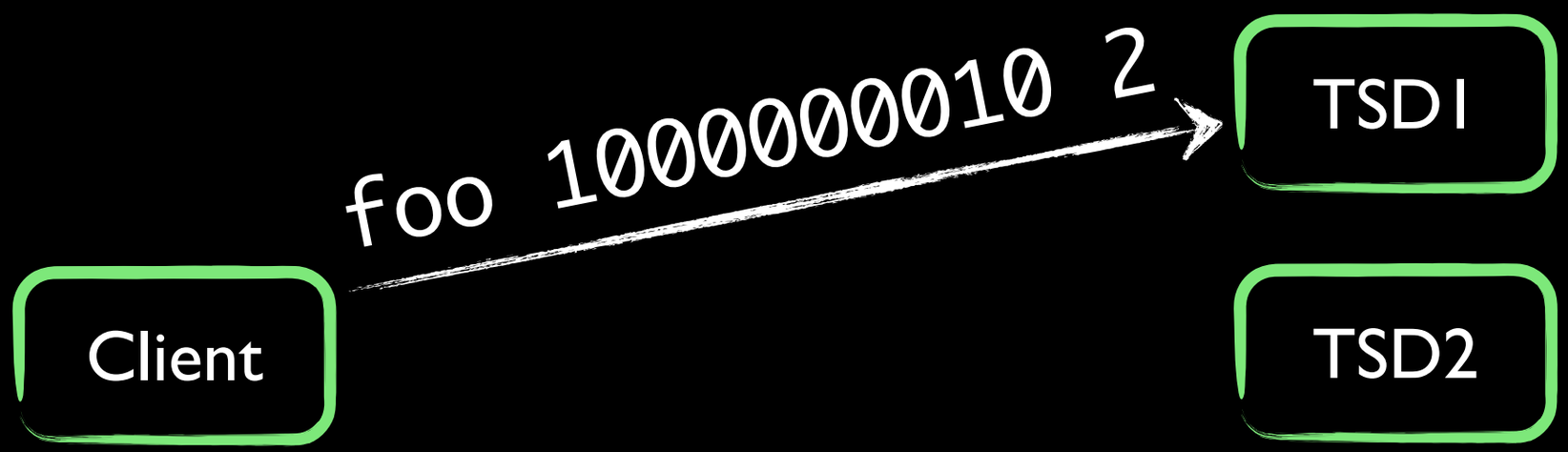



First data point:
Start a new row

# Time Series Data in HBase

Take 4

| Key \ Column | +0 | +10 | ... |
|---|---|---|---|
| 0x1 1000000000 | 1 | 2 | ... |

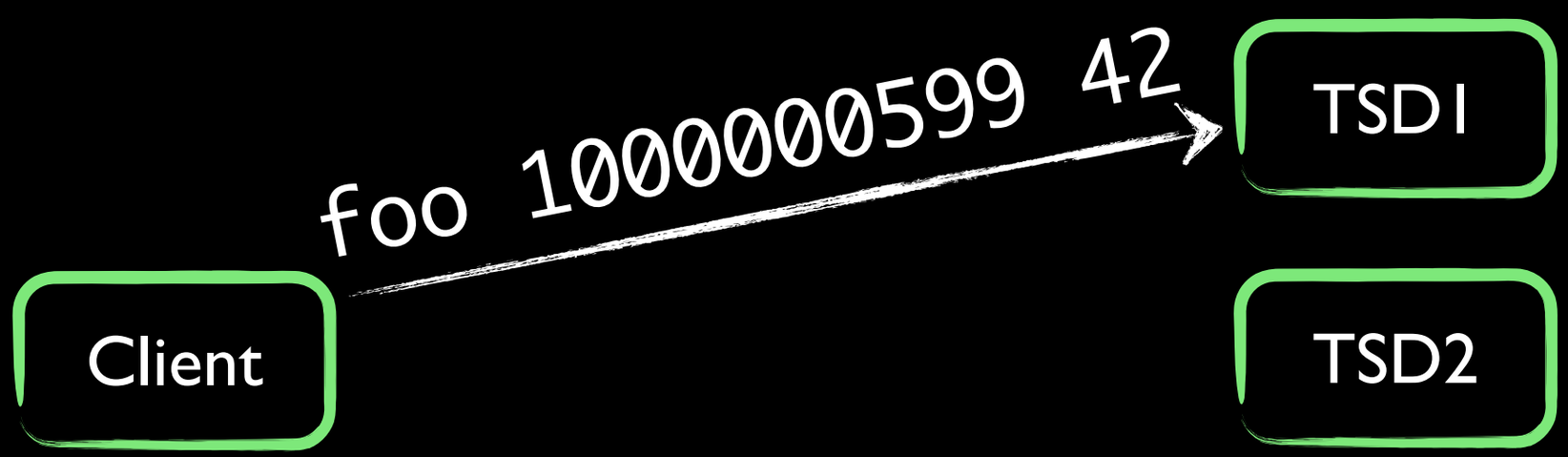



Keep adding points until...

# Time Series Data in HBase

Take 4

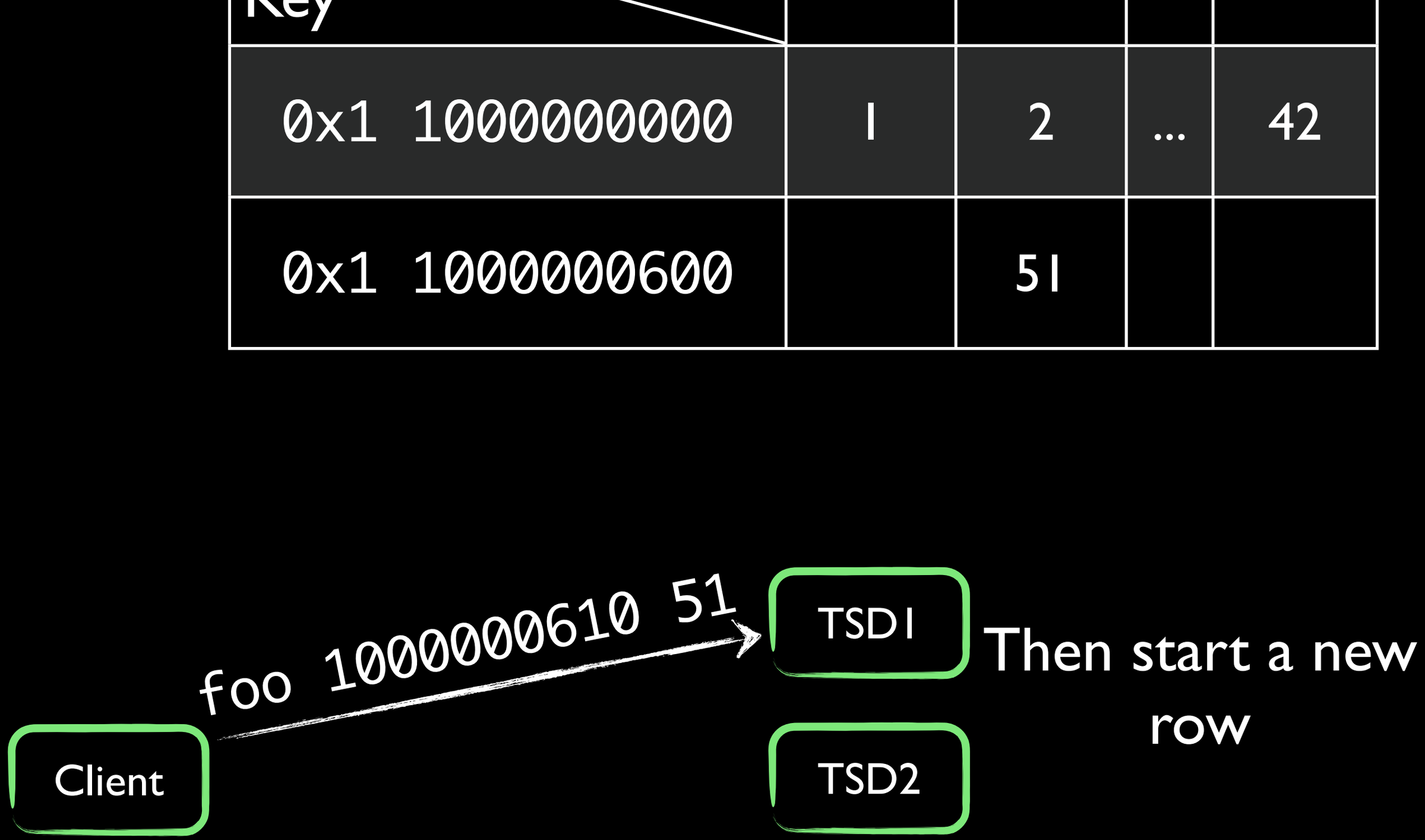
| Key \ Column | +0 | +10 | ... | +599 |
|---|---|---|---|---|
| 0x1 1000000000 | 1 | 2 | ... | 42 |



# Time Series Data in HBase

Take 4

| Key \ Column | +0 | +10 | ... | +599 |
|---|---|---|---|---|
| 0x1 1000000000 | 1 | 2 | ... | 42 |
| 0x1 1000000600 | | 51 | | |

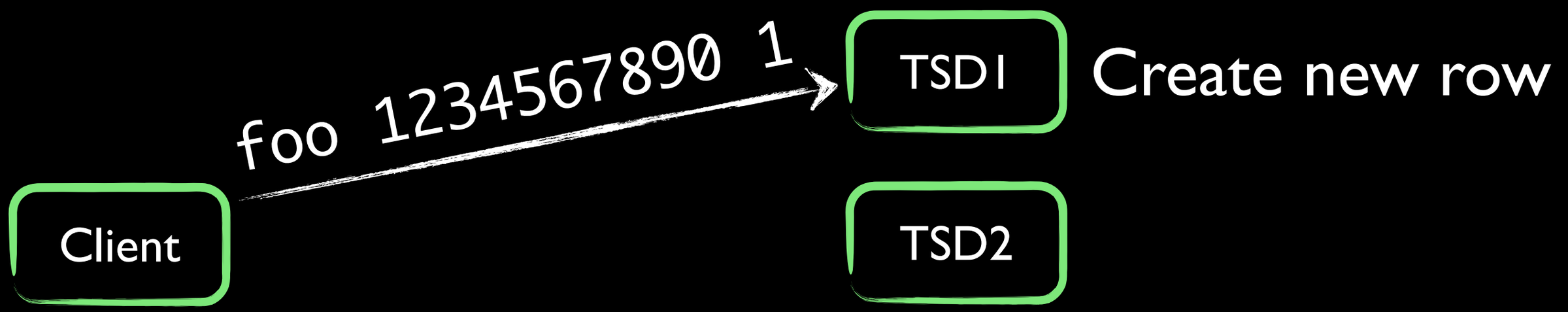


# Time Series Data in HBase

Take 4

| Key \ Column | +0 | |
|---|---|---|
| 0x1 1234567890 | I | |
| | | |

But this scheme fails with multiple TSDs



# Time Series Data in HBase

Take 4

| Key \ Column | +0 | +2 |
|---|---|---|
| 0x1 1234567890 | 1 | 3 |
| | | |

# Time Series Data in HBase

Take 4

| Key \ Column | +0 | +2 |
|---|---|---|
| 0x1 1234567890 | 1 | 3 |
| 0x1 1234567892 | 3 | |

Oops!

Maybe a connection failure occurred, client is retransmitting data to another TSD

# Time Series Data in HBase

Take 5

| Key \ Column | +90 | +92 |
|---|---|---|
| 0x1 1234567800 | 1 | 3 |
| 0x2 1234567800 | 2 | |

Base timestamp always a multiple of 600

In order to scale easily and keep TSD stateless, make writes independent & idempotent.
New rule: rows are aligned on 10 min. boundaries

# Time Series Data in HBase

Take 6

| Key \ Column | +1890 | +1892 |
|---|---|---|
| 0x1 1234566000 | 1 | 3 |
| 0x2 1234566000 | 2 | |

Base timestamp always a multiple of 3600

1 data point every ~10s => 60 data points / row
Not much. Go to wider rows to further increase seek speed. One hour rows = 6x fewer rows

# Time Series Data in HBase

Take 6

| Key \ Column | +1890 | +1892 |
|---|---|---|
| 0x1 1234566000 | 1 | 3 |
| 0x2 1234566000 | 2 | |

Remember: wider rows don't save any space!

Actual table stored

| Key | Colum | Value |
|---|---|---|
| 0x1 1234566000 | +1890 | 1 |
| 0x1 1234566000 | +1892 | 3 |
| 0x2 1234566000 | +1890 | 2 |

Key is easily 4x bigger than column + value and repeated

# Time Series Data in HBase

Take 7

| Key \ Column | +1890 | +1890 | +1892 | +1892 |
|---|---|---|---|---|
| 0x1 1234566000 | 1 | 1 | 3 | 3 |
| 0x2 1234566000 | 2 | | | |

## Solution: "compact" columns by concatenation

Actual table stored

| Key | Column | Value |
|---|---|---|
| 0x1 1234566000 | +1890 | 1 |
| 0x1 1234566000 | +1890,+1892 | 1, 3 |
| 0x1 1234566000 | +1892 | 3 |
| 0x2 1234566000 | +1890 | 2 |

Space savings on disk and in memory are huge: data is 4x-8x smaller!

Fork me on GitHub

# ¿ Questions ?

## opentsdb.net

Summary

- Use asynchbase
- Wider table > Taller table
- Make writes idempotent
- Compact your data
- Use Netty or Finagle
- Short family names
- Make writes independent
- Have predictable key sizes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