Scaling Graphite at Criteo

FOSDEM 2018 - “Not yet another talk about Prometheus”

Me

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- Working on Graphite with the Observability team at Criteo
- Worked on Bigtable/Colossus at Google

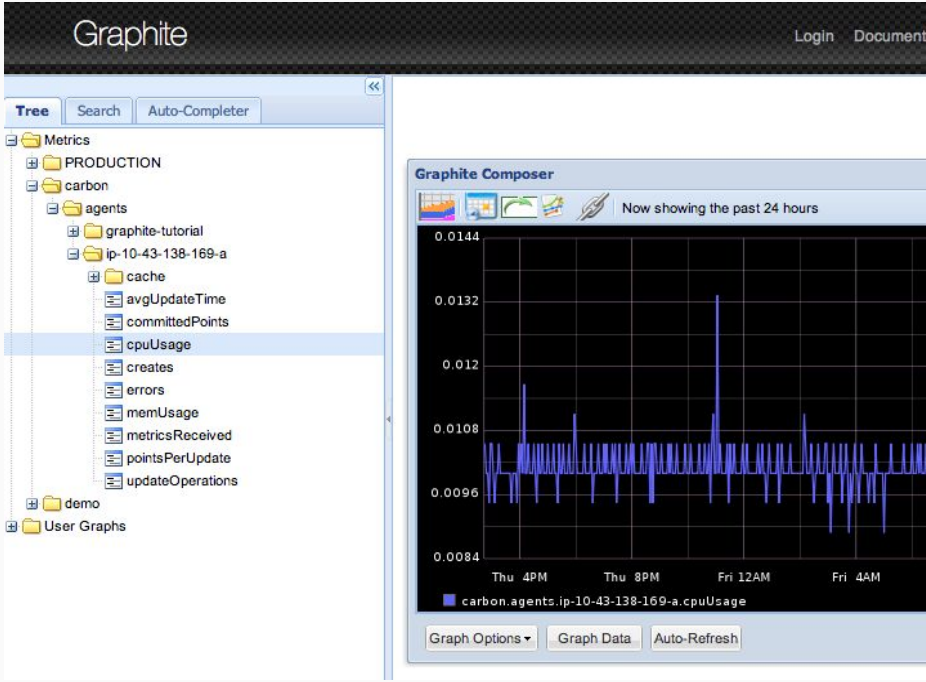
BigGraphite

Storing time series in Cassandra and querying them from Graphite

Graphite

- Graphite does two things:
    - Store numeric time-series data
    - Render graphs of this data on demand

- https://graphiteapp.org/
- https://github.com/graphite-project



graphite-web

- Django Web application

- UI to browse metrics, display graph, build dashboard
  - Mostly deprecated by [Grafana]

- API to list metrics and fetch points (and generate graphs)
  - /metrics/find?query=my.metrics.*
  - /render/?target=sum(my.metrics.*)&from=-10m

Carbon

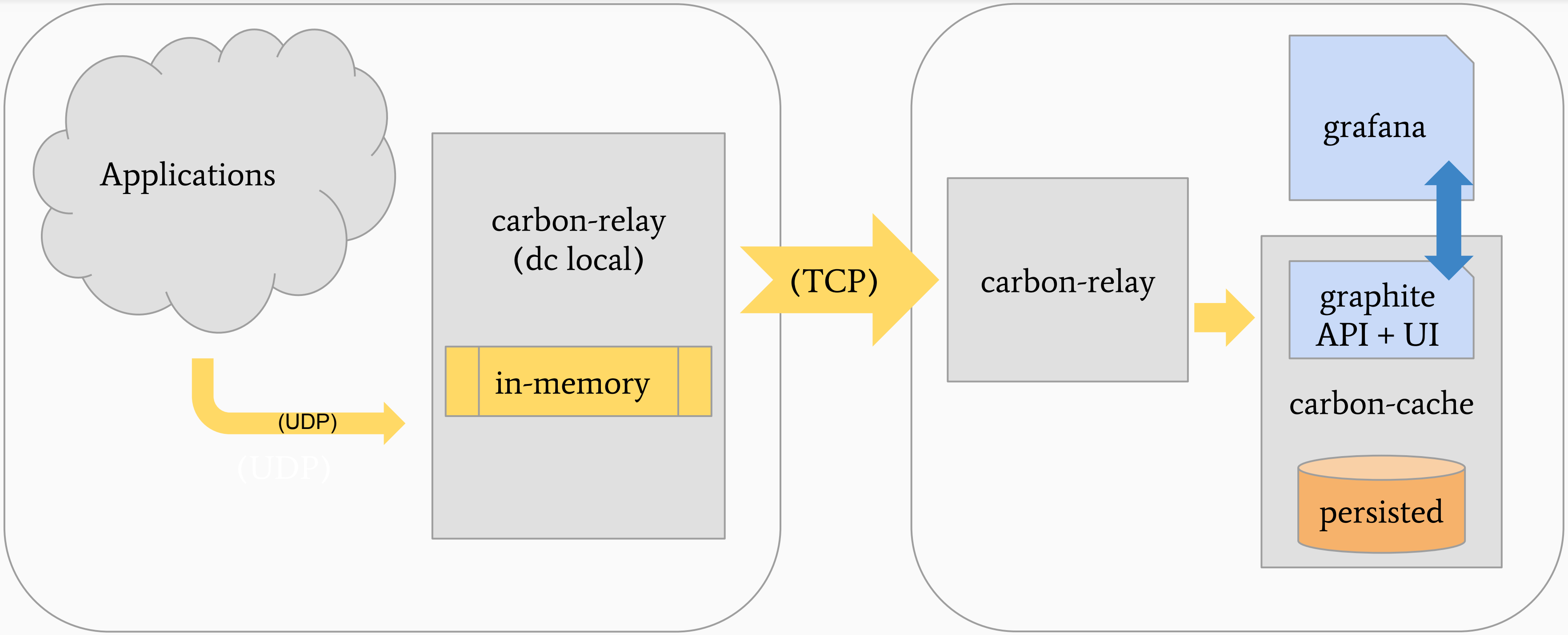
- Receives metrics and relay them
  - carbon-relay: receives the metrics from the clients and relay them
  - carbon-aggregator: ‘aggregates’ metrics based on rules
- Persist metrics to disk
  - carbon-cache: writes points to the storage layer
  - Default database: whisper, one file = one metric

host123.cpu0.user <timestamp> 100 → carbon → disk

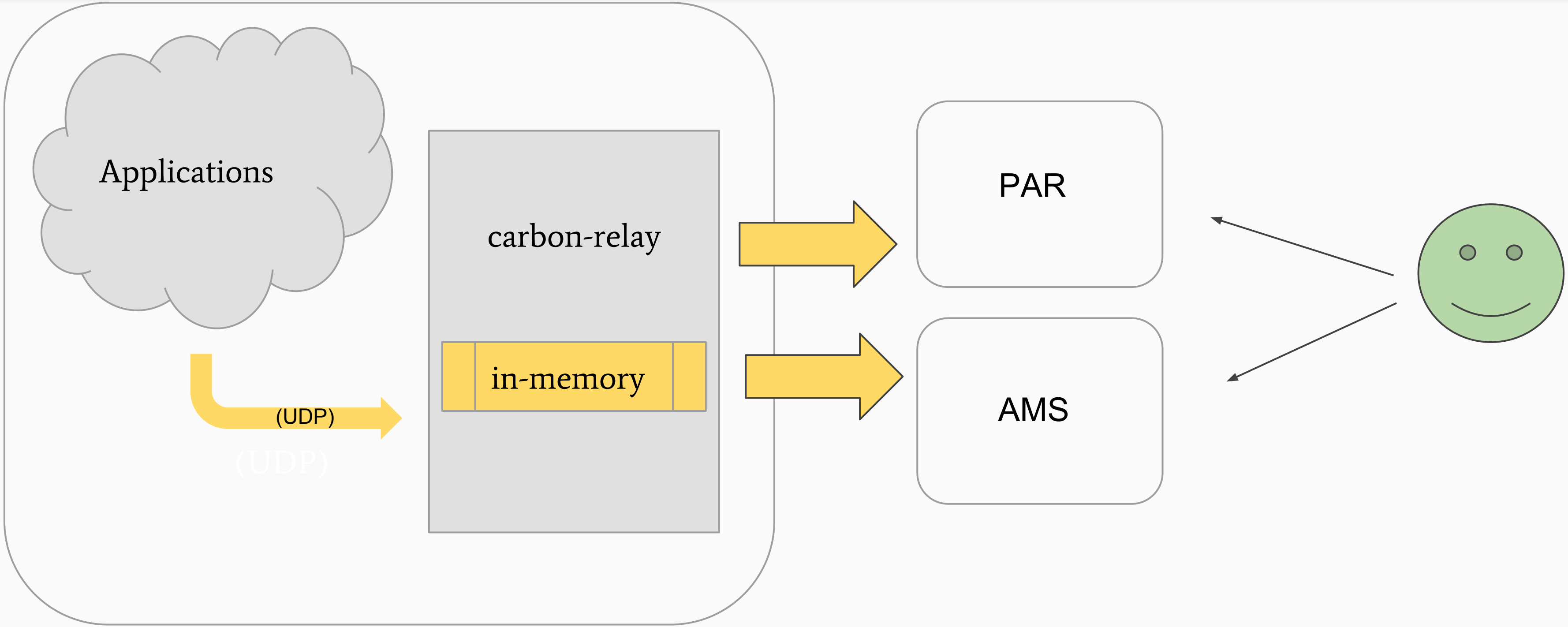
Our usage

- 6 datacenters, 20k servers, 10k+ “applications”
- We ingest and query >80M metrics
  - Read: ~20K metrics/s
  - Write: ~800K points/s
- 2000+ dashboards, 1000+ alerts (evaluated every 5min)

architecture overview



architecture overview (r=2)



current tools are improvable

- Graphite lacks true elasticity
    - … for storage and QPS
    - One file per metric is wasteful even with sparse files
- Graphite’s clustering is naïve (slight better with 1.1.0)
    - Graphite-web clustering very fragile
    - Single query can bring down all the cluster
    - Huge fan-out of queries
- Tooling
    - Whisper manipulation tools are brittle
    - Storage ‘repair’/’reconciliation’ is slow and inefficient (multiple days)
    - Scaling up is **hard** and error prone

solved problems?

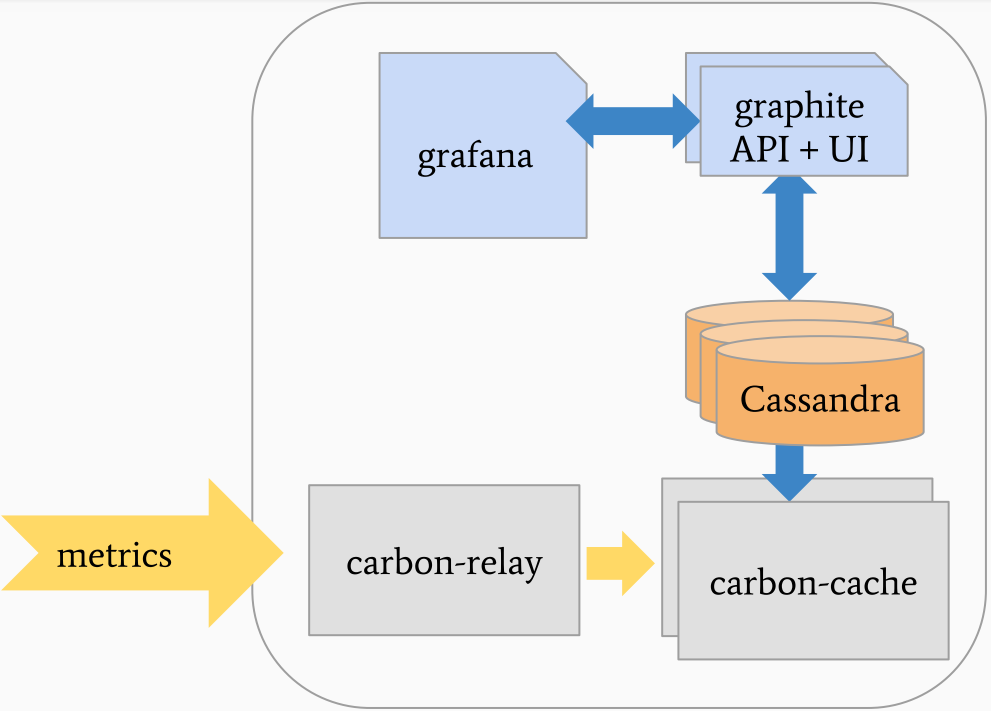
- Distributed database systems have already solved these problems
  - e.g. Cassandra, Riak, …
- Fault tolerance through replication
  - Quorum queries and read-repair ensure consistency
- Elasticity through consistent hashing
  - Replacing and adding nodes is fast and non-disruptive
  - Repairs are transparent, and usually fast
  - Almost-linear scalability

BigGraphite

decisions, decisions

- OpenTSDB (HBase)
  - Too many moving parts
  - Only one HBase cluster at Criteo, hard/costly to spawn new ones
- Cyanite (Cassandra/ES)
  - Originally depended on ES, manually ensures cross-database consistency…
  - Doesn’t behave exactly like Carbon/Graphite
- KairosDB (Cassandra/ES)
  - Dependency on ES for Graphite compatibility
  - Relies on outdated libraries
- [insert hyped/favorite time-series DBs]
- Safest and easiest: build a Graphite plugin using only Cassandra

Target architecture overview



plug'n'play

Slightly more complicated than that...

- Graphite has support for plug-ins since v1.0

carbon (carbon.py)

```
-   create(metric)
-   exists(metric)
-   update(metric, points)
```

```
update(uptime.nodeA, [now(), 42])
```

Graphite-Web (graphite.py)

```
-   find(glob)
-   fetch(metric, start, stop)
```

```
find(uptime.*) -> [uptime.nodeA]

fetch(uptime.nodeA, now()-60, now())
```

storing time series in Cassandra

- Store points…
  - (metric, timestamp, value)
  - Multiple resolutions and TTLs (60s:8d, 1h:30d, 1d:1y)
  - Write => points
  - Read => series of points (usually to display a graph)
- …and metadata !
  - Metrics hierarchy (like a filesystem, directories and metrics — like whisper)
  - Metric, resolution, [owner, …]
  - Write => new metrics
  - Read => list of metrics from globs (my.metric.*.foo.*)

<Cassandra>

storing data in Cassandra

- Sparse matrix storage
  - **Map**< *Row*, **Map**< *Column*, *Value* > >

- Row ⇔ Partition
  - Atomic storage unit (nodes hold full rows)
  - Data distributed according to **Hash(***rowKey***)**

- Column Key
  - Atomic data unit inside a given partition
  - Unique per partition
  - Has a value
  - Stored in lexicographical order (supports range queries)

store(row, col, val)

↓

H = hash(row)

↓

Node = get_owner(H)

↓

send(Node, (row, col, val))

naïve schema

```
CREATE TABLE points (
     path      text,   -- Metric name
     time      bigint, -- Value timestamp
     value     double, -- Point value
     PRIMARY KEY ((path), time)
) WITH CLUSTERING ORDER BY (time DESC);
```

- Boom! Timeseries.
  - (Boom! Your cluster explodes when your have many points on each metric.)
    (Boom! You spend your time compacting data and evicting expired points)

time sharding schema

```
CREATE TABLE IF NOT EXISTS %(table)s (
     metric uuid,               -- Metric UUID (actual name stored as metadata)
     time_start_ms bigint,      -- Lower time bound for this row
     offset smallint,           -- time_start_ms + offset * precision = timestamp
     value double,              -- Value for the point.
     count int,                 -- If value is sum, divide by count to get the avg
     PRIMARY KEY ((metric, time_start_ms), offset)
   ) WITH CLUSTERING ORDER BY (offset DESC)
     AND default_time_to_live = %(default_time_to_live)d
```

- table = datapoints_<resolution>
- default_time_to_live = <resolution.duration>
- (Number of points per partition limited to ~25K)

demo (sort of)

```
cqlsh> select * from biggraphite.datapoints_2880p_60s limit 5;

metric                               | time_start_ms | offset | count | value
-------------------------------------+---------------+--------+-------+-------
7dfa0696-2d52-5d35-9cc9-114f5dccc1e4 | 1475040000000 |   1999 |     1 |  2019
7dfa0696-2d52-5d35-9cc9-114f5dccc1e4 | 1475040000000 |   1998 |     1 |  2035
7dfa0696-2d52-5d35-9cc9-114f5dccc1e4 | 1475040000000 |   1997 |     1 |  2031
7dfa0696-2d52-5d35-9cc9-114f5dccc1e4 | 1475040000000 |   1996 |     1 |  2028
7dfa0696-2d52-5d35-9cc9-114f5dccc1e4 | 1475040000000 |   1995 |     1 |  2028

(5 rows)
```

Partition key   Clustering Key   Value

Finding nemo

- How to find metrics matching fish.*.nemo* ?
- Most people use ElasticSearch, and that’s fine, but we wanted a self-contained solution

we’re feeling SASI

- Recent Cassandra builds have secondary index facilities
  - SASI (**S**STable-**A**ttached **S**econdary **I**ndexes)
- Split metric path into components
  - criteo.cassandra.uptime ⇒ part0=criteo, part1=cassandra, part2=uptime, part3=end
  - criteo.* => part0=criteo,part2=end

- Associate metric UUID to the metric name’s components
- Add secondary indexes to path components
- Retrieve metrics matching a pattern by querying the secondary indexes

- See design.md and SASI Indexes for details

do you even query?

- a.single.metric (equals)
    - **Query**: part0=a, part1=single, part2=metric, part3=end
    - **Result**: a.single.metric
- a.few.metrics.* (wildcards)
    - **Query**: part0=a, part1=few, part2=metrics, **part4=end**
    - **Result**: a.few.metrics.a, a.few.metrics.b, a.few.metrics.c
- match{ed_by,ing}.s[ao]me.regexp.?[0-9] (almost regexp, post-filtering)
    - ^match(ed_by|ing)\.s[ao]me\.regexp\..[0-9]$
    - **Query**: *similar to wildcards*
    - **Result**: matched_by.same.regexp.b2, matched_by.some.regexp.a1, matching.same.regexp.w5, matching.some.regexp.z8

</Cassandra>

And then ?

BIGGEST GRAPHITE CLUSTER IN THE MULTIVERSE ! (or not)

- 800 TiB of capacity, 20 TiB in use currently (R=2)
- Writes: 1M QPS
- Reads: 10K QPS
- 24 bytes per point, 16 bytes with compression
  - But probably even better with double-delta encoding !
- 20 Cassandra nodes
- 6 Graphite Web, 10 Carbon Relays, 10 Carbon Cache
- x3 ! 2 Replicated Datacenters, one isolated to canary changes.

links of (potential) interest

- Github project: github.com/criteo/biggraphite
- Cassandra's Design Doc: CASSANDRA_DESIGN.md
- Announcement: BigGraphite-Announcement

You can just `pip install biggraphite` and voilà !

Roadmap ?

- Add Prometheus Read/Write support (BigGraphite as long term storage for Prometheus).
    - Already kind of works with https://github.com/criteo/graphite-remote-adapter
- Optimize writes: bottleneck on Cassandra is CPU, we could divide CPU usage by ~10 with proper batching
- Optimize reads: better parallelization, better long term caching (points usually don't change in the past)

More Slides

Monitoring your monitoring !

- Graphite-Web availability (% of time on a moving window)
- Graphite-Web performances (number of seconds to sum 500 metrics, at the 95pctl)
- Point loss: sending 100 points per dc per seconds, checking how many arrive in less than 2 minutes
- Point delay: setting the timestamp as the value, and diffing with now (~2-3 minutes)

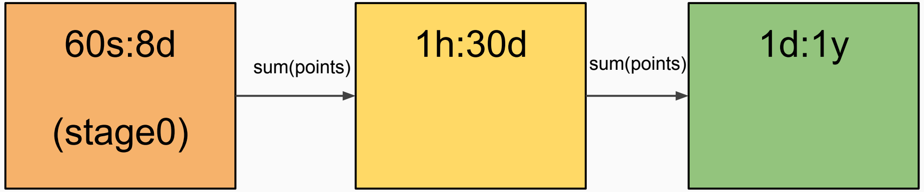

SLO
Read Availability (10min)
100.0%
Read Latency (90pctl - 15min)
3.77 s
Point Loss
0%
Ingestion Delay
1 min
Checkout the Graphite SLA for more details. Also look at HTTP Probe Dashboard for more HTTP metrics.
SLO Details
Read Availability
100.0%
97.5%
95.0%
92.5%
90.0%
87.5%
16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00
Availability dc:{am5,hk5,ny8,par,sh5,sv6,ty5,va1} (5min)
Point Loss
1.0%
0.8%
0.6%
0.4%
0.2%
0%
16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00
am5 hk5 ny8 par sh5 sv6 ty5 va1
Read Latency
12 s
10 s
8 s
6 s
4 s
2 s
0 ms
16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00
90pctl dc:am5 90pctl dc:hk5 90pctl dc:ny8 90pctl dc:par 90pctl dc:sh5 90pctl dc:sv6 90pctl dc:ty5 90pctl dc:va1
Ingestion Delay
2.2 min
2.1 min
2.0 min
1.9 min
1.8 min
1.7 min
1.6 min
16:00 18:00 20:00 22:00 00:00 02:00 04:00 06:00 08:00 10:00 12:00 14:00
Min dc:{am5,hk5,ny8,par,sh5,sv6,ty5,va1} Average dc:{am5,hk5,ny8,par,sh5,sv6,ty5,va1} Max dc:{am5,hk5,ny8,par,sh5,sv6,ty5,va1}

Aggregation

Downsampling/Rollups/Resolutions/Retentions/...

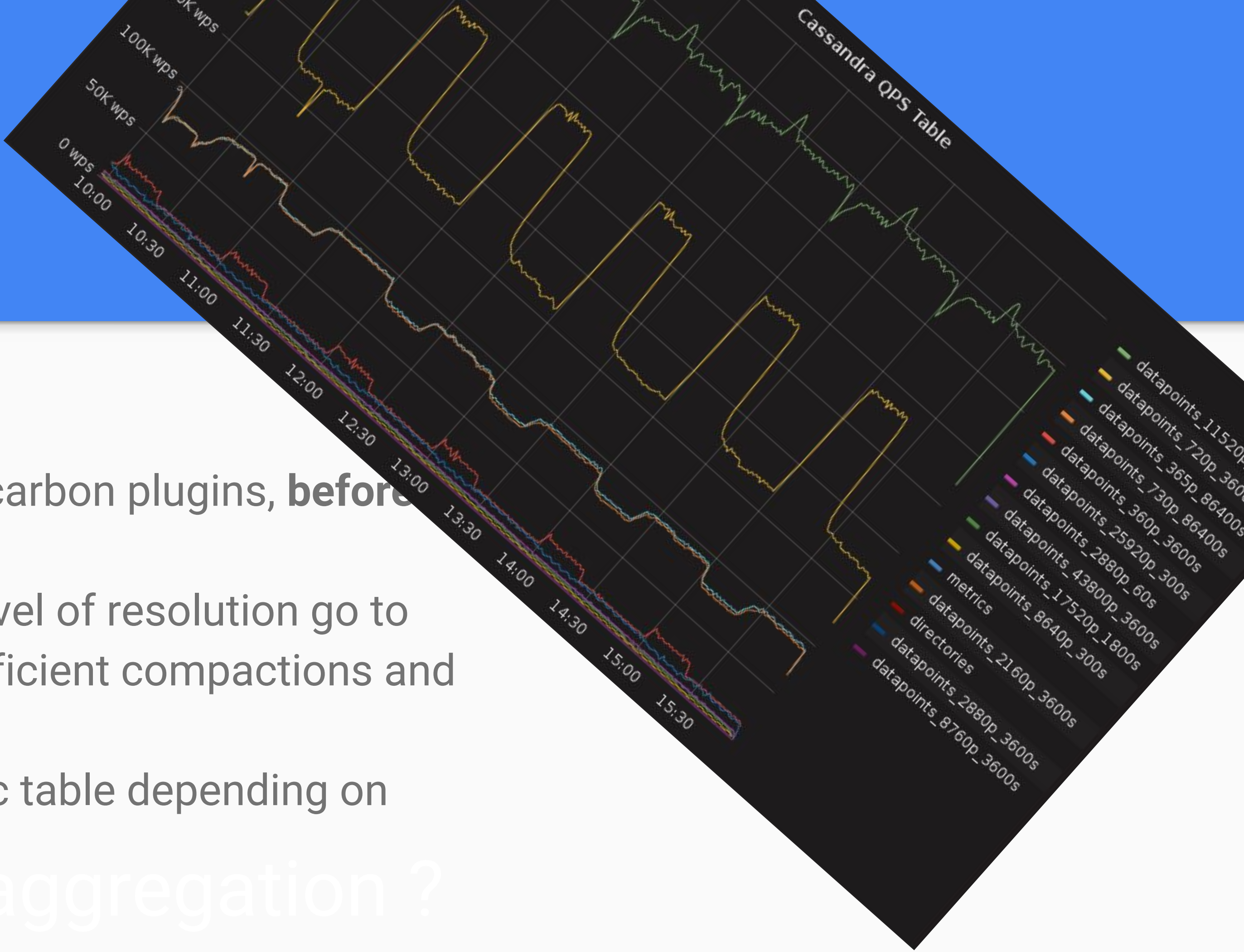
roll what? hmmm?

- Retention policy: 60s:8d,1h:30d,1d:1y (combinat
- Stage: 60s:8d (resolution 60 seconds for 8d)
- Aggregator functions: sum, min, max, avg
- stage[N] = *aggregator*(stage[N-1])



- Obviously this doesn't work for average
  - avg(avg(1, 2), avg(3, 4)) ≠ avg(1, 2, 3, 4)
  - We have to store both 'value' and 'count'!
  - (See downsampling.py for details)

- Cheaper / simpler to do directly on the write path
  - Checkpointed every 5 minutes
  - But since processes can restart !
  - We use unique write ids (and replica ids when using replicated clusters)
  - (See design.md)



- We **aggregate** in the carbon plugins, **before writing the points**
- Points for different level of resolution go to different tables for efficient compactions and TTL expiration
- Reads go to a specific table depending on the time window

What about aggregation ?