Sharding @ Instagram

SFPUG April 2012
Mike Krieger
Instagram

me

- Co-founder, Instagram
- Previously: UX & Front-end @ Meebo
- Stanford HCI BS/MS
- @mikeyk on everything

pug!

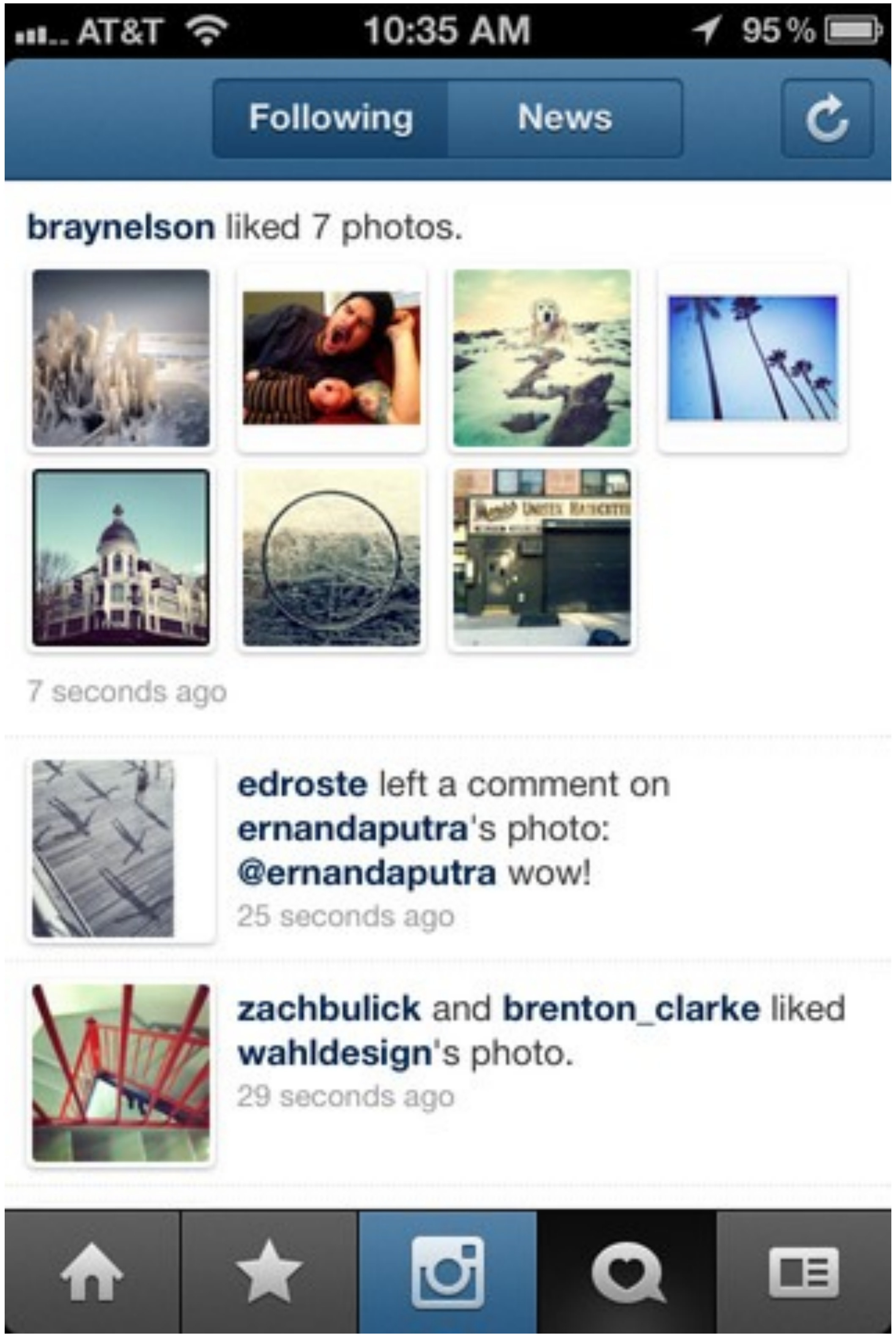
communicating and sharing in the real world


California
4WZC924
Normal
Amaro
Rise
Hudson
X-pro

247 likes

robinmay Union Station. All mine.

view all 51 comments



braynelson liked 7 photos.

7 seconds ago

edroste left a comment on **ernandaputra**'s photo: **@ernandaputra** wow!

25 seconds ago

zachbulick and **brenton_clarke** liked **wahldesign**'s photo.

29 seconds ago

30+ million users in less than 2 years

at its heart, Postgres-driven

a glimpse at how a startup with a small eng team scaled with PG

a brief tangent

the beginning

2 product guys

no real back-end experience

(you should have seen my first time finding my way around psql)

analytics & python @ meebo

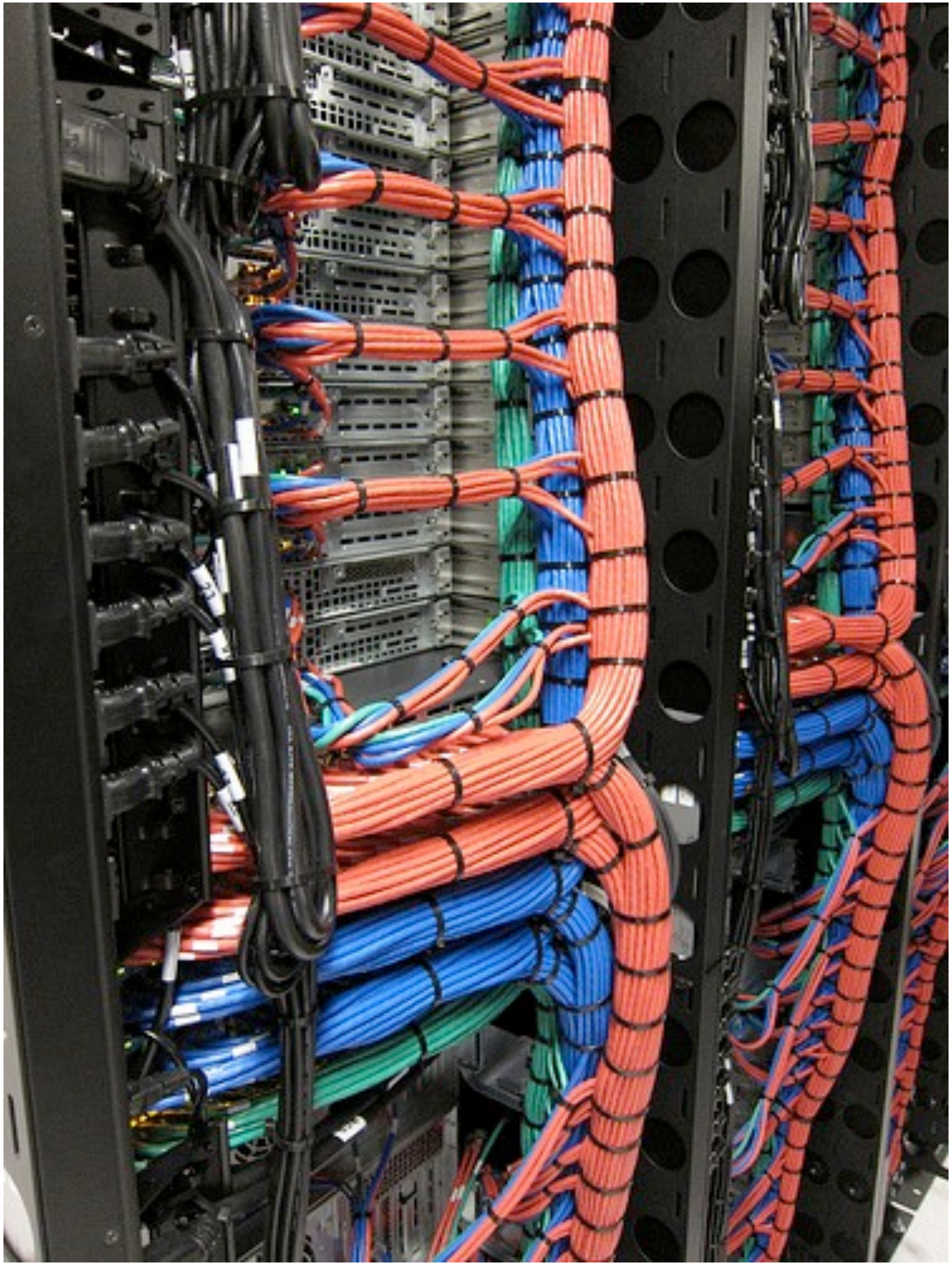
CouchDB

CrimeDesk SF


3G
9:41 AM
CRIME DESK
SAN FRANCISCO
Near Me
At an Address
By Neighborhood
Around Me
11:45 PM
85%
Turk Blv
Hast
College
Redwood S
Hayes St
Polk St
Grove St
Fell St
Filter
SF

early mix: PG, Redis, Memcached

...but were hosted on a single machine somewhere in LA



less powerful than my MacBook Pro

okay, we launched.
now what?

25k signups in the first day

everything is on fire!

best & worst day of our lives so far

load was through the roof

friday rolls around

not slowing down

let’s move to EC2.


Taurin- und koffeinhaltiges Spezialgetränk. Kohlensäurehaltig.
Boisson à base de taurine et caféine. Boisson gazéifiée.
Red Bull
ENERGY DRINK

PG upgrade to 9.0

scaling = replacing all components of a car while driving it at 100mph this is the story of how our usage of PG has evolved

Phase 1: All ORM, all the time

why pg? at first, postgis.

```
./manage.py syncdb
```

ORM made it too easy to not really think through primary keys pretty good for getting off the ground

`Media.objects.get(pk = 4)`

first version of our feed (pre-launch)

```
friends =
Relationships.objects.filter(source_use
r = user)

recent_photos =
Media.objects.filter(user_id__in =
friends).order_by(‘-pk’)[0:20]
```

main feed at launch

Redis:

```
// user 33 posts
friends = SMEMBERS followers:33
for user in friends:
  LPUSH feed:‹user_id› ‹media_id›

// for reading
LRANGE feed:4 0 20
```

canonical data: PG

feeds/lists/sets: Redis

object cache: memcache

post-launch

moved db to its own machine

at time, largest table:
photo metadata

ran master-slave from the beginning, with streaming replication backups: stop the replica, xfs_freeze drives, and take EBS snapshot

AWS tradeoff

3 early problems we hit with PG

1 oh, *that* setting was the problem?

work_mem

shared_buffers

cost_delay

2 Django-specific:
<idle in transaction>

3 connection pooling

(we use PGBouncer)

somewhere in this crazy
couple of months,
Christophe to the rescue!

photos kept growing and growing…

…and only 68GB of RAM on biggest machine in EC2

so what now?

Phase 2: Vertical Partitioning

django db routers make it pretty easy

```
def db_for_read(self, model):
  if app_label == 'photos':
    return 'photodb'
```

...once you untangle all your foreign key relationships

(all of those user/user_id interchangeable calls bite you now) plenty of time spent in PGFouine

read slaves (using streaming replicas) where we need to reduce contention a few months later…

photosdb > 60GB

precipitated by being on cloud hardware, but likely to have hit limit eventually either way

what now?

horizontal partitioning!

Phase 3: sharding

“surely we’ll have hired someone experienced before we actually need to shard”

...never true about scaling

1 choosing a method
2 adapting the application
3 expanding capacity

evaluated solutions

at the time, none were up to task of being our primary DB

NoSQL alternatives

Skype's sharding proxy

Range/date-based partitioning

did in Postgres itself

requirements

1 low operational & code complexity

2 easy expanding of capacity

3 low performance impact on application

schema-based logical sharding

many many many (thousands) of logical shards

that map to fewer
physical ones

```
// 8 logical shards on 2 machines

user_id % 8 = logical shard

logical shards -> physical shard map

{
  0: A, 1: A,
  2: A, 3: A,
  4: B, 5: B,
  6: B, 7: B
}
```

// 8 logical shards on ~~2~~ 4 machines

user_id % 8 = logical shard

logical shards -> physical shard map

```
{
  0: A, 1: A,
  2: C, 3: C,
  4: B, 5: B,
  6: D, 7: D
}
```

¡schemas!

all that ‘public’ stuff I’d been glossing over for 2 years

- database:
  - schema:
    - table:
      - columns

spun up set of machines

using fabric, created thousands of schemas

```
machineA:
  shard0
    photos_by_user
  shard1
    photos_by_user
  shard2
    photos_by_user
  shard3
    photos_by_user
```

```
machineB:
  shard4
    photos_by_user
  shard5
    photos_by_user
  shard6
    photos_by_user
  shard7
    photos_by_user
```

(fabric or similar parallel task executor is essential)

application-side logic

```
SHARD_TO_DB = {}

SHARD_TO_DB[0] = 0
SHARD_TO_DB[1] = 0
SHARD_TO_DB[2] = 0
SHARD_TO_DB[3] = 0
SHARD_TO_DB[4] = 1
SHARD_TO_DB[5] = 1
SHARD_TO_DB[6] = 1
SHARD_TO_DB[7] = 1
```

instead of Django ORM, wrote really simple db abstraction layer

select/update/insert/
delete

```
select(fields, table_name,
shard_key, where_statement,
where_parameters)
```

select(*fields*, *table_name*, ***shard_key***, *where_statement*, *where_parameters*)

...

shard_key % num_logical_shards = shard_id

in most cases, user_id
for us

custom Django test runner to create/tear-down sharded DBs most queries involve visiting handful of shards over one or two machines if mapping across shards on single DB, UNION ALL to aggregate clients to library pass in: ((shard_key, id), (shard_key,id)) etc library maps sub-selects to each shard, and each machine parallel execution! (per-machine, at least)

```
->  Append  (cost=0.00..973.72 rows=100 width=12) (actual
time=0.290..160.035 rows=30 loops=1)
    ->  Limit  (cost=0.00..806.24 rows=30 width=12) (actual
time=0.288..159.913 rows=14 loops=1)
        ->  Index Scan Backward using index on table
(cost=0.00..18651.04 rows=694 width=12) (actual time=0.286..159.885
rows=14 loops=1)
    ->  Limit  (cost=0.00..71.15 rows=30 width=12) (actual
time=0.015..0.018 rows=1 loops=1)
        ->  Index Scan using index on table  (cost=0.00..101.99 rows=43
width=12) (actual time=0.013..0.014 rows=1 loops=1)
    (etc)
```

eventually, would be nice to parallelize across machines

next challenge: unique IDs

requirements

1 should be time sortable without requiring a lookup

2 should be 64-bit

3 low operational complexity

surveyed the options

ticket servers?

UUID?

twitter snowflake?

application-level IDs ala Mongo?

hey, the db is already pretty good about incrementing sequences

[41 bits of time in millis]

[13 bits for shard ID]

[10 bits sequence ID]

[41 bits of time in millis]

[13 bits for shard ID]

[10 bits sequence ID]

[41 bits of time in millis]

[13 bits for shard ID]

[10 bits sequence ID]

[41 bits of time in millis]

[13 bits for shard ID]

[10 bits sequence ID]

```
CREATE OR REPLACE FUNCTION insta5.next_id(OUT result bigint) AS $$
DECLARE
    our_epoch bigint := 1314220021721;
    seq_id bigint;
    now_millis bigint;
    shard_id int := 5;
BEGIN
    SELECT nextval('insta5.table_id_seq') % 1024 INTO seq_id;

    SELECT FLOOR(EXTRACT(EPOCH FROM clock_timestamp()) * 1000) INTO
now_millis;
    result := (now_millis - our_epoch) << 23;
    result := result | (shard_id << 10);
    result := result | (seq_id);
END;
$$ LANGUAGE PLPGSQL;
```

```
# pulling shard ID from ID:

shard_id = id ^ ((id >> 23) << 23)
timestamp = EPOCH + id >> 23
```

pros: guaranteed unique in 64-bits, not much of a CPU overhead cons: large IDs from the get-go

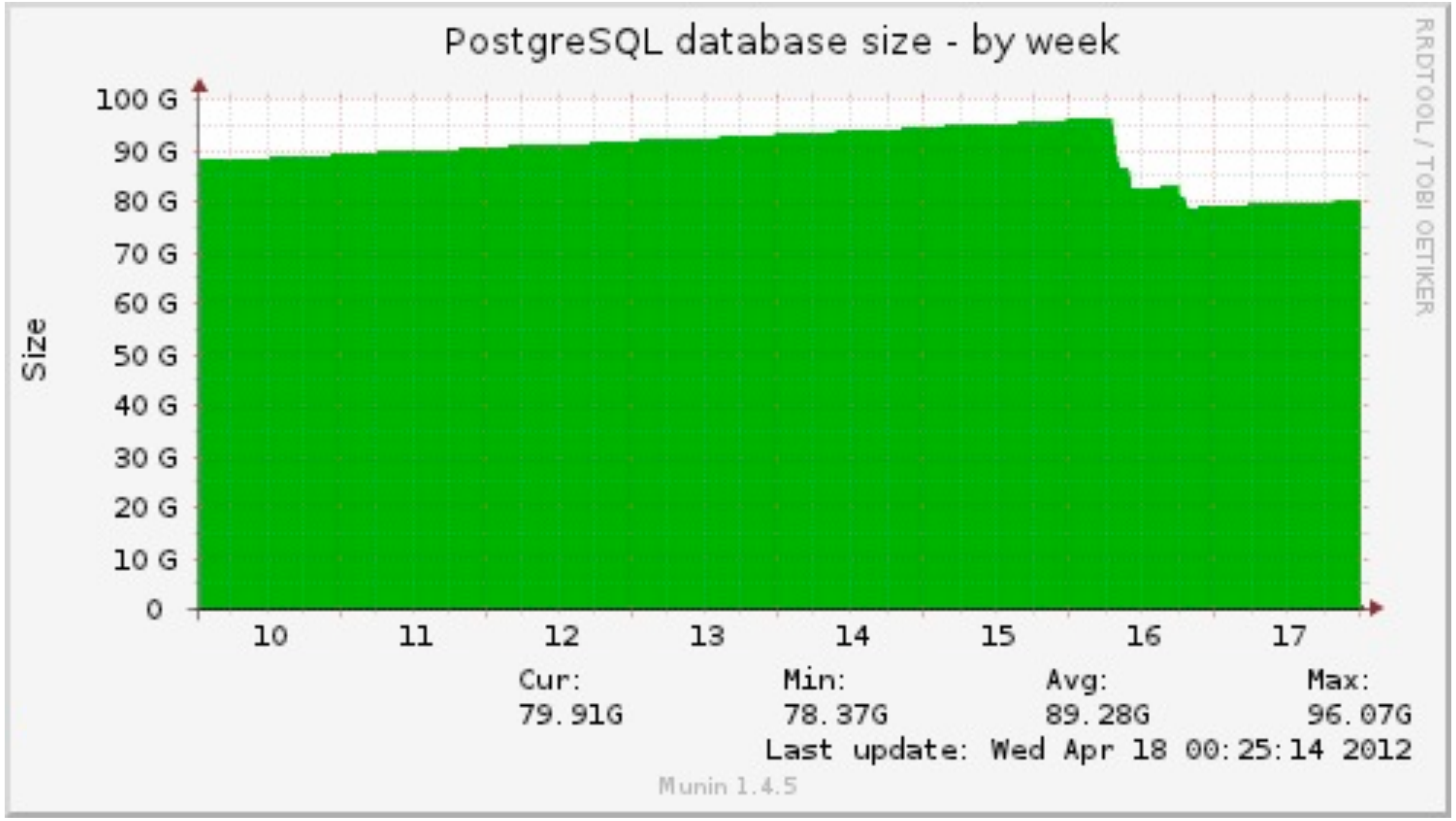
hundreds of millions of IDs generated with this scheme, no issues well, what about “re-sharding”

first recourse: pg_reorg

rewrites tables in index order

only requires brief locks for atomic table renames

20+GB savings on
some of our dbs


PostgreSQL database size - by week
Size
100 G
90 G
80 G
70 G
60 G
50 G
40 G
30 G
20 G
10 G
0
10
11
12
13
14
15
16
17
Cur:
79.91G
Min:
78.37G
Avg:
89.28G
Max:
96.07G
Last update: Wed Apr 18 00:25:14 2012
Munin 1.4.5
RRDTOOL / TOBI OETIKER

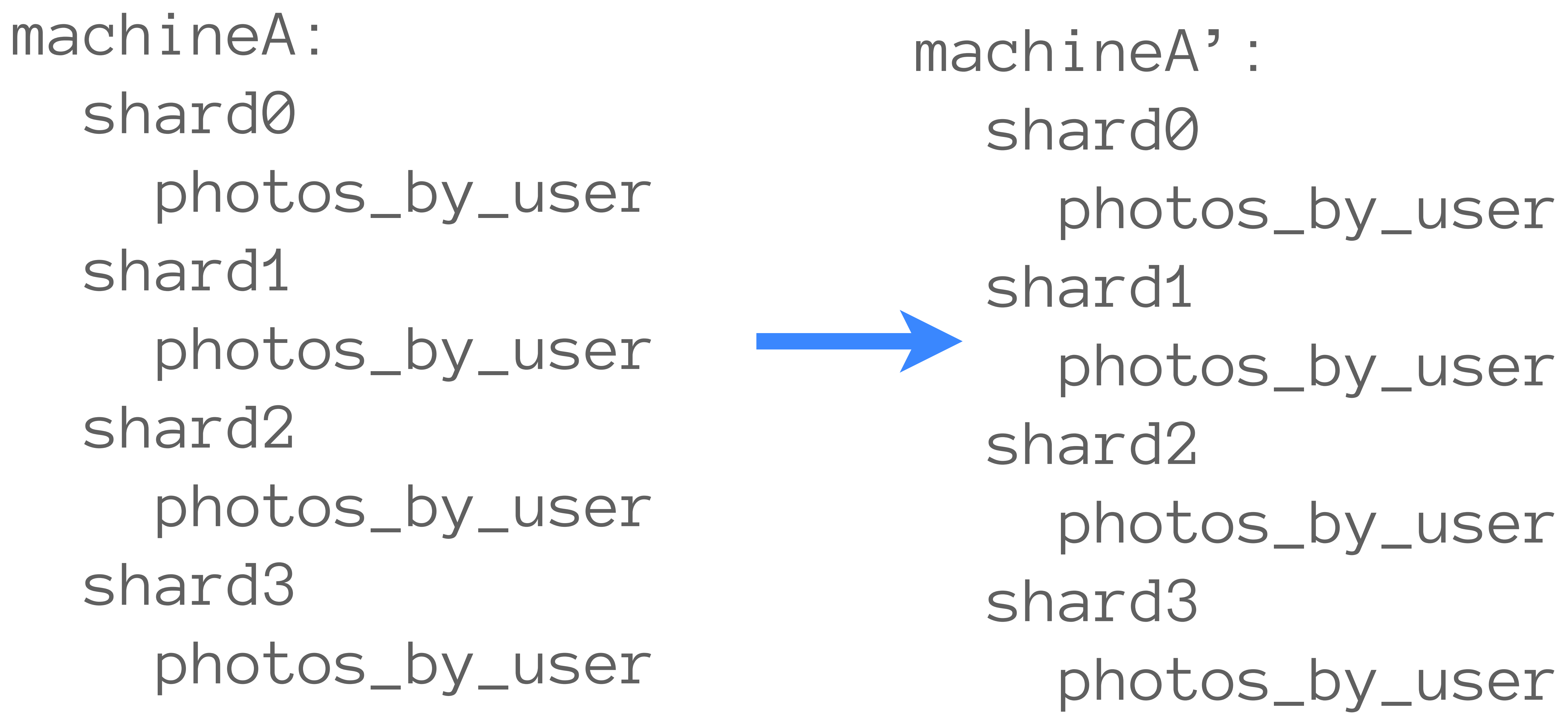
especially useful on EC2

but sometimes you just have to reshard

streaming replication to the rescue

(btw, repmgr is
awesome)

```
repmgr standby clone <master>
```



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  shard2
    photos_by_user
  shard3
    photos_by_user
```

```
machineA:
  shard0
    photos_by_user
  shard1
    photos_by_user
~~  shard2~~
~~    photos_by_user~~
~~  shard3~~
~~    photos_by_user~~
```

```
machineC:
~~  shard0~~
~~    photos_by_user~~
~~  shard1~~
~~    photos_by_user~~
  shard2
    photos_by_user
  shard3
    photos_by_user
```

PGBouncer abstracts moving DBs from the app logic can do this as long as you have more logical shards than physical ones beauty of schemas is that they are physically different files

(no IO hit when deleting,
no ‘swiss cheese’)

downside: requires ~30 seconds of maintenance to roll out new schema mapping

(could be solved by having concept of “read-only” mode for some DBs) not great for range-scans that would span across shards

latest project: follow graph

v1 : simple DB table (source_id, target_id, status) who do I follow?

who follows me?

do I follow X?

does X follow me?

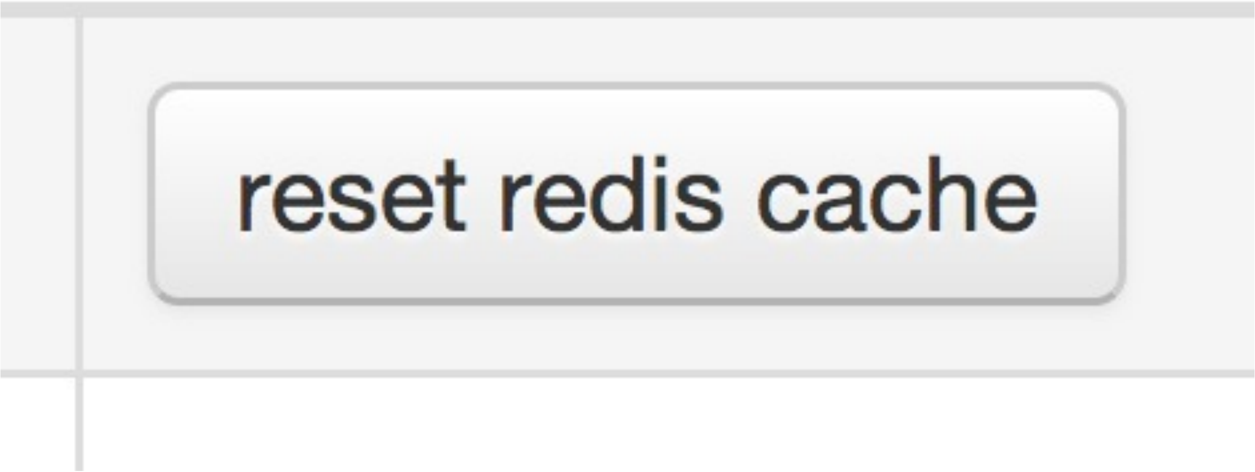
DB was busy, so we started storing parallel version in Redis follow_all(300 item list)

inconsistency

extra logic

so much extra logic

exposing your support team to the idea of cache invalidation


reset redis cache

redesign took a page from twitter's book

PG can handle tens of thousands of requests, very light memcached caching

next steps

isolating services to minimize open conns

investigate physical hardware / etc to reduce need to re-shard

Wrap up

you don’t need to give up PG’s durability & features to shard continue to let the DB do what the DB is great at “don’t shard until you have to”

(but don't over-estimate how hard it will be, either) scaled within constraints of the cloud

PG success story

(we're really excited about 9.2)

thanks! any qs?