POSTGRESQL ON AWS:

TIPS & TRICKS
(AND HORROR STORIES)

ALEXANDER KUKUSHKIN

PostgresConf US 2018
2018-04-20

ABOUT ME

Alexander Kukushkin

Database Engineer @ZalandoTech
Email: alexander.kukushkin@zalando.de
Twitter: @cyberdemn

zalando

FACTS & FIGURES

> 300 databases
on premise

> 150
on AWS EC2

> 200
on K8S

zalando

WHY WE USE AWS

- Fast hardware (service) provisioning
- Easy scale up/down/in/out
- Pay only for resources you need

GLOSSARY

- RDS - Relational Database Service
- EC2 - Elastic Compute Cloud
- EBS - Elastic Block Store
- S3 - Simple Storage Service
- AZ - Availability Zone
- ASG - Auto Scaling Group

POSTGRESQL HA ON AWS

- Shared storage - **EBS,** attach it to a different **EC2** Instance
  - Works within one **AZ**
- Storage mirroring - **Multi-AZ RDS** (**EBS** is replicated to another **AZ**)
  - Works between **AZ**
  - Replicas can’t execute queries
- Streaming replication - you can start additional **RDS** replicas
  - Replicas can execute queries
  - Automatic Failover problem (if not **Multi-AZ** deployment)
- Amazon Aurora
  - Keeps 6 copies of data in 3 **AZ**
  - Low latency read replicas
  - Failover typically takes less than 30 seconds.

EC2 VS. RDS VS. AURORA: MONTHLY PRICING*

Instance Type	EC2	RDS	Aurora
(db.)t2.micro	$9.78	$18.25	n/a
(db.)m4.large	$87.60	$158.41	n/a
(db.)m5.large	$83.95	n/a	n/a
(db.)r4.large	$116.80	$222.65	$255.50
(db.)r4.xlarge	$233.60	$445.30	$511.00

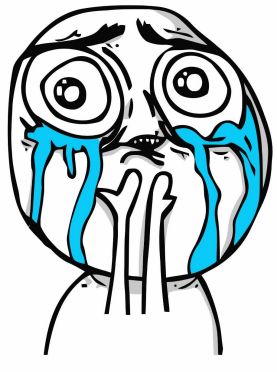
* storage price is not included

EC2 VS. RDS VS. AURORA: MONTHLY PRICING*

Instance Type	2 x EC2	3 x EC2	RDS Multi-AZ	2 x Aurora
(db.)t2.micro	$19.56	$29.34	$36.50	n/a
(db.)m4.large	$175.20	$262.80	$316.82	n/a
(db.)m5.large	$167.90	$251.85	n/a	n/a
(db.)r4.large	$233.60	$350.40	$445.30	$511.00
(db.)r4.xlarge	$467.20	$700.80	$890.60	$1022.00

* storage price and price for Aurora I/O Rate are not included

RDS SUMMARY

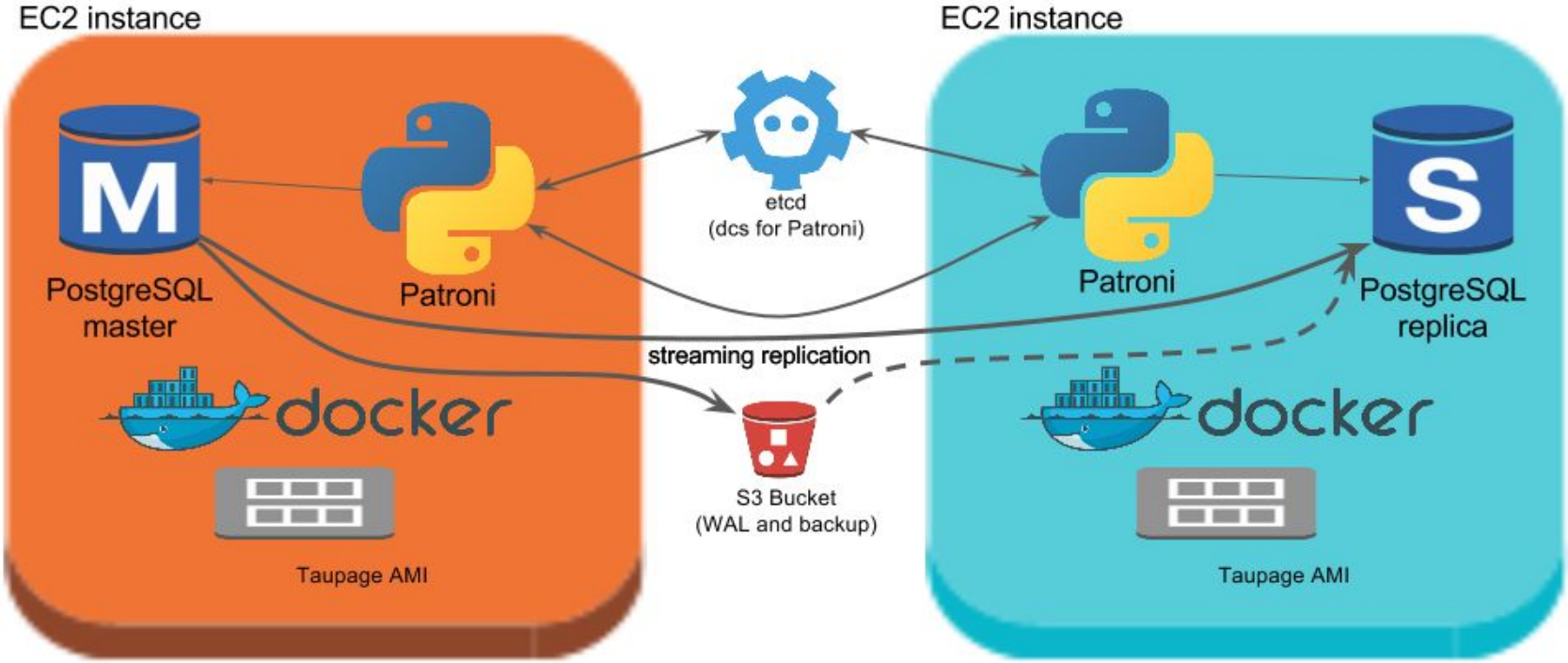


- No superuser access
- No replication connection
- No custom extensions
- **Multi-AZ RDS** doubles the price, but replica can’t execute queries
- **Aurora** works only on **R4** instances and price for “**I/O Rate”** can become really high

SPILO AND PATRONI

- Patroni - High-Availability and automatic failover
- Spilo - Docker package of Patroni and WAL-E for AWS or Kubernetes
- Use CloudFormation stacks and ASG for deployments
- One Docker container per EC2 Instance

AWS DEPLOYMENT



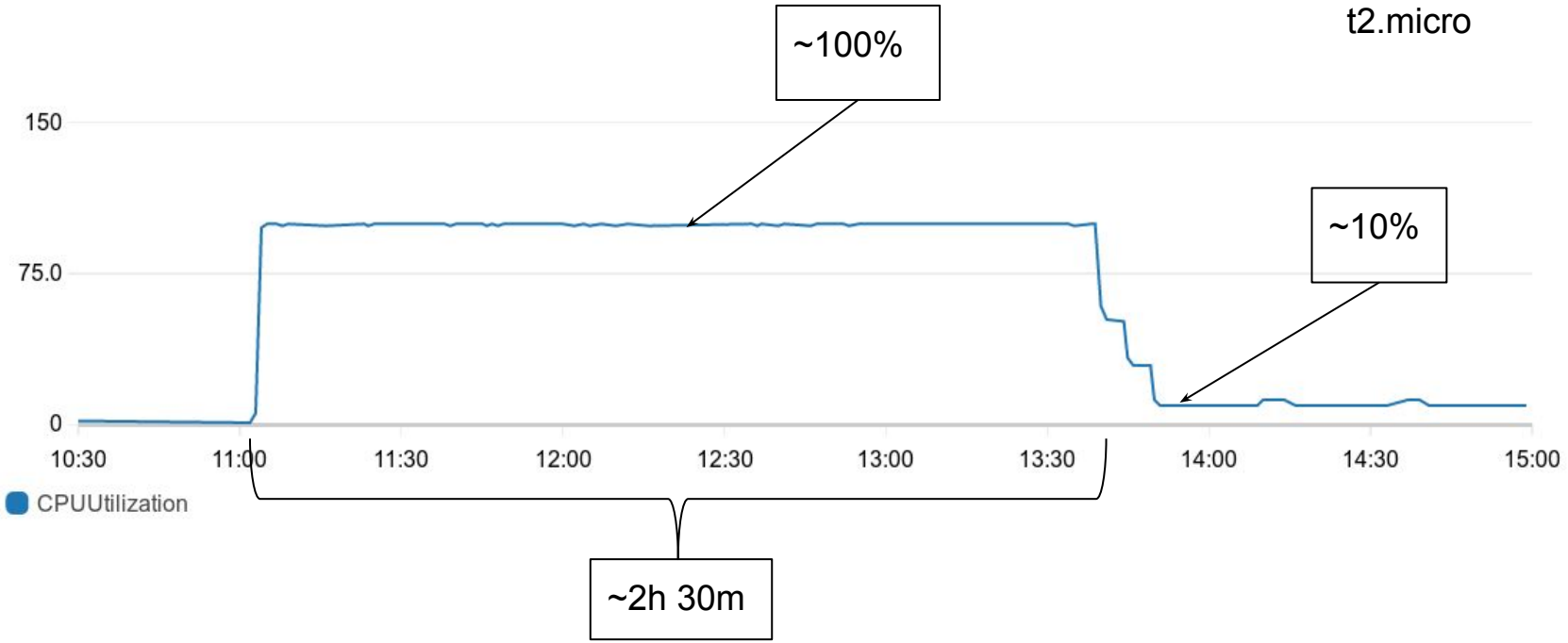
zalando

EC2 INSTANCE FEATURES

- Instance Types: t2, m5, m4, c5, x1, r4, p2, g3, f1, i3, d2
- Instance Sizes: nano, micro, small, medium, large, xlarge, 2xlarge, 4xlarge, 10xlarge, 16xlarge, 32xlarge
- Performance: Fixed vs. Burstable (T2 Instances)
- Storage: Instance Store (Ephemeral) vs. EBS
- EBS-optimized Instances
- Enhanced Networking

BURSTABLE PERFORMANCE OR WHY IS MY DATABASE VERY SLOW?

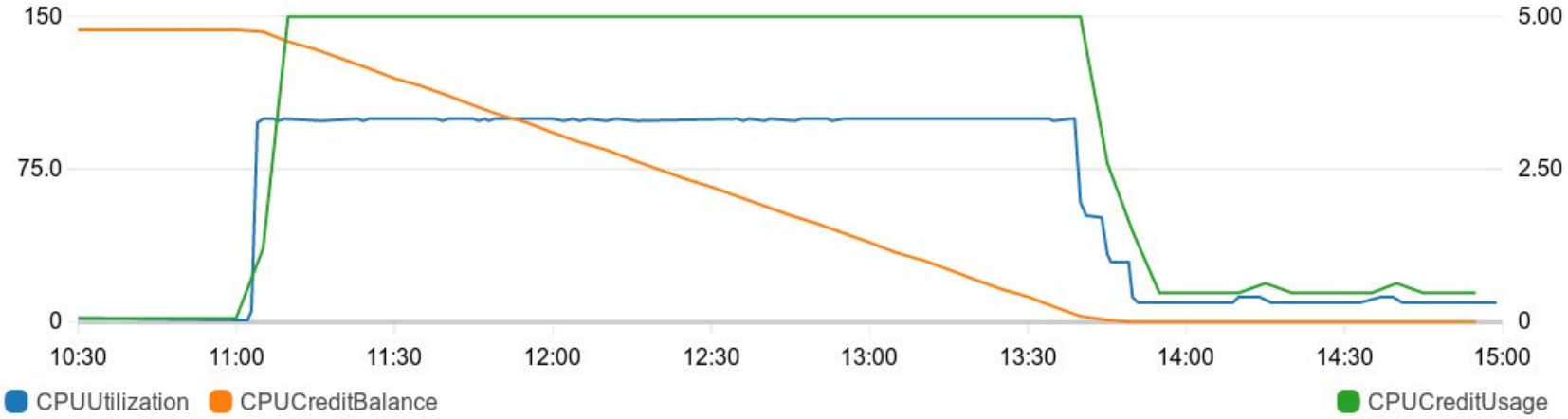
BURSTABLE PERFORMANCE



zalando

BURSTABLE PERFORMANCE

t2.micro



zalando

T2 INSTANCES

- Designed to provide moderate baseline performance and the capability to **burst** to significantly higher performance as required by your workload.
- If your account is less than 12 months old, you can use a t2.micro instance for **free** within certain usage limits.

Instance Type	Initial CPU credit	Credits earned per hour	vCPUs	Base performance (CPU utilization)	Max CPU credit balance
t2.micro	30	6	1	10%	144
t2.small	30	12	1	20%	288
t2.medium	60	24	2	40%	578
t2.large	60	36	2	60%	864

CPU CREDITS

- One CPU credit is equal to one vCPU running at 100% utilization for one minute.
- When a T2 instance uses fewer CPU resources than its base performance level allows (such as when it is idle), the unused CPU credits (or the difference between what was earned and what was spent) are stored in the credit balance for up to 24 hours, building CPU credits for bursting.
- When a T2 instance requires more CPU resources than its base performance level allows, it uses credits from the CPU credit balance to burst up to 100% utilization.

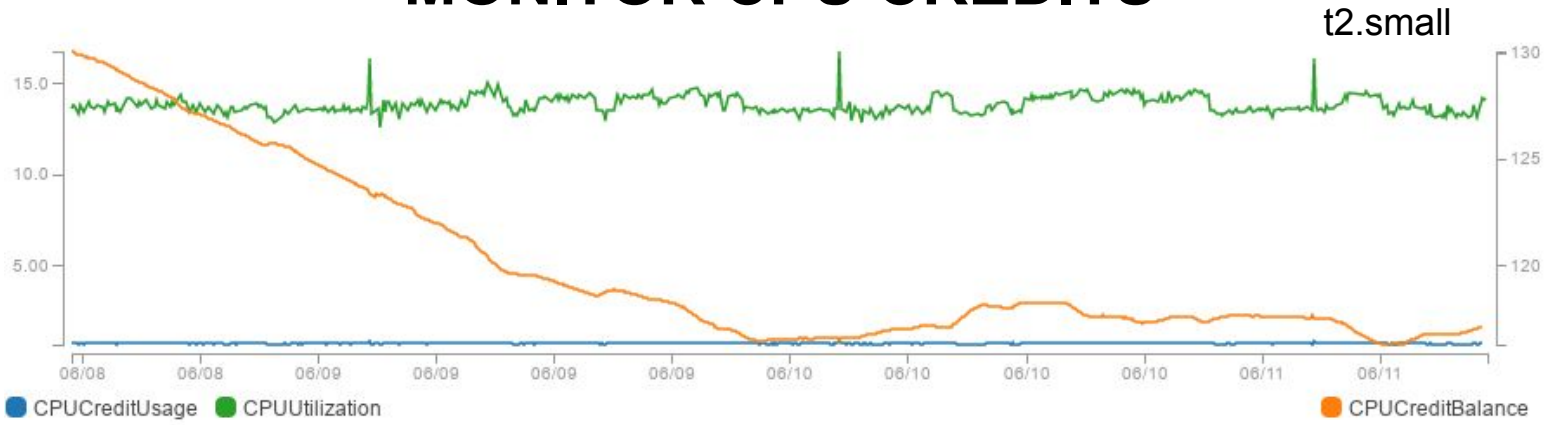
HORROR STORY

- WAL-E wal-fetch/wal-prefetch is terribly slow
  - Prefetch spawns 8 worker processes (by default) and can burn all CPU Credits

How we solved it:

1. use “-p 0” to disable prefetch
2. reimplemented ‘wal-fetch’ in bash + curl + openssl

MONITOR CPU CREDITS



- **CPUCreditUsage** metric indicates the number of CPU credits used during the measurement period
- **CPUCreditBalance** metric indicates the number of unused CPU credits a T2 instance has earned

RESERVED INSTANCES

- 1 year or 3 year contracts
- Significant discount compared to On-Demand instance pricing
- Capacity reservation
- Customers using both Reserved and On-Demand instances will have Reserved Instance rates applied first to minimize costs
- Discounts up to 70%

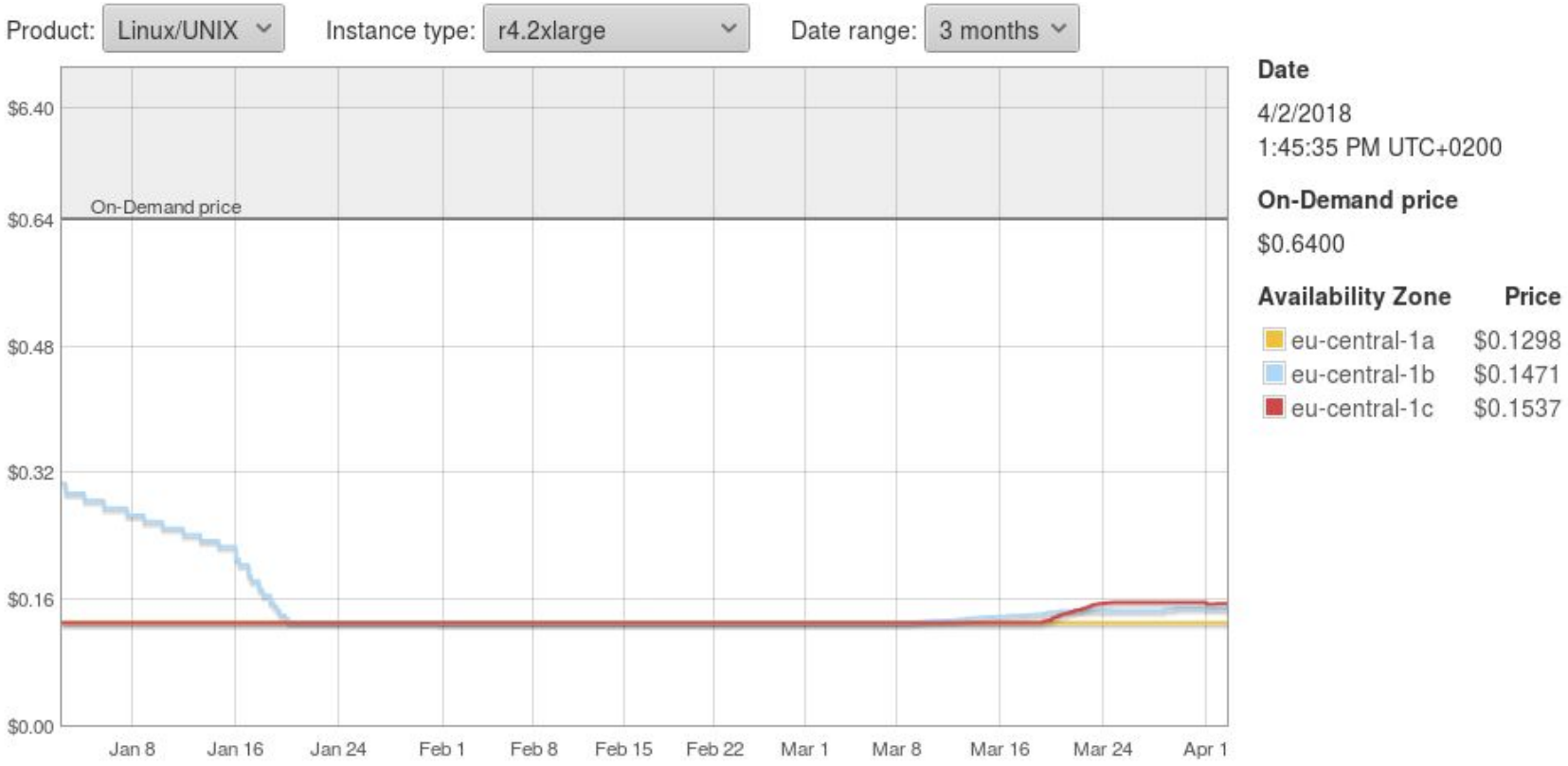
SPOT INSTANCES

- Bidding on “AWS overcapacity”
- Variable price point, save up to 90% vs. on-demand

Risks

Unavailability or loss of instance if outbid!!!

SPOT MARKET



zalando

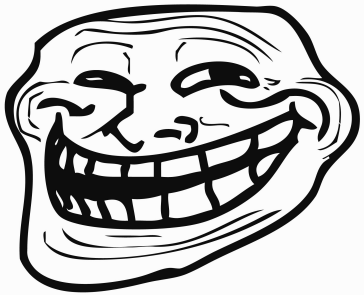
USE CASES

Everything that can fail or be unavailable for short duration

- Async processing
- Reporting
- CI
- Staging systems
- Testing of backups

HORROR STORY

- There were only 2 AZ in eu-central-1 until June 2017
- ASG is trying to do its best to distribute resources across different AZ, but when **Spot Price** is high, it might happen that two EC2 Instances will run in the same AZ
- When price will go down, ASG will rebalance resources, i.e. spawn a new instance in another AZ and terminate one of the running instances
- With 50% probability it will kill the “master”



How we solved it:

AutoScalingGroup -> “TerminationPolicies”: [“NewestInstance”, “Default”]

ELASTIC BLOCK STORE

Name	io1	gp2	st1	sc1
Size	4GB - 16TB	1GB - 16TB	500GB - 16TB	500GB - 16TB
Max IOPS/Volume	20000	10000	500	250
Max Throughput/Volume	320MB/s	160MB/s	500MB/s	250MB/s

ELASTIC BLOCK STORE

- ST1 and SC1 - HDD, good throughput, but low IOPS
- GP2 and IO1 - SSD, usually good choice for databases
- EBS volumes are created in a specific AZ, and can then be attached to any instances in that AZ
- IOPS and throughput depends on Volume Size

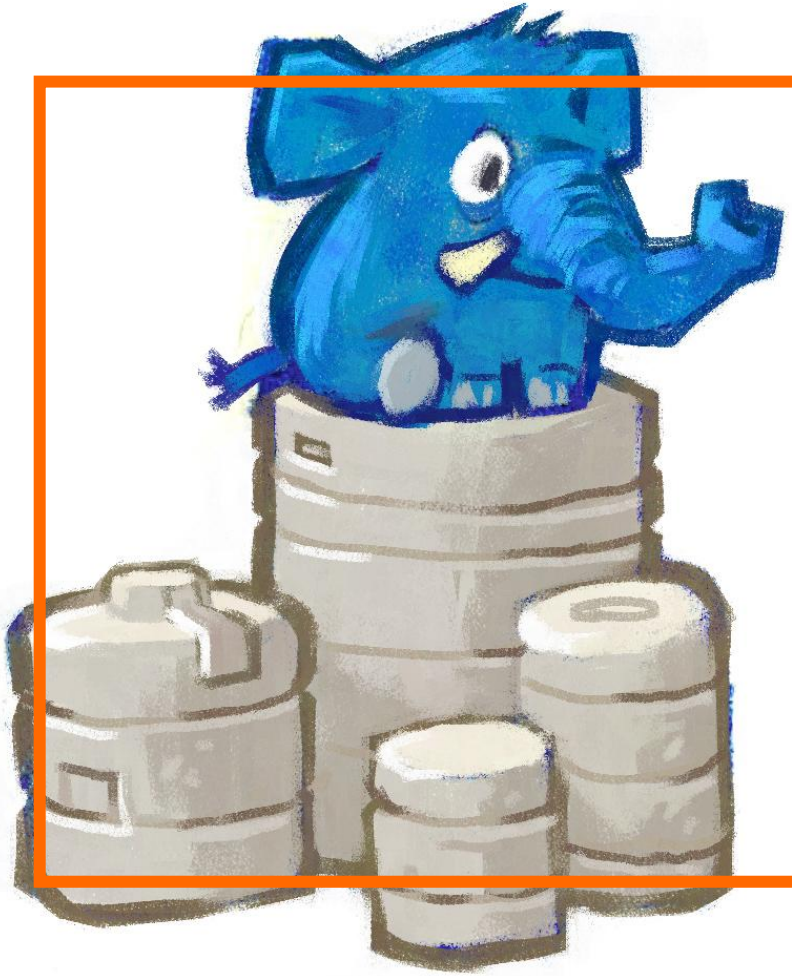
STORAGE PRICING

	io1	gp2
EC2	$0.149/GB-month $0.078/provisioned IOPS	$0.119/GB-month
RDS*	$0.149/GB-month $0.119/provisioned IOPS	$0.137/GB-month
Aurora	$0.119/GB-month + $0.22 / 1 million requests	

* **MultiAZ** doubles the price

IO1 VS. GP2

- IO1 gives better IOPS guarantees
- But you have to pay for it – the same size costs 25% more (or 9% more for RDS). Plus you have to pay for provisioned IOPS
- For RDS minimum size of IO1 volume is 100 GB + 1000 provisioned IOPS. It will cost you $14.90 + $119 per month
- You can get 1000 IOPS with 334 GB GP2 volume for $45.76/month



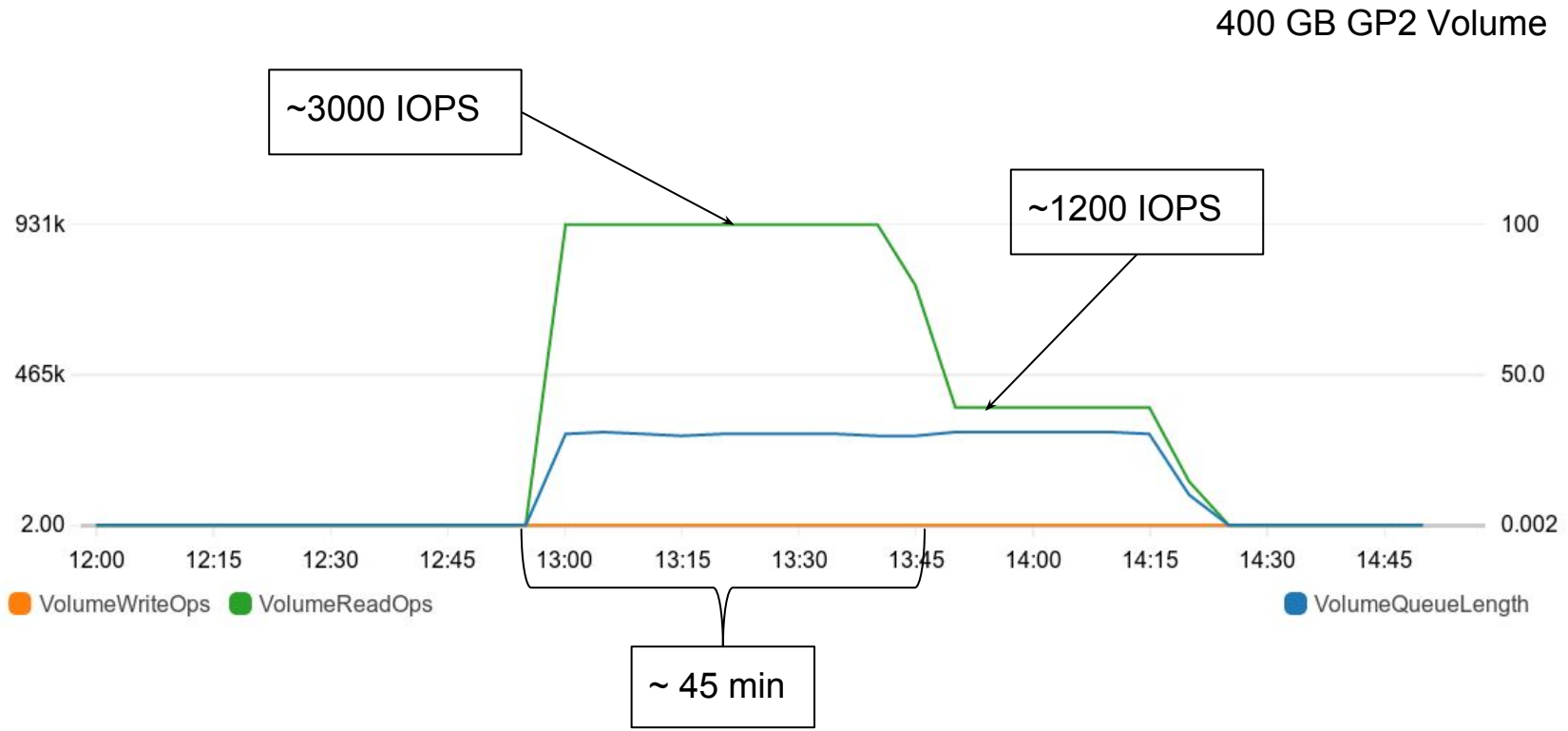
SEQUEL:

BURSTABLE PERFORMANCE

OR WHY IS MY DATABASE

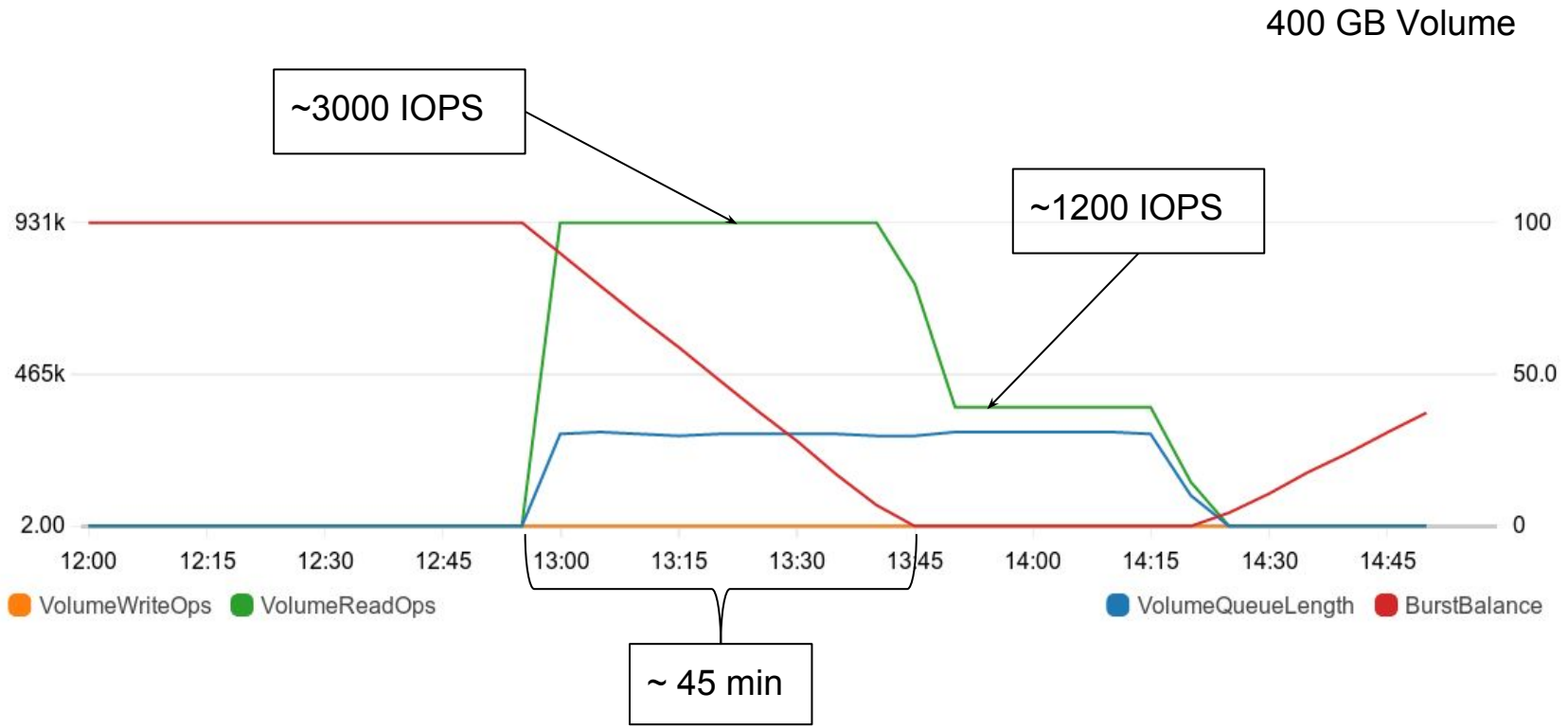
SLOW AGAIN?

BURSTABLE PERFORMANCE



zalando

BURSTABLE PERFORMANCE

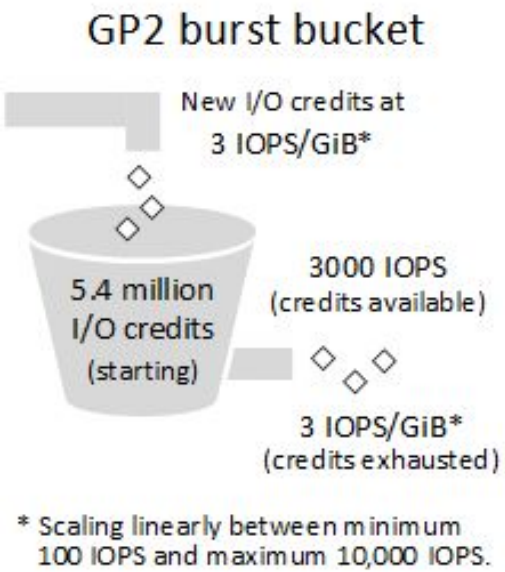


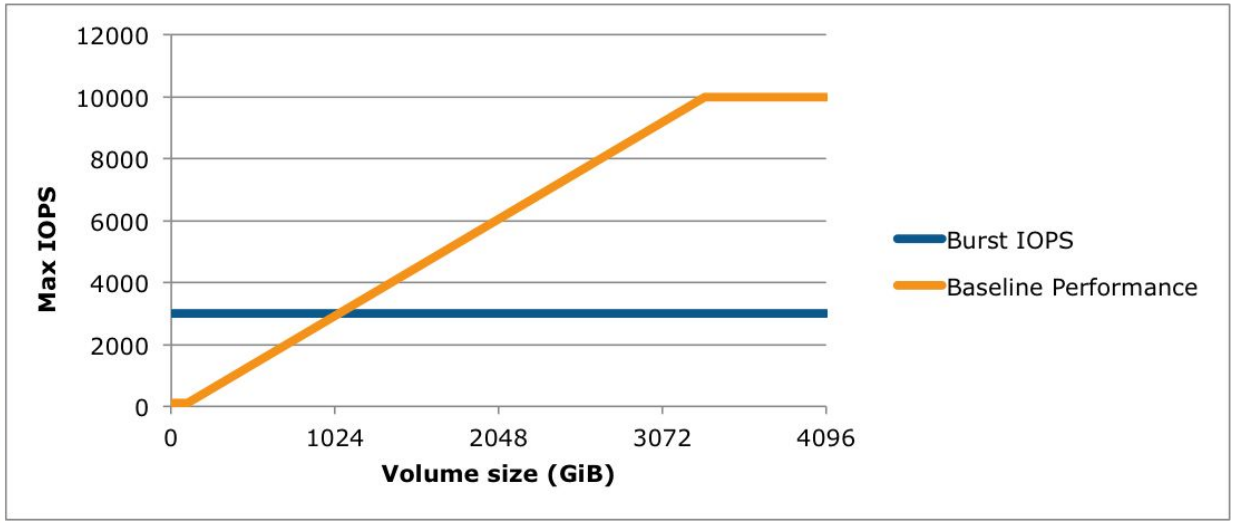
zalando

I/O CREDITS AND BURST PERFORMANCE

- The performance of gp2 volumes is tied to volume size (3 IOPS/GiB)
- The maximum and initial I/O credit balance for a volume is 5.4 million
- When your volume requires more than the baseline performance I/O level, it draws on I/O credits in the credit balance to burst to the required performance level, up to a maximum of 3,000 IOPS
- When your volume uses fewer I/O credits than it earns in a second, unused I/O credits are added to the I/O credit balance

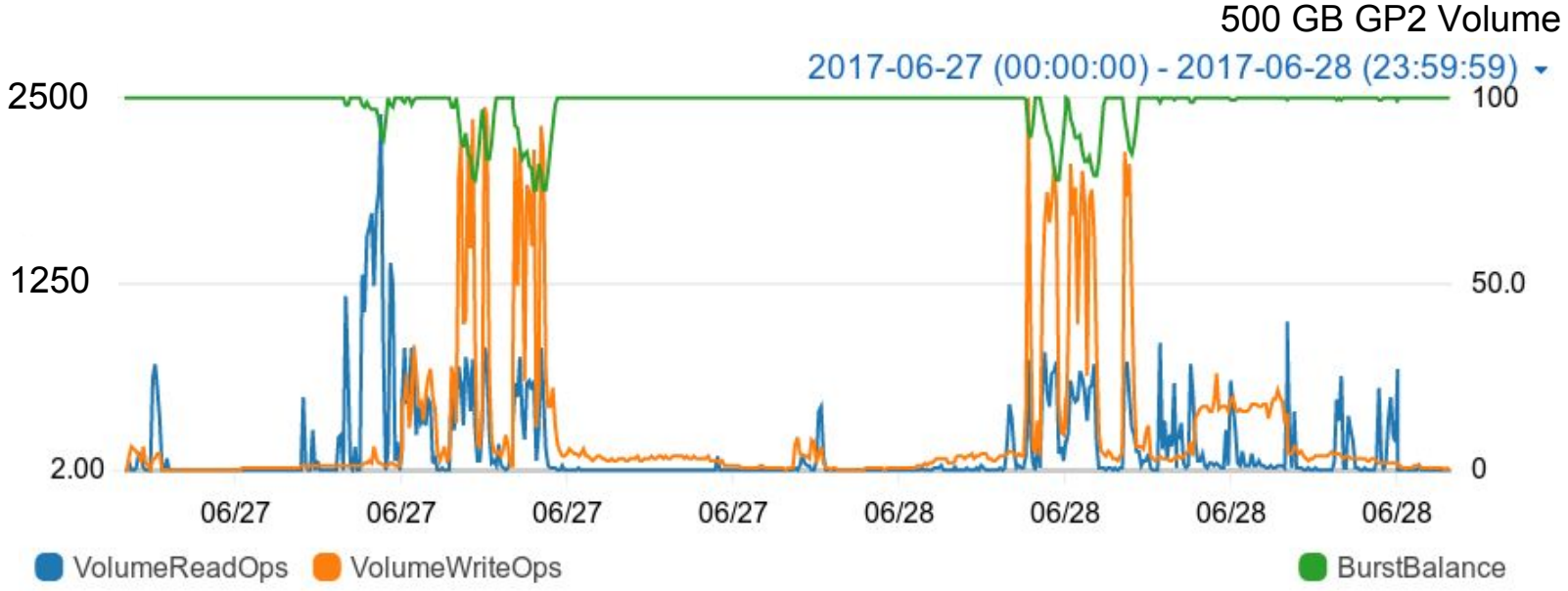
GP2 VOLUMES EXPLAINED





zalando

MONITOR I/O WITH CLOUDWATCH



- Especially **BurstBalance** if GP2 volume is smaller than 1TB

zalando

EBS-OPTIMIZED INSTANCES

- Dedicated bandwidth to Amazon EBS, with options between 500 Mbps and 12,000 Mbps, depending on the instance type you use

- Provides the best performance for your EBS volumes by minimizing contention between Amazon EBS I/O and other traffic from your instance

EBS THROUGHPUT

InstanceType	vCPU	Memory	Max IOPS	Throughput (Mb/s)	Price (per month)
m4.large	2	8 GB	3600	56.25	$87.6
r4.large	2	15 GB	3000	54	$116.8
m5.large*	2	8 GB	*Up to* 16000	*Up to* 265	$83.95
m4.xlarge	4	16 GB	6000	93.75	$175.2
r4.xlarge	4	30 GB	6000	106.25	$233.6
m5.xlarge*	4	16 GB	*Up to* 16000	*Up to* 265	$167.9

M5 INSTANCES

- Next generation
- Slightly cheaper than M4
- Better networking and storage performance
- **EBS burst** capability on smaller instance sizes (large, xlarge, 2xlarge)
  - can support maximum performance for 30 minutes at least once every 24 hours

M4 VS. M5 INSTANCES

	IOPS		Throughput (Mb/s)	
InstanceType	**Baseline**	**Max**	**Baseline**	**Max**
m4.large	3600	3600	56.25	56.25
m5.large	3600	16000	60	265
m4.xlarge	6000	6000	93.75	93.75
m5.xlarge	6000	16000	100	265
m4.xlarge	8000	8000	125	125
m5.xlarge	8333	16000	146	265

MORE CLOUDWATCH METRICS

- If you run m5.large, m5.xlarge or m5.2xlarge, you should monitor
  - **EBSIOBalance%** - percentage of I/O credits remaining in the burst bucket.
  - **EBSByteBalance%** - percentage of throughput credits remaining in the burst bucket
- *Instances with a consistently low balance percentage are candidates for upsizing*
- *Instances where the balance percentage never drops below 100% are candidates for downsizing*

EBS PERFORMANCE OF T2 INSTANCES

- t2.micro, t2.small and t2.medium are showing up to ~60 MB/s on EBS
- t2.large, t2.xlarge and t2.2xlarge are showing up to ~120 MB/s on EBS
- I don’t have any numbers about Max. IOPS for T2 instances
- There is no guaranteed throughput for T2 instances!

EBS TIPS

- GP2 is MUCH cheaper than IO1
- Choose an EC2 Instance with enough bandwidth
- Build a RAID-0 from multiple GP2 volumes to get more than 10000 IOPS or 160MB/s

HORROR STORY

- AWS didn’t provide a means to monitor EBS Burst Balance until November 2016
- RDS still doesn’t provide information about GP2 Volume Burst Balance

INSTANCE STORE VOLUMES

- Pros:
  - Located on disks that are physically attached to the host computer
  - Amazing throughput and latencies compared to EBS
- Cons:
  - Provides only **temporary** block-level storage
  - Data in the instance store is lost under the following circumstances:
    - The underlying disk drive fails
    - The instance stops or terminates

PRICE COMPARISON

InstanceType	r4.xlarge	i3.xlarge	r4.2xlarge	i3.2xlarge
vCPU	4	4	8	8
Memory	30 GB	30 GB	60 GB	60 GB
Max IOPS	6000	6000	12000	12000
Throughput (Mb/s)	109	100	218	200
Instance Storage (NVMe)	-	950 GB	-	1900 GB
Price (per month)	$233.6	**$271.56**	$467.2	**$543.12**
Price with 950 GB EBS	**$346.65**		$580.25	
Price with 1900 GB EBS	$459.7		**$693.3**	

INSTANCE STORE SUMMARY

- For high-intensive OLTP, i3 instances are a rescue:
  - r4.2xlarge + 3.3TB EBS ($863.75/month) wasn’t able to keep up
  - The switch to i3.2xlarge solved all problems and saved 37% of costs

We run ~40 clusters on i3 instances and only two i3 instances has failed during last year.

AVAILABILITY, DURABILITY AND SLA

- S3
  - availability - 99.9%
  - durability - 99.999999999%
- EBS
  - availability - 99.99%
  - AFR - 0.1%-0.2%
- EC2
  - SLA - 99.99%
- RDS
  - SLA - 99.95%

ANYTHING CAN FAIL

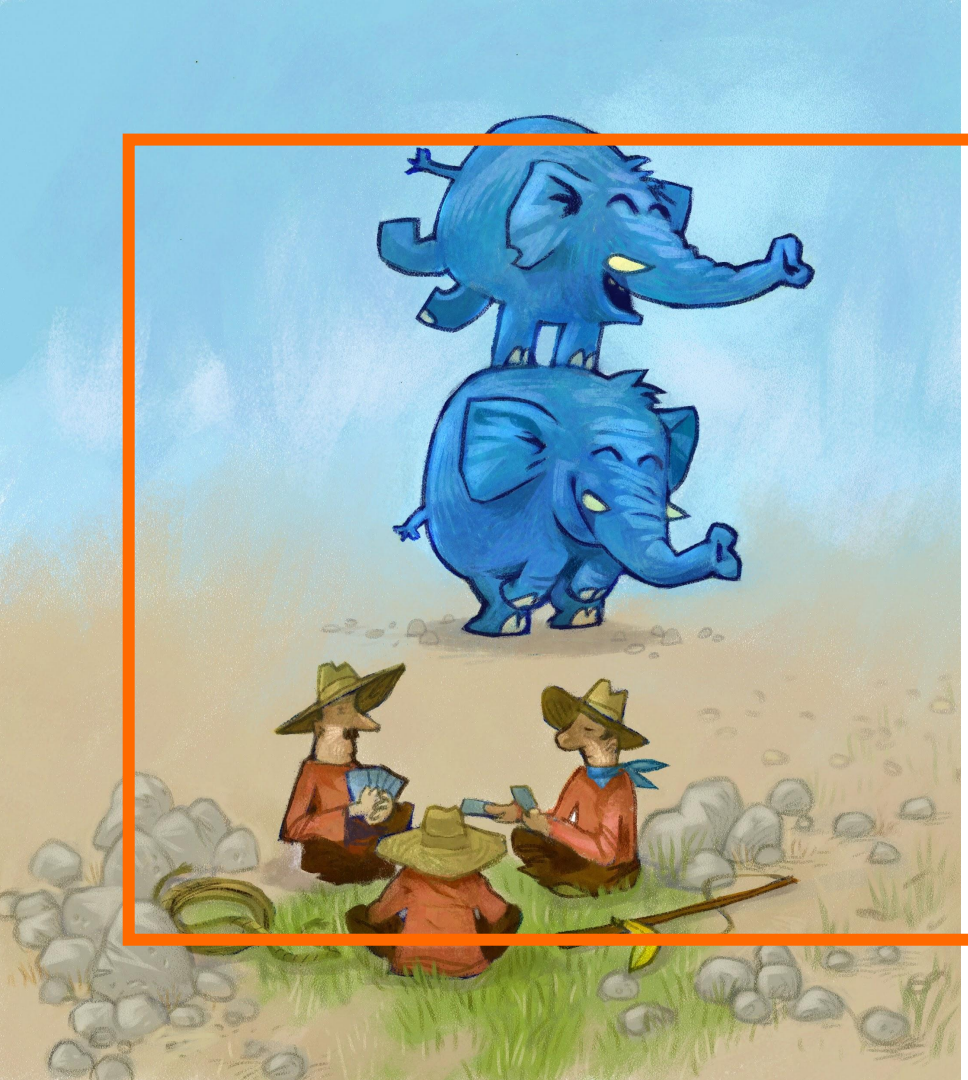
- We observed 4 failures of EBS during past year
- EC2 instances fail a few times more often than EBS
  - Sometimes they just fail
  - But usually AWS notifies you about degradation
- Please do continuous archiving to S3!
  - wal-e, wal-g, pgBackRest

SUMMARY

- Start with small Instances and Volumes, it’s easy to scale up later
- Some of the resources (**CPUCreditUsage**, **CPUCreditBalance**, **BurstBalance, EBSIOBalance%, EBSByteBalance%**) it’s possible to monitor only with CloudWatch
- Always do backups and test them

USEFUL LINKS

- Easy Amazon EC2 Instance Comparison - EC2instances.info
- Easy Amazon RDS Instance Comparison - RDSInstances.info
- Simple monthly calculator - calculator.s3.amazonaws.com/index.html
- Patroni - github.com/zalando/patroni
- Spilo - github.com/zalando/spilo



QUESTIONS?