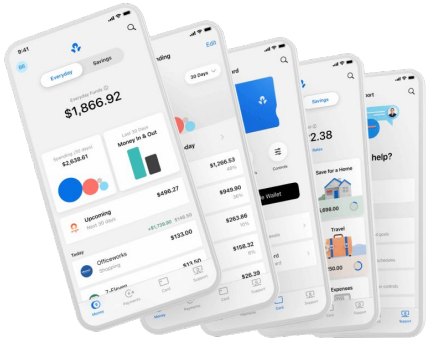
Lessons Learned Running GKE Clusters on Spot Instances

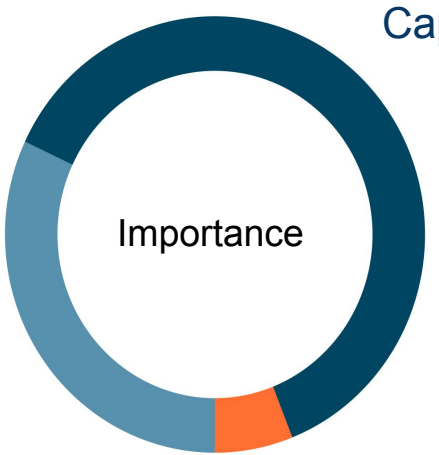
Olga Mirensky, Platform Engineer, ANZx



Spot Instances Quick Overview

	Google Cloud	aws	Azure
Discount	60 - 91%	Up to 90%	Up to 90%
Updates	Once a month	Can be frequent	Variable
Options	One size fits all	Price and/or capacity optimised	Set max price
Notice	30 sec	2 min	30 sec
On preemption	Stop/Hibernate	Stop/Hibernate/Terminate	Deallocate/Delete
Price Insights	API, Cost table	`aws ec2 describe-spot-price-history` Spot instance advisor	Portal price/eviction history, API

This Talk Scope



Disclaimer: This pie chart is a work of fiction. Any resemblance to actual stats is purely coincidental.

Spot Capacity Management in Kubernetes

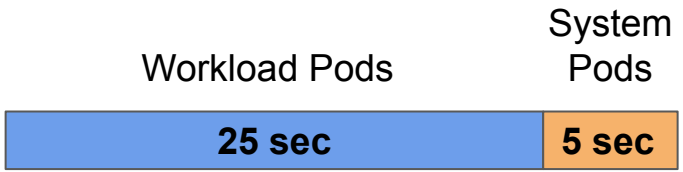
- Fallback to on-demand automatically (and un-fallback)
  - Priority based expander for Cluster Auto Scaler
  - GKE Cluster Auto Scaler price-optimised by default
  - Weighted NodeAffinity
- Cluster Reserved Capacity
  - Cluster Auto Scaler config option
  - Headroom / balloon pods
- Managed Dataplane
  - Spot by NetApp, etc.
- Service quota limit for Spot CPU

priority-expander-cm.yaml Raw

```yaml
# based on https://github.com/kubernetes/autoscaler
# higher number - higher priority (not in %)
apiVersion: v1
kind: ConfigMap
metadata:
  name: cluster-autoscaler-priority-expander
  namespace: kube-system
data:
  priorities: |-
    10:
      - .*on-demand.*
    50:
      - .*spot.*
```

Graceful Shutdown

- Fault tolerant applications
- Graceful shutdown on SIGTERM
  - In-flight requests handled
  - New requests not routed and not accepted
  - External connections are closed (DB)
  - App specific requirements
- Node Graceful Shutdown feature in k8s
  - Enabled by default since 1.21
  - Node NotReady
  - SIGTERM propagation: workload vs system pods



We broke everything (but not really)

	PF	READY	RESTARTS	STATUS	CPU	MEM	%CPU/R	%CPU/L	%MEM/R	%MEM/L
-66b95c8b9c-292qt	●	2/2	0	Running	5	243	1	0	31	7
6754f-mhvd2	●	7/7	0	Running	22	730	0	0	16	5
5w82	●	0/2	0	Completed	0	0	0	0	0	0
t	●	0/0	0	NodeAffinity	0	0	0	0	0	0
jlx	●	4/4	2	Running	1126	4056	21			
sjr	●	0/0	0	NodeAffinity	0	0	0			
7qn	●	0/0	0	NodeAffinity	0	0	0			
frm	●	4/4	0	Running	178	4206	3			
	●	0/2	0	Completed	0	0	0			
elop-865b95584d-lsn8p	●	2/2	0	Running	6	118	1			
-7d4df9dbf8-2q5dp	●	2/2	0	Running	5	240	1			
-7d4df9dbf8-95j8r	●	0/2	0	Error	0	0	0			
849696986-l4frx	●	2/2	0	Running	7	180	0			
6cpt	●	0/0	0	NodeAffinity	0	0	0			
wf6x	●	4/4	2	Running	87	5196	1			
pclg	●	0/0	0	NodeAffinity	0	0	0			
psgk	●	4/4	2	Running	46	4449	1			
	●	0/2	0	Completed	0	0	0			
-jgflj	●	2/2	0	Running	6	124	1	0	32	8
-xxw98	●	2/2	0	Running	6	117	1	0	30	7
-zncds	●	2/2	0	Running	11	132	2	0	34	8

Name	Status	Type	Pods	Namespace	Cluster	Pods Running	Pods Desired
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2
	OutOfcpu	Deployment	2/2			2	2

ingressgateway-564594c67c-njcdm	0/1	NodeAffinity	0	6d15h
ingressgateway-564594c67c-nlrdp	1/1	Running	0	37h
ingressgateway-564594c67c-nz6j2	0/1	Completed	0	6d15h
ingressgateway-564594c67c-pqvdk	1/1	Terminated	0	6d15h
ingressgateway-564594c67c-psf8t	1/1	Running	0	2d9h
ingressgateway-564594c67c-q947l	1/1	Running	0	2d9h
ingressgateway-564594c67c-qcw2g	1/1	Running	0	6d15h
ingressgateway-564594c67c-qp8lj	0/1	NodeAffinity	0	6d15h
ingressgateway-564594c67c-qqg9n	0/1	NodeAffinity	0	6d15h
ingressgateway-564594c67c-t9fhm	0/1	NodeAffinity	0	6d15h
ingressgateway-564594c67c-v8wq8	1/1	Running	0	6d15h
ingressgateway-564594c67c-xf7dd	1/1	Running	0	2d9h
ingressgateway-564594c67c-xfbds	0/1	NodeAffinity	0	6d15h

OutOfpods, Error, NotReady,

ContainerStatusUknown,

NodeShutdown, Terminated,

Init:ContainerStatusUnknown

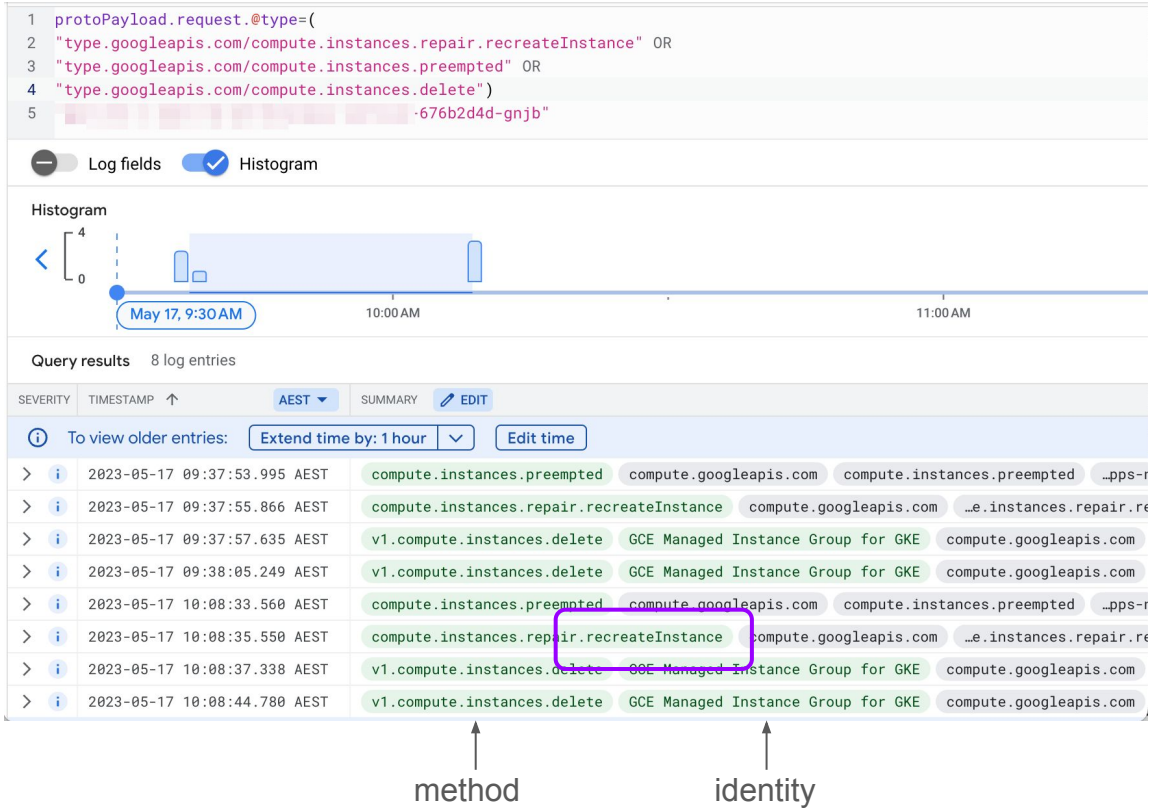
and more!! 🫠

message: Pod Predicate NodeAffinity failed

```
Warning  FailedMount  2m21s (x3870 over 5d10h) kubelet  MountVolume.SetUp failed for volume “xxxx”
                      : object “<namespace>“/”<name>” not registered
```

```
Warning  FailedMount   45m (x185 over 6h45m)  kubelet  MountVolume.SetUp failed for volume
.                      kube-api-access-12345" : object "my-ns"/"kube-root-ca.crt" not registered
Warning  NodeAffinity  41m                    kubelet  Predicate NodeAffinity failed
Warning  FailedMount   26s (x28 over 41m)     kubelet  MountVolume.SetUp failed for volume
.                      kube-api-access-12345" : object "my-ns"/"kube-root-ca.crt" not registered
```

Automatic Reclaiming



The same node can be backed by different VMs over its lifetime

recreateInstance

NodeAffinity

- NodeAffinity pods traced back to a node with reclaimed VM and still in cluster
- Related to https://issuetracker.google.com/issues/185362914
  - Kubelet restart edge case
  - Still an issue with GKE preemptible VMs at the time.
  - Users still report this issue (1.24.10-gke.2300)

“Note that this issue has little to no impact on workloads. As long as the pod is backed by controller (deployment/statefulset, etc) a new pod is immediately created and rescheduled.”

```
$ kubectl get pod $name -o yaml
…
status:
  message: Pod Predicate NodeAffinity failed
  phase: Failed
  reason: NodeAffinity
```

Little to no impact on workloads…

```
% k get pods --field-selector status.phase=Failed -o custom-columns=CREATED_AT:.metadata.creationTimestamp,NAME:.metadata.name,NODE:.spec.nodeName | sort
2023-02-28T02:50:24Z   prometheus-kube-state-metrics-6756f8f968-hxw7f   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:14Z   prometheus-kube-state-metrics-6756f8f968-s4nfz   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:18Z   prometheus-kube-state-metrics-6756f8f968-9b9fl   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:19Z   prometheus-kube-state-metrics-6756f8f968-f9vhw   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:20Z   prometheus-kube-state-metrics-6756f8f968-lrrjh   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:21Z   prometheus-kube-state-metrics-6756f8f968-fntvj   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:25Z   prometheus-kube-state-metrics-6756f8f968-2v8pt   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:26Z   prometheus-kube-state-metrics-6756f8f968-d2gm6   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:27Z   prometheus-kube-state-metrics-6756f8f968-l59nw   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:28Z   prometheus-kube-state-metrics-6756f8f968-7kv2d   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:28Z   prometheus-kube-state-metrics-6756f8f968-x9qjg   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:30Z   prometheus-kube-state-metrics-6756f8f968-chhzg   gke-[redacted]-03cbca2c-2pt6
2023-02-28T03:06:35Z   prometheus-kube-state-metrics-6756f8f968-qnjtg   gke-[redacted]-03cbca2c-2pt6
```

- 12 pods in 21 seconds on the same node
- At least 21 seconds deployment did not have desired capacity
- It is not a problem now, but something happened in the past

No Panic!

Does my Deployment (StatefulSet / DaemonSet) have desired number of replicas Running and Ready?

But there is a better way…

Not so “little impact”

- Platform should be easy to consume
- Software Engineers are not experts in Dead Pods
- Engineers raise “issues” and support requests again and again, wastes time
- Spot instances became the first suspect when anything goes wrong even when
  - Technically there is no issue
  - Or issues are not caused by Spot preemptions

Solutions

- k8s Garbage Collector
  - In GKE threshold is 1000 objects
- https://github.com/kubernetes-sigs/descheduler
  - Safely evicts (not deletes) pods
  - Rebalance Availability Zones
  - Spread pods of the same deployment across nodes
  - Remove ‘Failed’ pods immediately, and more
- Data
  - Platform Critical User Journeys (CUJ) and SLOs

Takeaways

Implementing well-known SRE k8s practices are crucial on Spot:

- Replication
- Spread across zones and nodes (TSC[1], pod AntiAffinity)
- Graceful shutdown
- Probes
- Tier applications by priority
- PDBs. Don’t protect from Spot preemptions, but improve overall availability

[1] new features: https://kubernetes.io/blog/2023/04/17/fine-grained-pod-topology-spread-features-beta/

What doesn’t kill you makes you stronger

Thank you

CAS expanders: https://github.com/kubernetes/autoscaler/tree/master/cluster-autoscaler/expander

Open Source CAS developed by AWS: https://karpenter.sh/

GKE on-demand fallback:
https://cloud.google.com/blog/topics/developers-practitioners/running-gke-application-spot-nodes-demand-nodes-fallback

TopologySpreadConstraints new features: https://kubernetes.io/blog/2023/04/17/fine-grained-pod-topology-spread-features-beta/