
Scalability testing of a production Kubernetes cluster

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30000+ customers

2000+ employees

55 global offices

Founded 2001 in Oslo



```

    //fires the appear event when appropriate
    var check = function() {
        //is the element hidden?
        if (!t.is('visible')) {
            //it became hidden
            t.appeared = false;
            return;
        }

        //is the element inside the visible window?
        var a = w.scrollLeft();
        var b = w.scrollTop();
        var o = t.offset();
        var x = o.left;
        var y = o.top;

        var ax = settings.accX;
        var ay = settings.accY;
        var th = t.height();
        var wh = w.height();
        var tw = t.width();
        var ww = w.width();

        if (y + th + ay >= b &&
            y <= b + wh + ay &&
            x + tw + ax >= a &&
            x <= a + ww + ax) {

            //trigger the custom event
            if (!t.appeared) t.trigger('appear', settings.data);
        } else {

            //it scrolled out of view
            t.appeared = false;
        }
    };

    //create a modified fn with some additional logic
    var modifiedFn = function() {
        //mark the element as visible
        t.appeared = true;
        //is this supposed to happen only once?
        if (settings.one) {
            //remove the check
            w.unbind('scroll', check);
            var i = $.inArray(check, $._fn.appear.checks);
            if (i >= 0) $._fn.appear.checks.splice(i, 1);
        }
        //trigger the original fn
        fn.apply(this, arguments);
    };
}

```

December 2018



71



1251



283



150



25

December 2018

May 2019



71

146



1251

2102



283

561



150

435



25

77

December 2018

May 2019

October 2019



71

146

265



1251

2102

3954



283

561

944



150

435

818



25

77

103

December 2018

May 2019

October 2019

Today



71

146

265

385



1251

2102

3954

5968



283

561

944

1073



150

435

818

815



25

77

103

112

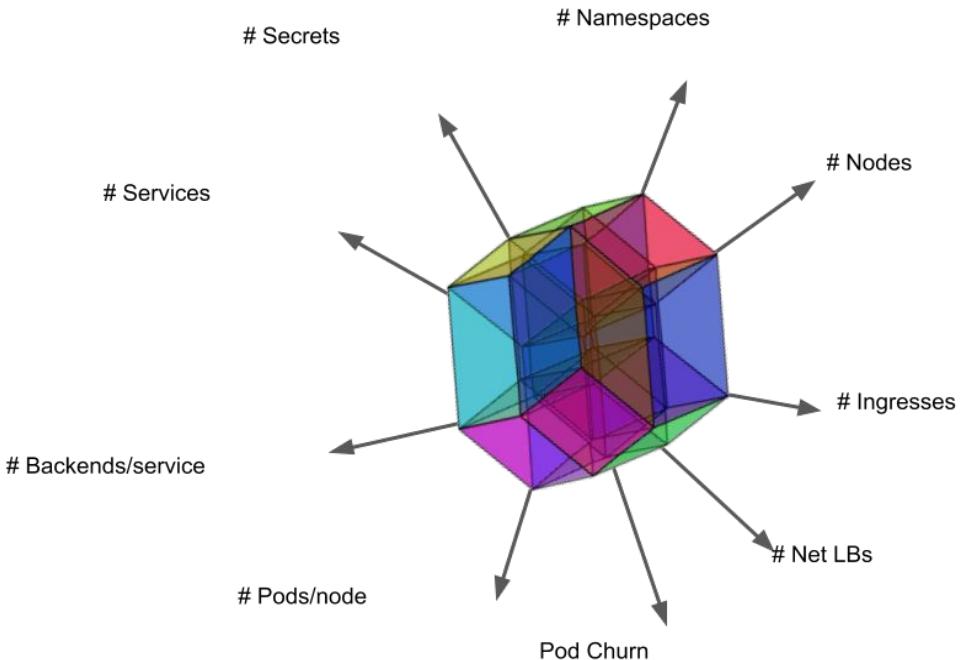


Kubernetes Failure Stories

- [CPU limits and aggressive throttling in Kubernetes - Omio - blog post 2020](#)
 - involved: GKE, CPU Limit, CPU throttling
 - impact: high latency, errors
- [When GKE ran out of IP addresses - loveholidays - blog post 2020](#)
 - involved: GKE, cluster autoscaler, HPA, Alias IP VPC (VPC Native)
 - impact: stuck deployment, blocked autoscaling of both pods and nodes
- [How we failed to integrate Istio into our platform - Exponea - blog post 2019](#)
 - involved: Istio, GKE, proxy injection
 - impact: stopped Istio rollout, developers' time spent
- [Kubernetes made my latency 10x higher - Adevinta - blog post 2019](#)
 - involved: IAM, DNS, AWS IAM, latency
 - impact: service showing up to x10 higher latencies compared to a deployment in EC2
- [A Kubernetes failure story \(dex\) - anonymous Fullstack client - Dutch kubernetes meetup slides 2019-06](#)
 - involved: etcd, apiserver, dex, custom resources
 - impact: broken control plane on production with no access to o11y due to broken authentication system, no actual business impact
- [A Kubernetes crime story - Prezi - blog post 2019](#)
 - involved: AWS EKS, SNAT, conntrack, Amazon VPC CNI plugin
 - impact: delay of 1-3 seconds for outgoing TCP connections
- [Postmortem: New K8s workers unable to join cluster - FREE NOW - postmortem 2019](#)
 - involved: AWS spot instances, kops, CentOS, container-selinux
 - impact: insufficient cluster capacity in testing environments, failed deployments in production and staging environments
- [How a simple admission webhook lead to a cluster outage - Jetstack - blog post 2019](#)
 - involved: ValidatingWebhookConfiguration, GKE node auto-repair

Kubernetes official thresholds

Quantity	Threshold: scope=namespace	Threshold: scope=cluster
#Nodes	n/a	5000
#Namespaces	n/a	10000
#Pods	3000	150000
#Pods per node	n/a	min(110, 10*#cores)
#Services	5000	10000
#All service endpoints	TBD	TBD
#Endpoints per service	250	n/a
#Secrets	TBD	TBD
#ConfigMaps	TBD	TBD
#Deployments	2000	TBD
#DaemonSets	TBD	TBD
#Jobs	TBD	TBD
#StatefulSets	TBD	TBD



<https://git.io/JvzB2>

Source <https://bit.ly/3bZXu6q>

Kubernetes official SLOs

Latency of mutating API calls, 99th percentile: < 1s

Latency of non-streaming read-only API class, 99th percentile: < 1s

Startup latency of schedulable stateless pods, 99th percentile: < 5s

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Startup latency of schedulable stateful pods, 99th percentile: < TBD

Latency of programming DNS, 99th percentile: < TBD

In-cluster network latency from a single pod, 99th percentile: < TBD

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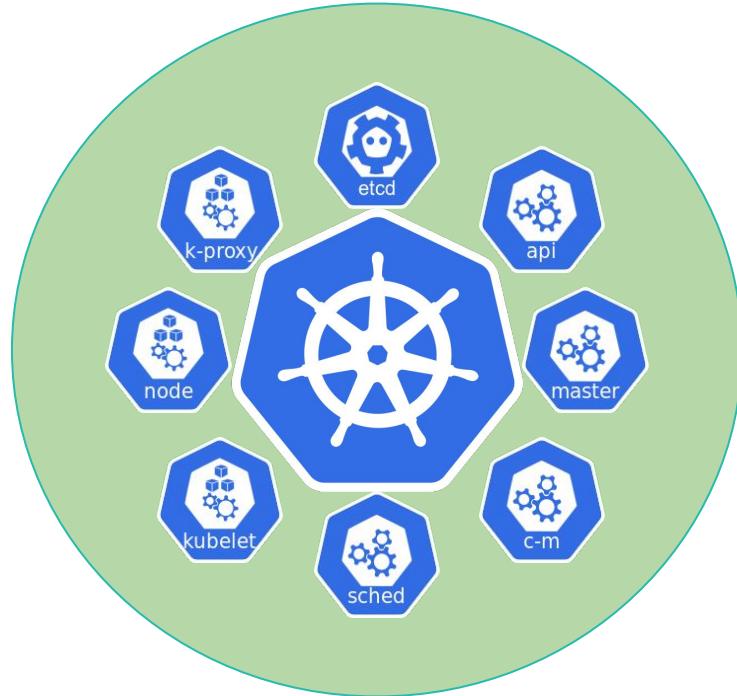
- Runs a single or more appropriately sized master machines ✓
- Events are stored in a separate etcd instance (or cluster) ✓
- All etcd instances are running on master machine(s) ✓

Cluster churn is ≤ 20 , where churn is defined as:

Churn = # (Pod spec creations/updates/deletions)
+ # (user originated requests) in a given second

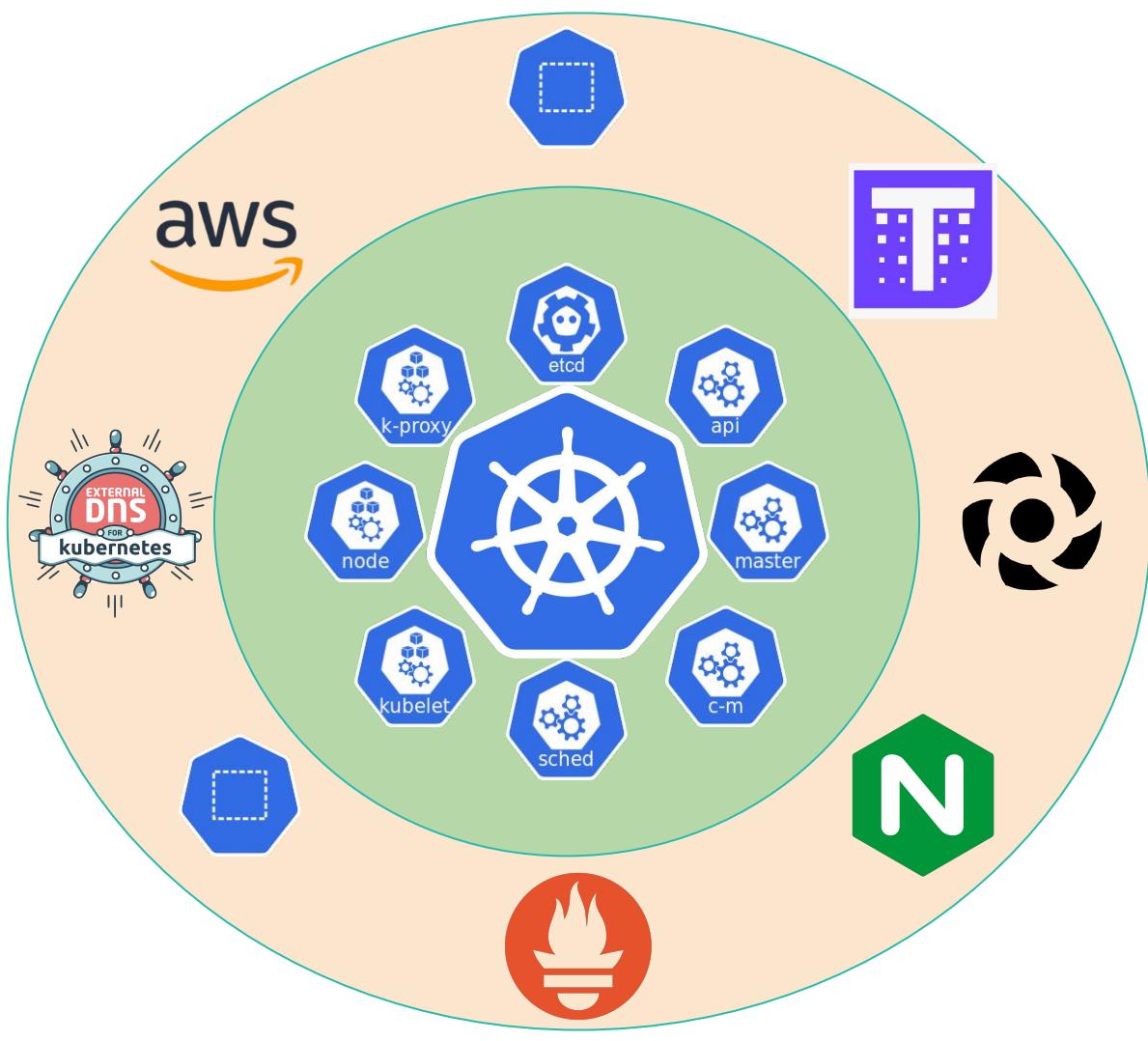
?

Kubernetes Core



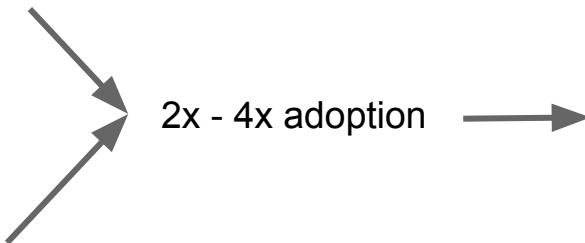
Kubernetes Core

Additional Components



Defining a real-world scalability test

- Current cluster size
- Architecture
- Utilization
- Thresholds
- SLOs



Nodes	NS	Dep/NS	Pods/Dep
2x	=	=	=
=	2x	2x	=
2x	2x	2x	=
4x	2x	2x	=

Known parameters

Hypothesis

Validation





> **k8s objects and resources** (14 panels)

> **pod and node state** (2 panels)

> **aws cni** (32 panels)

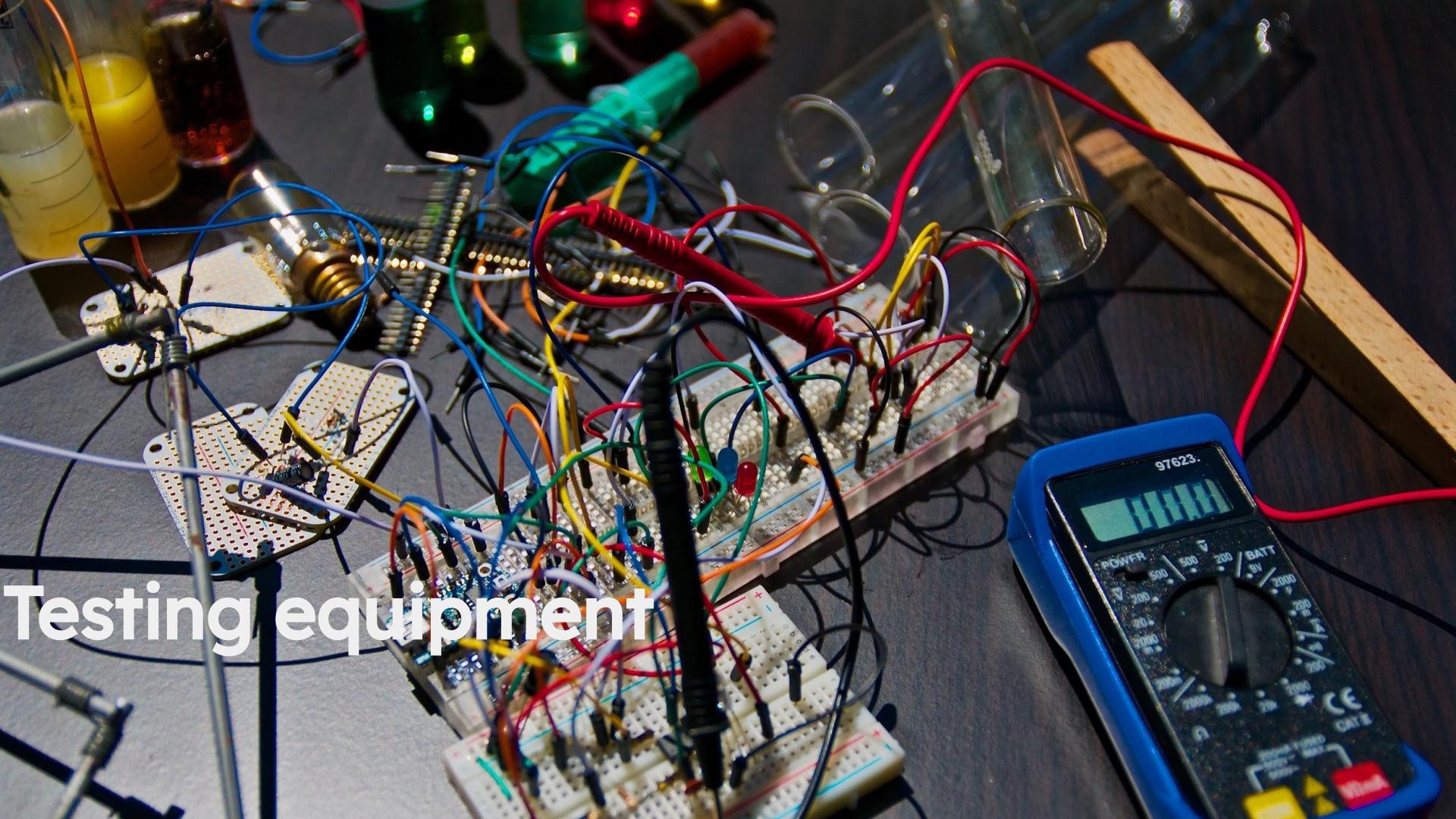
> **etcd** (16 panels)

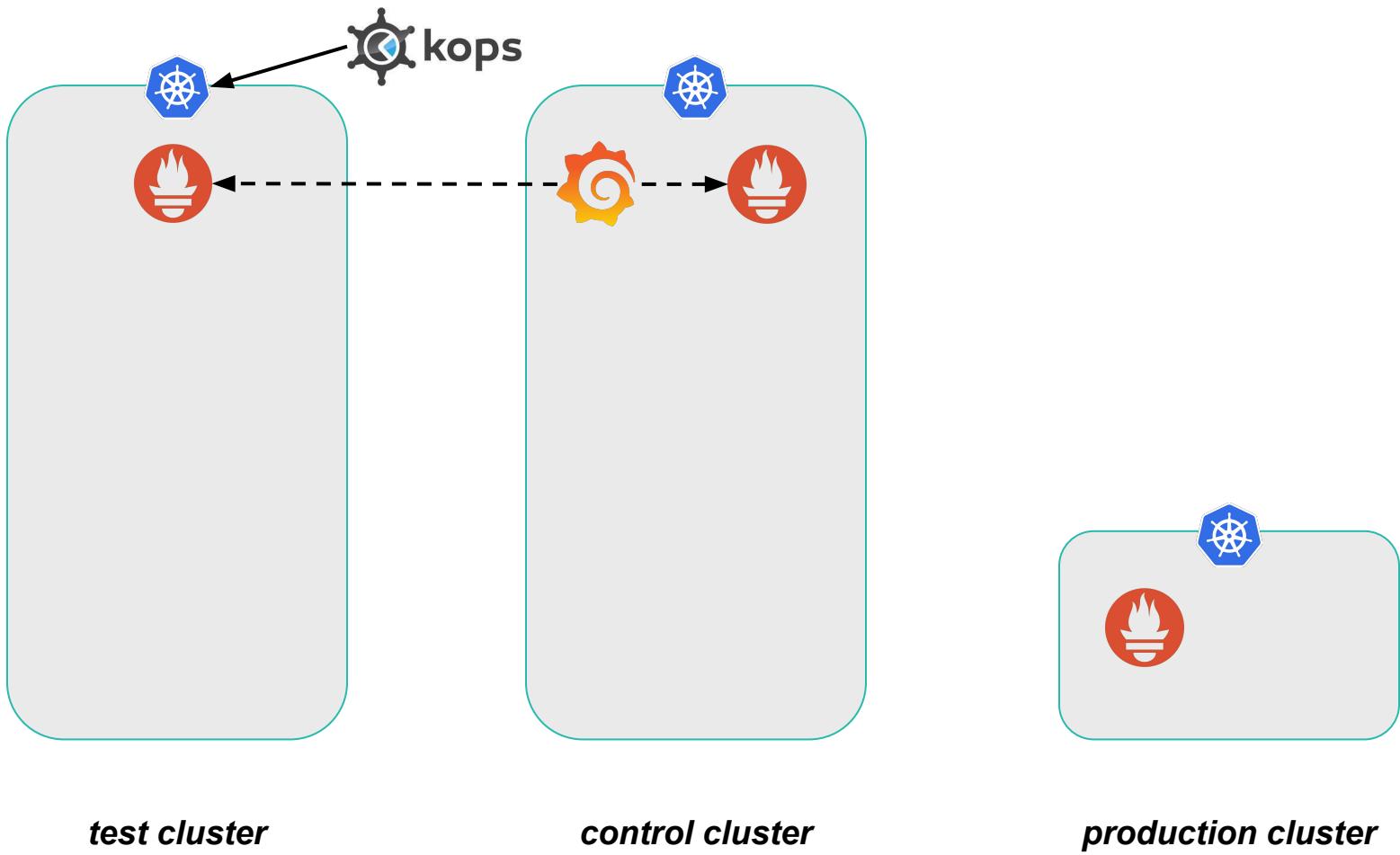
> **kube-dns** (2 panels)

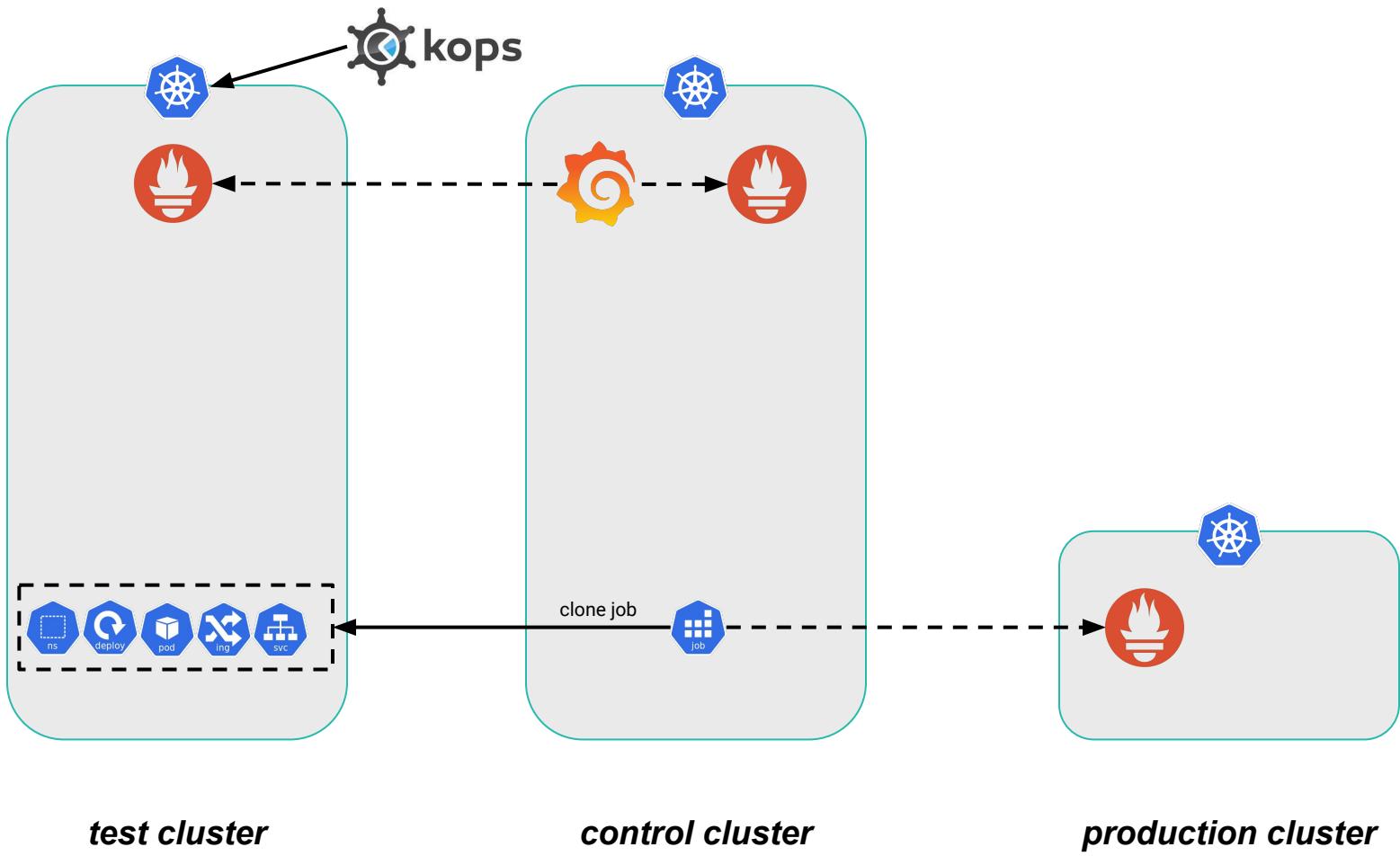
> **masters cpu memory** (6 panels)

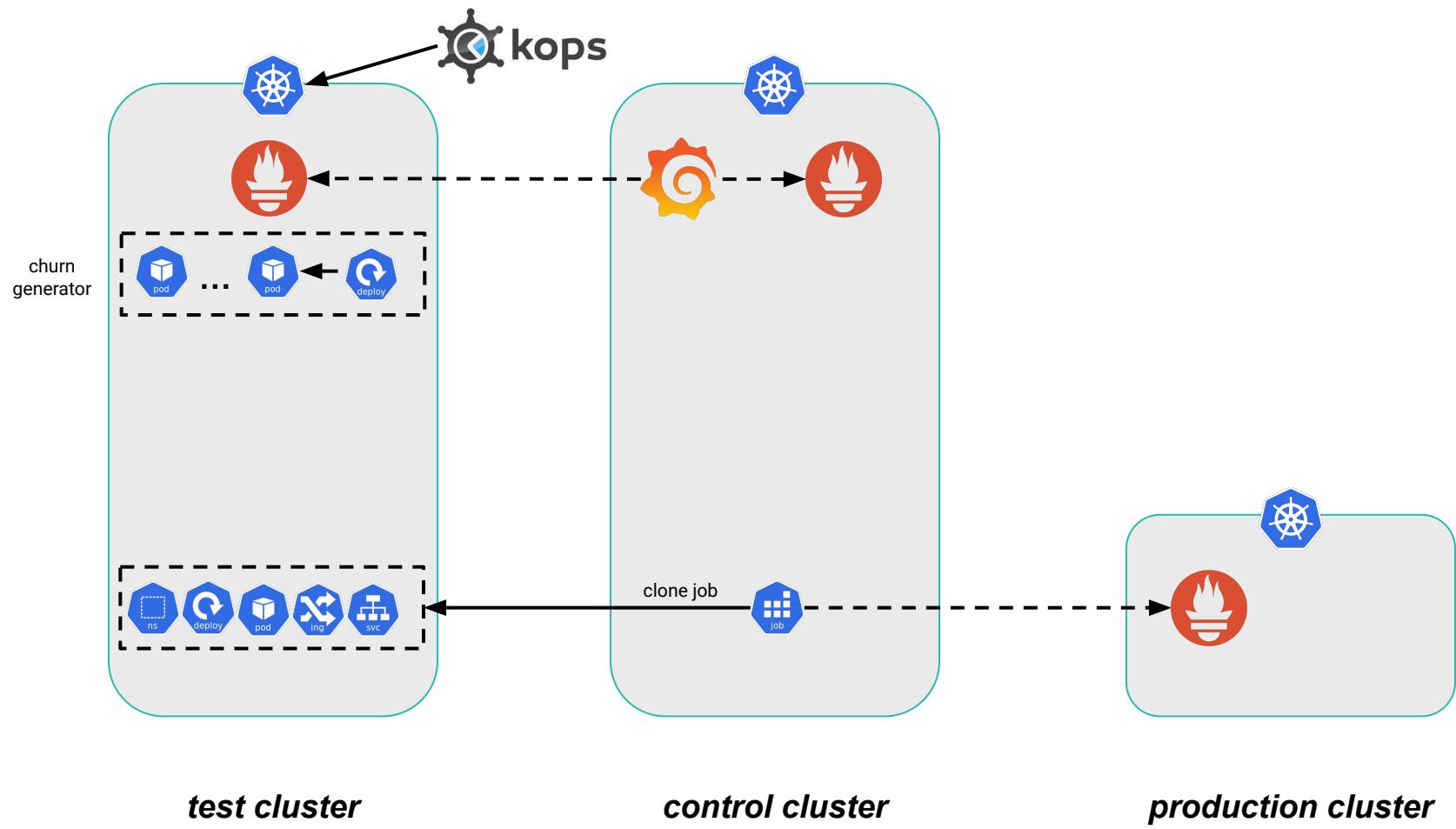
> **k8s slo** (5 panels)

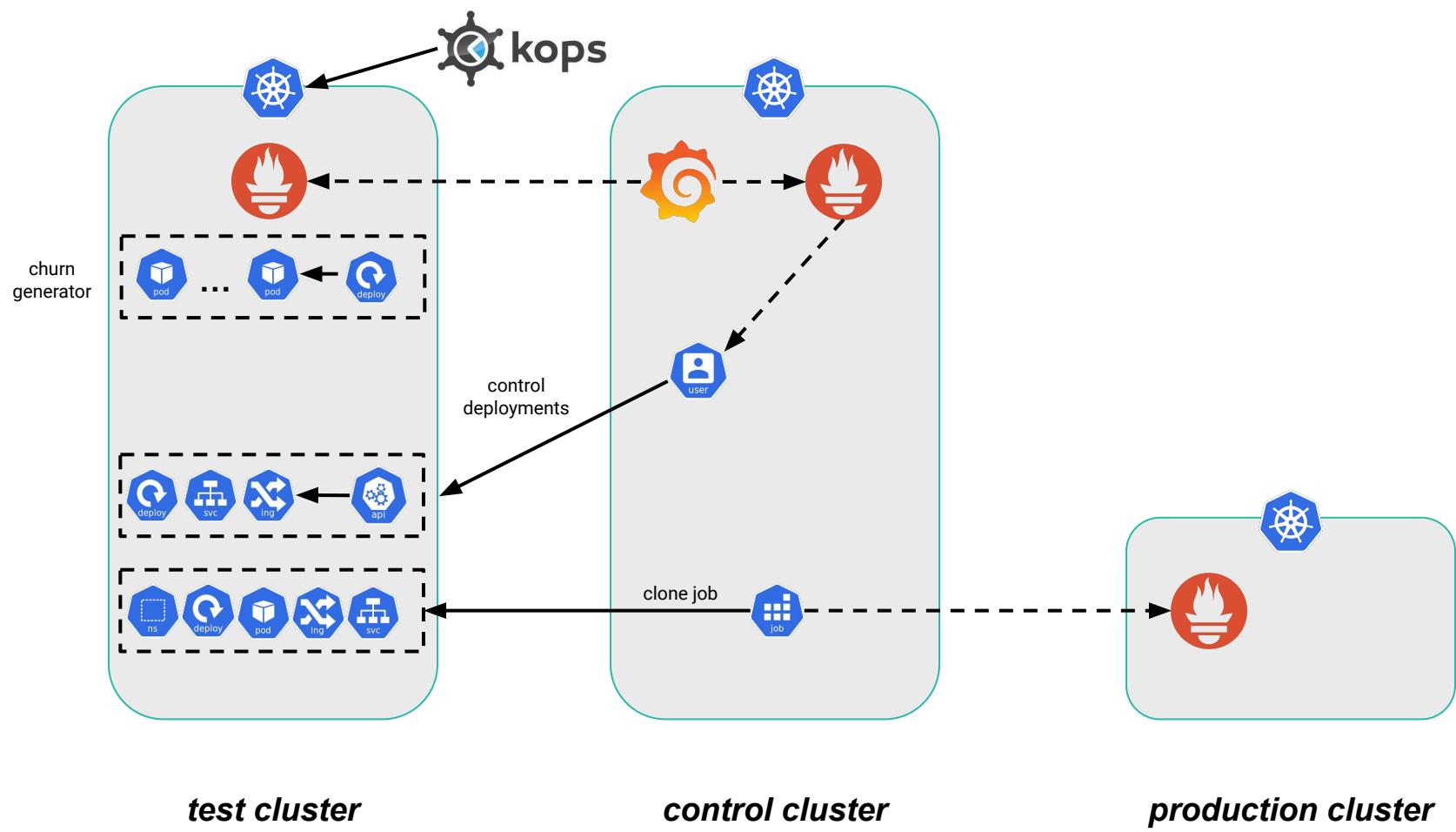
Testing equipment

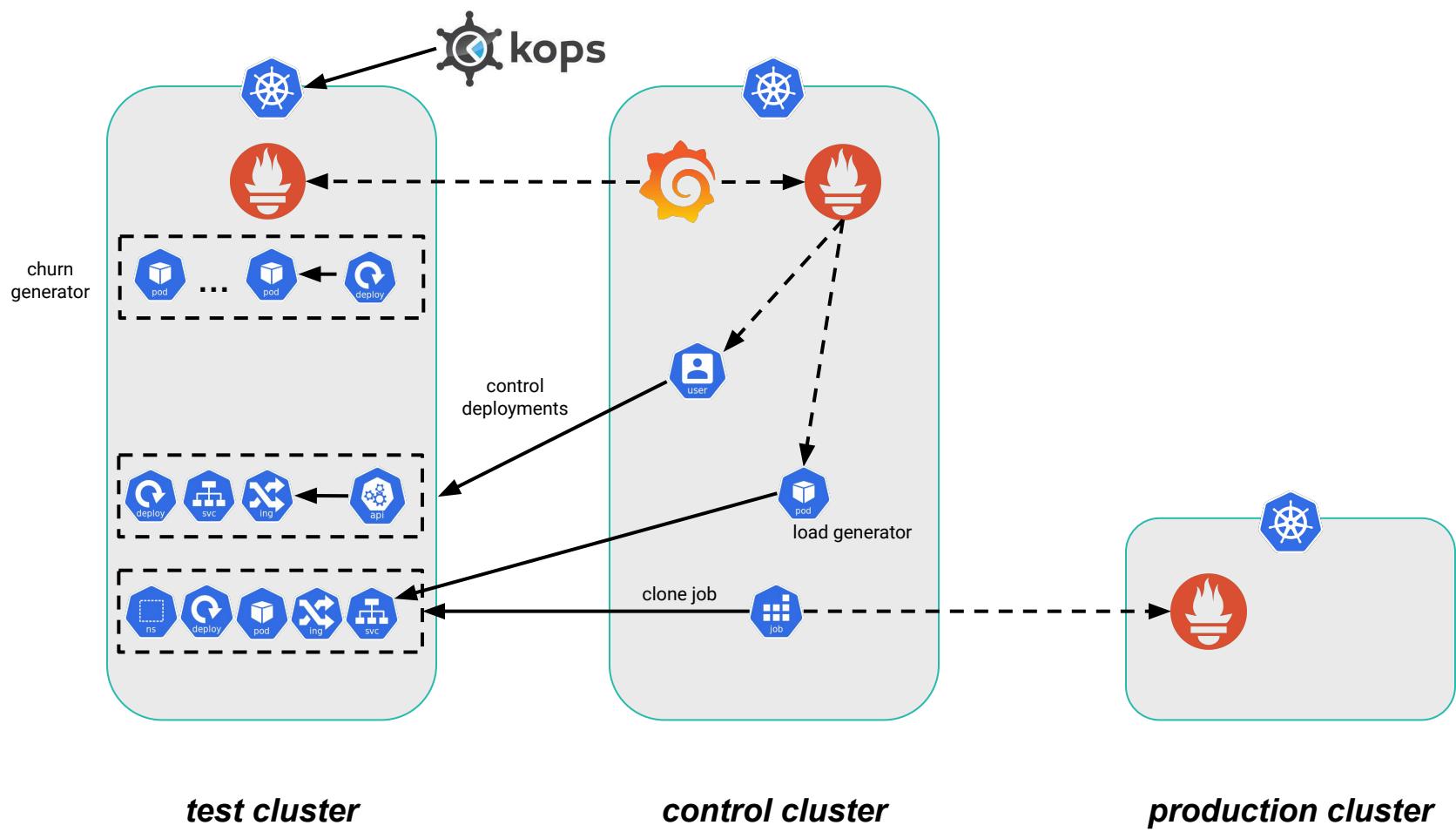












What broke on the way to 4x

- Cluster Autoscaler OOM
- kube-state-metrics
- prometheus
- grafana
- external-dns
- kubernetes dashboard
- etc



Results and Learnings

Kubernetes itself is quite robust.

We could scale up to 4x the number of nodes and workloads of our current production cluster.

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But...

User experience starts to degrade without performance tuning.

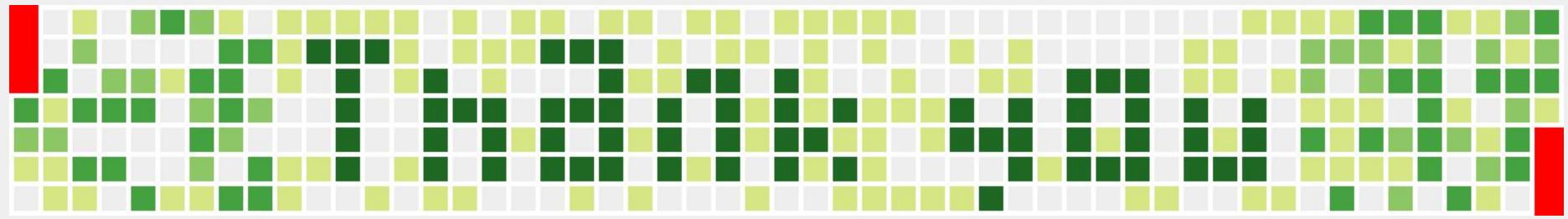
Some components for monitoring and add-on functionality needed resource tuning and a different setup to cope with a larger cluster.

Our todo list

- Dedicated nodes for cluster addons
- Sharding for kube-state-metrics
- Tune aws cnf for less greedy pre allocation (or Cilium)
- Resource tuning for CA and metrics-server
- Investigate "externalTrafficPolicy: Local" for ingress controller

Next steps

- Easier setup - everything as a kubernetes deployable
- Dashboards for AWS API calls
- Test DNS
- Test resources other than deployments
- Reduce cost



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