Eating Your Vegetables: How to Manage 2.5 Million Lines of YAML

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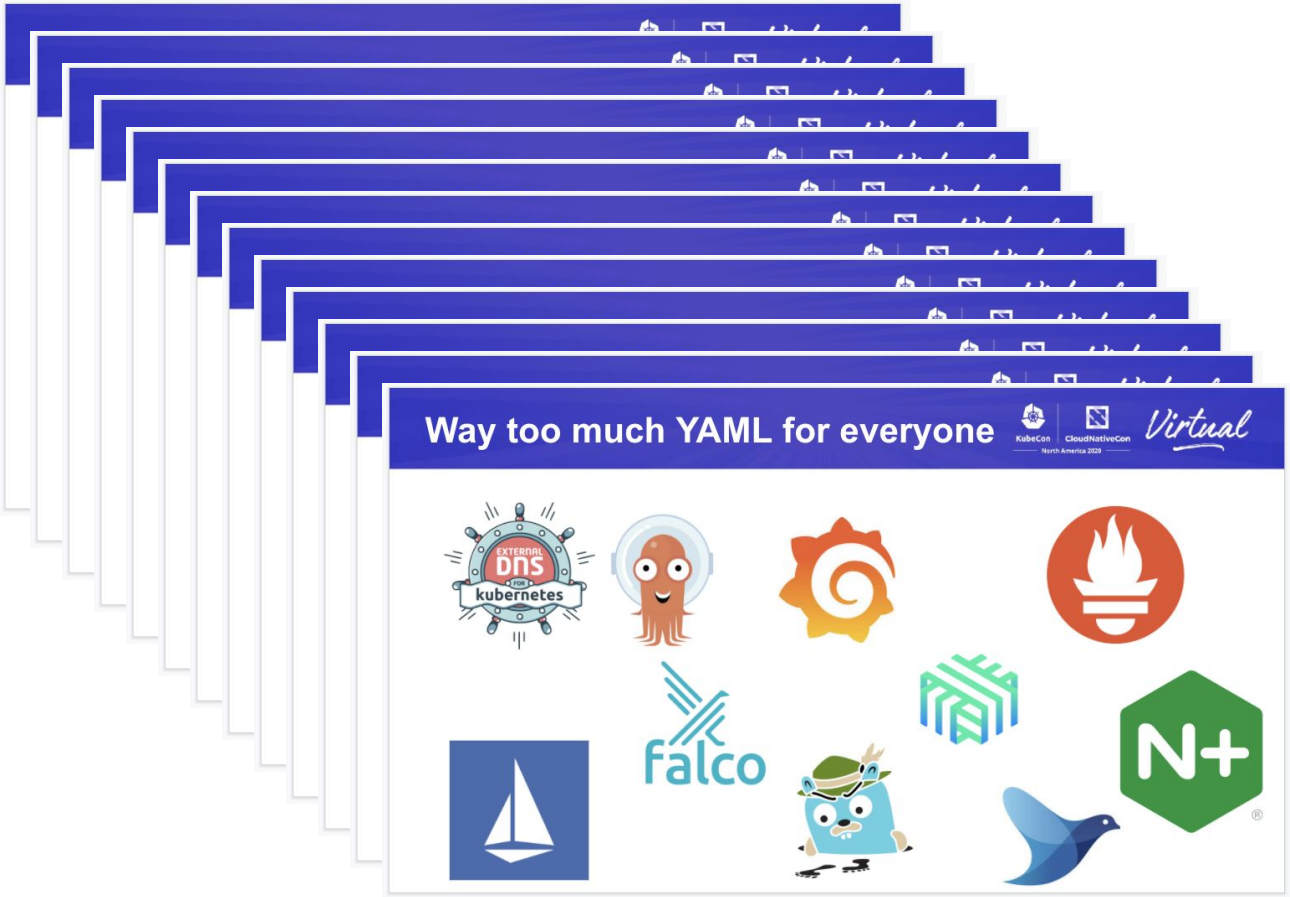
K8s YAML is very powerful, but hard


```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
 name: guestbook
spec:
 replicas: 3
 selector:
  ...
 affinity:
   podAntiAffinity:
     requiredDuringSchedulingIgnoredDuringExecution:
     - labelSelector:
         matchExpressions:
         - key: app
           operator: In
           values:
           - web
     topologyKey: "kubernetes.io/hostname"
 template:
   metadata:
     labels:
       app: web
   spec:
    containers:
    - name: app
      image: guestbook:1.0
```

Way too much YAML for everyone

What about multiple clusters



Considerations

Considerations - Personas

Operators

- Deploying off-the-shelf (OTS) software to run the platform
- Want controlled and stable upgrades, semantic versions

Developers

- Building bespoke applications as a service
- Focused on business logic, and less about platform
- Want to deploy early and often, don’t care about semantic versioning

Considerations - Developer Experience

- Experience and comfort level with Kubernetes
  - Highly specialized power users vs. zero interest
  - e.g. How do you achieve basic K8s use-cases:
    - anti affinity

- Affects how you expose the platform to the user
  - e.g. Abstraction v. RAW YAML

Considerations - Control

Centralized control

- Provide standard patterns and best practices
- Easier maintenance (e.g. upgrades, deprecated APIs)
- Security restrictions (e.g. creating ClusterRoles)

Developer control

- Self-service where it makes sense
  - onboarding to new environments (e.g. additional namespaces)
  - specifying HPA metrics
  - choosing a deployment strategy (e.g. rolling update, blue-green, canary)
- Leverage documentation and automation

Approaches

Approaches - Raw YAML

Just manage Kubernetes YAML

Advantages:

- Simple and straightforward
- Full flexibility
- Nothing to learn

Disadvantages:

- Zero configuration re-use (unmaintainable)

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
 name: guestbook
spec:
 replicas: 3
 selector:
   matchLabels:
     app: guestbook
 template:
   metadata:
     labels:
       app: guestbook
   spec:
     containers:
     - image: guestbook:v1.0
       name: guestbook
       ports:
       - containerPort: 80
```

Approaches - Templating

Expose only the top level parameters to a template, which control the final output.

Advantages:

- Simpler configuration
- Flexible

Disadvantages:

- Need to parameterize everything
- Templates become complex and unreadable

Examples:

- helm, jsonnet

```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: {{ include "guestbook.fullname" . }}
 labels:
   {{- include "guestbook.labels" . | nindent 4 }}
spec:
{{- if not .Values.autoscaling.enabled }}
 replicas: {{ .Values.replicaCount }}
{{- end }}
 selector:
   matchLabels:
     {{- include "guestbook.selectorLabels" . | nindent 6 }}
 template:
   metadata:
   {{- with .Values.podAnnotations }}
     annotations:
       {{- toYaml . | nindent 8 }}
   {{- end }}
     labels:
       {{- include "guestbook.selectorLabels" . | nindent 8 }}
   spec:
     {{- with .Values.imagePullSecrets }}
     imagePullSecrets:
       {{- toYaml . | nindent 8 }}
     {{- end }}
     serviceAccountName: {{ include "guestbook.serviceAccountName" . }}
...
...
```

Approaches - Overlay

Overlaying defines a common “base” to share across variants.
Each variant only contains the configuration differences for that environment.

Advantages:

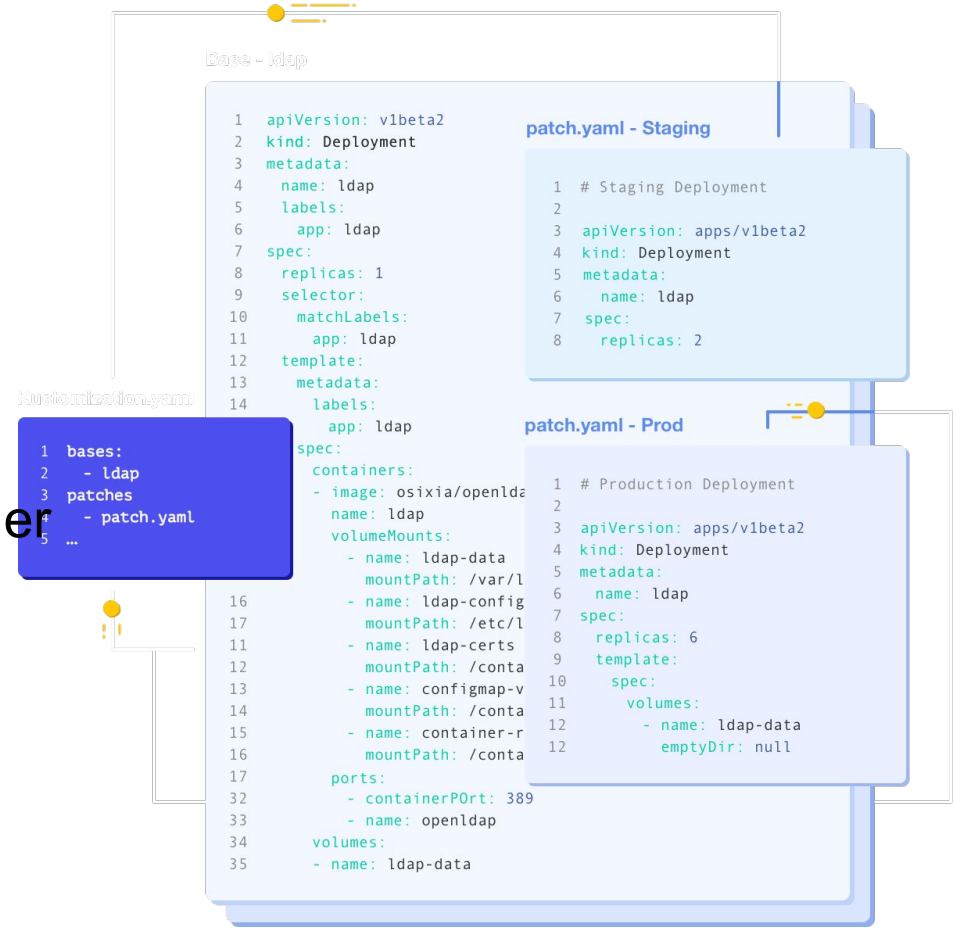
- Excellent readability
- Excellent configuration reuse
- Mostly flexible

Disadvantages:

- Not immediately intuitive
- Lack of parameterization makes many use cases harder than necessary

Examples:

- kustomize, jsonnet



Approaches - Abstraction

Hide the details from the user with an abstraction and simpler interface.

Advantages:

- Simpler configuration
- Can implement and control organizational standards

Disadvantages:

- Less flexibility
- Eventually end up with a leaky abstraction
- No one has figured out the right abstraction yet for Kubernetes

Examples:

- pulumi, cdk8s, helm

```
name: guestbook
type: WebService
dnsname: guestbook.intuit.com
image: guestbook:v1.0
updateStrategy: BlueGreen
replicas:
  min: 3
  max: 10
mesh:
  enabled: true
```

Approaches - Codify

Just use a programing language!

Advantages:

- Leverage programming features (e.g. loops, conditionals, functions)
- Tends to go hand-in-hand with abstraction, including its benefits
- Can be tested

Disadvantages:

- Just another codebase with bugs
- Difficult to understand how code affects final result

Examples:

- cdk8s, pulumi, jsonnet

```
import { Chart } from 'cdk8s';
import { Construct } from 'constructs';
import { WebService } from
'./lib/web-service';

export class MyChart extends Chart {
 constructor(scope: Construct, ns: string) {
   super(scope, ns);

   new WebService(this, guestbook, {
     image: guestbook:v1.0',
     replicas: 3
   });
   new WebService(this, 'redis', {
     image: 'redis',
     containerPort: 6379
   });
 }
}
```

Intuit Case Study

Use Case & Requirements

Use Case

- 4,000 developers deploying SaaS applications
- Manage multiple environments
  - Namespace (qa, e2e, prd-use2, prd-usw2)
  - Mostly identical, with slight variations in config (e.g. DNS names, AWS ARNs, IAM roles)
- DevOps culture: you build it, you run it

Requirements

- Provide standard set of patterns and best practices (paved road)
- Provide flexibility (even at the cost of simplicity)
  - Exposed developers to Kubernetes YAML
- GitOps friendly

Solution - Kustomize

- Preserves the full power of Kubernetes
- Kubernetes native, well supported and documented
- Readable for both developers & platform team
- Overlay pattern promotes config re-use maintainability
- Centrally control & distribute standard patterns across organization

Kustomize's Killer Feature

Centrally Managed Remote Base

- A "catalog" of generic starter YAML
- Simple base consists of:
  - Deployment + Service + Ingress
- Advanced examples:
  - HPA, Canary Analysis
- Semantically versioned
- Provides standard patterns & best practices
  - (e.g. pod readiness gates, resource requests, ingress annotations)

Developer Owned Deployment Repository

- Derives from central remote base
- Customized for the needs for their service

Standard Ingress Example


```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
 annotations:
   alb.ingress.kubernetes.io/backend-protocol: HTTPS
   alb.ingress.kubernetes.io/load-balancer-attributes: access_logs.s3.enabled=false
   alb.ingress.kubernetes.io/certificate-arn: TODO:certificate-ARN
   alb.ingress.kubernetes.io/healthcheck-path: /health/full
   alb.ingress.kubernetes.io/healthcheck-protocol: HTTPS
   alb.ingress.kubernetes.io/listen-ports: '[{"HTTPS": 443}]'
   alb.ingress.kubernetes.io/scheme: internet-facing
   alb.ingress.kubernetes.io/security-groups: intuit-vpn-tcp-443
   alb.ingress.kubernetes.io/ssl-policy: ELBSecurityPolicy-TLS-1-2-2017-01
   alb.ingress.kubernetes.io/subnets: PublicSubnetAz1, PublicSubnetAz2, PublicSubnetAz3
   alb.ingress.kubernetes.io/healthcheck-interval-seconds: "60"
   kubernetes.io/ingress.class: aws-alb
   external-dns.alpha.kubernetes.io/hostname: TODO:albDnsHostname
 name: ingress
spec:
 rules:
 - http:
     paths:
     - backend:
         serviceName: service
         servicePort: 443
       path: /*
```

Deployment Repository


```
guestbook
├── app-base
│   ├── kustomization.yaml
│   ├── deployment-patch.yaml
│   └── ingress-patch.yaml
└── environments
    ├── e2e-usw2
    │   ├── kustomization.yaml
    │   ├── deployment-patch.yaml
    │   └── ingress-patch.yaml
    └── prd-usw2
        ├── kustomization.yaml
        ├── deployment-patch.yaml
        └── ingress-patch.yaml
```

- app-base directory inherits from central remote base. contains the common definitions for all environments of the service.
- environments directories inherit from the base, and only include changes specific to the environment.

Deployment Repository


```
guestbook
├── app-base
│   ├── kustomization.yaml
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│   └── ingress-patch.yaml
└── environments
    ├── e2e-usw2
    │   ├── kustomization.yaml
    │   ├── deployment-patch.yaml
    │   └── ingress-patch.yaml
    └── prd-usw2
        ├── kustomization.yaml
        ├── deployment-patch.yaml
        └── ingress-patch.yaml
```

```yaml
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

namePrefix: guestbook-

resources:
- >
  https://github.intuit.com/dev-patterns/
  intuit-kustomize//intuit-service-base?ref=v4.0.0

patchesStrategicMerge:
- deployment-patch.yaml
- ingress-patch.yaml
```

Deployment Repository


```
guestbook
├── app-base
│   ├── kustomization.yaml
│   ├── deployment-patch.yaml
│   └── ingress-patch.yaml
└── environments
    ├── e2e-usw2
    │   ├── kustomization.yaml
    │   ├── deployment-patch.yaml
    │   └── ingress-patch.yaml
    └── prd-usw2
        ├── kustomization.yaml
        ├── deployment-patch.yaml
        └── ingress-patch.yaml
```

```yaml
apiVersion: kustomize.config.k8s.io/v1beta1
kind: Kustomization

resources:
- ../../app-base

patchesStrategicMerge:
- deployment-patch.yaml
- ingress-patch.yaml

images:
- name: guestbook
  newTag: master-9f29eb5
```

Deployment Repository


```
guestbook
├── app-base
│   ├── kustomization.yaml
│   ├── deployment-patch.yaml
│   └── ingress-patch.yaml
└── environments
    ├── e2e-usw2
    │   ├── kustomization.yaml
    │   ├── deployment-patch.yaml
    │   └── ingress-patch.yaml
    └── prd-usw2
        ├── kustomization.yaml
        ├── deployment-patch.yaml
        └── ingress-patch.yaml
```

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
 annotations:
   alb.ingress.kubernetes.io/certificate-arn: >
     arn:aws:acm:us-west-2:1234567890:certificate/
     da97886a-11e0-4665-b767-5d8f50713da6
   external-dns.alpha.kubernetes.io/hostname: >
     guestbook-prod.intuit.com
 name: ingress
```

Where are we now?

Single Environment × Environments × Services = Deployed YAML

$$250 \times 4 \times 2500 = 2.5M$$

Base + (4 x environment overlays) × Services = Managed YAML

$$90 + (4 \times 45) \times 2500 = 675K$$

$$270 \times 2500 = 675K$$

Challenges

#1 User support

- Given a lot of foot guns
- Users will fall off the paved road

#2 Automation & migrations

- YAML is hard to “upgrade”
- Thousands of pull requests

#3 Kustomize

- Breaking behavior
- Lack of CRD support

Final Thoughts

- No perfect solution
- No one-size-fit-all, highly dependent on your organization
- At a certain scale, managing YAML is a lot of work

What's next?

- Better abstractions
- UI assisted configuration management

Resources

- Declarative Application Management Whitepaper - Bryan Grant
- https://jobs.lexver.co/stytch

http://bit.ly/gitops-and-k8s


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