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基于云原生供应链的配置策略管理新范式

Kubernetes Resource Model (KRM) KCL Specification

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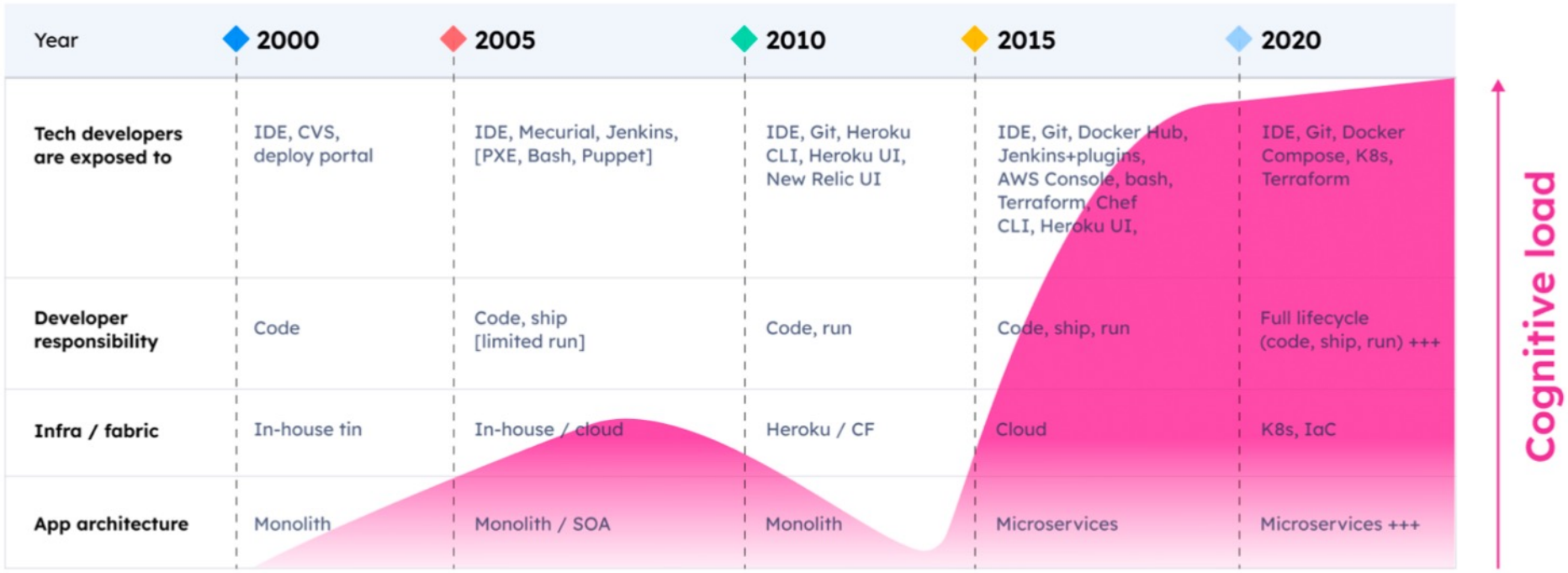
01. 背景

为什么我们需要一个新范式

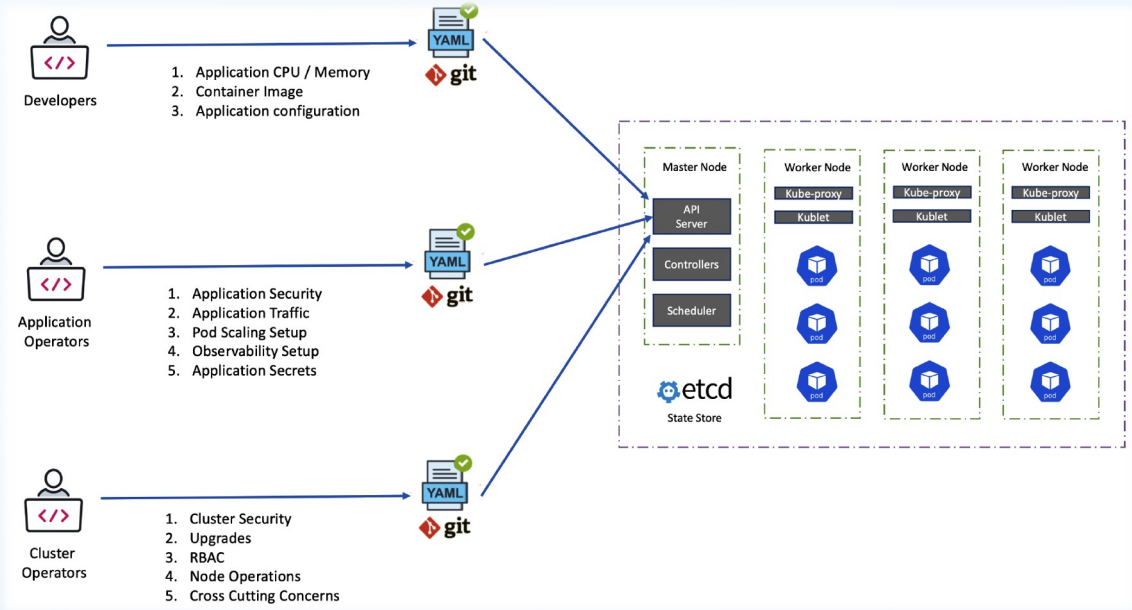
背景



Inspired by Daniel Bryant at PlatformCon 2022

随着云原生技术的发展，Kubernetes 底座和 Terraform 等 IaC 工具已成为越来越流行的管理和部署基于 (云) API 的应用程序工具

问题



认知负担

- 应用开发人员需要面对复杂的基础设施和平台概念
- 不像云基础设施配置有 Terraform 等 IaC 工具，Kubernetes 是平台的平台，特别是在客户端缺乏轻量的配置组合和校验工具

静态配置

- YAML 膨胀，维度爆炸
- 跨团队配置协作负担和配置漂移

效率、可靠性低

- 缺乏标准的测试验证手段，大多是胶水代码或者脚本的拼盘
- 缺乏高效配置协同的工具，大多通过人肉拉群解决

减轻基础设施对开发人员的认知负担，提高配置管理效率

Kubernetes 中的声明式应用管理: https://docs.google.com/document/d/1cLPGweVEYrVqQvBLJg6sxV-TrE5Rm2MNOBA_cxZP2WU/edit#
CNCF 平台工程白皮书: https://tag-app-delivery.cncf.io/whitepapers/platforms/
Google SRE 工作手册: https://sre.google/workbook/configuration-specifics/

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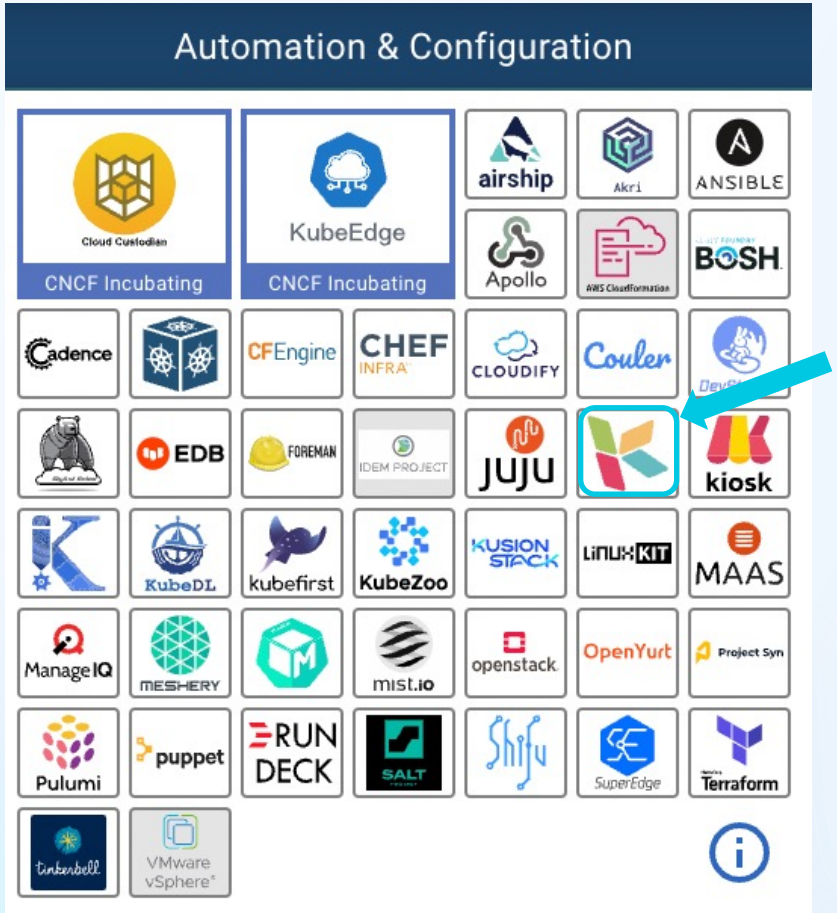
02. 概念

KCL、KRM KCL 规范、语言核心元素

KCL

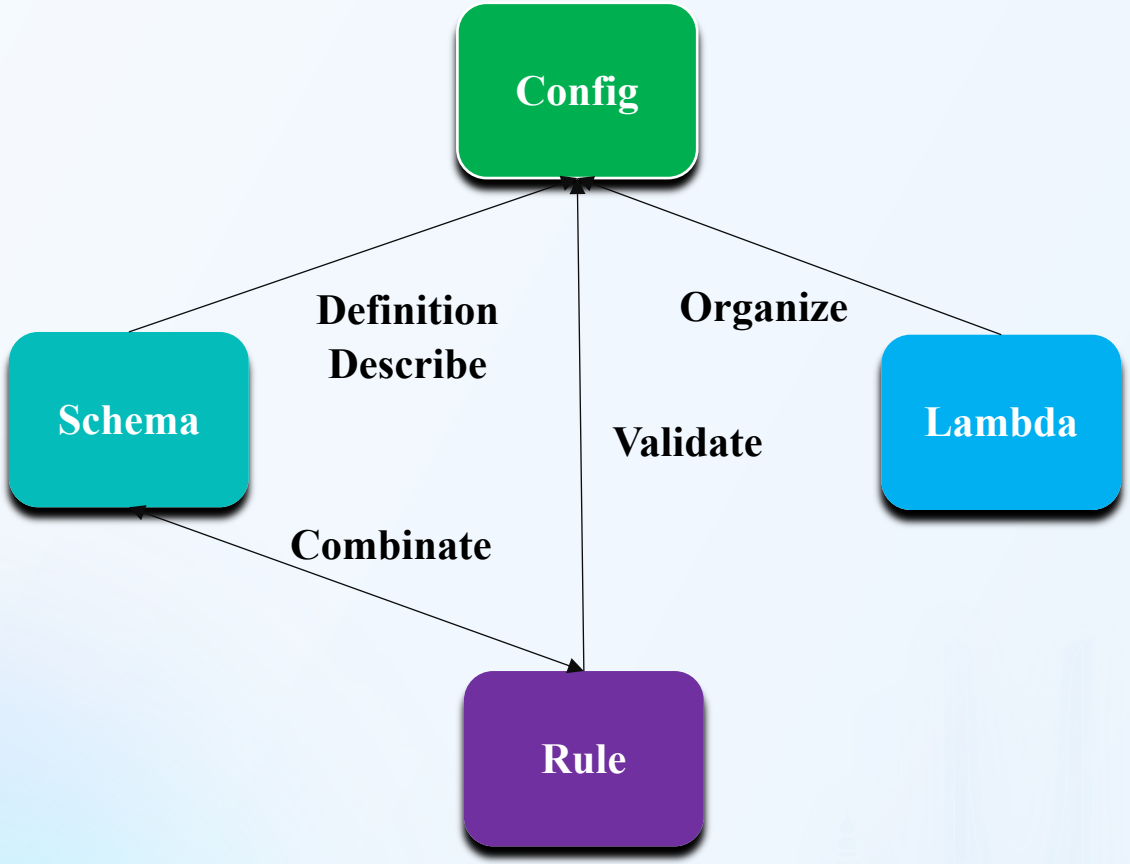
面向云原生领域的专用配置策略语言 (2022.6 开源，2023.9 成为 CNCF 基金会托管的 Sandbox 项目)



- ✓ **领域特定**：以收敛的语言和工具集合解决领域问题近乎无限的变化和复杂性
- ✓ **以应用为中心**：开发者可以理解的声明式应用配置模型
- ✓ **关注点分离**：应用/平台 Dev/SRE
- ✓ **动态配置管理**: 多租户多环境、可编程可扩展
- ✓ **风险左移**：实时的配置错误提示
- ✓ **可复用扩展**: OCI 等标准**软件供应链**集成和包管理工具支持，官方 Registry 提供 60+ 模型包
- ✓ **引擎解耦**：建立在一个完全开放的云原生世界当中，几乎不与任何编排/引擎工具或者 Kubernetes 控制器绑定，可同时为**客户端和运行时场景**提供 **API 抽象、组合和校验的能力**

Standalone KCL

Config + Schema + Rule + Lambda Pattern: $k = (T)v$




```
import k8s.core.v1
# Create a Kubernetes Deployment resource.
v1.Deployement {
    metadata.name = "nginx"
    metadata.labels.app = metadata.name
    spec = {
        replicas = 3
        selector.matchLabels.app = metadata.name
        template = {
            metadata.labels.app = metadata.name
            spec.containers = [{
                name = metadata.name
                image = "nginx"
                ports = [{ containerPort = 80 }]
            }]
        }
    }
}
```

可复用可扩展、抽象和组合能力、稳定性、高性能

KRM KCL

- **Mutation**

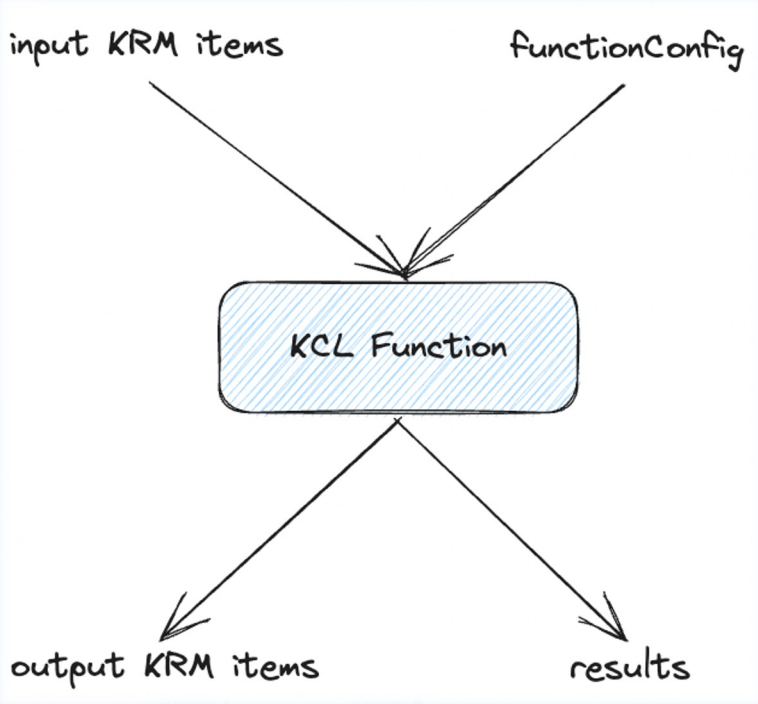
```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: set-annotations
  metadata:
    annotations:
      krm.kcl.dev/version: 0.0.1
      krm.kcl.dev/type: mutation
      documentation: >-
        Add or change annotations
spec:
  params:
    toAdd: addValue
  source: oci://ghcr.io/kcl-lang/set-annotation
```

- **Abstraction**

```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: web-service
  metadata:
    annotations:
      krm.kcl.dev/version: 0.0.1
      krm.kcl.dev/type: abstraction
      documentation: >-
        Web service application abstraction
spec:
  params:
    name: app
    containers:
      ngnix:
        image: ngnix
        ports:
          containerPort: 80
    labels:
      name: app
  source: oci://ghcr.io/kcl-lang/web-service
```

- **Validation**

```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: https-only
  metadata:
    annotations:
      krm.kcl.dev/version: 0.0.1
      krm.kcl.dev/type: validation
      documentation: >-
        Requires Ingress resources to be HTTPS only.  Ingress resources must
        include the `kubernetes.io/ingress.allow-http` annotation, set to `false`.
        By default a valid TLS {} configuration is required, this can be made
        optional by setting the `tlsOptional` parameter to `true`.
        More info: https://kubernetes.io/docs/concepts/services-networking/ingress/#tls
spec:
  source: oci://ghcr.io/kcl-lang/https-only
```



- **遵循统一的 KRM Function 规范**
- **多种代码源支持:** OCI, Git, Https, Filesystem...
- **可编程可扩展: 使用 KCL 语言简单编写模型**

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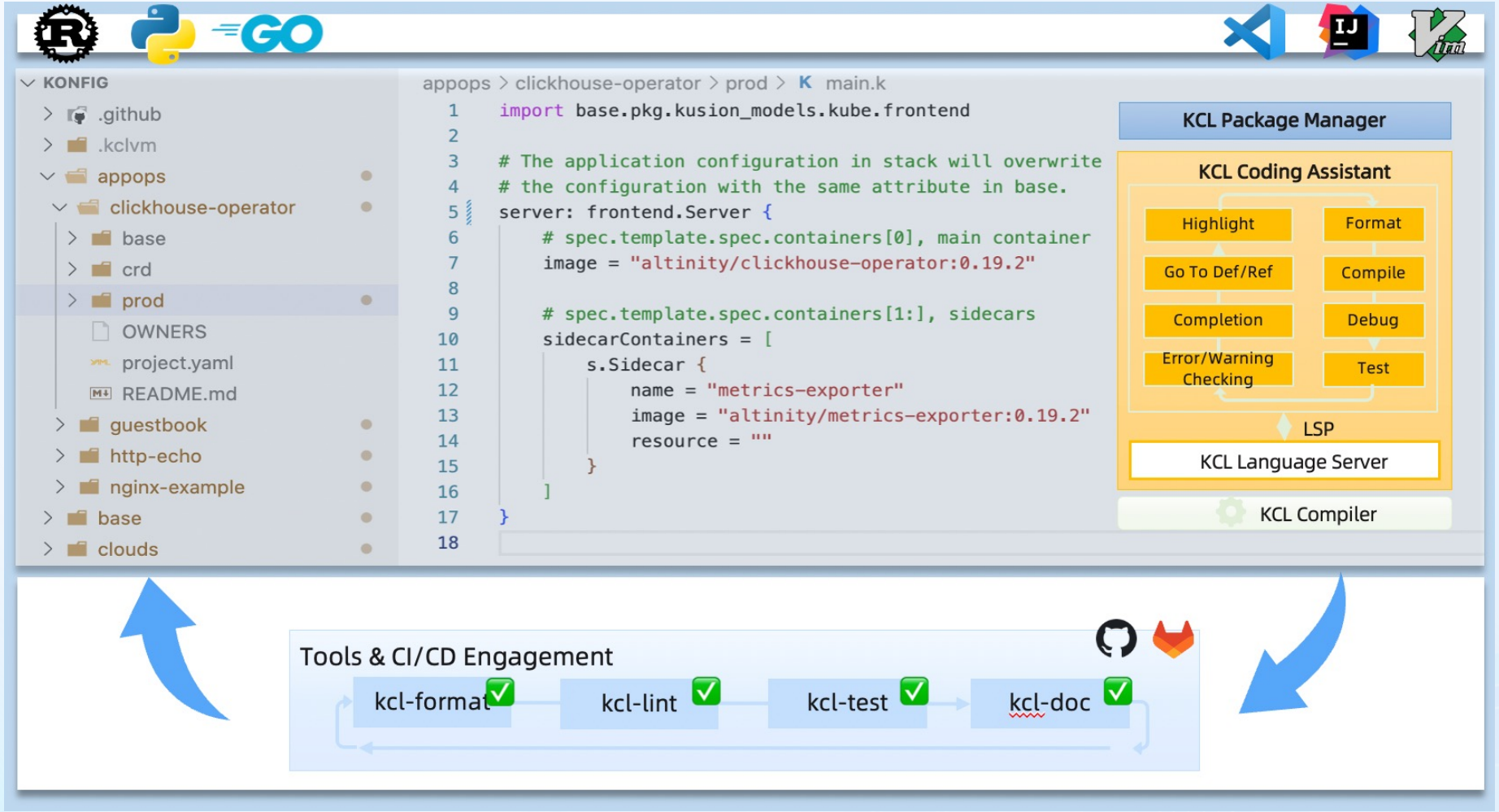
03. 体验

语言、工具、云原生集成

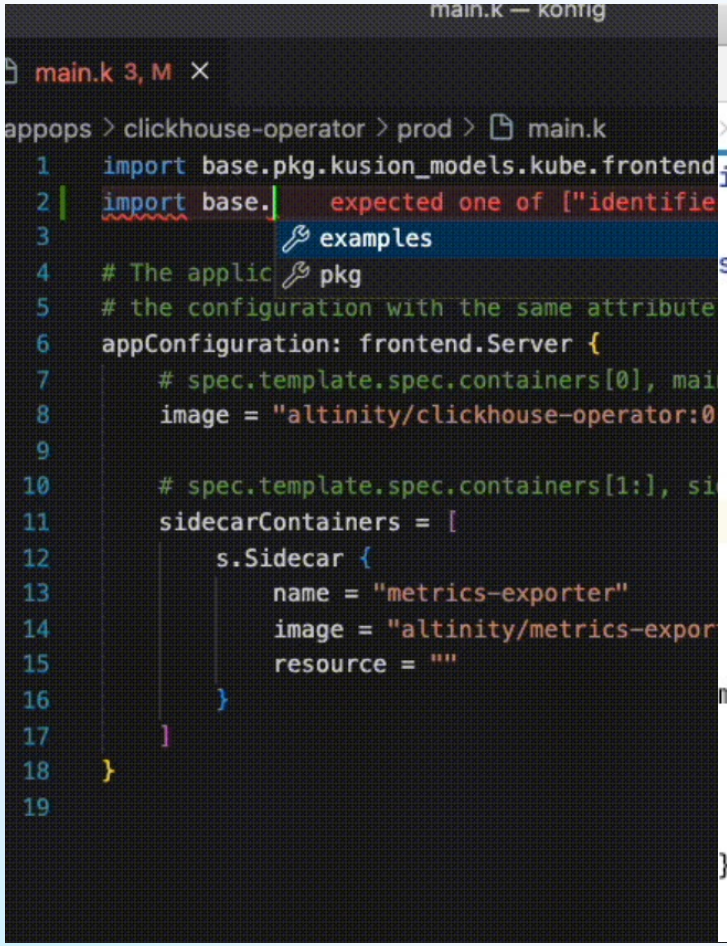
Workspace

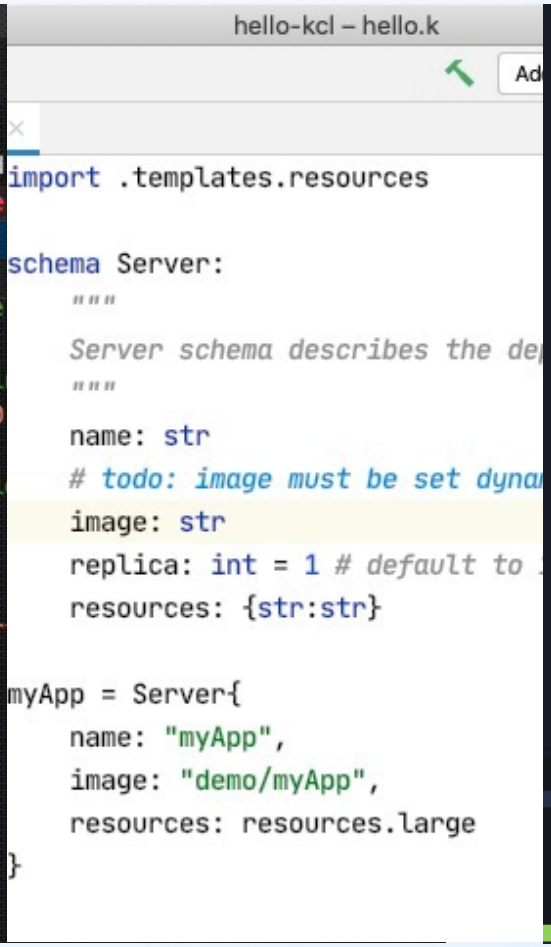
Language + Tools + IDEs + SDKs + Plugins

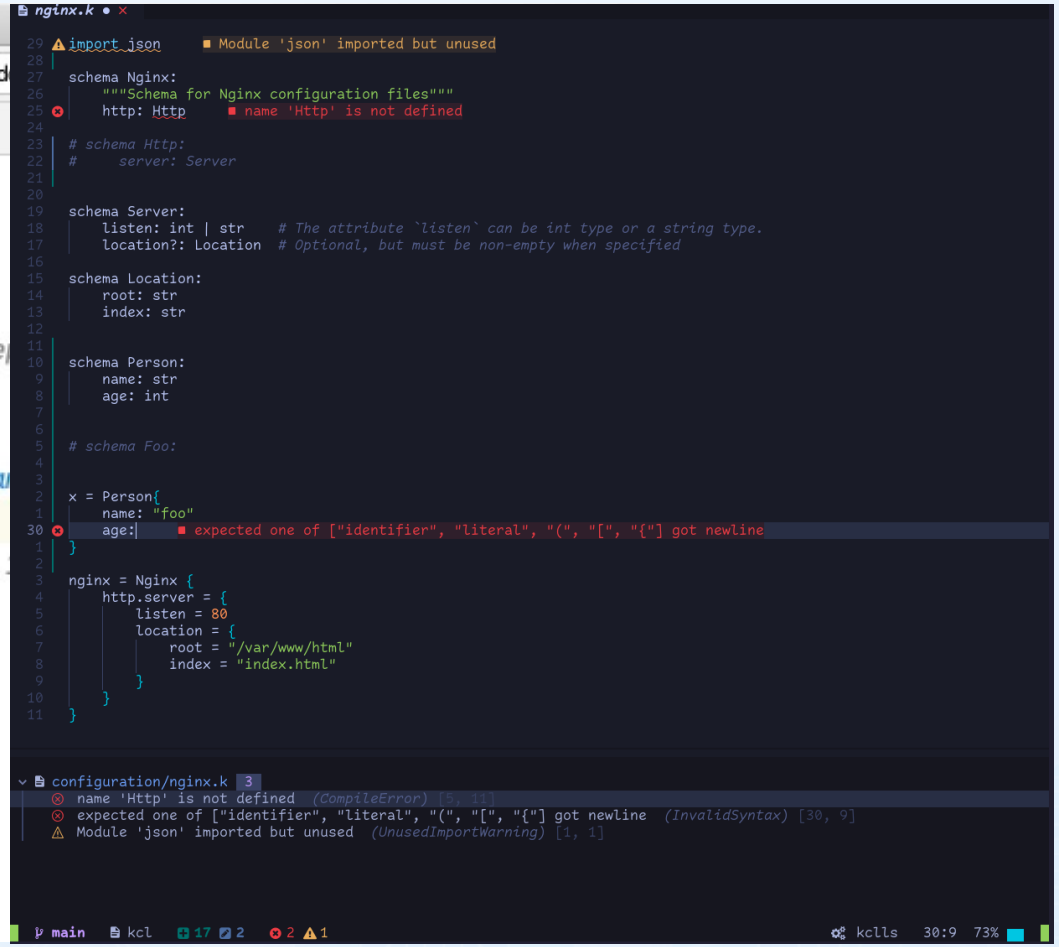


IDE Extension

- VS Code
- Idea
- NeoVim

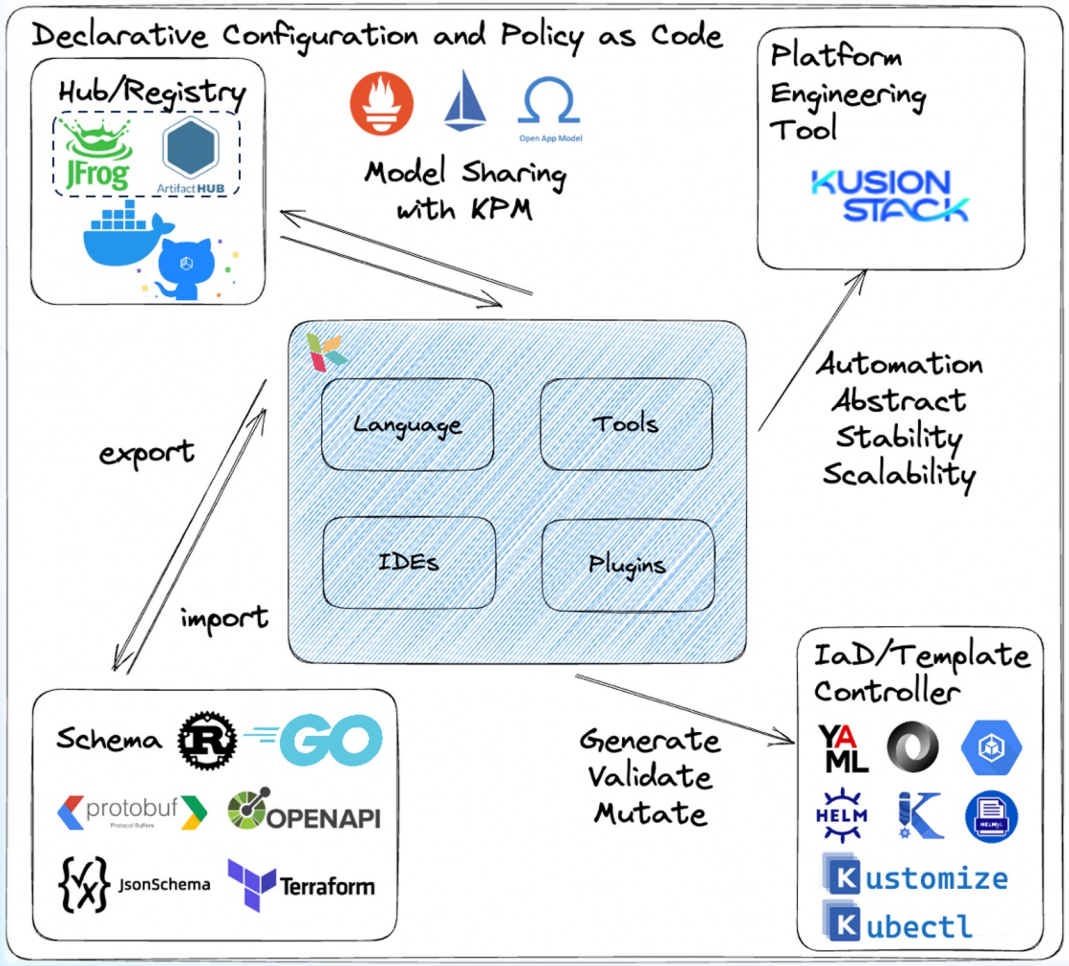






https://kcl-lang.io/docs/tools/Ide/

Integration



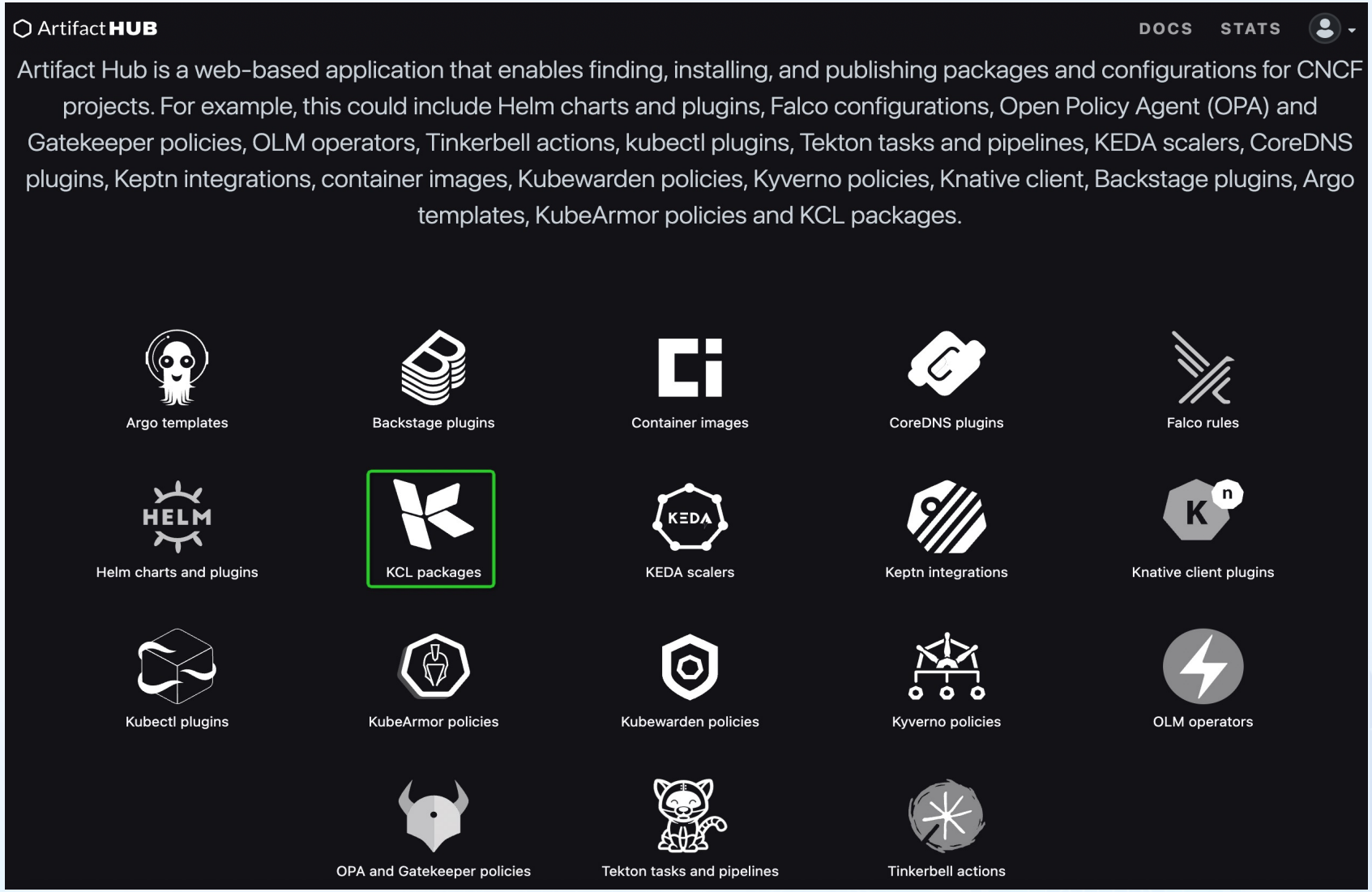
Client IaC/IaD ↔ Helm/Kustomize/KPT/.. KCL Plugins

Runtime Admission Request Mutating/Validating Webhook ↔ KCL Operator

SDKs

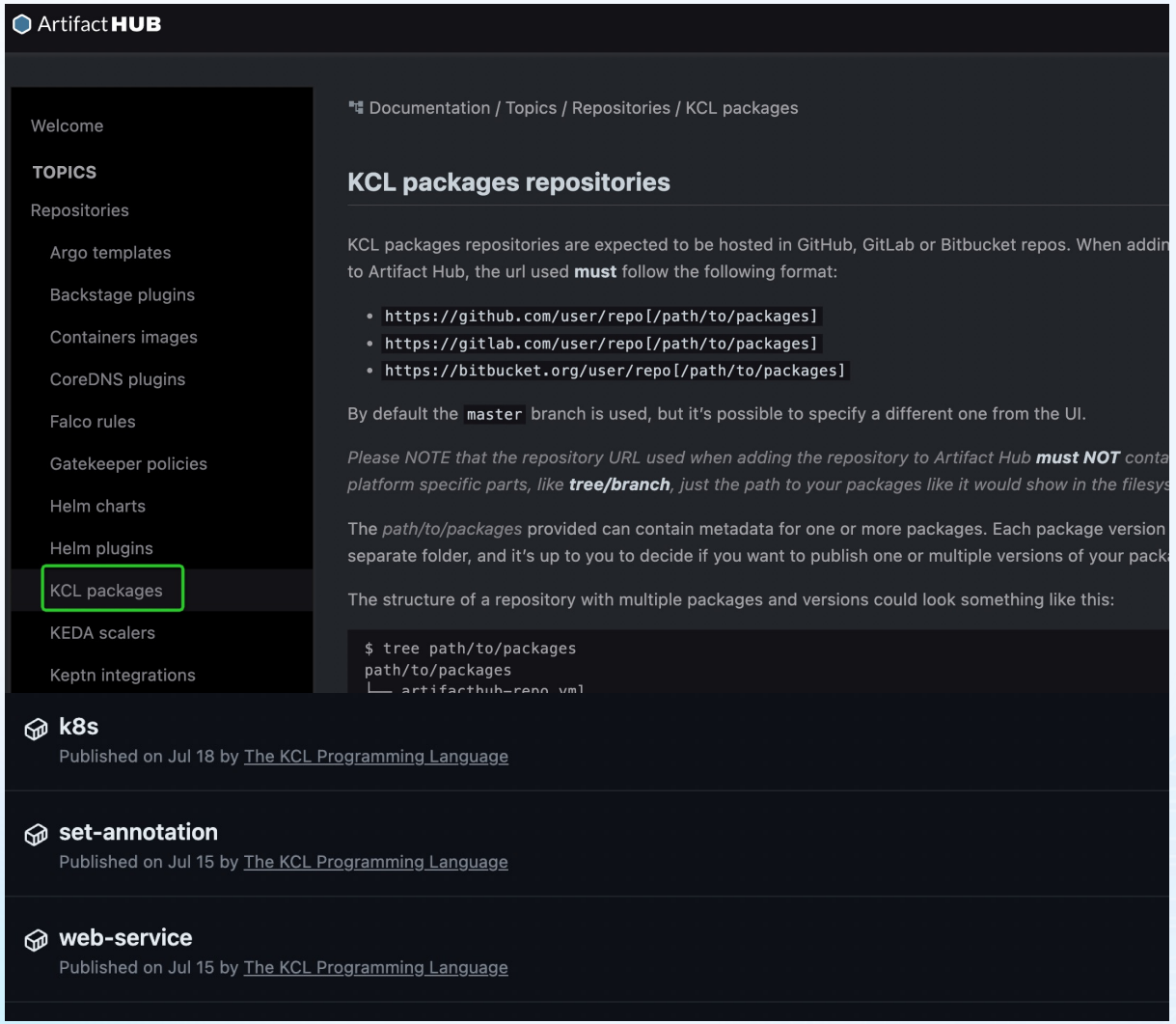
- **多语言 SDK:** Rust, Go, Python, Java SDK
- **包管理支持:** KPM 工具和多种 Registry /Hub支持
- **数据和 Schema 集成**：KCL Import/Export 工具
- **运行时集成:** 使用 KCL Operator 而不是重复开发 Kubernetes Admission Webhook
- **KRM 支持:** 统一的规范和插件支持 e.g., kubectl-kcl plugin, helm-kcl plugin, helmfile-kcl plugin, kustomize-kcl plugin, kpt-kcl-plugin ...
- **平台工程工具支持:** 作为 DCM 语言配合不同引擎/编排器进行应用交付

Artifact Hub KCL Integration (Staging)



ArtifactHub KCL Package 预览版：https://staging.artifacthub.io/

Registry & Modules



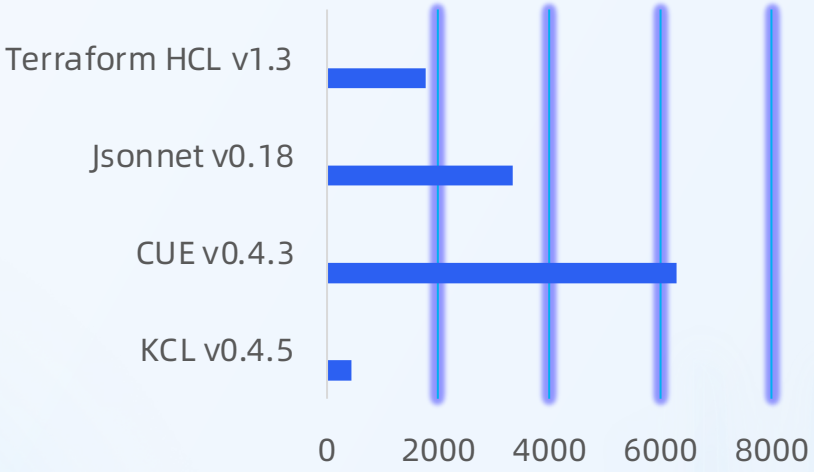
- **开箱即用:** 一行命令添加依赖 e.g., kpm add k8s，现阶段官网模型 **60+** (欢迎共建)
- **多种场景支持**：配置编辑、校验、模型抽象，Kubernetes 生态模型，Terraform 生态模型，应用配置，...
- **多种 Registry /Hub支持**: Docker Hub, ghcr.io, Harbor, ...
- **Artifact Hub KCL Integration (WIP):** 支持浏览器查询、身份认证等

ArtifactHub KCL Module 预览版：https://staging.artifacthub.io/packages/search?kind=20&sort=relevance&page=1

Performance

Loop and Function

```
a = lambda x: int, y: int -> int {
    max([x, y])
}
temp = {"a${i}": a(1, 2) for i in range(10000)}
```

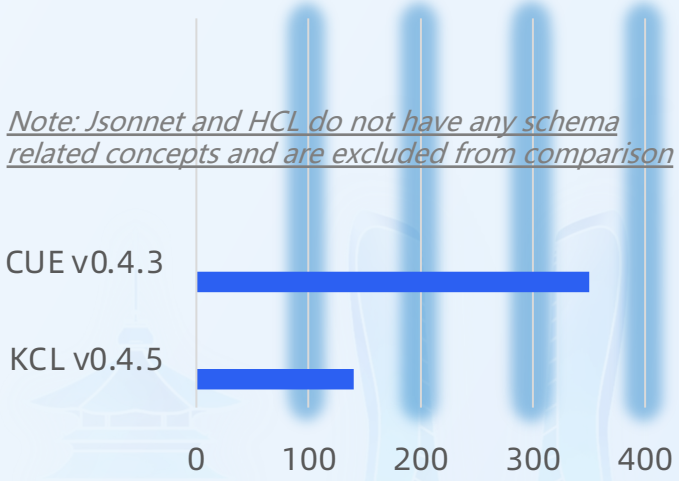


Kubernetes Configuration

```
import kubernetes.api.apps.v1

deployment = v1.Deployment {}
```

Note: Jsonnet and HCL do not have any schema related concepts and are excluded from comparison



Test environment: single core macOS 10.15.7 CPU: i7-8850H 2.6GHz 32GB 2400Mhz DDR4 No NUMA, e2e run time (ms)

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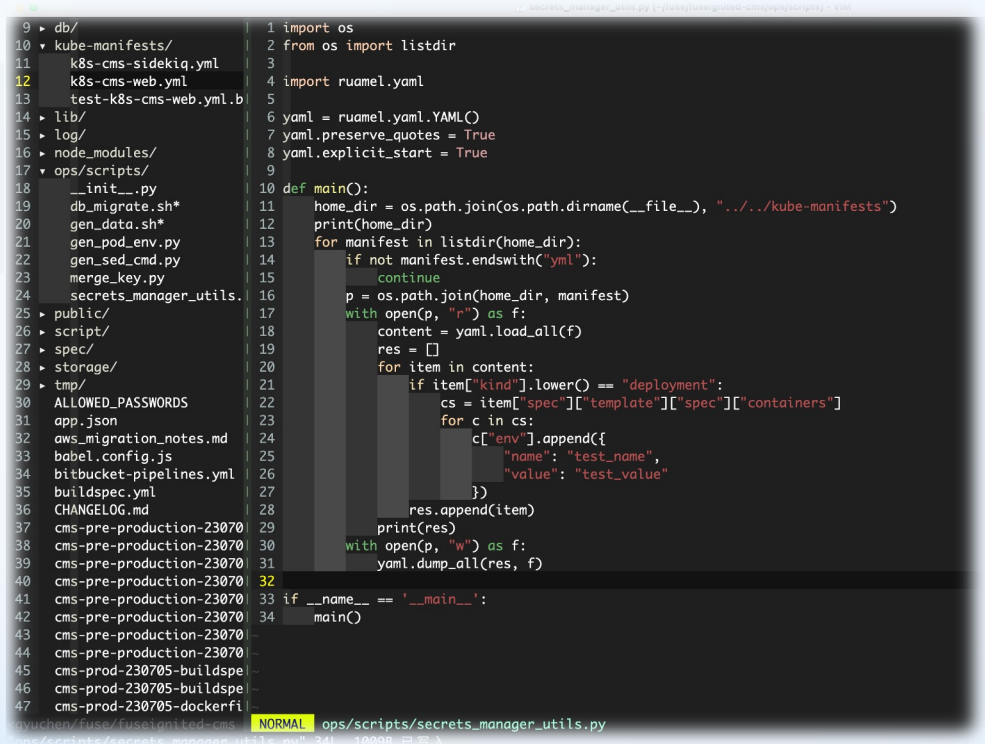
04. 实践

Mutation、Validation、Abstraction

Kubernetes Mutation

Before



After

```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
spec:
  params:
    env:
    - name: test_name
      value: test_value
  source: oci://ghcr.io/kcl-lang/append-env
```

OCI Registry 上存放的 KCL 代码包

```
items = [item | {
    if item.kind == "Deployment":
        spec.template.spec.containers: [{
            env += option("params").env
        } for container in item.spec.template.spec.containers]
} for item in option("items") or []]
```

- 避免脚本、胶水代码拼盘
- 可复用，可测试

https://github.com/kcl-lang/krm-kcl

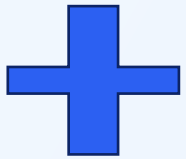
Kubernetes Validation

Disallow Service Load Balancer Module

```yaml
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  selector:
    app.kubernetes.io/name: MyApp
  ports:
    - name: http
      protocol: TCP
      port: 80
  type: LoadBalancer # 错误地设置了 LoadBalancer
```

Allow Https Only Module

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  # Required the annotation kubernetes.io/ingress.allow-http: "false"
  name: tls-example-ingress
spec:
  tls:
  - hosts:
      - https-example.foo.com
    secretName: testsecret-tls
  rules:
  - host: https-example.foo.com
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: service1
            port:
              number: 80
```



```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: disallow-svc-lb
spec:
  source: oci://ghcr.io/kcl-lang/disallow-svc-lb
```

将 K8s Manifests 和 KCL 策略同时使用，检查 K8s Manifests 配置是否合规

```yaml
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: https-only
spec:
  source: oci://ghcr.io/kcl-lang/https-only
```

- 统一界面：KCL 可以同时编写 Schema 和约束条件，无需配合 OpenAPI Schema/JSON Schema 使用

https://github.com/kcl-lang/krm-kcl

Kubernetes Abstraction

UI/CLI/API

Code

Standalone KCL Form

```
import .app

app.App {
    name = "app"
    containers.ngnix = {
        image = "ngnix"
        ports = [{containerPort = 80}]
    }
    service.ports = [{ port = 80 }]
}
```

KRM KCL Form

```
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: web-service
  metadata:
    annotations:
      krm.kcl.dev/version: 0.0.1
      krm.kcl.dev/type: abstraction
      documentation: >-
        Web service application abstraction
spec:
  params:
    name: app
    containers:
      ngnix:
        image: ngnix
        ports:
          containerPort: 80
    labels:
      name: app
  source: oci://ghcr.io/kcl-lang/web-service
```

Generate

Kubernetes Manifests

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-e
  namespace: ng
spec:
  ports:
  - nodePort: 30201
    port: 80
    targetPort: 80
  selector:
    app.kubernetes.io/name: nginx-example
    app.kubernetes.io/env: dev
    app.kubernetes.io/instance: nginx-example-dev
    app.kubernetes.io/component: nginx-exampledev
  type: NodePort
```

```
apiVersion: v1
kind: Namespace
metadata:
  name: nginx-example
```

```
apiVersion: a
kind: Deploym
metadata:
  name: ngin
  namespace:
spec:
  replicas: 1
  selector:
    matchLabe
      app.kut
      app.kut
      app.kut
      app.kut
  template:
    metadata:
      labels:
        app.k
        app.k
        app.k
        app.kubernetes.io/component: nginx-exampledev
    spec:
      containers:
      - image: nginx:latest
        name: main
        ports:
        - containerPort: 80
          protocol: TCP
        resources:
          limits:
            cpu: 100m
            memory: 100Mi
            ephemeral-storage: 1Gi
          requests:
            cpu: 100m
            memory: 100Mi
            ephemeral-storage: 1Gi
```

- Kubernetes API 自由组合/抽象，关注点分离

https://github.com/kcl-lang/krm-kcl

- Step 1. 在集群当中安装 KCL Operator
- Step 2. Apply KCL and K8s manifests

```
kubectl apply -f- << EOF
apiVersion: krm.kcl.dev/v1alpha1
kind: KCLRun
metadata:
  name: set-annotation
spec:
  params:
    annotations:
      managed-by: kcl-operator
  source: oci://ghcr.io/kcl-lang/set-annotation
EOF
```

```
kubectl apply -f- << EOF
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  annotations:
    app: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    ports:
    - containerPort: 80
EOF
```

- Step 3. 获得资源 Mutation/Validation 结果

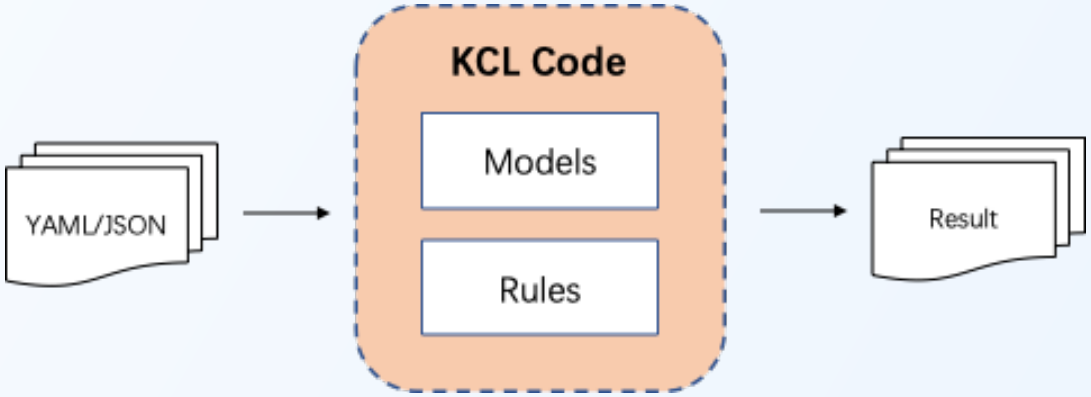
```
kubectl get po nginx -o yaml | grep kcl-operator
    managed-by: kcl-operator
```

- 少数几行 KCL 代码即可完成对应配置编辑/校验功能 (客户端和运行时代码可以复用)
- 无需开发额外的 Kubernetes Webhook 编辑和验证配置
- 多种代码源支持 OCI, Git, Https, Filesystem, ...

https://github.com/kcl-lang/kcl-operator

Terraform Configuration Validation & Generation

Validation Process



- ✓ **多种数据支持**：JSON/YAML/...
- ✓ **结构定义**：Schema 结构化定义及自定义错误支持
- ✓ **生态集成**：OpenAPI/Terraform Provider Schema 转换 KCL Schema 支持
- ✓ **开箱即用**：丰富的配置策略模型库和代码示例 (欢迎共建)

main.tf

```
provider "aws" {
    region = "us-west-1"
}
resource "aws_instance" "web" {
  instance_type = "t2.micro"
  ami = "ami-09b4b74c"
}
resource "aws_autoscaling_group" "my_asg" {
  availability_zones        = ["us-west-1a"]
  name                      = "my_asg"
  max_size                  = 5
  min_size                  = 1
  health_check_grace_period = 300
  health_check_type         = "ELB"
  desired_capacity          = 4
  force_delete              = true
  launch_configuration      = "my_web_config"
}
resource "aws_launch_configuration" "my_web_config" {
    name = "my_web_config"
    image_id = "ami-09b4b74c"
    instance_type = "t2.micro"
}
```

terraform plan

tfplan.json

```
{
  "format_version": "0.1",
  "terraform_version": "0.12.6",
  "planned_values": {
    "root_module": {
      "resources": [
        {
          "address": "aws_autoscaling_group.my_asg",
          "mode": "managed",
          "type": "aws_autoscaling_group",
          "name": "my_asg",
          "provider_name": "aws",
          "schema_version": 0,
          "values": {
            "availability_zones": [
              "us-west-1a"
            ],
            "desired_capacity": 4,
            "enabled_metrics": null,
            "force_delete": true,
            "health_check_grace_period": 300,
            "health_check_type": "ELB",
            "initial_lifecycle_hook": [],
```

validate

generate

main.k

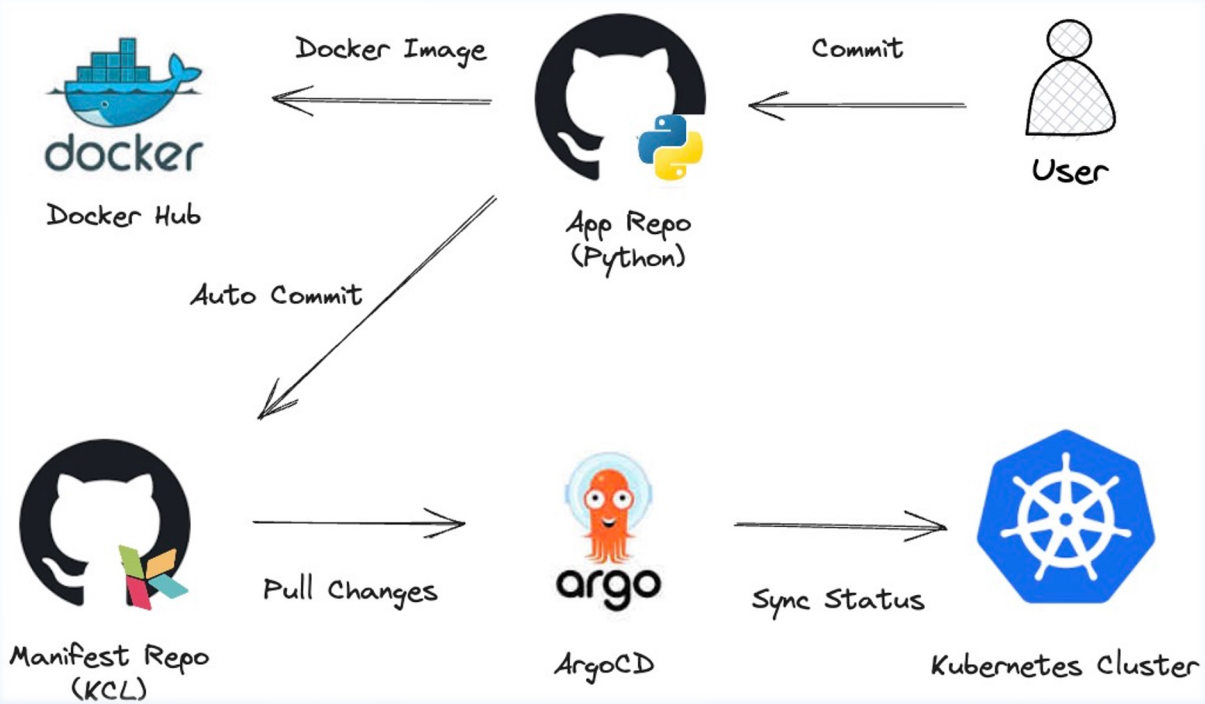
```
schema TFPlan:
    # Omit other attributes
    [...str]: any
    resource_changes?: [AcceptableChange]

schema AcceptableChange:
    # Omit other attributes
    [...str]: any
    check:
        # Reject AWS autoscaling group Resource delete action
        all action in change.actions {
            action not in ["delete"]
        } if type == "aws_autoscaling_group", "Disable AWS autoscaling group resourc
```

kcl-vet tfplan.json main.k

https://kcl-lang.io/docs/user_docs/guides/working-with-terraform/validation

IaC & GitOps

Better Configuration & Automation using KCL APIs



Commit

kcl code set image to kcllang/flask_demo:6428cff4309afc8c1c40ad180bb9...

...cfd82546be3e

main

github-actions[bot] committed 3 minutes ago

Showing 1 changed file with 1 addition and 1 deletion.

2 main.k

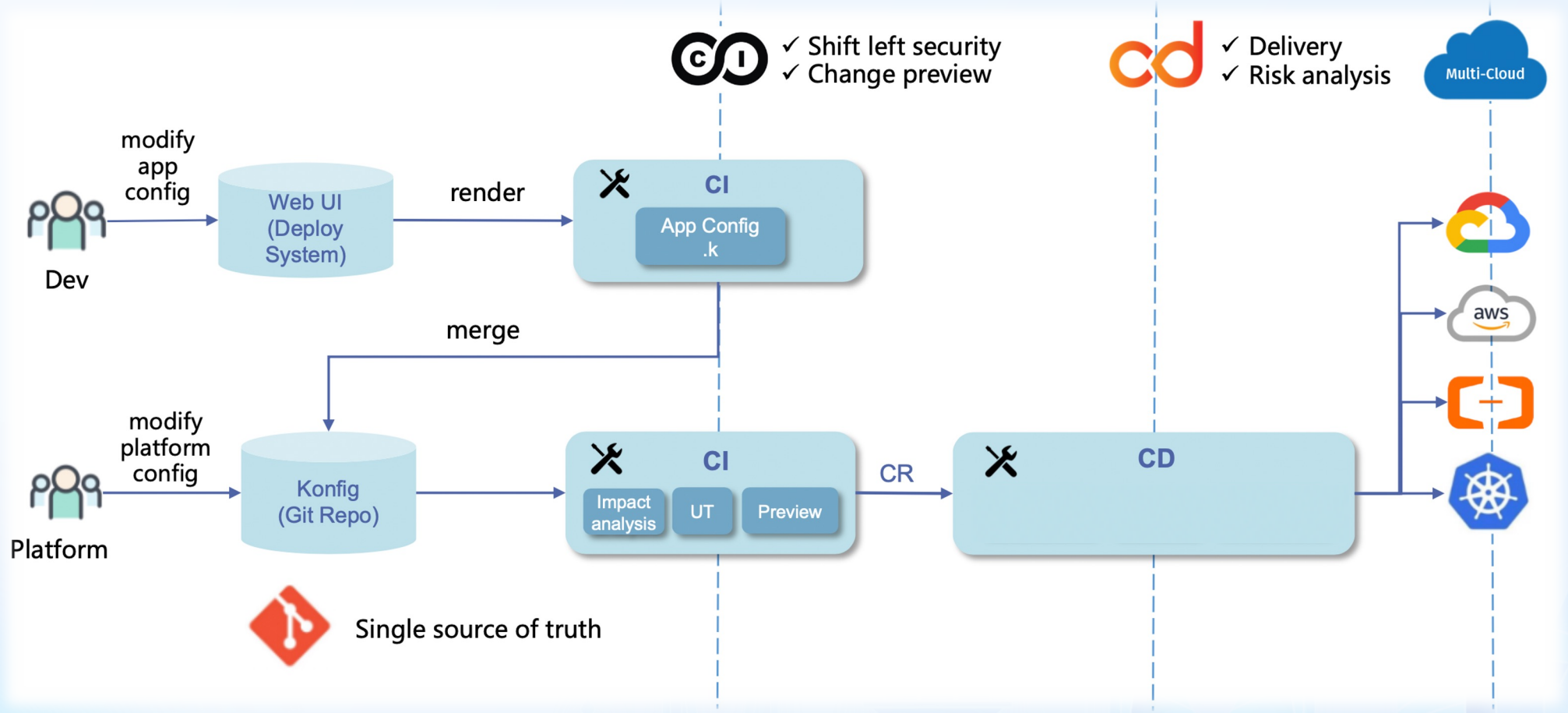
```
@@ -3,7 +3,7 @@ config = app.App {
3  3      name = "flask_demo"
4  4      containers: {
5  5          flask_demo = {
6     -            image = "kcllang/flask_demo:f1f2cbc0c4555d141e9f642fbd12edaf34d0b723"
   6  +            image = "kcllang/flask_demo:6428cff4309afc8c1c40ad180bb9cfd82546be3e"
7  7              ports = [{containerPort = 5000}]
8  8          }
9  9      }
```

配置驱动的工作流：同时支持 Standalone KCL 和 KRM KCL 配置格式
多种 CI/CD 和 GitOps 工具支持 e.g., ArgoCD

https://kcl-lang.io/docs/user_docs/guides/gitops/gitops-quick-start

App Delivery

For Kubernetes and Cloud Resources



多种支持应用交付引擎支持: 如 KusionStack, KubeVela

https://kusionstack.io
https://kubevela.net

App Delivery

Demo

Summary

Mutation, Validation, Abstraction
Production-Ready

KCL is an open-source constraint-based record & functional language mainly used in configuration and policy scenarios.

- 从云原生配置策略及软件供应链层面解决***认知负担高、静态配置、效率和稳定性等问题***
- 通过定义合适的 API 抽象，配置编辑策略隐藏基础设施和平台细节，减轻开发人员的负担。
- 通过通过更现代的声明式配置策略语言和工具，KRM KCL 规范, OCI Registry 和 Artifact Hub 等，帮助不同团队/角色之间更轻松地共享、传播和交付配置和策略。（**欢迎共建配置和策略模型**👏）

More Resources

- **官方网站**
  - https://kcl-lang.io/
  - https://kusionstack.io/
- **GitHub**
  - https://github.com/kcl-lang
  - https://github.com/kusionStack
- **Twitter**
  - @kcl language
- **Slack**
  - CNCF KCL Slack Channel: https://cloud-native.slack.com/archives/C05TC96NWN8

钉钉(DingTalk ID 42753001)

微信公众号

KUBERNETES
COMMUNITY DAYS HANGZHOU

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THANKS

感谢您的观看

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HANGZHOU 2023

Appendix

Community Projects

Structured KV

Pros.

- Easy to write and read
- Rich multi-language API
- Various Path Tools

Cons.

- Redundant information
- Insufficient functionality e.g. abstraction, constraint, ...

Tech.

- JSON
- YAML

Product

- Kustomize
- ...

Templated KV

Pros.

- Simple config logic support
- Dynamic argument input

Cons.

- Increase of argument makes it difficult to maintain
- Insufficient functionality e.g. abstraction, constraint, ...

Tech.

- Velocity
- Go Template

Product

- Helm
- Helmfile
- ...

Programmable KV

Pros.

- Required programming features
- Code modularity
- Templates & Data abstraction

Cons.

- Insufficient type constraints
- Insufficient restraint ability
- Runtime error

Tech.

- GCL
- HCL
- Bicep
- Starlark
- Jsonnet
- CEL
- OPA/Rego
- ...

Product

- Terraform
- Tanka
- Radius
- ytt
- kpt

Typed KV

Pros.

- Rich config constraint syntax
- Unified type & value constraint
- Configuration conflict checking

Cons.

- Difficult to configuration override for multi-environment scenarios
- Runtime checks and limited performance

Tech.

- CUE
- Nickel
- ...

Product

- KubeVela
- ...

Modeled KV

Pros.

- Model-centric & constraint-centric
- Scalability on separated block writing with rich merge strategies
- Static type system & analysis
- High Performance

Cons.

- Expansion of different models requires investment in R&D

Tech.

- **KCL**
- ...

Product

- KusionStack
- KRM-KCL Tools and Operators