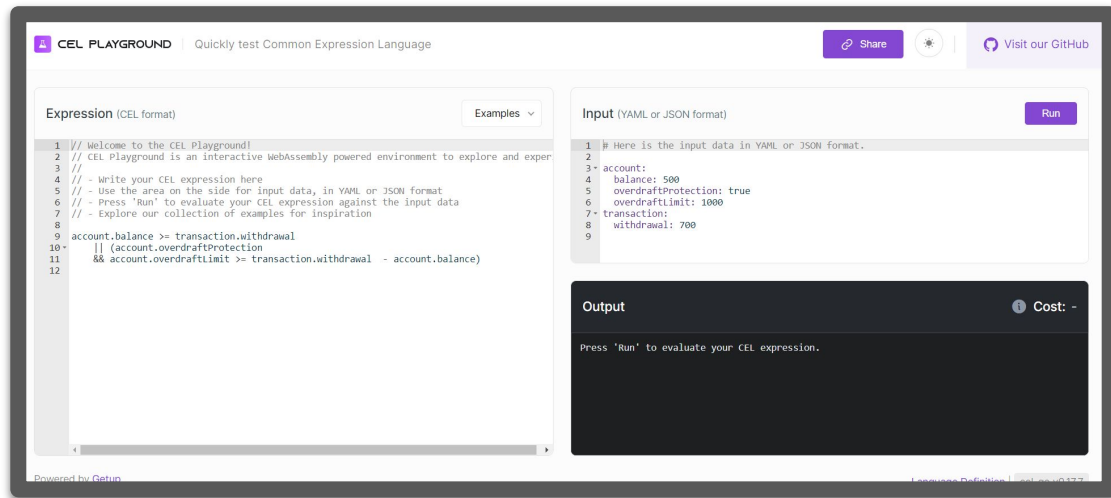






# CEL PLAYGROUND



**Kevin Conner, Director of Engineering**  
[kev.conner@getupcloud.com](mailto:kev.conner@getupcloud.com)

# ABOUT GETUP



# Agenda



## CEL Playground

### Common Expression Language (CEL)

- Quick Tour
- Kubernetes Extensions

### Kubernetes Use Cases

- WebHooks
- ValidatingAdmissionPolicy
- Authentication Configuration Claim Mapping
- Authorization Configuration
- Custom Resource Validation

### Questions

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CEL PLAYGROUND

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# What is CEL Playground?

CEL Playground is an interactive WebAssembly (Wasm) powered environment to explore and experiment with the [Common Expression Language \(CEL\)](#) providing a simple and user-friendly interface to write and quickly evaluate CEL expressions for use in Kubernetes, Istio and other Cloud Native technologies.



Easy Sharing



Learning



Quick Testing



Avoid Mistakes

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The original idea was to provide a simple browser-based testing environment for Common Expression Language (CEL), the Playground enable and enhance the user experience and exploration of CEL.

### # sig-api-machinery-cel-dev



Matheus Moraes 11:03 AM

Hello everyone,

Does anyone working with `ValidatingAdmissionPolicy` use a playground for CEL or something similar?

I'm working on `Marvin`, a cluster scanner that also uses CEL, and I think a playground would help a lot in testing CEL expressions.

Something similar to `rego playground` and `CUE playground`



jpbetz 4 months ago

This has been suggested a few times. I think it is very much needed, but I'm not aware of anyone building one yet.



jpbetz 4 months ago

It might be possible to build it as a static site using WASM if anyone is interested in building it but concerned about hosting costs.



SIG API machinery Agenda & Notes...

File Edit View Insert Format Tools Extensions ...

100% Heading 3

- Downside
  - Maintain effort
  - Immature itself(missing tooling)
- Tooling to experience with CEL in K8s (kubectl get, dry run, etc.)
  - Command line tool ([repo](#))
  - A cel playground would be a great idea (not client validation) (could be kubectl get format)

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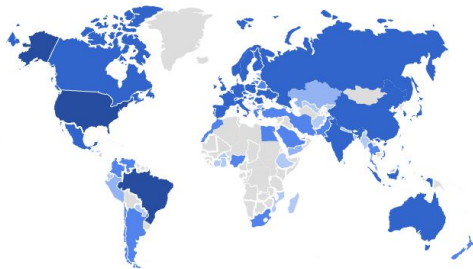


CEL PLAYGROUND

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# Where is CEL Playground?

Users▼ by Country ID▼



COUNTRY	USERS	
United States	725	-
Brazil	317	-
India	141	-
Germany	128	-
United Kingdom	126	-
France	102	-
China	82	-

Users

2.5K

New users

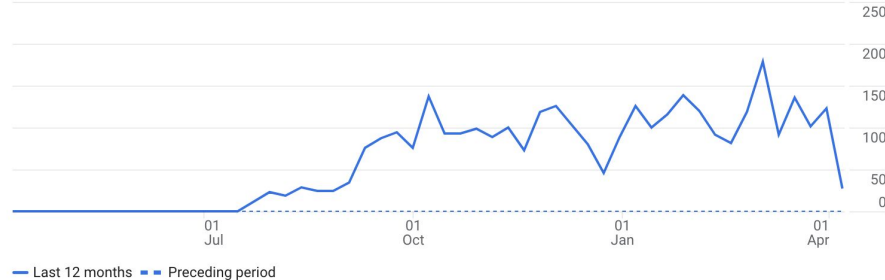
2.5K

Conversions

0

Event count

34K



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# Demo

[playcel.undistro.io](https://playcel.undistro.io)

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# Agenda

CEL Playground

## Common Expression Language (CEL)

- Quick Tour
- Kubernetes Extensions

Kubernetes Use Cases

- WebHooks
- ValidatingAdmissionPolicy
- Authentication Configuration Claim Mapping
- Authorization Configuration
- Custom Resource Validation

Questions

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# Common Expression Language

- Developed by Google
  - Small & Fast
  - Embeddable
  - Extensible
- Supports
  - Logical Expressions
  - Relationships
  - Arithmetical Expressions
  - Conditional Expressions

&&, ||, !

==, !=, <, >, <=, >=, in

-, \*, /, %, +, -

?:

.?

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# Common Expression Language

- Types

- Unsigned and Signed 64 bit integers    -1, 0, 1, 255u
- 64-bit Double    3.1415926
- Booleans    true, false
- Strings    "Test string"
- Bytes    b"abc", b"\303\277"
- Lists    ["abc", "def"]
- Maps    {"abc": <val>, "def": <val2>}
- Null    null
- Duration    duration("10m")
- Timestamp    timestamp("2024-04-10T09:00:00-07:00")

# Common Expression Language

- Conversions

- bytes
- integer
- unsigned integers
- double
- boolean
- strings
- bytes

`bytes("abc")` - string

`int(5u)` - uint, double, string, timestamp

`uint("5")` - int, double, string

`double("3.1415926")` - int, uint, string

`bool("true")`, `bool("false")`

`string(10.5)` - int, uint, double, bytes, timestamp, duration

`bytes("abc")` - string

# Common Expression Language

- Macros

- `has(e.f)` `has(map_data.key4), has(obj_data.field1)`
- `e.all(x, p)` `list_data.all(x, x>10), map_data.all(k, k.startsWith("key"))`
- `e.exists(x, p)` `list_data.exists(x, x<10), map_data.exists(k, k > "key2")`
- `e.map(x, t)` `list_data.map(x, x+10)`
- `e.map(x, p, t)` `list_data.map(x, x>=12, x+10)`
- `e.filter(x, p)` `list_data.filter(x, x>=12)`

# Common Expression Language

- Functions
  - contains `"abcdef".contains("cd")`
  - endsWith `"abcdef".endsWith("ef")`
  - startsWith `"abcdef".startsWith("ab")`
  - size `size("abcdef"), size(list_data), size(map_data)`
  - matches `"abcdef".matches("^.*c.*f$"), matches("abcdef", "^.*c.*f$")`
- Plus Timestamp/Duration functions

# Kubernetes Extensions

- Optional Expressions `.?`
- Cross Type Numeric Comparisons `1.0 < 2`
- String Library Extensions
  - `charAt` `"abc".charAt(1)`
  - `indexOf` `"abcdefedcba".indexOf("c")`
  - `lastIndexOf` `"abcdefedcba".lastIndexOf("c")`
  - `lowerAscii` `"ABCDEF".lowerAscii()`
  - `replace` `"bababaaaba".replace("ab", "yz", 2)`
  - `split` `"abc, def, ghi".split(", ")`
  - `substring` `"bababaaaba".substring(3, 5)`
  - `trim` `" abcdef ".trim()`
  - `format` `"testing formatting: %s-%d".format(["abc", 5])`
  - `join` `["1", "2", "3"].join(",")`

# Kubernetes Extensions

- URL
  - `getScheme` `url("https://example.com/path?query=true").getScheme()`
  - `getHost` `url("https://example.com/path?query=true").getHost()`
  - `getHostname` `url("https://example.com/path?query=true").getHostname()`
  - `getPort` `url("https://example.com:433/path?query=true").getPort()`
  - `getEscapedPath` `url("https://example.com/p a t h ?query=true").getEscapedPath()`
  - `getQuery` `url("https://example.com/path?query=true").getQuery()`
  - `isURL` `isURL("https://example.com/path?query=true")`



# Kubernetes Extensions

Decimal values - m, "", k, M, G, T, P, E

International System of Units(SI) - Ki, Mi, Gi, Ti, Pi, Ei

- Quantities

- isQuantity
- isGreaterThan
- isLessThan
- compareTo
- asApproximateFloat
- asInteger
- isInteger
- add
- sub

```
isQuantity("100Mi")
```

```
quantity("50k").isGreaterThan(quantity("90k"))
```

```
quantity("50k").isLessThan(quantity("90k"))
```

```
quantity("50k").compareTo(quantity("90k"))
```

```
quantity("3m").asApproximateFloat()
```

```
quantity("1Ki").asInteger()
```

```
quantity("50k").isInteger()
```

```
quantity("50k").add(quantity("90k")).asInteger() - can also be integer
```

```
quantity("50k").sub(quantity("90k")).asInteger() - can also be integer
```

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# Kubernetes Extensions

- Regex
  - find `"abcdef abc def abcddeff".find("c[a-z]*e")`
  - findAll `"abcdef abc def abcddeff".findAll("c[a-z]*e")`
- Lists
  - indexOf `[1, 5, 3, 1, 6, 3, 9].indexOf(3)`
  - lastIndexOf `[1, 5, 3, 1, 6, 3, 9].lastIndexOf(3)`
- Lists (Comparable Types)
  - isSorted `[1, 5, 3, 1, 6, 3, 9].isSorted()`
  - max `[1, 5, 3, 1, 6, 3, 9].max()`
  - Min `[1, 5, 3, 1, 6, 3, 9].min()`
- Lists (Summable Types)
  - sum `[1, 5, 3, 1, 6, 3, 9].sum()`

# Kubernetes Extensions

## Authorizer resource based authorization

- Obtain ResourceCheck for resource
- Refine with combination of
  - subresource
  - namespace
  - name
- Check verb for decision
- Check if allowed
- Check if errored

```
Authorizer.group("").resource("pods")
```

```
resourceCheck.subresource("status")  
resourceCheck.namespace("default")  
resourceCheck.name("podname")  
resourceCheck.check("watch")  
decision.allowed(), decision.reason()  
decision.errored(), decision.error()
```

# Kubernetes Extensions

## Authorizer non-resource based authorization

- Obtain PathCheck for resource
- Check HTTP verb for decision
- Check if allowed
- Check if errored

```
Authorizer.path("/health")  
resourceCheck.check("get")  
decision.allowed(), decision.reason()  
decision.errored(), decision.error()
```

## Service Account authorization

- Obtain Authorizer for service account
- Perform resource and non-resource based authorization

```
authorizer.serviceAccount("default", "myserviceaccount")
```

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# Demo

[playcel.undistro.io](https://playcel.undistro.io)

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# Agenda

CEL Playground

Common Expression Language (CEL)

- Quick Tour
- Kubernetes Extensions

 **Kubernetes Use Cases**

- **WebHooks**
- **ValidatingAdmissionPolicy**
- **Authentication Configuration Claim Mapping**
- **Authorization Configuration**
- **Custom Resource Validation**

Questions

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# Webhooks

## Webhooks are

- Remote services for mutating and validating resources
- Invoked by the kubernetes API server
- Expensive
  - Time consuming network calls
  - Can Potentially fail
  - Coarse Grained access
  - Can filter using labels
    - namespaceSelector
    - objectSelector

```
apiVersion: admissionregistration.k8s.io/v1
kind: ValidatingWebhookConfiguration
metadata:
  name: "pod-policy.example.com"
webhooks:
- name: "pod-policy.example.com"
  rules:
  - apiGroups:  [""]
    apiVersions: ["v1"]
    operations:  ["CREATE"]
    resources:   ["pods"]
    scope:       "Namespaced"
  clientConfig:
    service:
      namespace: "example-namespace"
      name: "example-service"
    caBundle: <CA_BUNDLE>
  admissionReviewVersions: ["v1"]
  sideEffects: None
  timeoutSeconds: 5
```

# Webhooks

## CEL webhook integration

- Applies to both Mutating & Validating Webhooks
- Provides fine grained request filtering
- Runs within the kubernetes API server
- All conditions must evaluate to true

*# You can have up to 64matchConditions per webhook*

**matchConditions:**

- **name:** 'exclude-leases' *# Each match condition must have a unique name*  
**expression:** '!(request.resource.group == "coordination.k8s.io" && request.resource.resource == "leases")'
- **name:** 'exclude-kubelet-requests'  
**expression:** '!("system:nodes" in request.userInfo.groups)' *# Match requests made by non-node users.*
- **name:** 'rbac' *# Skip RBAC requests, which are handled by the second webhook.*  
**expression:** 'request.resource.group != "rbac.authorization.k8s.io"'

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# Webhooks

**CEL matchConditions** have access to

- 'object'
- 'oldObject'
- 'request'
- 'authorizer'
- 'authorizer.requestResource'

The object from the incoming request (null for DELETE)

The existing object (null for CREATE)

The request portion of **AdmissionReview**, not including **object** and **oldObject**

An Authorizer for performing authorization checks

Authorizer request configured within the requested resource group, resource, subresource, namespace, name

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# Demo

[playcel.undistro.io](https://playcel.undistro.io)

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# Validating Admission Policy

- An alternative to Validating Webhooks for many use cases
- Runs within the kubernetes API server
- Consists of
  - ValidatingAdmissionPolicy
  - ValidatingAdmissionPolicyBinding
  - Optional Parameter Resources
- Can Deny, Warn or Audit
- CEL Expressions used in
  - variables
  - matchConditions
  - validations
  - auditAnnotations

```
apiVersion: admissionregistration.k8s.io/v1beta1
kind: ValidatingAdmissionPolicy
metadata:
  name: "demo-policy.example.com"
spec:
  failurePolicy: Fail
  matchConstraints:
    resourceRules:
      - apiGroups: ["apps"]
        apiVersions: ["v1"]
        operations: ["CREATE", "UPDATE"]
        resources: ["deployments"]
  validations:
    - expression: "object.spec.replicas <= 5"
```

```
apiVersion: admissionregistration.k8s.io/v1beta1
kind: ValidatingAdmissionPolicyBinding
metadata:
  name: "demo-binding-test.example.com"
spec:
  policyName: "demo-policy.example.com"
  validationActions: [Deny]
  matchResources:
    namespaceSelector:
      matchLabels:
        environment: test
```

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# ValidatingAdmissionPolicy

## CEL expressions have access to

- 'object' The object from the incoming request (null for DELETE)
- 'oldObject' The existing object (null for CREATE)
- 'request' The request portion of **AdmissionReview**, not including **object** and **oldObject**
- 'params' Optional parameters bound through the **ValidatingAdmissionPolicyBinding**
- 'namespaceObject' The namespace object for the incoming resource
- 'variables' The variables defined in the policy
- 'authorizer' An Authorizer for performing authorization checks
- 'authorizer.requestResource' Authorizer request configured within the requested resource group, resource, subresource, namespace, name

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# Validating Admission Policy

## Variables

- Define variables for use in other expressions
- Evaluated on-demand
- Located under **variables**
- Can reference earlier variables

```
variables:  
- name: environment  
  expression: "'environment' in namespaceObject.metadata.labels ? namespaceObject.metadata.labels['environment'] : 'prod'"  
- name: exempt  
  expression: "'exempt' in object.metadata.labels && object.metadata.labels['exempt'] == 'true'"  
- name: containers  
  expression: "object.spec.template.spec.containers"  
- name: containersToCheck  
  expression: "variables.containers.filter(c, c.image.contains('example.com/'))"
```

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# Validating Admission Policy

## Match Conditions

- Same as with Webhooks
- Provides fine grained request filtering
- Runs within the kubernetes API server
- All conditions must evaluate to true

### matchConditions:

- **name:** 'exclude-leases' *# Each match condition must have a unique name*  
**expression:** '!(request.resource.group == "coordination.k8s.io" && request.resource.resource == "leases")'
- **name:** 'exclude-kubelet-requests'  
**expression:** '!("system:nodes" in request.userInfo.groups)' *# Match requests made by non-node users.*
- **name:** 'rbac' *# Skip RBAC requests.*  
**expression:** 'request.resource.group != "rbac.authorization.k8s.io"'

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# ValidatingAdmissionPolicy

## Validations

- Only run if resource matched by **matchConditions**
- Runs within the kubernetes API server
- All validations must evaluate to true
- Can return friendly messages using expressions

```
variables:  
- name: environment  
  expression: "'environment' in namespaceObject.metadata.labels ? namespaceObject.metadata.labels['environment'] : 'prod'"  
- name: exempt  
  expression: "'exempt' in object.metadata.labels && object.metadata.labels['exempt'] == 'true'"  
- name: containers  
  expression: "object.spec.template.spec.containers"  
- name: containersToCheck  
  expression: "variables.containers.filter(c, c.image.contains('example.com/'))"  
validations:  
- expression: "variables.exempt || variables.containersToCheck.all(c, c.image.startsWith(variables.environment + '.'))"  
  messageExpression: "'only ' + variables.environment + ' images are allowed in namespace ' + namespaceObject.metadata.name"
```

# Validating Admission Policy

## Audit Annotations

- Only run if request is rejected
- Include friendly audit annotations in the audit event of the API request

```
validations:  
  - expression: "object.spec.replicas > 50"  
    messageExpression: "'Deployment spec.replicas set to ' + string(object.spec.replicas)"  
auditAnnotations:  
  - key: "high-replica-count"  
    valueExpression: "'Deployment spec.replicas set to ' + string(object.spec.replicas)"
```



# Demo

[playcel.undistro.io](https://playcel.undistro.io)

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# Claim Mapping

## CEL authentication integration

- Command Line option to API Server
- Applies to JWT Authenticators
- Supports
  - Claim Validation Rules
  - Claim Mapping
  - User Validation Rules

```
apiVersion: apiserver.config.k8s.io/v1beta1
kind: AuthenticationConfiguration
jwt:
- issuer:
  url: https://example.com
  audiences:
  - my-app
  - other-app
  audienceMatchPolicy: MatchAny
  claimValidationRules:
  - claim: hd
    requiredValue: example.com
  - expression: 'claims.hd == "example.com"'
    message: the hd claim must be set to example.com
  - expression: 'claims.exp - claims.nbf <= 86400'
    message: total token lifetime must not exceed 24 hours
  claimMappings:
    username:
      expression: 'claims.username + ":external-user"'
    groups:
      expression: 'claims.roles.split(",")'
    uid:
      claim: 'sub'
      extra:
      - key: 'client_name'
        valueExpression: 'claims.some_claim'
    userValidationRules:
  - expression: "!user.username.startsWith('system:')"
    message: username cannot use reserved system: prefix
  - expression: "user.groups.all(group, !group.startsWith('system:'))"
    message: groups cannot use reserved system: prefix
```

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# Claim Mapping

## Claim Validation Rules

- Has access to token claims via 'claims' map

## Claim Mapping

- Maps username, groups, uid and extra claims
- Has access to token claims via 'claims' map

## User Validation Rules

- Has access to single 'user' map containing
  - username
  - groups
  - uid
  - extra

```
apiVersion: apiserver.config.k8s.io/v1beta1
kind: AuthenticationConfiguration
jwt:
- issuer:
  url: https://example.com
  audiences:
  - my-app
  - other-app
  audienceMatchPolicy: MatchAny
  claimValidationRules:
  - claim: hd
    requiredValue: example.com
  - expression: 'claims.hd == "example.com"'
    message: the hd claim must be set to example.com
  - expression: 'claims.exp - claims.nbf <= 86400'
    message: total token lifetime must not exceed 24 hours
  claimMappings:
  username:
    expression: 'claims.username + ":external-user"'
  groups:
    expression: 'claims.roles.split(",")'
  uid:
    claim: 'sub'
    extra:
    - key: 'client_name'
      valueExpression: 'claims.some_claim'
  userValidationRules:
  - expression: "!user.username.startsWith('system:')"
    message: username cannot used reserved system: prefix
  - expression: "user.groups.all(group, !group.startsWith('system:'))"
    message: groups cannot used reserved system: prefix
```

# Authorization Configuration

## CEL authorization integration

- Command Line option to API Server
- Specifies authorizer chain for server
- Enables use of multiple webhooks
- Filtered using CEL **matchConditions**
- Can access **SubjectAccessReview** contents
  - resourceAttributes
  - nonResourceAttributes
  - user
  - groups
  - uid
  - extra

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```
apiVersion: apiserver.config.k8s.io/v1beta1
kind: AuthorizationConfiguration
authorizers:
- name: system-crd-protector
  type: Webhook
  webhook:
    unauthorizedTTL: 30s
    timeout: 3s
    subjectAccessReviewVersion: v1
    matchConditionSubjectAccessReviewVersion: v1
    failurePolicy: Deny
    connectionInfo:
      type: KubeConfig
      kubeConfigFile: /kube-system-authz-webhook.yaml
    matchConditions:
      # only send resource requests to the webhook
      - expression: has(request.resourceAttributes)
      # only intercept requests to kube-system
      - expression: request.resourceAttributes.namespace == 'kube-system'
      # don't intercept requests from kube-system service accounts
      - expression: !('system:serviceaccounts:kube-system' in request.user.groups)
- type: Node
- type: RBAC
- name: opa
  type: Webhook
  webhook:
    unauthorizedTTL: 30s
    timeout: 3s
    subjectAccessReviewVersion: v1
    matchConditionSubjectAccessReviewVersion: v1
    failurePolicy: Deny
    connectionInfo:
      type: KubeConfig
      kubeConfigFile: /opa-kube-system-authz-webhook.yaml
    matchConditions:
      # only send resource requests to the webhook
      - expression: has(request.resourceAttributes)
      # only intercept requests to kube-system
      - expression: request.resourceAttributes.namespace == 'kube-system'
      # don't intercept requests from kube-system service accounts
      - expression: !('system:serviceaccounts:kube-system' in request.user.groups)
```



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# Custom Resource Validation

- Validation rules bound within schema
  - x-kubernetes-validations
- Rules bound within the schema
- Rules have access to
  - self
  - oldSelf

```
...
openAPIV3Schema:
  type: object
  properties:
    spec:
      type: object
      x-kubernetes-validations:
        - rule: "self.minReplicas <= self.replicas"
          message: "replicas should be greater than or equal to minReplicas."
        - rule: "self.replicas <= self.maxReplicas"
          message: "replicas should be smaller than or equal to maxReplicas."
      properties:
        ...
        minReplicas:
          type: integer
        replicas:
          type: integer
        maxReplicas:
          type: integer
      required:
        - minReplicas
        - replicas
        - maxReplicas
```

# Custom Resource Validation

- Rules can be bound to
  - Root object
    - 'apiVersion', 'kind', 'metadata.name' & 'metadata.namespace'
  - Embedded object
    - Properties accessible via 'self.field'
  - Object with additionalProperties
    - Properties accessible via 'self["name"].field'
  - An Array
    - Accessed via 'self[index].field'
  - A Scalar
    - Self is bound to scalar value

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# Agenda

## CEL Playground

### Common Expression Language (CEL)

- Quick Tour
- Kubernetes Extensions

### Kubernetes Use Cases

- WebHooks
- ValidatingAdmissionPolicy
- Authentication Configuration Claim Mapping
- Authorization Configuration
- Custom Resource Validation



### Questions

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# CEL Playground RoadMap

On the Road to [CNCF sandbox!](#)

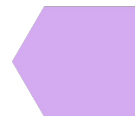
Better support for Kubernetes use cases



ValidatingAdmissionPolicy **validations**



ValidatingWebhookConfiguration  
**matchConditions**



CRD **validations**



Authorization **matchConditions**

**Supporting other  
CNCF & OSS projects**

Istio, Envoy & Google Cloud Certificate Authority Service...  
Others?

**Testing on live clusters**



CEL PLAYGROUND

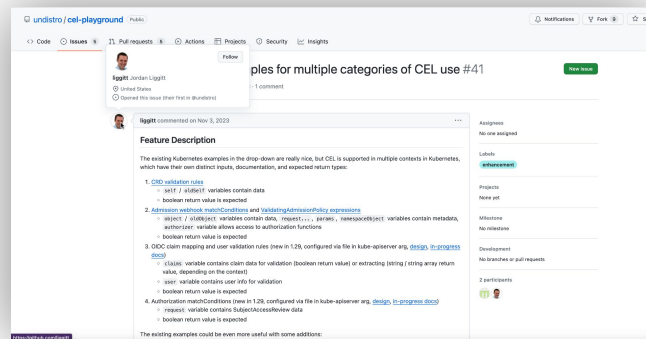
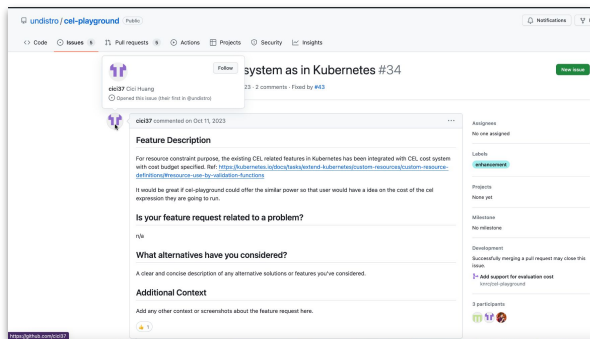
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# Give Us your Feedback, Please!

<https://github.com/undistro/cel-playground/issues>

Be like [Jordan](#), [CiCi](#) and others!  
Give feedback, submit an issue!



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# Are you already using CEL Playground?

**Support our community efforts!**

Add your organization to our Adopters.md file here:

<https://github.com/undistro/cel-playground/blob/main/ADOPTERS.md>



# Contributions are welcome!

▶ **CEL Playground:** [playcel.undistro.io](https://playcel.undistro.io)

▶ **GitHub Repository:** [github.com/undistro/cel-playground](https://github.com/undistro/cel-playground)

## CONTACT US

**Matheus Faria:** [matheus.faria@getupcloud.com](mailto:matheus.faria@getupcloud.com)

**Kevin Conner:** [kev.conner@getupcloud.com](mailto:kev.conner@getupcloud.com)

<https://github.com/undistro/cel-playground/tree/main/presentations/OpenShiftCommons>

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THANK YOU!

GETUP.IO