Kubernetes Policy WG Session

KubeCon Shanghai 2019

Zhipeng Huang, Huawei

WG Overview

Motivation (from Brian G)

- Kubernetes The Policy Framework
- Policies impose permissions, quotas, constraints, requirements, defaults, etc. on other resources
- What patterns should we adopt going forward?
  - Built in vs extensions
  - Extension using DSLs vs APIs
  - Domain-specific (scheduling policy) vs resource-specific (pod restriction)
  - Conventions across policy types: whitelists, blacklists, profiles, defaults, etc.
  - Cluster-level vs namespace-level
  - Policies vs component flags
- How do we provide policy defaults?

Motivation (from ourselves)

- Policy are needed and designed all over the place in kubernetes
- Policy description are domain specific in nature:
  - Not only in the sense Brian G meant (Kubernetes’ domain), but also in a larger context of usage (audit, security, storage, network, AI...), vertical adoption (finance, telco, pharma,...), languages, ...
  - Usually out of scope for WG description
- Policy semantic and control mechanism is universal
  - Policy semantic: the underlying description of the policy description
  - Policy control mechanism: life cycle of policy itself, and life cycle of elements defined in policy

Motivation (Policy is needed in many places outside k8s)

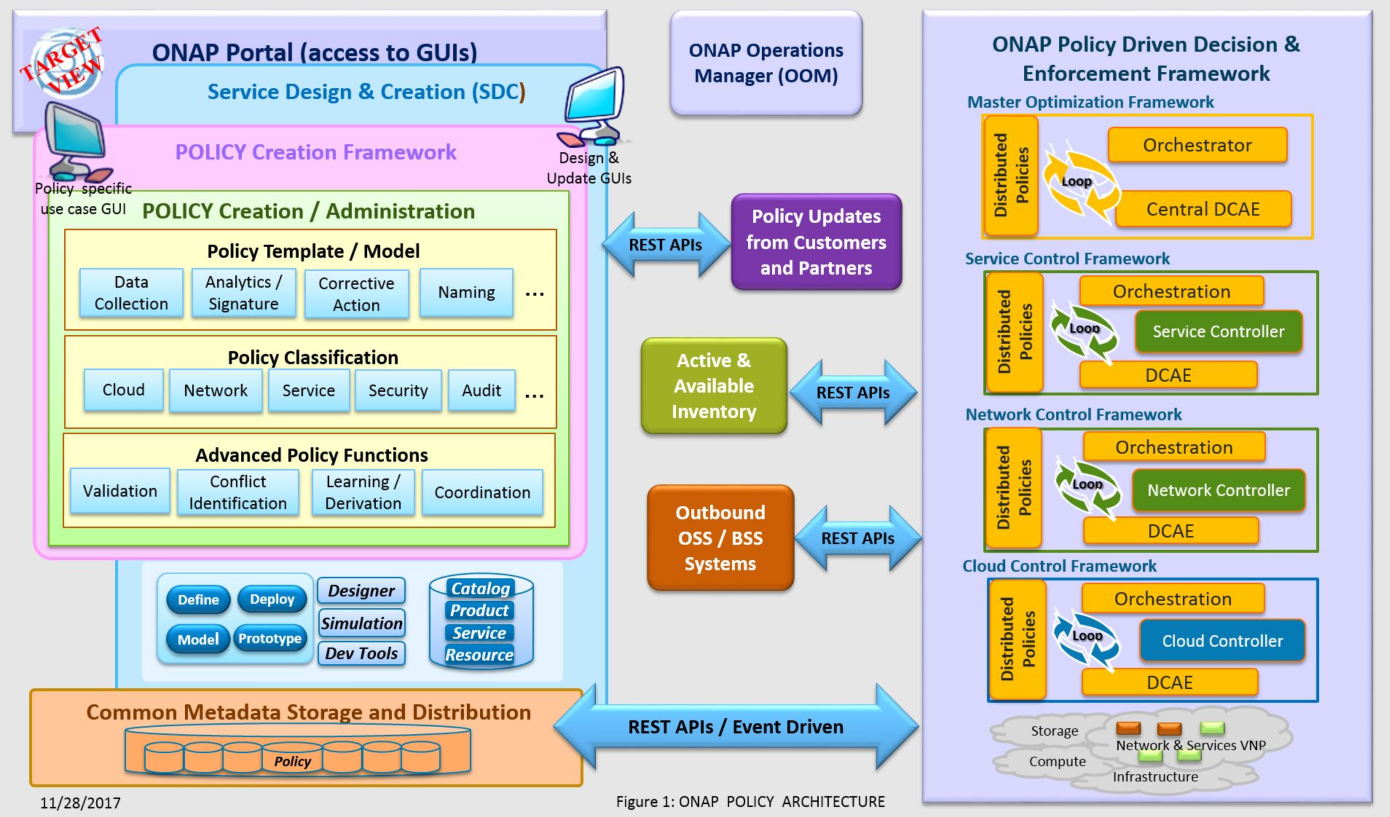

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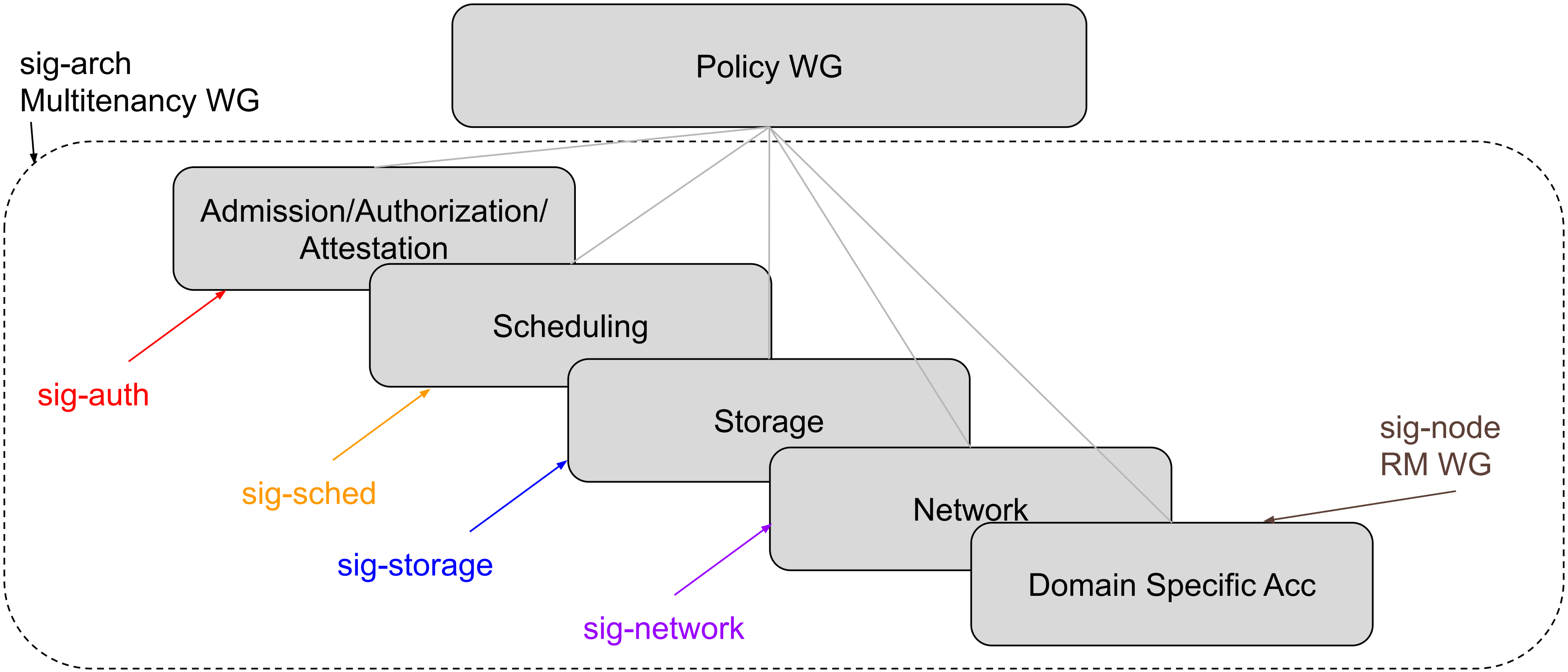
Figure 1: ONAP POLICY ARCHITECTURE

Overview (SIG Relationship)

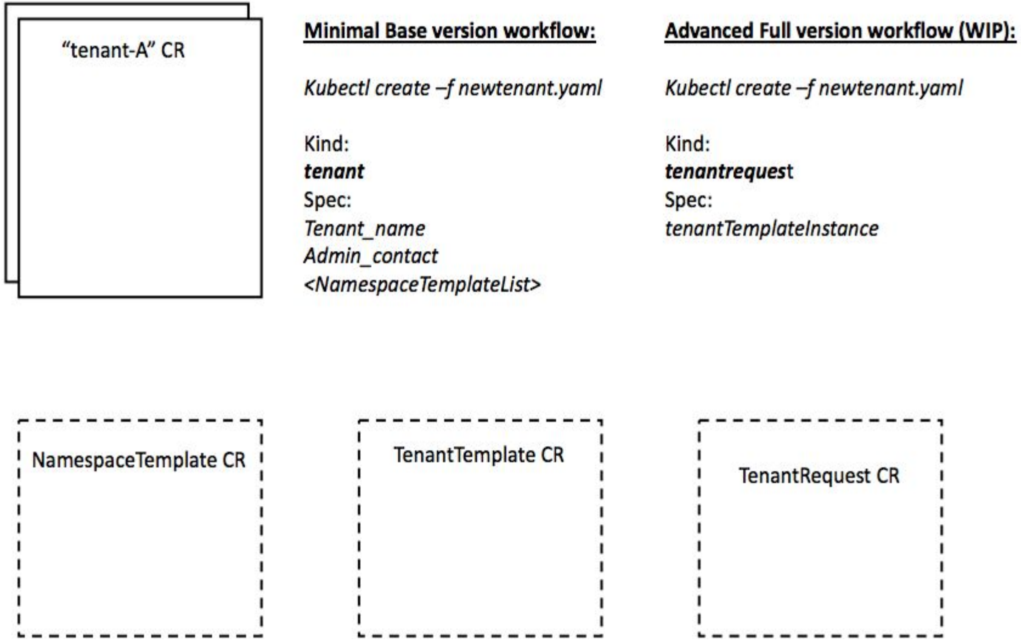


WG Work Items

Policy WG Work Items Overview

- Running list of interested items
  - Multi-tenancy: https://github.com/kubernetes-sigs/multi-tenancy
  - Gatekeeper: https://docs.google.com/document/d/1A1-Q-1OMw3QODs1wT6eqfLTagcGmgzAJAjJihiO3T48/edit#heading=h.rosd3aktkpys
  - PodSecurityPolicy Migration: https://github.com/kubernetes/enhancements/issues/5
- New Area Exploration
  - Policy as type system
  - Policy formal verification
- Case Studies

WG Running List 2019 - Multi-Tenancy Policy



“tenant-A” CR

Minimal Base version workflow:

Kubectl create –f newtenant.yaml

Kind:
tenant
Spec:
Tenant_name
Admin_contact
<NamespaceTemplateList>

Advanced Full version workflow (WIP):

Kubectl create –f newtenant.yaml

Kind:
***tenantreques*t**
Spec:
tenantTemplateInstance

NamespaceTemplate CR

TenantTemplate CR

TenantRequest CR

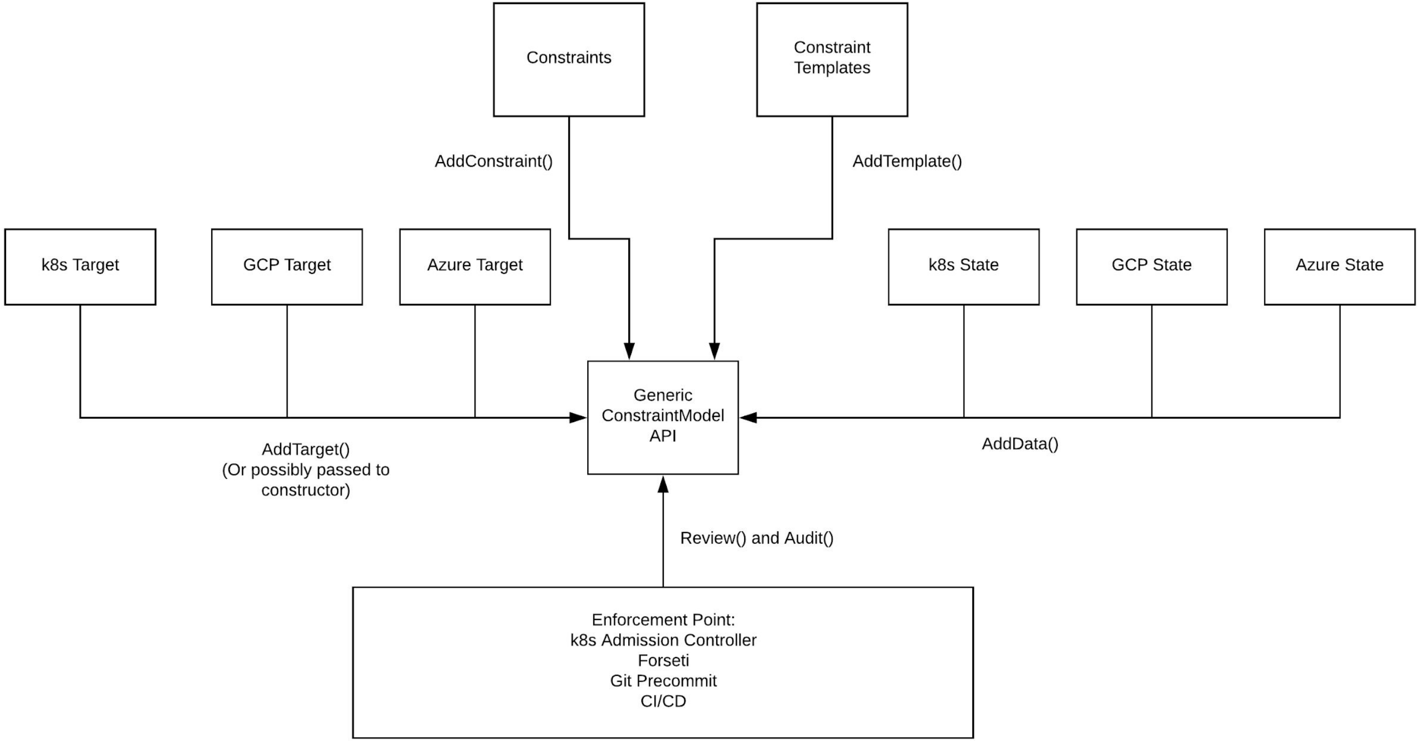
WG Running List 2019 - Multi-Tenancy Policy

- Self-service Namespace Creation
  - “kubectl create ns” by tenant admins without going over an indirect way through Tenant CRD and Tenant CRD controller.
- Cluster-scoped Resources
  - the tenant admins may have permissions to create cluster scoped resources like PodSecurityPolicy
- In a nutshell, help solving the CR population problem in the context of multi-tenancy

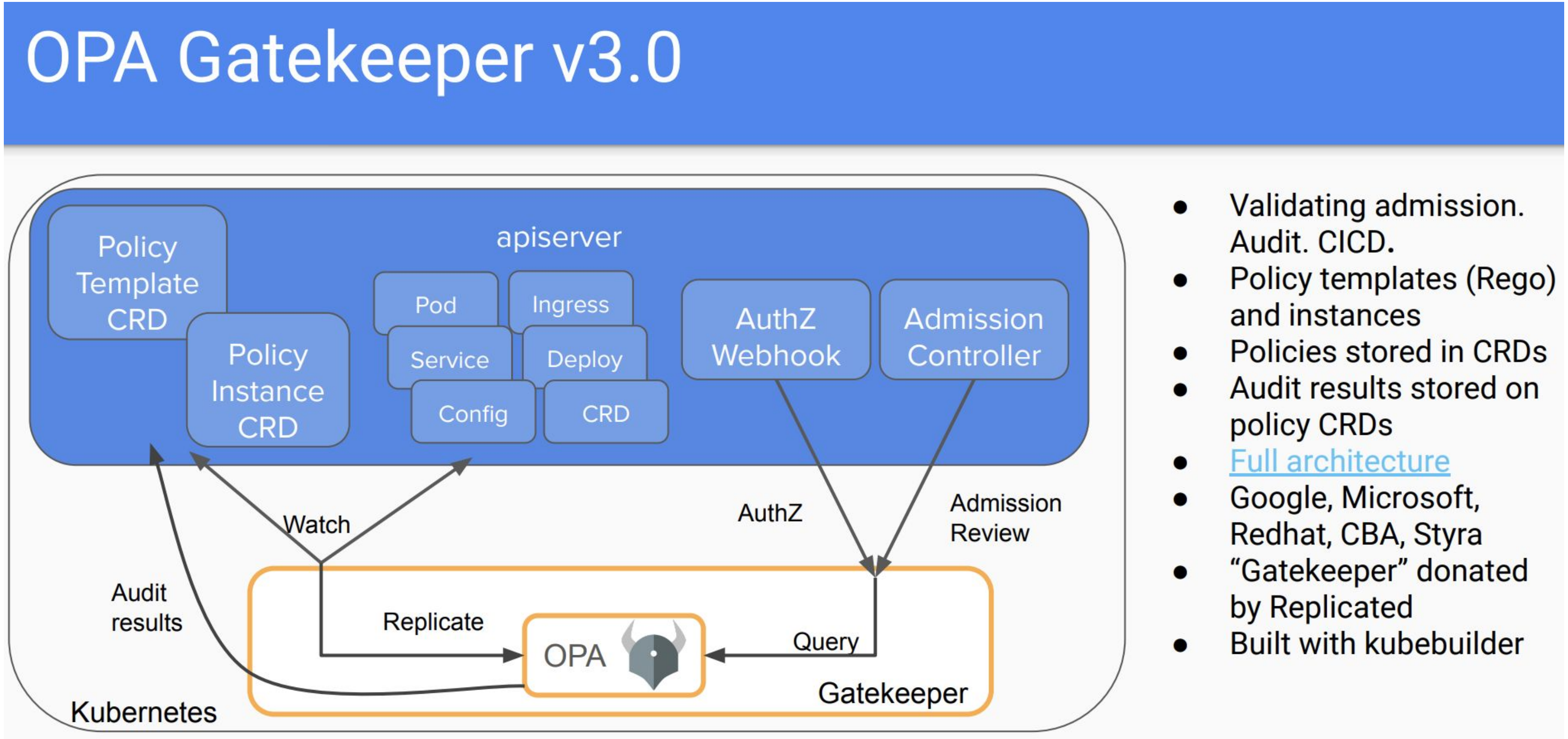
WG Running List 2019 - Multi-Tenancy Policy

- **Proposal** : Policy Engine -> Policy Compiler -> Tenant Policy object -> Resource Population (ns, podsec, network, rbac, ...)
- **Example** : OPA -> Gatekeeper (Tenant Policy Object -> Resource Population) -> General Kubernetes Cluster
- **Problem**: how to define the constraint for a population (when do we hit a wall and stop)

WG Running List 2019 - OPA Gatekeeper Project



WG Running List 2019 - OPA Gatekeeper Project



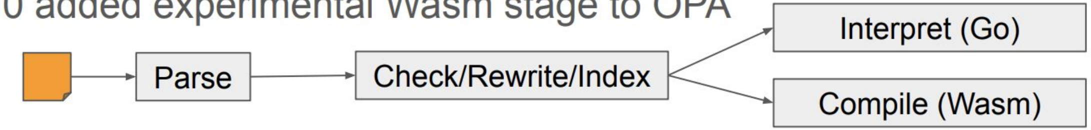
OPA Gatekeeper v3.0

- Validating admission. Audit. CICD.
- Policy templates (Rego) and instances
- Policies stored in CRDs
- Audit results stored on policy CRDs
- Full architecture
- Google, Microsoft, Redhat, CBA, Styra
- “Gatekeeper” donated by Replicated
- Built with kubebuilder

WG Running List 2019 - OPA Gatekeeper Project

v0.11: Native Integrations: WebAssembly progress

- WebAssembly (Wasm) is an instruction format for virtual machines
  - Provides a safe/efficient/portable runtime for policy evaluation
  - Goal: enable library embeddings of OPA policies in any language/runtime
- v0.10 added experimental Wasm stage to OPA



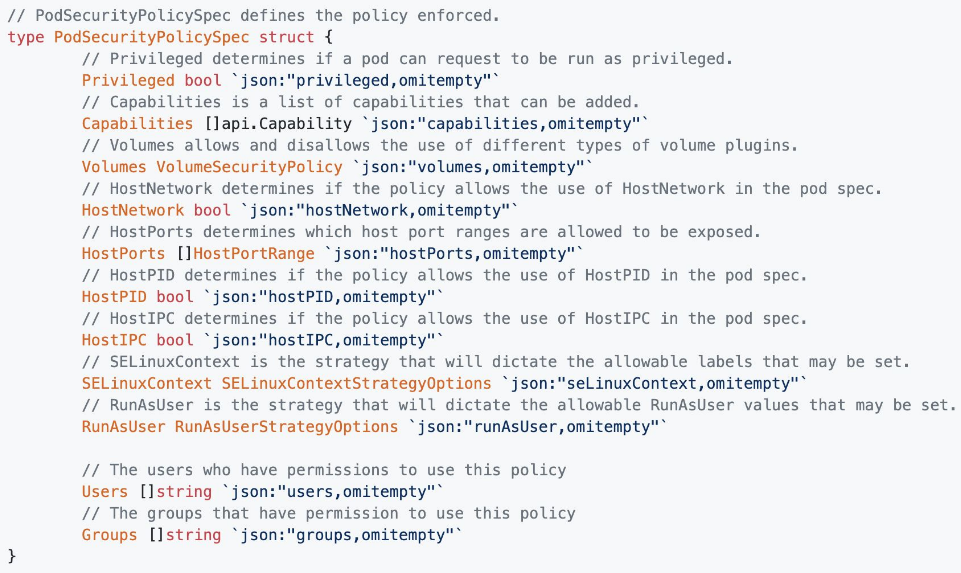
- v0.11 expands the fragment of Rego supported by the Wasm stage
  - All types of rules (ordered/unordered, default, partial sets/objects) now supported
- Example: open-policy-agent/contrib/wasm (CDN example)

openpolicyagent.org

WG Running List 2019 - OPA Gatekeeper Project

PodSecurityPolicy Migration

- Explore the possibility of using Gatekeeper for PSP



```
// PodSecurityPolicySpec defines the policy enforced.
type PodSecurityPolicySpec struct {
	// Privileged determines if a pod can request to be run as privileged.
	Privileged bool `json:"privileged,omitempty"`
	// Capabilities is a list of capabilities that can be added.
	Capabilities []api.Capability `json:"capabilities,omitempty"`
	// Volumes allows and disallows the use of different types of volume plugins.
	Volumes VolumeSecurityPolicy `json:"volumes,omitempty"`
	// HostNetwork determines if the policy allows the use of HostNetwork in the pod spec.
	HostNetwork bool `json:"hostNetwork,omitempty"`
	// HostPorts determines which host port ranges are allowed to be exposed.
	HostPorts []HostPortRange `json:"hostPorts,omitempty"`
	// HostPID determines if the policy allows the use of HostPID in the pod spec.
	HostPID bool `json:"hostPID,omitempty"`
	// HostIPC determines if the policy allows the use of HostIPC in the pod spec.
	HostIPC bool `json:"hostIPC,omitempty"`
	// SELinuxContext is the strategy that will dictate the allowable labels that may be set.
	SELinuxContext SELinuxContextStrategyOptions `json:"seLinuxContext,omitempty"`
	// RunAsUser is the strategy that will dictate the allowable RunAsUser values that may be set.
	RunAsUser RunAsUserStrategyOptions `json:"runAsUser,omitempty"`

	// The users who have permissions to use this policy
	Users []string `json:"users,omitempty"`
	// The groups that have permission to use this policy
	Groups []string `json:"groups,omitempty"`
}
```

WG New Area Exploration - policy formal verification

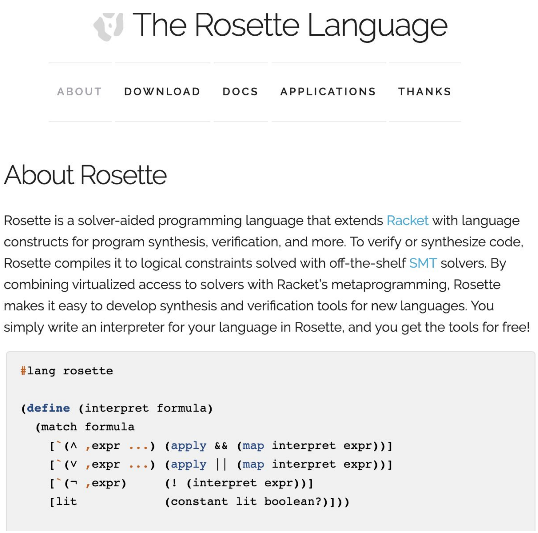
- Background Knowledge
  - SMT can be thought of as a form of the constraint satisfaction problem and thus a certain formalized approach to constraint programming
  - an SMT instance is a formula in first-order logic, where some function and predicate symbols have additional interpretations, and SMT is the problem of determining whether such a formula is satisfiable
  - A predicate is a binary-valued function of non-binary variables. Example predicates include linear inequalities (e.g. $3x + 2y - z \geq 4$) or equalities involving uninterpreted terms and function symbols (e.g: $f(f(u,v),v) = f(u,v)$

WG New Area Exploration - policy formal verification

$$(\sin(x)^3 = \cos(\log(y) \cdot x) \vee b \vee -x^2 \geq 2.3y) \wedge (\neg b \vee y < -34.4 \vee \exp(x) > \frac{y}{x})$$

where

$$b \in \mathbb{B}, x, y \in \mathbb{R}$$

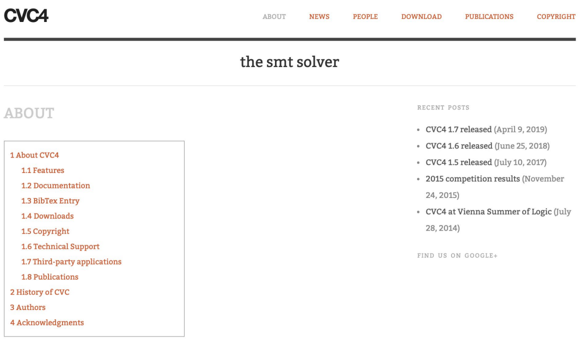


About Rosette

Rosette is a solver-aided programming language that extends Racket with language constructs for program synthesis, verification, and more. To verify or synthesize code, Rosette compiles it to logical constraints solved with off-the-shelf SMT solvers. By combining virtualized access to solvers with Racket's metaprogramming, Rosette makes it easy to develop synthesis and verification tools for new languages. You simply write an interpreter for your language in Rosette, and you get the tools for free!

```
#lang rosette

(define (interpret formula)
  (match formula
    [`(∧ ,expr ...) (apply && (map interpret expr))]
    [`(∨ ,expr ...) (apply || (map interpret expr))]
    [`(¬ ,expr)     (! (interpret expr))]
    [lit            (constant lit boolean?)]))
```



the smt solver

ABOUT

- 1 About CVC4
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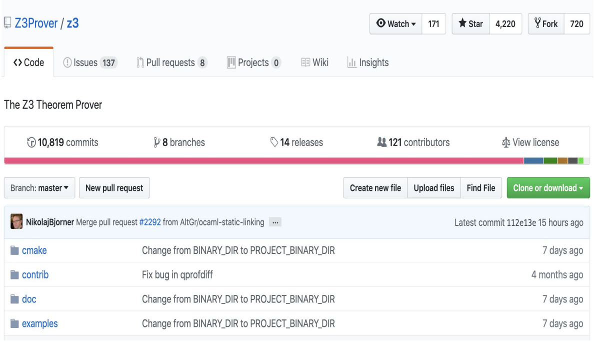
  - 1.4 Downloads
  - 1.5 Copyright
  - 1.6 Technical Support
  - 1.7 Third-party applications
  - 1.8 Publications
- 2 History of CVC
- 3 Authors
- 4 Acknowledgments

RECENT POSTS

- CVC4 1.7 released (April 9, 2019)
- CVC4 1.6 released (June 25, 2018)
- CVC4 1.5 released (July 10, 2017)
- 2015 competition results (November 24, 2015)
- CVC4 at Vienna Summer of Logic (July 28, 2014)

FIND US ON GOOGLE+



The Z3 Theorem Prover

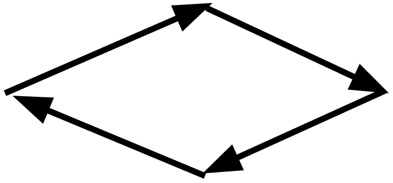
10,819 commits · 8 branches · 14 releases · 121 contributors · View license

NikolajBjorner Merge pull request #2292 from AltGr/ocaml-static-linking ... Latest commit 112e13e 15 hours ago

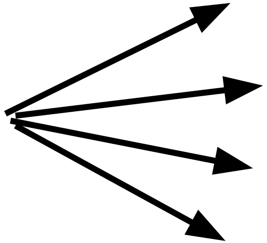
cmake	Change from BINARY_DIR to PROJECT_BINARY_DIR	7 days ago
contrib	Fix bug in qprofdiff	4 months ago
doc	Change from BINARY_DIR to PROJECT_BINARY_DIR	7 days ago
examples	Change from BINARY_DIR to PROJECT_BINARY_DIR	7 days ago

WG New Area Exploration - policy formal verification

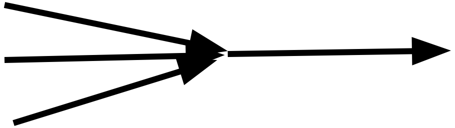
Construct a policy symbolic graph for each kubernetes domain



networking



Multi-tenancy



Security

WG New Area Exploration - policy formal verification

- Starting with use case for “Privilege Escalation”, requirements from operator LCM, multitenancy, Istio,...
- Collaboration involving AWS, Styra, and many others in the community
- Keep an eye on the slack channel or ping us via email (**zhipengh512@gmail, evb@redhat.com**) if you are also interested

WG New Area Exploration - policy as type system

Together, these concepts

1. Identity
2. Outcome Set
3. State
4. Rules

enable us to define a policy in a way that is consistent and automatable.

WG New Area Exploration - policy as type system

Proposed long term vision:

1- Strong type system for Kubernetes resources

- Better specifications and validation with a formal type system
- Algebraic types:
  - Allows you to define more complex resource types (e.g. “pod”+”configmap”, union types)
  - Compositional transformations and admission chains

WG New Area Exploration - policy as type system

Proposed long term vision:

2- Policy Hooks at key points

- Lifecycle: Admission, deletion
- Network traffic in and pod of pods
- Pod start up and down
- API calls - webhook not quite enough

WG New Area Exploration - policy as type system

Proposed long term vision:

3- Capabilities

- Pod “leases”
- Delegation, access control

WG New Area Exploration - policy as type system

Proposed long term vision:

4- Kubernetes as the “now”

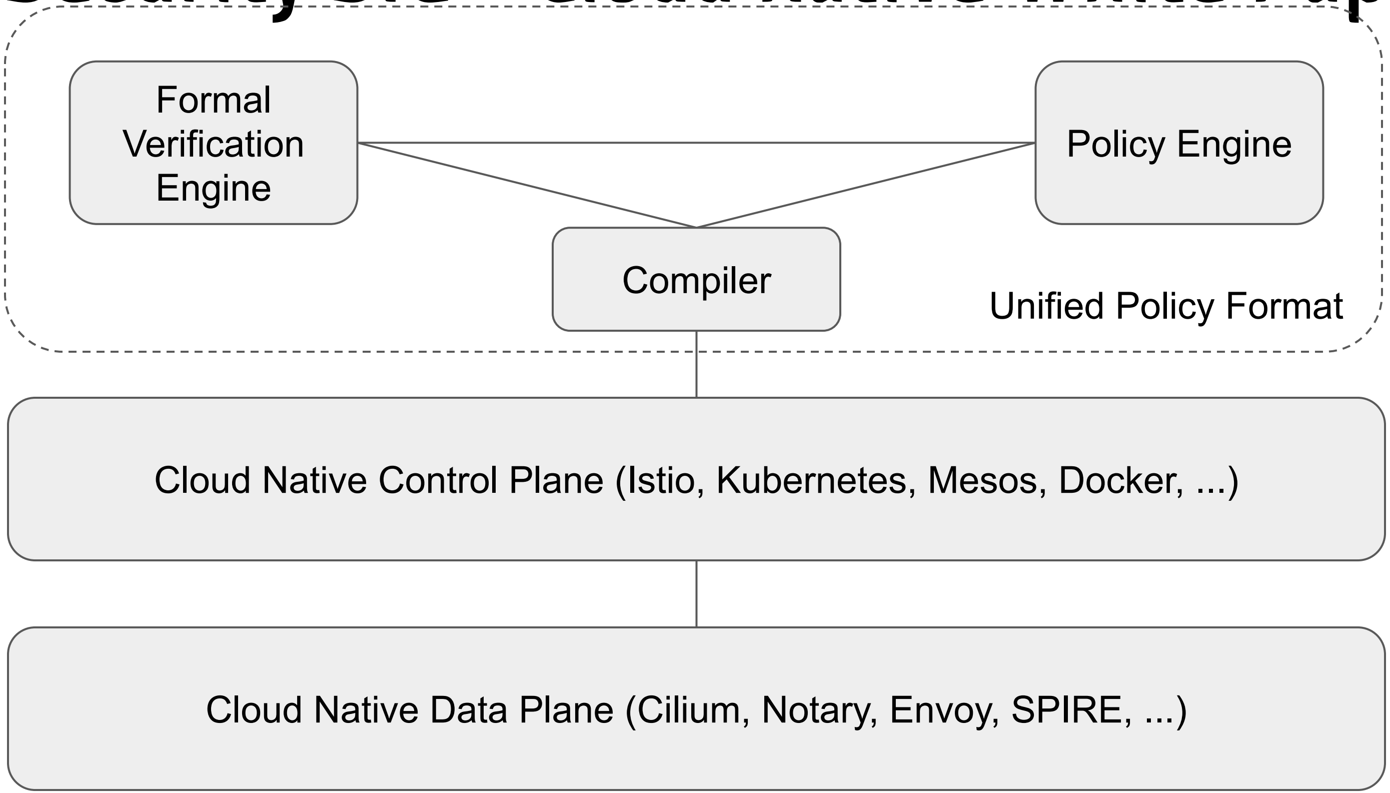
- Flattened view with explicit consistency bands
- Pipeline of transformations to facilitate managing clusters
- Favor “compiled” over runtime interpretation

WG New Area Exploration - policy as type system

- **Everything in namespaces**
  - Doesn’t have to be the same “namespace”
    - e.g. “organization” concept over users
    - Needs to be - every resource is in one and only one namespace (or zone or class or whatever)
- **Immutable labels or annotations**
  - Keep context, allow chains of validations
- **Improved ownership**
  - Cross-namespace
  - “Object pairs” or other way to easily tie lifecycles together

CNCF Wide Collaboration

CNCF Security SIG - Cloud Native White Paper


Formal Verification Engine
Policy Engine
Compiler
Unified Policy Format
Cloud Native Control Plane (Istio, Kubernetes, Mesos, Docker, ...)
Cloud Native Data Plane (Cilium, Notary, Envoy, SPIRE, ...)

Semantic + Control = Architecture

Contact and Contribute

WG Facts

- Feel free to join the weekly meeting or leave a note on the meeting minute doc (https://goo.gl/auTfy2) if you have more interesting topics or projects could be used for **case studies** !
- Find us at **#wg-policy on slack**, propose any new interesting idea like we talked here for futuristic open source study !
- Add **label wg-policy for your KEPs** if it is policy related !

Thank you !

Q & A