

O'REILLY®

Programming Kubernetes

Developing Cloud Native Applications



Michael Hausenblas &
Stefan Schimanski

Table of Contents

Preface.....	vii
1. Introduction.....	1
What does Programming Kubernetes Mean?	1
A Motivational Example	3
Extension Patterns	4
2. Kubernetes API basics.....	7
The API Server	7
The HTTP Interface of the API Server	8
How The API Server Processes Requests	9
API Server Terminology	11
The Kubernetes API	13
Declarative State Management	13
Using the API from the Command Line	14
3. Basics of client-go.....	19
The Repositories	19
The Client Library	19
Kubernetes API Types	21
API Machinery	21
Creating and Using a Client	22
Versioning and Compatibility	24
API Versions and Compatibility Guarantees	26
Kubernetes Objects in Go	27
TypeMeta	29
ObjectMeta	31
Spec and Status	32

Client sets	32
Status Subresources	34
Listings And Deletions	34
Watches	35
Events	35
Deployment Expansion	36
Client options	36
Informers and Caching	38
API Machinery in Depth	41
Kinds	41
Resources	41
REST Mapping	42
Scheme	43
Vendoring	43
Glide	44
Dep	44
Go Modules	45
4. Using Custom Resources.....	47
Discovery Information	49
Type definitions	50
Advanced Features of Custom Resources	52
Validating Custom Resources	52
Short Names And Categories	54
Printer Columns	55
Subresources	56
A Developers View on Custom Resources	60
Dynamic Client	60
Typed Clients	61
Controller-runtime Client of Operator SDK and Kubebuilder	66
5. Automating Code Generation.....	69
Why Code Generation	69
Calling the Generators	69
Controlling the generators with tags	71
Global Tags	72
Local Tags	73
deepcopy-gen tags	73
runtime.Object and DeepCopyObject	74
client-gen tags	75
informer-gen and lister-gen	76
Further Material	76

6. Controllers and Operators.....	77
The Controller Loop	77
Events	79
Edge Versus Level Driven Triggers	80
Changing The Resource State	81
Optimistic Concurrency	82
Operators	84
7. Solutions For Writing Operators.....	87
Kubebuilder	87
The Operator SDK	94
Metacontroller	99
Other Approaches	101
Uptake And Future Directions	101
8. Packaging.....	103
Packaging: The Challenge	103
Helm	104
Kustomize	106
Other Packaging Options	108
Packaging Good Practices	108
9. Custom API Servers.....	111
Use Cases For Custom API Servers	111
The Architecture: Aggregation	113
API Services	114
Inner Structure of a Custom API Server	117
Delegated Authentication and Trust	118
Delegated Authorization	119
Writing Custom API Servers	121
Options and Config Pattern and Startup Plumbing	121
The First Start	128
Internal Types and Conversion	129
Writing the API Types	133
Conversions	134
Defaulting	137
Roundtrip Testing	138
Validation	140
Registry and Strategy	141
API Installation	145
Admission	149
Deploying Custom API Servers	155

Certificates and Trust	156
Sharing Etc	156
10. Advanced Custom Resources.....	159
Custom Resources Versioning	159
Conversion	160
Admission Webhooks	160
Production-ready Deployments Of Custom Controllers	160
Getting The Permissions Right For Custom Resources	161
Performance Considerations For Custom Resources	163
Observability	163
11. Cloud Native Programming Languages.....	167
The Approach	167
Ballerina	169
Pulumi	170
Metaparticle	170
A. Resources.....	173
Index.....	177

A

- admission configuration, 153
- admission plugin, 149
- admission plugin initializer, 153
- admission webhook, 112
- admission webhooks, 160
- aggregation, 111
 - API aggregation, 113
- alpha version, 26
- API
 - invoke via command line, 14
 - proxy, 14
- API group, 24
- API Machinery, 21
- API server, 7
 - API group, 12
 - HTTP interface, 8
 - kind, 11
 - processing requests, 9
 - resource, 12
 - version, 12
- apixtensions-apiserver, 47, 117
- APIService, 155
- apps group, 24
- auditing, 118, 151

B

- Ballerina, 169
- bearer token, 119
- beta version, 26
- builder pattern, 23
- burst, 37

C

- CA bundle, 156
- category, 55
- client set, 32
- client-gen, 43, 60, 64
- client-set, 23
- clientset, 64
- CNPL (cloud native programming language), 167
- cobra command, 126
- code examples from this book, x
- cohabitation, 112
- control plane, 7
 - API server, 7
 - controller manager, 7
 - etcd, 7
 - scheduler, 7
- control vs. convenience, 168
- controller
 - changing resource state, 81
 - events, 79
 - loop, 77
 - optimistic concurrency, 82
 - triggers, 80
- controller-runtime, 60
- controllers
 - definition, 77
 - conversion, 27, 134
 - conversion function
 - conversion function naming pattern, 135
 - conversion-gen, 134
- core group
 - legacy group, 30
- CRDs, 133

- custom API server
 - aggregated API server, 111
- Custom Resource Definition
 - CRD, 48
- custom resources
 - conversion, 160
 - versioning, 159
- CustomResources
 - CRDs, 23
 - CRs, 47

D

- deep-copy, 64
- defaulter-gen, 137
- defaulting, 132
- defaulting function naming pattern, 137
- DeferredDiscoveryRESTMapper
 - RESTMapper, 42
- delegated authentication, 119
- delegated authorization, 119
- discovery endpoint, 128
- dynamic client, 60

E

- edge-driven trigger, 80
- etcd, 121
- etcd operator, 156
- etcdproxy-controller, 157
- event, 35
- external version, 131

F

- field selector, 34
- fuzzer, 138

G

- GA, 26
- generic registry, 141
- Git, viii
- Go (build system), viii
- go modules, 45
- go.mod, 46
- graceful termination, 127
- GroupVersion, 33
- GroupVersionKind
 - GVK, 28, 41
- GroupVersionResource
 - GVR, 41

- GVR
 - GroupVersionResource, 61

H

- Helm, 104
 - chart, 104
- HTTP/2, 112

I

- informers, 38
- internal clients, 33
- internal version
 - hub version, 129

J

- JSON, 13

K

- kind, 41
- kube-aggregator, 113
- kube-apiserver, 52, 113
- kubebuilder, 66
- Kubebuilder, 87
- kubeconfig, 22
- kubectrl, 23, 101
- Kubernetes
 - releases, viii
- Kubernetes API, 13
- Kustomize, 106

L

- label selector, 34
- level-driven trigger, 80

M

- man-in-the-middle, 115
- manifests
 - GitHub repository, x
- master node, 7
- meta/v1, 22
- Metacontroller, 99
- Metaparticle, 170
- mutating admission webhooks, 149

N

- NameGenerator, 144

O

- ObjectMeta, 141
- ObjectTyper, 144
- OpenAPI, 126
- OpenAPI Schema, 52
- OpenAPI), 55
- OpenShift, 112, 112
- operator
 - advanced, 159
 - alternatives, 101
 - KUDO, 101
 - kutil, 101
 - logging, 164
 - monitoring, 164
 - observability, 163
 - performance, 163
 - permissions, 161
 - production ready, 160
 - Rook Operator kit, 101
- Operator SDK, 66, 94
- operators
 - basics, 84
 - definition, 77
- optimistic concurrency, 58
- options and config pattern, 121

P

- package management, viii
- packaging, 103
 - Ansible, 108
 - challenge, 103
 - Chef, 108
 - good practices, 108
 - Helm, 104
 - Ksonnet, 108
 - Kustomize, 106
 - Puppet, 108
 - sed, 108
 - YAML, 103
- post start hook, 126
- Protobuf
 - protocol buffers, 23
- protobuf
 - protocol buffers, 30
- Protocol buffer
 - protobuf, 36
- Protocol Buffer
 - protobuf, 111
- Protocol Buffers, 13

- pseudo version, 46
- Pulumi, 170

Q

- QPS, 37

R

- RBAC, 108, 161
 - role based access control, 57, 119
- recommended options, 122
- relist period, 38
- request header, 118
- request header client CA, 118
- resource, 41
- REST, 141
- rest config, 23
- REST mapping, 42
- RESTMapper, 33, 42
- roundtrippable, 133
- runtime.Object, 43

S

- scale subresource, 58, 76
- scheme, 31, 43
- semantic versioning
 - semver, 20, 25
- server-side printing, 55
- shared informer factory, 39
- short name, 54
- spec-status split, 57
- status subresource, 34, 57
 - subresource, 75
- storage version, 27, 130
- strategy, 143
- subject access review
 - SubjectAccessReview
 - SAR, 119
- SubjectAccessReview, 118, 141
- subresource, 56
- subresources, 37

T

- throttling
 - rate limiting, 36
- timeout, 36
- TokenAccessReview, 119
- TokenReview, 118
- typed client, 60

TypeMeta, [29](#), [62](#), [62](#)

U

unstructured.Unstructured, [60](#)

UserAgent, [36](#)

V

validating admission webhooks, [149](#)

W

watch, [35](#)

webhook admission plugins

admission webhook, [149](#)

websocket, [112](#)

About the Authors

Michael Hausenblas is a developer advocate for containers at AWS. His background is in large-scale data processing and container orchestration and he is experienced in advocacy and standardization at W3C and IETF. Before Amazon, Michael worked at Red Hat, Mesosphere, MapR, and two research institutions in Ireland and Austria. He contributes to open source software mainly using Go, blogs, writes books, and hangs out on Twitter too much.

Stefan Schimanski is a principal software engineer for Go, Kubernetes, and OpenShift at Red Hat. His focus is the Kubernetes API server, especially the implementation of CustomResourceDefinitions, API Machinery in general and the publishing of the Kubernetes staging repositories client-go, apimachinery, api, etc. Before Red Hat, Stefan worked at Mesosphere on Marathon, Spark and their Kubernetes offering and before as freelancer and consultant in high availability and distributed systems. In a former life Stefan did research in Mathematical Logic about constructive mathematics, type systems and lambda calculus.