Deploying a scalable web application with Docker and Kubernetes

Learn how to test and deploy a Node.js app using containers and an orchestration engine

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As cloud applications grow in complexity, sometimes teams reorganize into a distributed microservice architecture and software delivery cycles get faster. Throughout all of this, DevOps engineers keep looking for ways to streamline and automate the continuous deployment of code.

Some teams use containers, like Docker, to simplify and automate the deployment process for their applications. This is an effective way of packaging software in a way that is predictable and consistent. You can expect the software to behave similarly whether you're on a laptop or in the cloud.

Once you get to a point where you're running multiple containers across multiple machines, spinning up more instances of your components doesn't scale linearly and dealing with this growing complexity gets a little hairy. Many teams will address this complexity by also using an orchestration engine, like Kubernetes. Teams are using Kubernetes as a higher-level abstraction to manage Docker container technology and further simplify the pipeline to enable their teams to go faster.

> We're already seeing tremendous benefits with Kubernetes — improved engineering productivity, faster delivery of applications and a simplified infrastructure.
>
> Teams who were previously limited to 1–2 releases per academic year can now ship code multiple times per day!
>
> Chris Jackson, Director for Cloud Platforms & SRE at Pearson

You don't need to have Google- or Facebook-level traffic to care about making your web applications scalable. You might have a varying number of users, need to accurately predict your infrastructure costs, or just want to manage your systems more efficiently.

To better understand software containers, let's first talk about physical shipping containers.

Why use containers?

Before someone invented physical shipping containers, dock workers needed specialized skills to handle different types of precious cargo. Physical containers allow us to standardize how our cargo is shipped.

There's many reasons to use a container to ship something like bundles of firewood, for example.

- **Portability** — your container can be loaded onto any ship, transported by any shipping provider, or even transferred to a truck to travel over the road

Photo by Erwan Hesry on Unsplash

- **Modularity** — containers are all the same size and dimension, so the same crane that is used at any port to handle your container of firewood can also be used to load and unload a container of loose chickens 🐔
- **Security** — your container is isolated from other containers, so that someone shipping fish tanks won't slosh fish water 🐡 onto your bundle of firewood
- **Scalability** — your firewood will only take up the space needed, so you can either occupy a small corner of one container or ramp up to reserve a bunch more containers across a fleet of ships

Similar to physical shipping containers, software containers are useful for standardization. In this case, software containers standardize IT infrastructure. Containers are a tidy way to package code with their dependencies into building blocks that can be deployed consistently and efficiently.

- **Portability** — a container is decoupled from the host operating system, so that it can run on anything from a laptop to your cloud of choice

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- **Modularity** — containers give you the flexibility to create easily interchangeable application stack components, so you have a separation of concerns between components like your web server and your database
- **Security** — containers are immutable so updates are made by replacing the container in its entirety, making it easy to issue security patches or rollback an update quickly
- **Scalability** — containerized applications can scale up to handle additional load or ramp down to conserve resources during a lull

How do containers work?

Let’s revisit our physical shipping containers analogy and imagine a busy seaport where ships are coming and going all day long. There’s a ***container manifest*** that lists the contents and the loading sequence of everything getting stuffed into the ***container***. The container gets stuffed according to this manifest and then loaded onto a ship. The dock workers will ***orchestrate*** the logistics, keeping a schedule of when the containers get loaded and unloaded, managing the arrival and departure of the ships, and coordinating with the freight carriers. At a busy port like this, we’d have some pretty hefty tools to coordinate and govern all of these details.

Now, back to the world of software containers.

Docker is one of the most popular, open-source container technologies that allows you to build, run, test, and deploy distributed applications. There’s a lot of terminology, so let’s contain our excitement, and just tackle some of the basics.

Container image

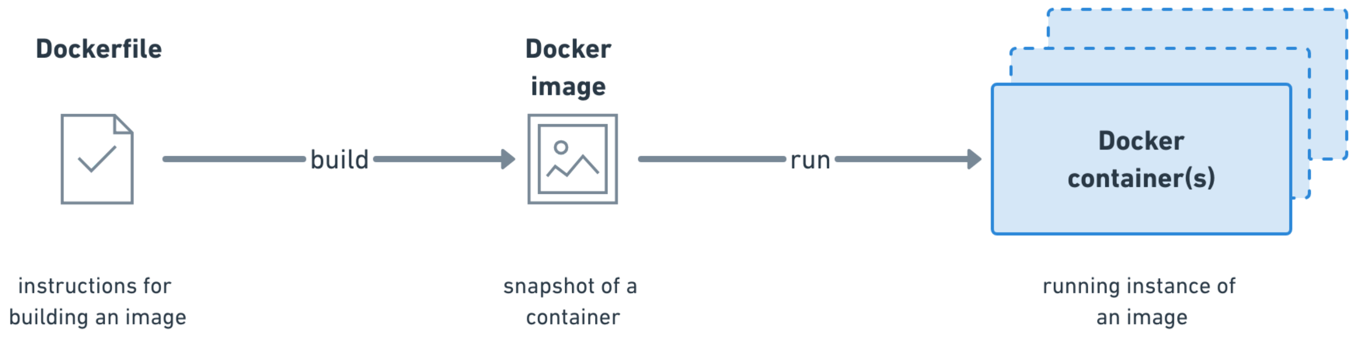
This image will inform how a container is instantiated, determining which software components will run and how. You can also create an image from a container, and share these specifications with someone else, so that an app runs the same way on a developer’s laptop as it would in production.

Container

This describes a virtual environment that bundles the application code with all the binaries and libraries that are required to run an application. Since the container includes all of its dependencies, you don’t have to install anything on the host operating system, keeping it separate and pristine.

Container orchestration

This refers to coordinating behaviors for containers and between containers, such as scheduling, resource management, and load balancing. In complex or dynamic ecosystems, teams will use an orchestration engine to control, manage, and automate this activity.



contain your excitement

After the Postman engineering team reorganized into a microservice architecture, every service now uses Docker to configure their own environments. Every service owner defines their own Dockerfile from which an image is generated when new code is deployed as part of the CI/CD pipeline. The resulting image is pushed to the team's container registry, and their Beanstalk environments are configured to pull the image from the registry to run the containers.

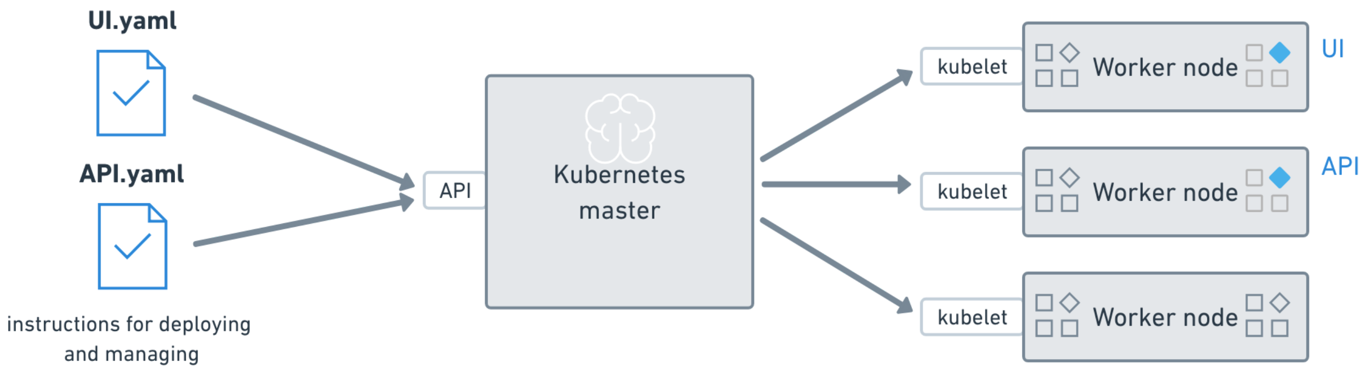
> Every service gets the flexibility of configuring how to run their services. So services engineers can focus on building the application while platform engineers can focus on how to build and deploy automatically.
>
> Docker takes over the responsibility of configuring the environment and standardising the deployment pipeline. This gives us faster deployment and scaling time because the build happens only once during CI.
>
> — Saswat Das, Platform engineer at Postman

Why use Kubernetes?

With a microservice architecture, a number of services can go into making a single application, and each of these services can live in its own container. Even a simple web application might not live in a single container. You might have one container for the web frontend, one for the backend APIs, and maybe another for data storage. If you start seeing some traffic, you can spin up more instances of your app's components.

However, simply spinning up more instances doesn't scale linearly. Containers allow you to scale, but managing these operations at scale can be complicated. When you're operating at scale, you will be coordinating behavior for containers and between containers.

That's when an orchestration engine like Kubernetes comes into play. Kubernetes is an open-source, orchestration system for automating deployment, scaling, and management of containerized applications. As a higher-level abstraction to deal with container management, there's a somewhat steep learning curve to get set up, but then it makes day-to-day life easier.



The Kubernetes master is responsible for maintaining the desired state for your cluster

Kubernetes simplifies the deployment process for your application, and provides tools to make your application super robust.

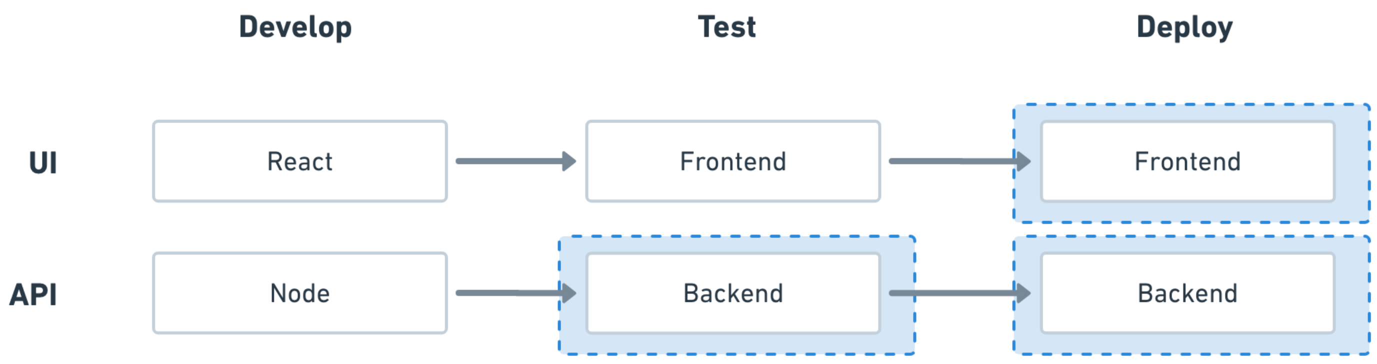
With Kubernetes, you get rolling deployments with no downtime, service discovery, and the flexibility to change cloud providers easily.

— Dan Pastusek, Founder of Kubesail

A Postman recipe for deploying a Node application with Docker and Kubernetes

Let's try it out! We'll start with a simple Node app that functions like a URL shortener. In our case, we'll transform one URL into a different one using cat verbs, cat adjectives, and cat emojis 🐱 — and when you input your custom URL into a browser, you'll be redirected back to the original website.

The beauty of using containers is that even if I'm developing this app on a machine with my Operating System and a different version of Node, you can rely on my container image to prescribe the exact specifications you'll need to run the same application seamlessly on your machine, or in the cloud, or wherever you choose to deploy.



Use containers to test and deploy the app

If you want to follow along, go ahead and clone this example, and follow the README steps to spin up a local version of these APIs.

1. Develop
2. Test
3. Deploy

Develop the app

Let's start with a Node app using React for the frontend and Express for the backend. To simplify this demonstration, we won't be implementing persistent data storage.

The backend boils down to 2 APIs.

1. Transform the original URL

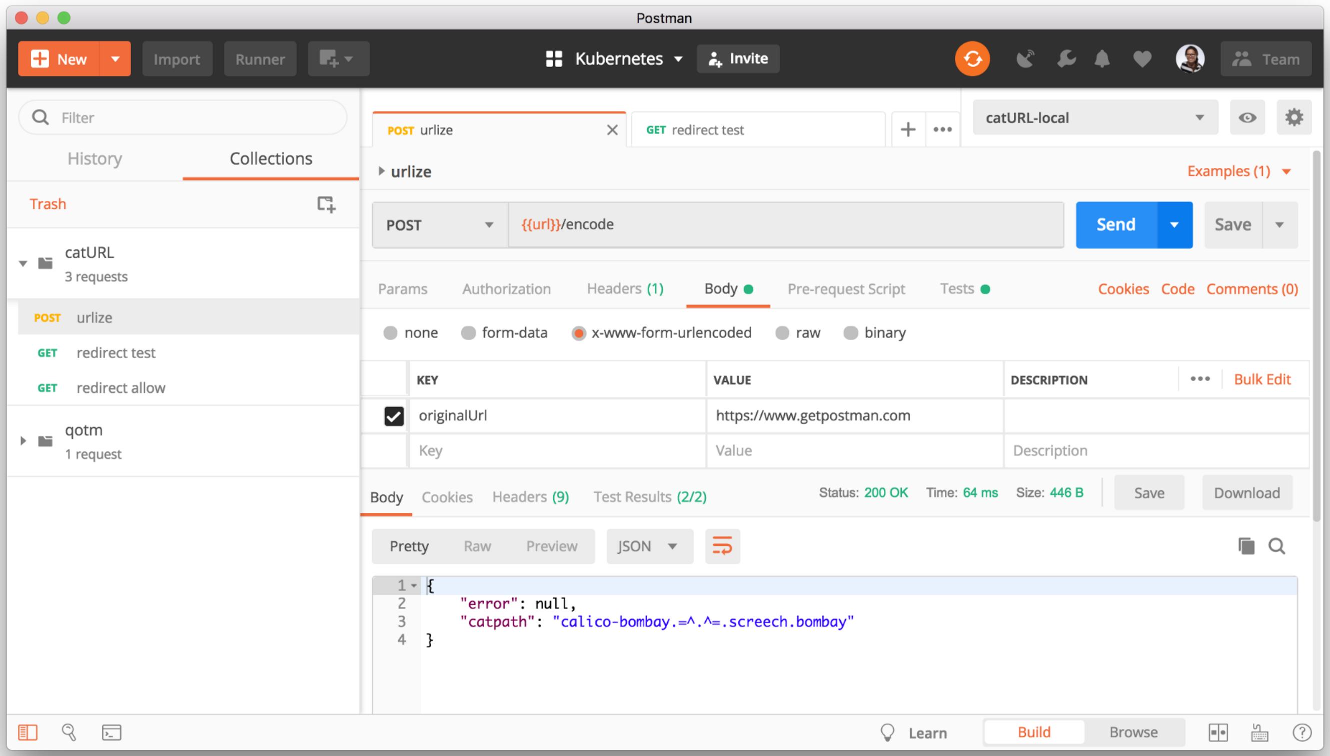
2. Redirect the new URL back to the original URL

Even before you begin developing the frontend, you can use Postman as a client to send requests to our local server. It'll save us time every time we update our payload and inspect the server response.

This is the quintessential use case most people know about when they think of Postman. You probably knew this already. Don't worry. We'll learn a few more ways to increase our efficiency with Postman.

> 💡**POSTMAN TIP**: use a Postman environment to save **configuration parameters** so you can switch quickly between server setups. For example, I used an environment variable called `url` in my collection and created separate templates for local development and production. Now, selecting the desired Postman environment allows me to toggle between `http://localhost:5500` to `https://cat-kube-stateless-prod-2ea747e90b.kubesail.io`, and other configuration options, more quickly.

Start these endpoints on your local server, and then let's move over to the Postman app. Find the Postman template called **catURL** in the Postman app, and then import the example collection and environment.



POST urlize

POST {{url}}/encode

KEY	VALUE	DESCRIPTION
✓ originalUrl	https://www.getpostman.com	
Key	Value	Description

Status: 200 OK Time: 64 ms Size: 446 B

```
{
    "error": null,
    "catpath": "calico-bombay.=^.^=.screech.bombay"
}
```

Import the **catURL** collection and **catURL-local** environment from the Postman templates

We'll use the **catURL** collection along with the **catURL-local** environment to debug and test our 2 APIs. Read through the collection documentation, and try it out for yourself.

Test the app

In this recipe, we won't cover the basics of how to write tests in Postman, or how to run these tests in Postman. However, you can see a few tests already written under the Tests tab of the **catURL** collection. Feel free to add your own tests to validate the behavior of our APIs.

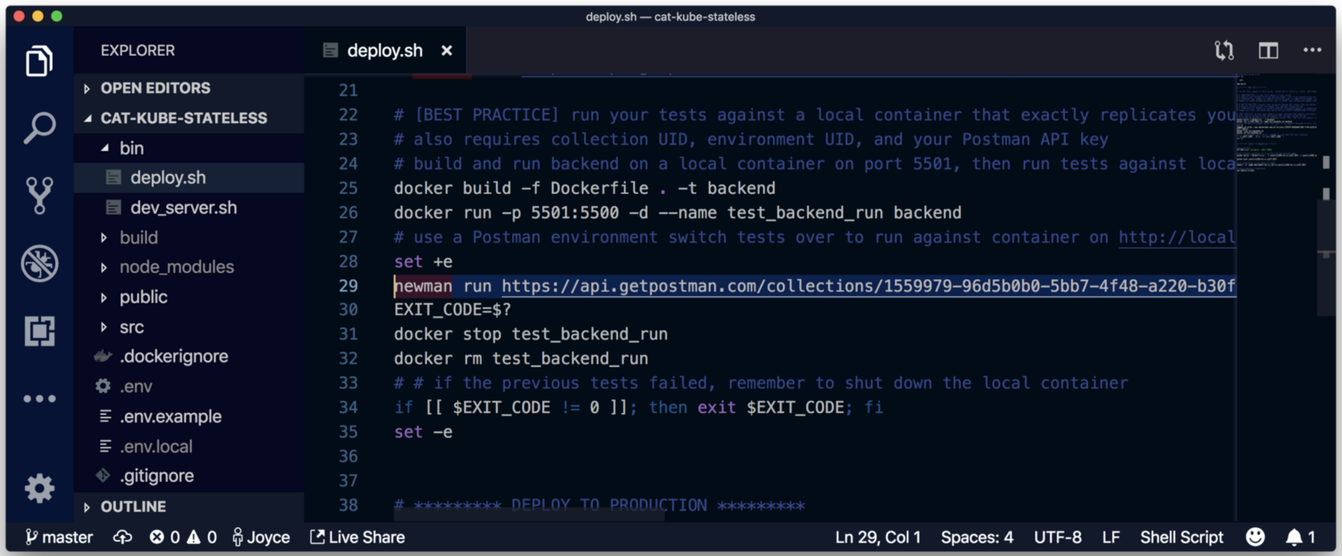
Make sure to update your general Postman settings to disallow redirects so that we can inspect our server's response headers before the redirection. More on how to do that here.

Now that we've manually tested our APIs in Postman, or used the collection runner as our first step towards automation, let's use Postman's open source library Newman to run our collection at build time. We have 3 options:

- **Good practice**: test against your APIs running on a local server using static Postman collection and environment JSON files located within the project directory

- **Better practice**: still testing against your local server, run these tests using the Postman API to dynamically pull the latest versions of your collection and environment
- **Even better practice**: still using the Postman API, test against your APIs running on a container hosted by your local server so that your test environment exactly replicates your production environment

Let's try out the last scenario — the even better practice. Add a deployment script that builds and starts our APIs in a local container. If any Postman tests fail, Newman will return an error code to immediately terminate the remainder of the script before any deployment steps are executed.



```
# [BEST PRACTICE] run your tests against a local container that exactly replicates you
# also requires collection UID, environment UID, and your Postman API key
# build and run backend on a local container on port 5501, then run tests against loca
docker build -f Dockerfile . -t backend
docker run -p 5501:5500 -d --name test_backend_run backend
# use a Postman environment switch tests over to run against container on http://local
set +e
newman run https://api.getpostman.com/collections/1559979-96d5b0b0-5bb7-4f48-a220-b30f
EXIT_CODE=$?
docker stop test_backend_run
docker rm test_backend_run
# # if the previous tests failed, remember to shut down the local container
if [[ $EXIT_CODE != 0 ]]; then exit $EXIT_CODE; fi
set -e


# ********* DEPLOY TO PRODUCTION *********
```

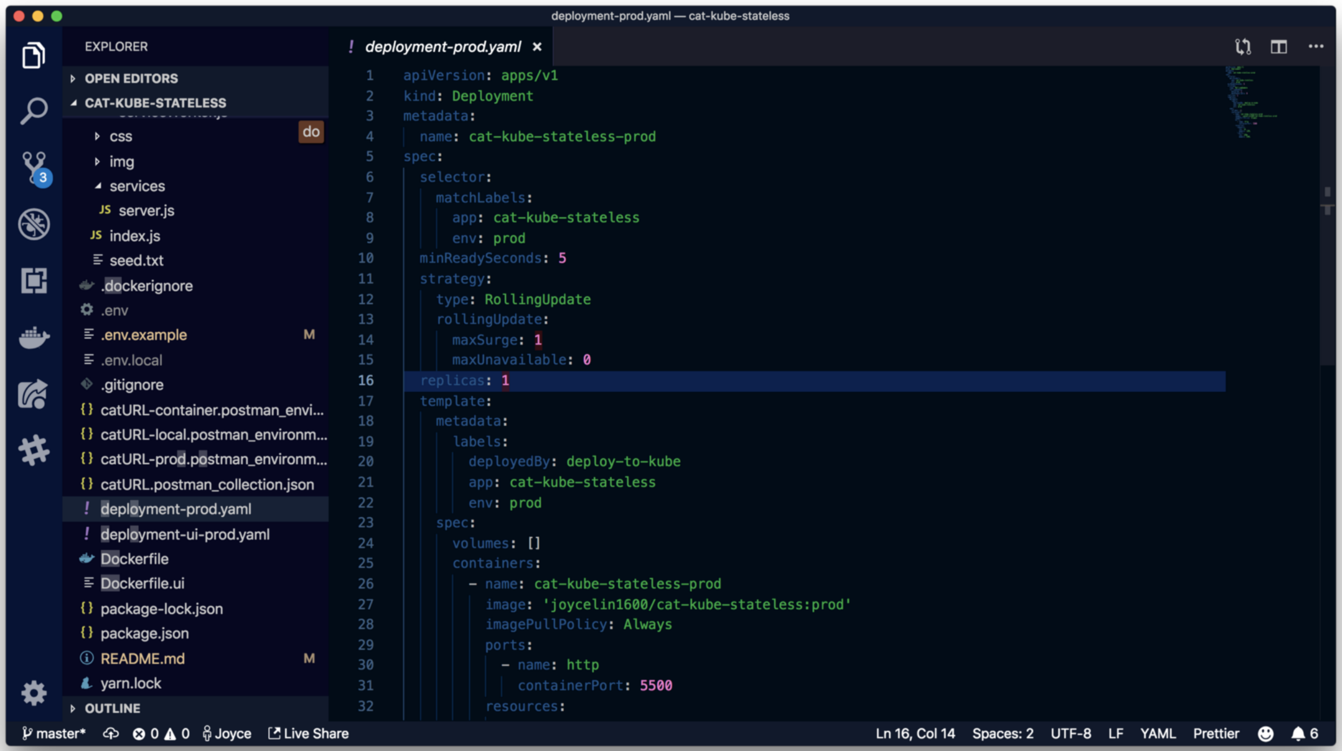
If the tests don't pass, your code doesn't deploy.

> 💡**POSTMAN TIP**: use the Postman API to pull the latest version of your collection or environment. Using a static JSON file doesn't ensure you're running the latest version of your tests.
>
> Then, run the collection and environment using Newman as part of your Continuous Deployment / Continuous Integration (CI/CD) pipeline. The process is the same if you're using Jenkins, Travis CI, or any similar build system. You will add a build time script telling Newman to run your Postman tests. If the tests don't pass, your code doesn't deploy.

Deploy the app

In this example, we will be using Kubernetes to deploy our frontend and backend to separate containers. Consequently, we'll be describing our deployment steps in separate YAML files. These files will include your container image, resource allocation, the desired number of replicas, and other important information.

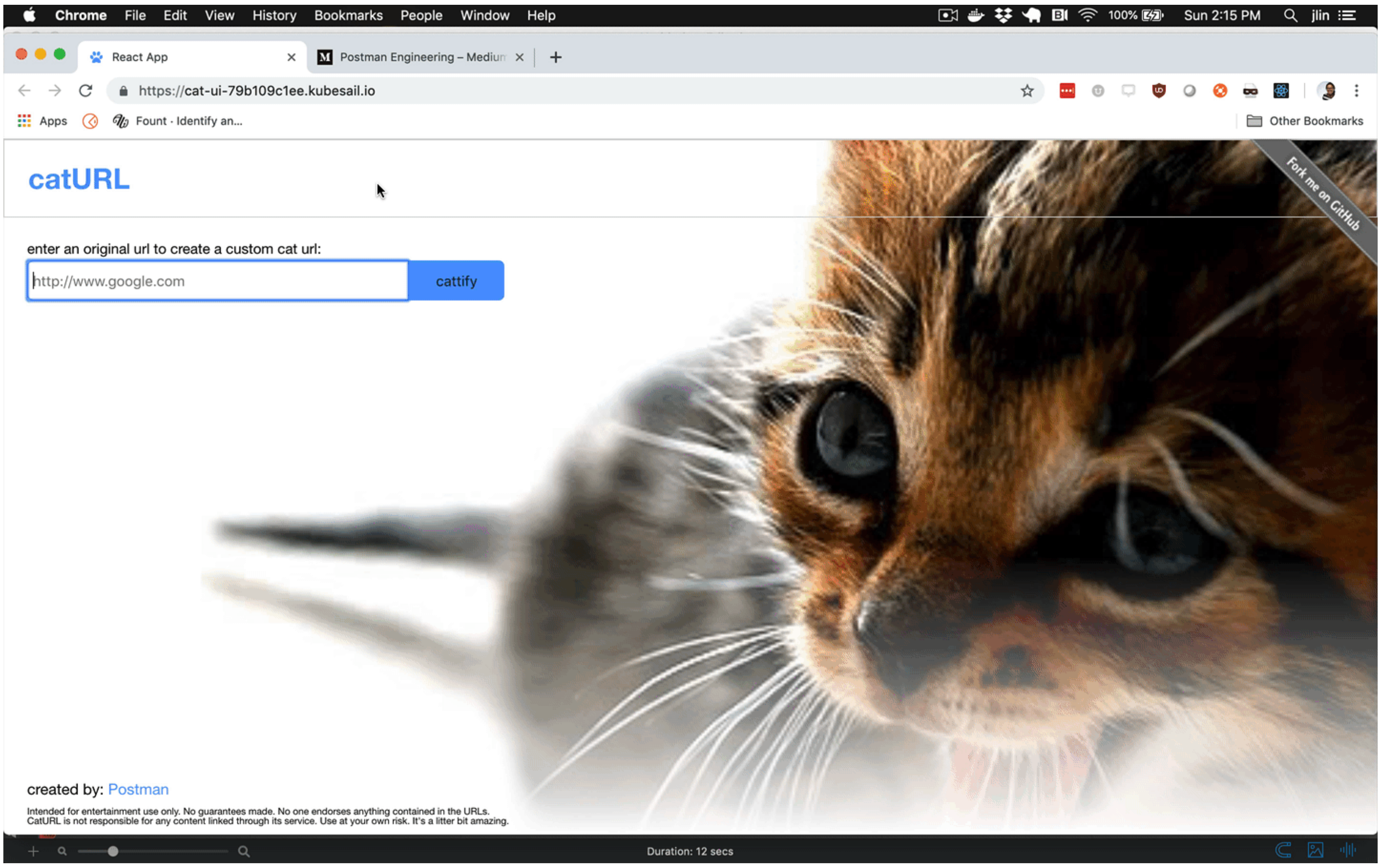
In this example, I only designated a single replica of our APIs. However, if I wanted to have 3 replicas, Kubernetes would keep a steady eye on my app instances and replace them if any single one crashed for some reason.



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: cat-kube-stateless-prod
spec:
  selector:
    matchLabels:
      app: cat-kube-stateless
      env: prod
  minReadySeconds: 5
  strategy:
    type: RollingUpdate
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 0
  replicas: 1
  template:
    metadata:
      labels:
        deployedBy: deploy-to-kube
        app: cat-kube-stateless
        env: prod
    spec:
      volumes: []
      containers:
        - name: cat-kube-stateless-prod
          image: 'joycelin1600/cat-kube-stateless:prod'
          imagePullPolicy: Always
          ports:
            - name: http
              containerPort: 5500
          resources:
```

Configuration file for backend deployment

For the deployment, I used a hosted Kubernetes provider called Kubesail that creates a free managed namespace. However, the underlying deployment utility `npx deploy-to-kube` supports any Kubernetes cluster. By running it inside your app's directory, this utility will automatically generate a Dockerfile, build and push deployment images, generate Kubernetes configuration files, and trigger a deployment on your Kubernetes cluster.


Chrome File Edit View History Bookmarks People Window Help
React App
Postman Engineering – Medium
https://cat-ui-79b109c1ee.kubesail.io
catURL
Fork me on GitHub
cattify
Duration: 12 secs

enter an original url to create a custom cat url:

http://www.google.com

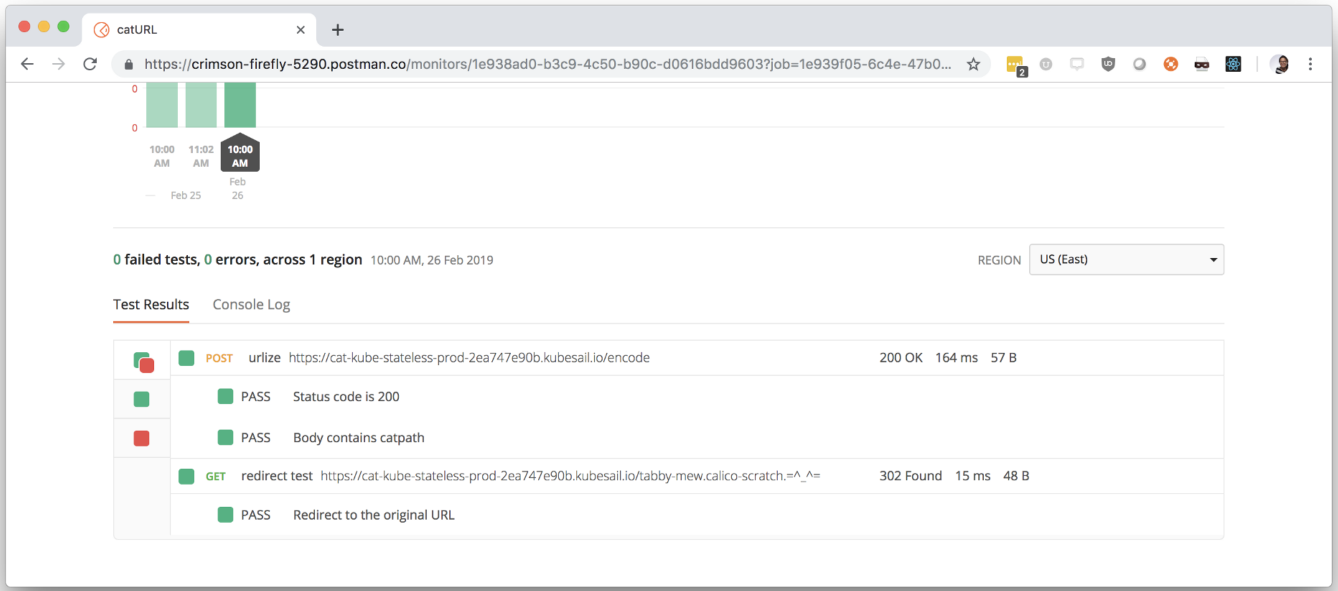
created by: Postman

Intended for entertainment use only. No guarantees made. No one endorses anything contained in the URLs. CatURL is not responsible for any content linked through its service. Use at your own risk. It's a litter bit amazing.

It's a litter bit amazing.

Once our app is in production, we can continue testing our production APIs periodically to ensure they're still functioning properly.

- **Good practice**: on an ad hoc basis, use the Postman collection runner to run the same tests along with a Postman environment that is set up with your production configuration.
- **Better practice**: set up a Postman monitor to schedule your tests on a recurring frequency, or set up a custom cron job using Newman to do the same thing.


catURL
https://crimson-firefly-5290.postman.co/monitors/1e938ad0-b3c9-4c50-b90c-d0616bdd9603?job=1e939f05-6c4e-47b0...
10:00 AM
11:02 AM
10:00 AM
Feb 25
Feb 26
Test Results
Console Log

0 failed tests, 0 errors, across 1 region 10:00 AM, 26 Feb 2019

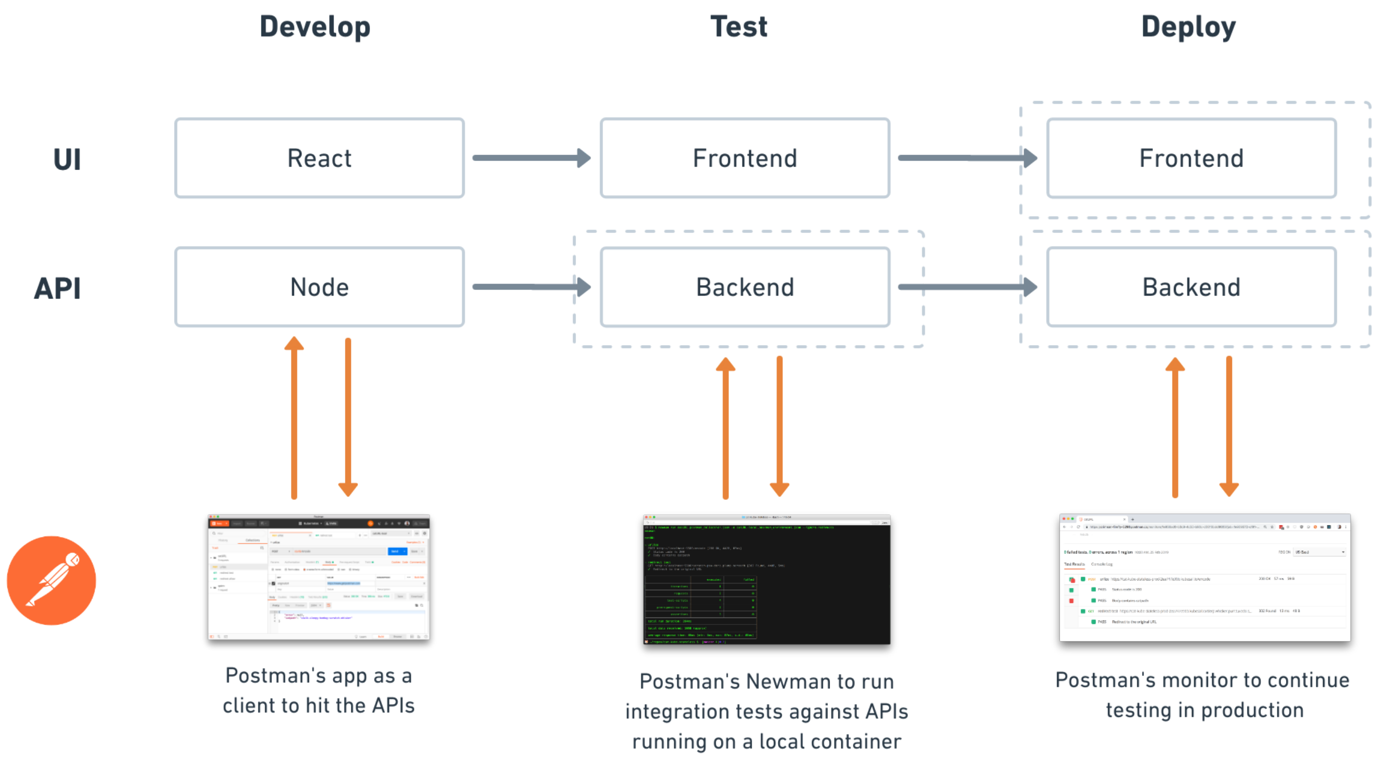
REGION US (East)

```
🟩 POST  urlize  https://cat-kube-stateless-prod-2ea747e90b.kubesail.io/encode          200 OK     164 ms   57 B
     🟩 PASS   Status code is 200
     🟩 PASS   Body contains catpath
🟩 GET   redirect test  https://cat-kube-stateless-prod-2ea747e90b.kubesail.io/tabby-mew.calico-scratch.=^_^=   302 Found   15 ms   48 B
     🟩 PASS   Redirect to the original URL
```

Continue testing your production APIs to ensure they're functioning properly

In addition to basic monitoring, the Kubernetes community has developed a bunch of open source resources for introspection. Tools like Prometheus and Istio provide more advanced features for logging and debugging for your Kubernetes clusters.

In summary, we used a local container to test our Node app, and then Kubernetes to deploy both the frontend and backend on containers in the cloud. Along the way, we used Postman to test our APIs locally, then before releasing our code, and finally once they were in production.


Develop
Test
Deploy
UI
API
React
Frontend
Frontend
Node
Backend
Backend
Postman's app as a client to hit the APIs
Postman's Newman to run integration tests against APIs running on a local container
Postman's monitor to continue testing in production

A final thought about containers and orchestration

In case you missed it, I wanted to highlight the importance of using containers during testing. Container images make it easier to reproduce and run an application that more closely replicates the production environment.

You can use your container images to reliably run your tests against an application in a test environment, like the Postman engineering team does. Containers also allow you to scale up more instances for concurrent performance testing. And in the event you've released a bug into production, containers make it really easy to quickly roll back an update to a previous version of the application.

There's a bunch of ways that you can use containers in your development, testing, and deployment processes. The strategy you choose will be determined by your team's current infrastructure, talent, and goals.

Docker Kubernetes DevOps Site Reliability Engineer Nodejs