Getting Started With Serverless Application Architecture

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CONTENTS

Before getting your hands in the soil, it's important to review what "serverless" actually means. Of course, servers are still present in serverless computing; in a serverless architecture, DevOps teams don't have to worry about building out, configuring, and managing the hardware. And for developers, serverless means that they can communicate with the database as if it was a single API endpoint in a cloud environment. All of which is to say: "Serverless" removes application architecture maintenance, which creates more room for innovation.

The intention of this Refcard is to help you easily get started with serverless application architecture by jumping right into a hands-on tutorial for building a serverless Java web application.

WHEN TO BUILD WITH A SERVERLESS DATABASE

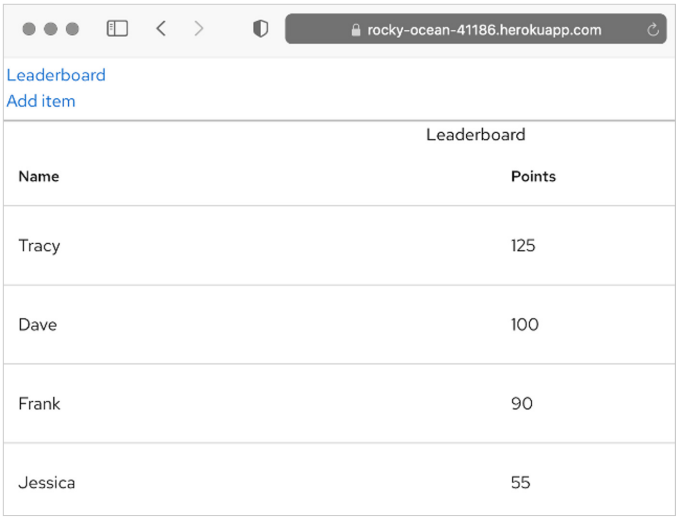
Almost all modern cloud-native applications require persistent data storage. However, storing data becomes more challenging in serverless architectures where each service is deployed independently. Specifically, transactions in serverless apps require consistency so that they can eventually be reconciled, but the applications also need to scale effectively without being hampered by fragmented data. For these reasons, it's important to use a serverless database because it will allow for rapid development of scalable data stores for modern applications.

For the following tutorial, we're going to use CockroachDB Serverless, but there are a handful of other serverless databases available, such as Fauna DB and Amazon Aurora Serverless. CockroachDB is easy to use with Quarkus and offers support for Hibernate ORM, and Quarkus works particularly well with Hibernate, thanks to Panache. To implement a serverless solution, you only need to create the cluster and connect your application to the database, similar to how you would add any other SQL database. This means you can start building your application in minutes.

BUILDING A SAMPLE SERVERLESS APPLICATION

In this tutorial, we'll demonstrate how to build a serverless Java application by creating the leaderboard app shown below:

Figure 1



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We'll first build the app's back end using Quarkus to enable CRUD operations on CockroachDB Serverless, which we will then use to store leaderboard items displayed on the front end. We'll build the front end using Node.js and React, enabling users to display and add new leaderboard items. Then, we will deploy the entire solution to Heroku to make it globally available.

You can follow along using the companion repository on GitHub. Examples were created in Visual Studio Code on macOS, but we've included instructions for other operating systems where necessary.

Note: We're assuming you have at least an intermediate level of Java programming skills and are familiar with Quarkus. If you're unfamiliar with JPA and MVC in Java, please check the following tutorial: "Learn JPA & Hibernate."

Here is a list of tools you will need:

- Visual Studio Code with the Extension Pack for Java
  - Check out Managing Extensions to learn how to install the extension.
- Java version 16.0.2, 2021-07-20
- curl for app testing (you can use another testing tool if you prefer)
- Node.js, since we will be using npm to build out React front end
- Git for version control
- Maven, the build tool
- A free Heroku account

BUILD OUT THE APP'S BACK END

We'll start by creating the Quarkus back end. Let's go to the Quarkus project generator and set up our application's extensions, which we can think of as dependencies.

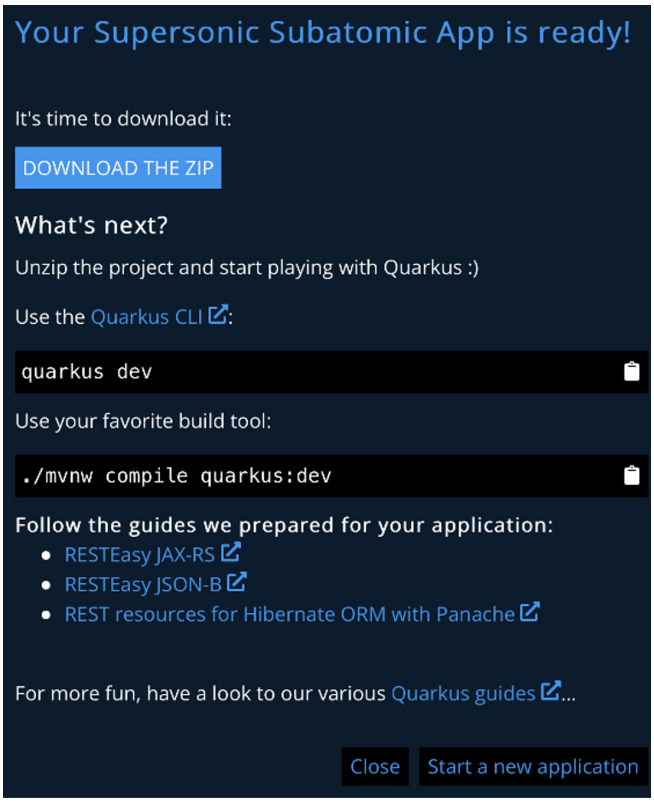
In the **Group** field, enter "org.db." In the **Artifact** field, enter "cockroach-serverless." In the **Build Tool** field, enter "Maven." Next, select the following four packages:

- RESTEasy Classic
- RESTEasy Classic JSON-B
- REST resources for Hibernate ORM with Panache [quarkus-hibernate-orm-rest-data-panache]
- JDBC Driver – PostgreSQL [quarkus-jdbc-postgresql]

Once the project is configured, select **Generate your application**. Quarkus then displays another window where you can download the source code (Figure 2).

SEE FIGURE 2 IN NEXT COLUMN

Figure 2



Download the zip file to receive the Java project with a static page, an `index.html` file (in `src/main/resources`), one REST API, a `GreetingResource.java` file (in `src/main/java/org/db`), some unit tests, and some Docker files.

The `GreetingResource.java` file implements a simple `/hello` endpoint with one `GET` method, which returns the static string, `Hello RESTEasy`:

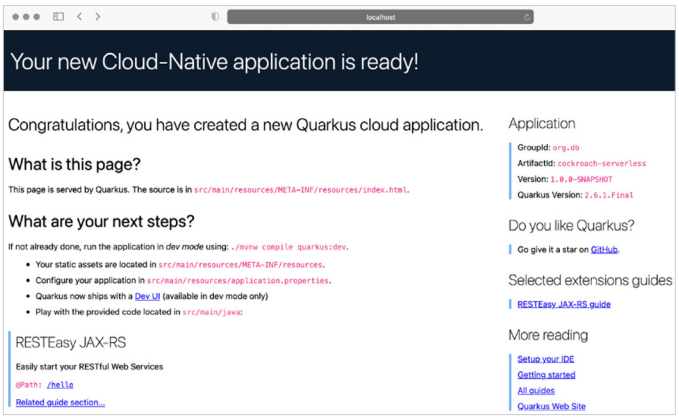
```
@Path("/hello")
public class GreetingResource {

    @GET
    @Produces(MediaType.TEXT_PLAIN)
    public String hello() {
        return "Hello RESTEasy";
    }
}
```

To see this code at work, navigate to the unzipped file, `/path/to/cockroach-serverless/`, and enter the following command in your terminal:

```
./mvnw quarkus:dev
```

Next, use your browser and navigate to `localhost:8080`. You will see `index.html` being rendered. You can ignore any test output generated in the log.

Figure 3



Append the request to the `/hello` endpoint to see the static string, `Hello  RESTEasy`. Once this is done, we can add the class implementing the actual REST API for our leaderboard app. Create a file called `LeaderboardItem.java` in `src/main/java/org/db` and add the following code:

```
package org.db;
import javax.enterprise.inject.Produces;
import javax.persistence.Column;
import javax.persistence.Entity;

import io.quarkus.hibernate.orm.panache.
PanacheEntity;

@Entity
public class LeaderboardItem extends PanacheEntity {
    @Column
    public String name;
    @Column
    public double points;
}
```

This will represent the items on the leaderboard.

The `LeaderboardItem` class has two fields: `name` and `points`. The class derives from `PanacheEntity`, so the getters and setters for `name` and `points` fields will be generated automatically. Additionally, `PanacheEntity` provides a default identifier, `id`, which helps to keep the definition of the `LeaderboardItem` class clean and simple.

Next, let's implement the actual REST resource for the leaderboard items. Add the `LeaderboardResource.java` class in the `src/main/java/org/db` directory:

```
package org.db;

import io.quarkus.hibernate.orm.rest.data.panache.
PanacheEntityResource;

public interface LeaderboardResource extends
PanacheEntityResource
    <LeaderboardItem, Long> {
}
```

`PanacheEntityResource`, used as a base class, is generic and implements our CRUD operations. It will work for instances of `LeaderboardItem` and identify particular database objects using the default identifier, `Long` (from the `PanacheEntity` class). Also note that `LeaderboardResource` will automatically generate the REST API endpoint exposed at the `/leaderboard` path.

We are now ready to create the CockroachDB database and connect it to our back end.

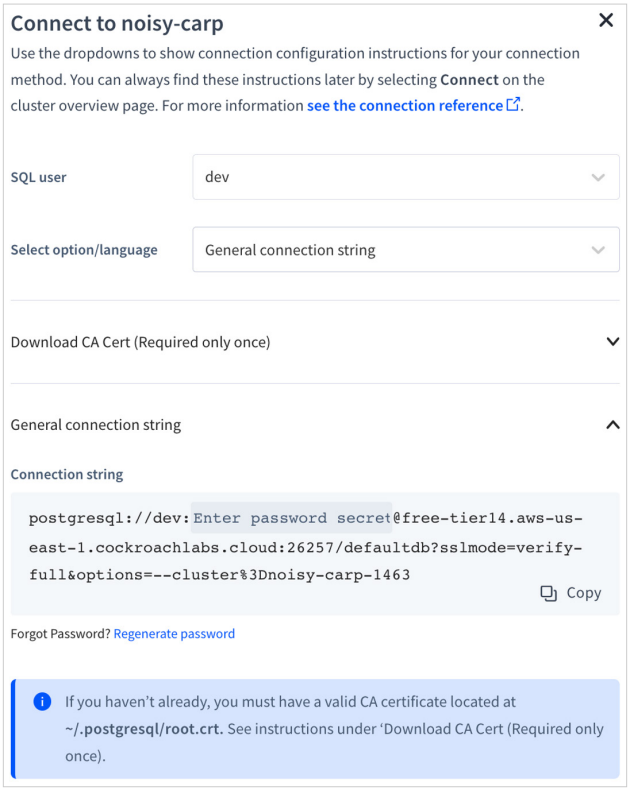
ADD THE SERVERLESS DATABASE

If you do not have a free CockroachDB account, you will need to create one. After signing up, you will be redirected to the dashboard.

Select **Create Cluster**, and in the display that pops up, choose **Serverless**. The Serverless option requires you to choose your cloud provider and its region: Set AWS as your provider and use the region closest to your physical location. Optionally, you can modify the cluster name, though we are using the default value, `fluffy-possum`.

Select **Create your free cluster** to begin the process of creating the cluster. In a few seconds, you will see a window containing your connection info:

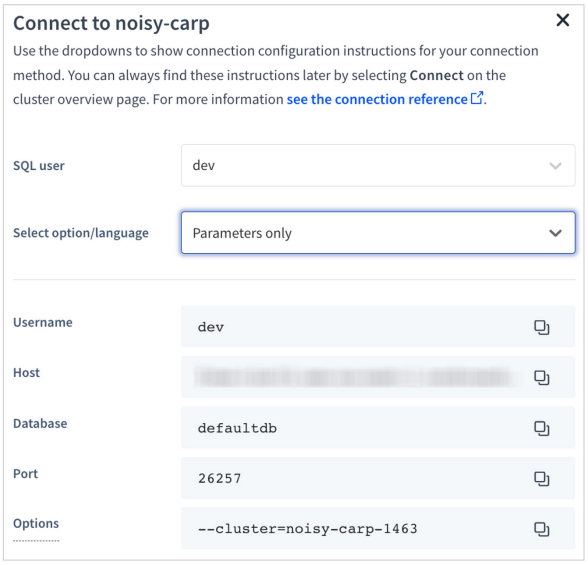
Figure 4



Be sure to note your database password at this point, as this is the only place where you can reveal it. Otherwise, you'll need to reset the password using the CockroachDB dashboard, found in: **SQL Users** > **Action** > **Change Password**. While you have this window open, you will also want to grab a few more values that you'll soon need to configure the `application.properties` class.

Select the **Parameters Only** dropdown and note the values it presents (username, host, database, and port):

Figure 5



Next, open `src/main/resources/application.properties` and enter the following code. Replace the username, password, host, port, and database with the values taken from CockroachDB Serverless. Use the cluster name in the JDBC URL:

```
# configure your datasource
quarkus.datasource.db-kind = postgresql
quarkus.datasource.username = dev
quarkus.datasource.password = <your password>
quarkus.datasource.jdbc.url =
jdbc:postgresql://<your host>:26257/<cluster-
name>.<your database>

quarkus.hibernate-orm.database.generation = update
```

We are now ready to test the application. Go ahead and run the app again by entering the following command in your terminal:

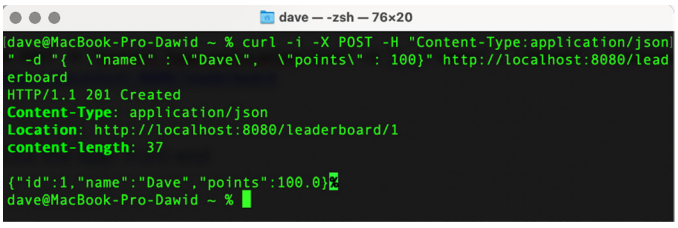
```
./mvnw quarkus:dev
```

Then, navigate to `localhost:8080/leaderboard`. The resource returns an empty collection. We can add one item using `curl`:

```
curl -i -X POST -H "Content-Type:application/json"
-d "{  \"name\" : \"Dave\",  \"points\" : \"100\"}"
http://localhost:8080/leaderboard
```

The resource should respond with a 201 HTTP status code:

Figure 6



The item was successfully added to the database. We can check this by sending a `GET` request to `http://localhost:8080/leaderboard`, either using curl or a web browser:

Figure 7

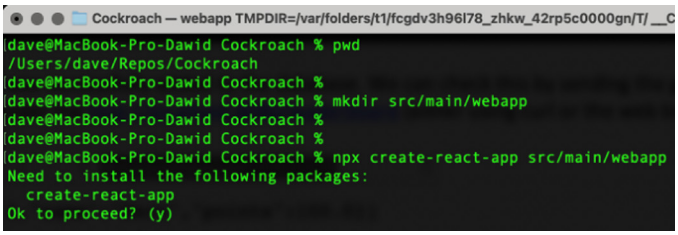
BUILD OUT THE APP'S FRONT END

With the back end ready, let's add the front end. Because we will build using React, we'll need to make sure we also have Node.js. Install it now if necessary.

First, open your terminal and go to the project's directory. Create a new directory called `webapp` in `/src/main`. Then, create the React project by entering the following command:

```
npx create-react-app src/main/webapp/
```

Figure 8

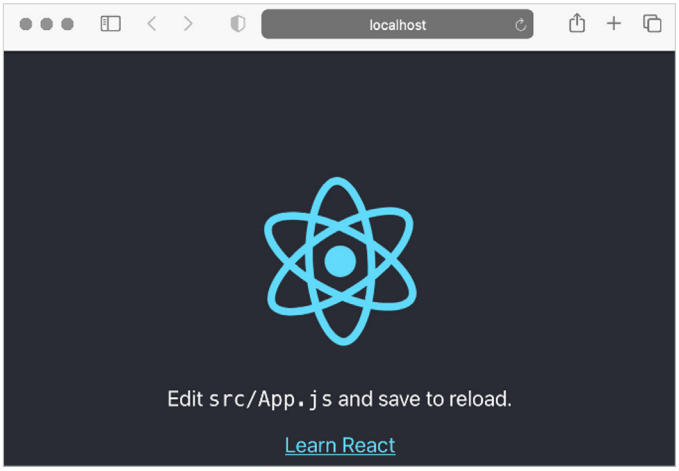


Enter `y` to proceed. The React web application will be bootstrapped in `src/main/webapp`. You can preview the app by changing your working directory to `src/main/webapp` and then entering the following command:

```
npm start
```

You will see the following welcome screen:

Figure 9



Let's now customize our web app and add the leaderboard. We will use the PatternFly package to create the table.

Install the PatternFly `npm` package by invoking the following command from the `src/main/webapp` directory:

```
npm install @patternfly/patternfly -save
```

Then, import `patternfly.css` in `index.js`:

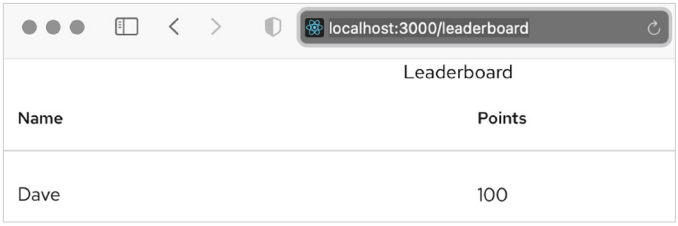
```
import React from 'react';
import ReactDOM from 'react-dom';
import './index.css';
import App from './App';
import reportWebVitals from './reportWebVitals';
import '@patternfly/patternfly/patternfly.css';
```

Next, create a subdirectory named `components` in the `webapp/src` directory. Then, in `webapp/src/components`, create a `leaderboard.jsx` file and add the following code:

```
import React from 'react'

const Leaderboard = ({ items }) => {
    return (
        <div>
            <center><h1>Leaderboard</h1></center>
            <table className="pf-c-table pf-m-
grid-md">
                <thead>
                    <tr role="row">
                        <th
role="columnheader">Name</th>
                        <th
role="columnheader">Points</th>
                    </tr>
                </thead>
                {items.map((item) => (
                    <tbody role="rowgroup">
                        <tr role="row">
                            <td role="cell">{item.
name}</td>
                            <td role="cell">{item.
points}</td>
                        </tr>
                    </tbody>
                ))}
            </table>
        </div>

    )
};

export default Leaderboard
```

This component, when given the list of leaderboard items, will render them as the two-column table we want to display:

Figure 10



To that end, the `Leaderboard` component iterates over the items collection and displays each item as a table row.

Let's now use the `Leaderboard` component in `App.js`:

```
import React, {Component} from 'react';
import Leaderboard from './components/leaderboard';

class App extends Component {
  state = {
    items: []
  }

  componentDidMount() {
    fetch('http://localhost:8080/leaderboard')
    .then(res => res.json())
    .then((data) => {
        this.setState({ items: data.
sort((a,b)=>{return a.points < b.points}) })
    })
    .catch(console.log)
  }

  render () {
    return (
      <Leaderboard items={this.state.items} />
    );
  }
}

export default App;
```

The `App` component will send a `GET` request to our `Leaderboard` resource, which we've implemented using the Quarkus REST API. The collection of items retrieved from the API is stored in `state.items` and then passed to the `Leaderboard React` component. Importantly, the items are also sorted in descending order by their points property.

To make this work, we need to configure cross-origin resource sharing (CORS). By default, the front end is exposed on the `localhost` at port `3000`, while the REST API is exposed at port `8080`. This could prevent fetching data from the API — the web browser could block a request due to misconfigured CORS.

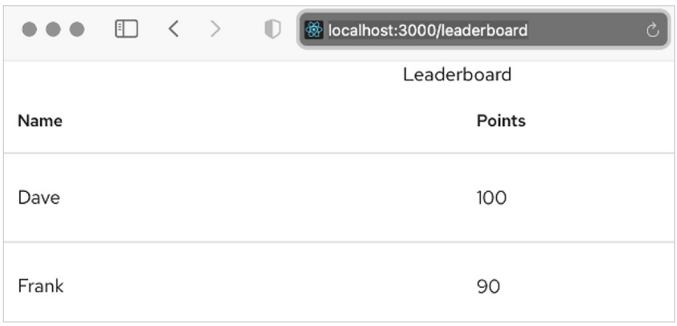
To enable CORS, add the following line to `application.properties` in the Quarkus project:

```
quarkus.http.cors=true
```

Now, run the REST API project again by running `./mvnw quarkus:dev` and restart the web application by running `npm start`. Then, open `localhost:3000/leaderboard`.

You should see something like this:

Figure 11

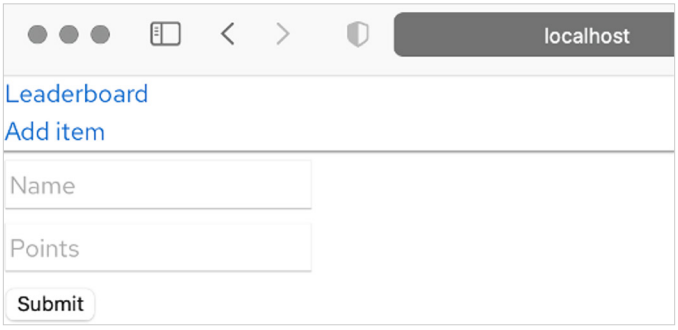


At this point, we can add items using curl or any other REST API client. Let's see how to do this.

ADD ITEMS

We'll now add a form that enables users to add new entries to the leaderboard through REST API. The application will also contain two links that enable the user to switch between the *Leaderboard* and *Form* screens:

Figure 12



We start by supplementing the React app with the react router. To do so, install the `react-router-dom npm` package:

```
npm install react-router-dom
```

Then, in the `components` directory, add an `AddItem.css` file:

```
input {
    margin: 5px;
}
```

Next, implement the `AddItem.jsx` component with the code below:

```
import React from 'react';
import './AddItem.css'

class AddItem extends React.Component {
    constructor(props) {
      super(props);
      this.state = { name: '', points: 0 };
    }

    handleChange = (event) => {
      this.setState({[event.target.name]: event.
target.value});

      console.log(this.state);
    }

    handleSubmit = (event) => {
      console.log(JSON.stringify(this.state));
      fetch('http://localhost:8080/leaderboard', {
          method: 'POST',
          body: JSON.stringify(this.state),
          headers: {
            'Content-Type': 'application/json'
          },
        }).then(function(response) {
          return response.json();
        });

      event.preventDefault();
  }

    render() {
      return (
        <form onSubmit={this.handleSubmit}>
            <input type="text" value={this.state.
value}
                        name="name" onChange={this.
handleChange} placeholder="Name"/>
            <br/>
            <input type="text" value={this.state.
value}
                        name="points" onChange={this.
handleChange}placeholder="Points"/>
            <br/>
            <input type="submit" value="Submit" />
        </form>
      );
    }
  }

  export default AddItem
```

The `AddItem` component consists of a form with two text fields.

The values of these text fields are used to update the state of the component. When the user selects the **Submit** button, a `POST` request is sent to our back end.

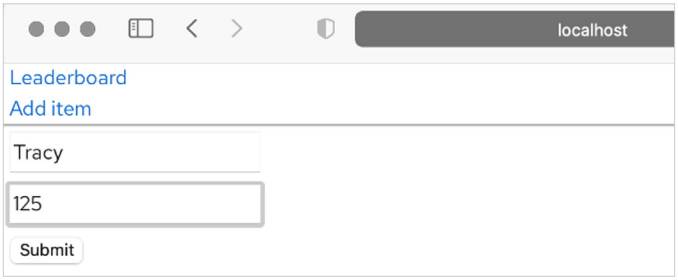
Finally, we modify `App.js` to include links to `Leaderboard` and `AddItem` components:

```
import React, {Component} from 'react';
import {BrowserRouter as Router, Routes, Route,
Link} from 'react-router-dom'
import Leaderboard from './components/Leaderboard';
import AddItem from './components/AddItem';

class App extends Component {
  state = {
    items: []
  }

  componentDidMount() {
    fetch('http://localhost:8080/leaderboard')
    .then(res => res.json())
    .then((data) => {
      this.setState({ items: data.
sort((a,b)=>{return a.points < b.points}) })
    })
    .catch(console.log)
  }

  render () {
    return (
      <Router>
        <div style={{padding: "5px"}}>
     <Link to="/">Leaderboard</Link><br/>
     <Link to="/addItem" >Add item</Link> <br/>
 </div>

        <hr/>

        <Routes>
          <Route exact path='/'
                 element={<Leaderboard items={this.
state.items}/>} />
          <Route exact path='/addItem'
                 element={< AddItem />} />
        </Routes>
      </Router>
    );
  }
}

export default App;
```

Now, run the web app again. You can see the links at the top of the Leaderboard window.

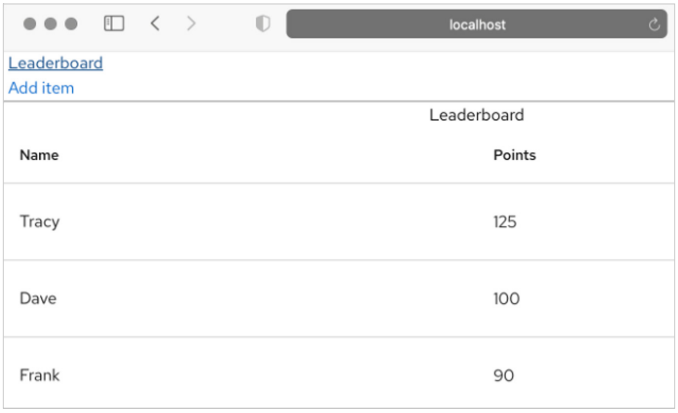
Select **Add item**, then fill in the form:

Figure 13



After submitting the form, select **Leaderboard** and refresh the page to see the new item:

Figure 14



You can also use the `setInterval` JavaScript function to automatically refresh the leaderboard at the predefined intervals.

DEPLOY TO HEROKU

In this section, we'll deploy our entire solution to Heroku, doing so in a cloud-native way by deploying the back end and front end independently. To complete all of the instructions, you will need Heroku and Git accounts, as well as the Heroku CLI installed on your development machine.

To install Heroku CLI on macOS, use `brew`:

```
brew install heroku/brew/heroku
```

On Ubuntu, use `snap`:

```
sudo snap install heroku --classic
```

On other Linux distributions, use a tarball.

On Windows, use one of the dedicated installers.

BACK-END DEPLOYMENT

First, let's deploy the back end through Heroku CLI and Git. Start by logging into Heroku:

```
heroku login
```

Then, update your `application.properties` file with the following configuration:

```
quarkus.http.port=${PORT:8080}
```

This updates the HTTP port on which our back end is listening for requests so that it matches the port provided by Heroku. Next, create a `system.properties` file:

```
echo "java.runtime.version=11" >> system.properties
```

We use this to set our JDK to version 11 to match the Quarkus configuration. Next, create the `Procfile`, which Heroku uses to start our application:

```
echo "web: java \$JAVA_OPTS -jar target/quarkus-app/
quarkus-run.jar" >> Procfile
```

Before we create our app, we need to collate everything through Git. Initialize a local Git repository and commit all these files:

```
git init
git add .
git commit -am "Initial version"
```

Now, create the application on Heroku:

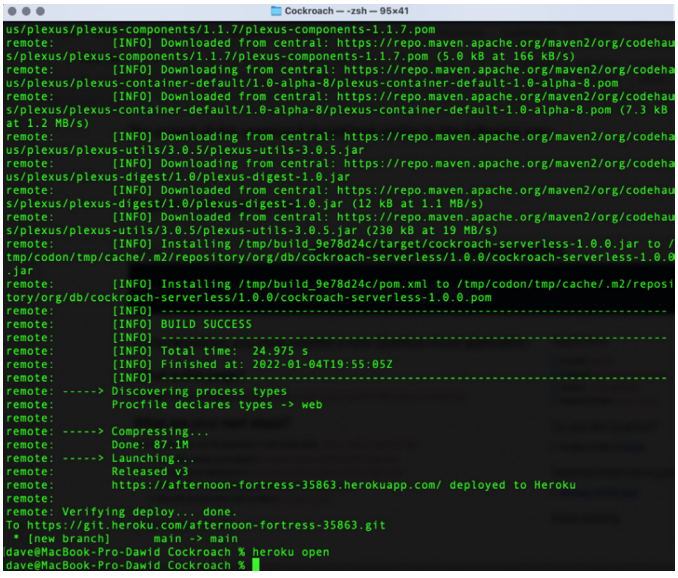
```
heroku create
```

Finally, deploy through Git:

```
git push heroku main
```

The output of this command should look similar to this:

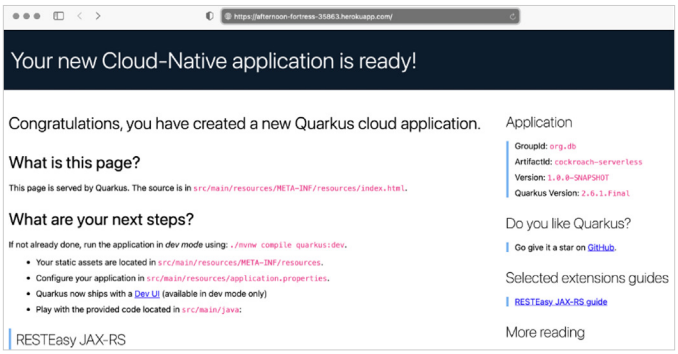
Figure 15



To see the app running, enter `heroku open`. This opens the default web browser and navigates to the Heroku application URL (Figure 16).

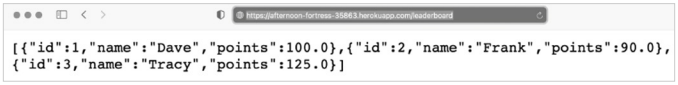
SEE FIGURE 16 IN NEXT COLUMN

Figure 16



Append the `/leaderboard` path to the URL to see the back end communicate with CockroachDB and return the list of leaderboard items. Note that this list matches what we had before because the data is retrieved from the same database:

Figure 17



FRONT-END DEPLOYMENT

After ensuring that the back end works, let's deploy the front end. We will start by updating the code with the Heroku app's URL. In our case, that is `https://afternoon-fortress-35863.herokuapp.com/leaderboard`. Your URL will be similar.

Update this section of the `App.js` file — in `src/main/webapp/src` — with your URL:

```
componentDidMount() {
  fetch('https://afternoon-fortress-35863.herokuapp.
com/leaderboard')
  .then(res => res.json())
  .then((data) => {
    this.setState({ items: data.sort((a,b)=>{return
a.points < b.points}) })
  })
  .catch(console.log)
}
```

Then, update the URL in the `AddItem.jsx` file within `src/main/webapp/src/components`:

```
handleSubmit = (event) => {
  console.log(JSON.stringify(this.state));
  fetch('https://afternoon-fortress-35863.herokuapp.
com/leaderboard', {
      method: 'POST',
      body: JSON.stringify(this.state),
      headers: {
        'Content-Type': 'application/json'
      },
    }).then(function(response) {
```

CODE CONTINUES ON NEXT PAGE

```
      return response.json();
    });

  event.preventDefault();
}
```

Before proceeding, let's ensure everything works locally. Change your working directory to `src/main/webapp` and then run using `npm start`. Then, go to `localhost:3000`. Note that it may take longer than before to retrieve leaderboard items. Now, we are ready to deploy the front end to Heroku. Start by creating the `Procfile`:

```
echo "web: npm start" >> Procfile
```

Now, initialize another repository. Add and commit all of the files, ensuring to do this from the `src/main/webapp` subdirectory:

```
git init
git add .
git commit -am "webapp"
```

Create the new Heroku app:

```
heroku create
```

Finally, deploy the front end through Git:

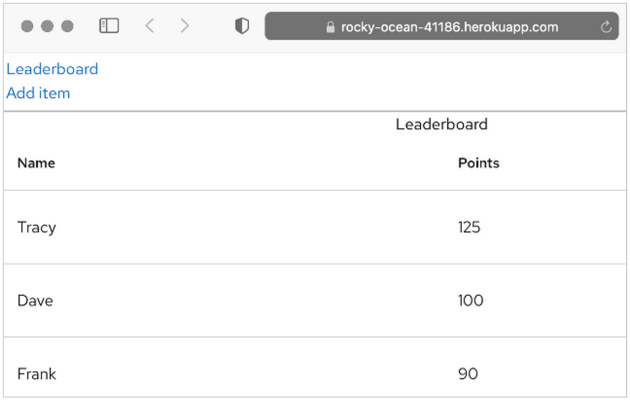
```
git push heroku main
```

All that remains to do now is to open your application:

```
heroku open
```

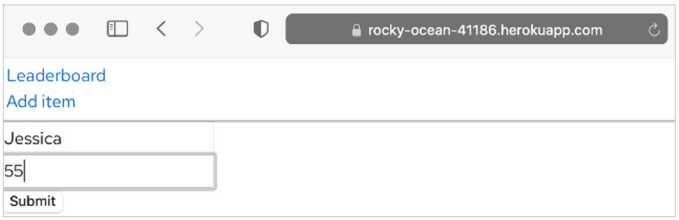
You should see the solution up and running:

Figure 18



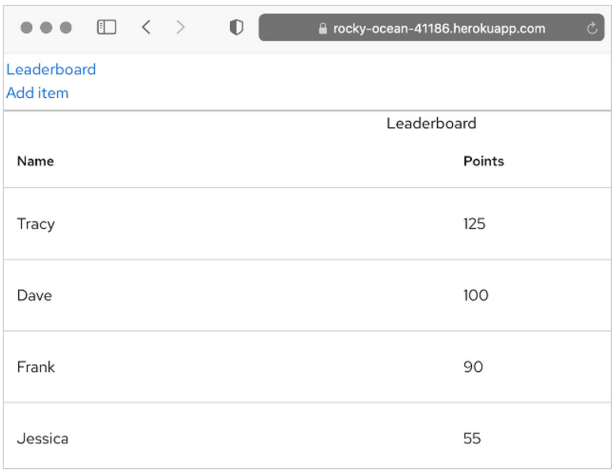
Try to add another item:

Figure 19



The item appears as an entry in the leaderboard:

Figure 20



CONCLUSION

In this Refcard, we walked through the creation and deployment of a Java application, using Quarkus for the back end, React for the front end, CockroachDB for our serverless database, Panache for ORM, and Heroku to deploy the whole package. As you've seen, we quickly connected CockroachDB to our Quarkus back end, but we could have just as easily deployed to Heroku as a Docker container instead. We also demonstrated how easy it is to automatically generate REST CRUD resources using Panache. All of these tools accelerate the development of serverless apps. And by removing server-centric friction from the application development process, serverless development liberates developers to spend more time on innovation and feature development, which will ultimately result in better end-user experiences.

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