Backend with Express.js and Authorization

CIS 1962 (Winter 2026)
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Penn Engineering

Lesson Plan

5	Backend Development
10	HTTP & REST API
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47	Authorization
58	Intro to Databases (Redis)

Logistics

<u>CIS 19xx Midterm Evaluation!</u>

- Please take some time to fill this out, your feedback is valuable!

HW6: Blog Part 1 Released, Due 3/19 (After Spring Break)

- Build the backend of a blogging platform!
- Learn account registration/login/auth systems
- Interact with a Redis Cloud database

Review Activity

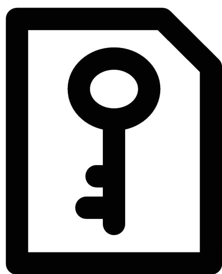
https://edstem.org/us/courses/91614/lessons/161213/slides/946446

Let's review some content from the previous lecture before we start!

What does it mean to develop the “backend” of a web application?

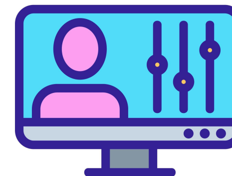
What is a Backend?

The **backend** of a web application is the logic that needs to happen behind the scenes. This includes tasks like:



Security & Authorization

Data Storage & Database Access



Business Logic: Rules, Calculation, Validation

Full-Stack Illustration

Frontend

CLICK BELOW FOR A JOKE!

GET JOKE

Backend

```
await fetch('/api/fetchjoke');
```

WHY DID DRACULA LIE IN THE WRONG COFFIN? HE MADE A GRAVE MISTAKE.

JavaScript & Backend

With Node.js, you can write code to run on a server, because it is a runtime environment that allows networking and file system access.

While you can create a backend manually with Node, there are many frameworks that make it easier:

- Express.js
- Next.js

```
// Without Next or Express
const http = require('http');

const server = http.createServer((req, res) => {
  res.setHeader('Content-Type', 'application/json');

  if (req.method === 'GET' && req.url === '/') {
    res.statusCode = 200;
    res.end(JSON.stringify({ message: 'Hello World!' }));
  } else {
    res.statusCode = 404;
    res.end(JSON.stringify({ error: 'Not found' }));
  }
});

server.listen(3000, () => {
  console.log('Server running at http://localhost:3000');
});
```

General Backend Terms

API: Application programming interface, or how the frontend will talk to the backend

Endpoint: The specific URL the frontend (or terminal) can call or get/send data

Request/Response: The flow of data to (request) and from (response) the backend

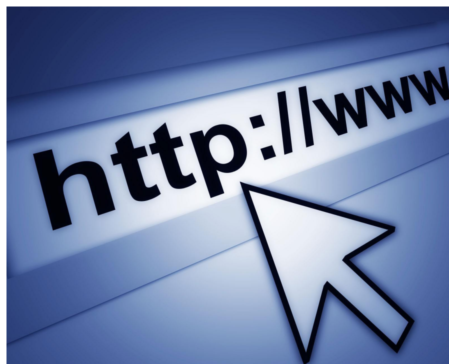
Business Logic: The rules, calculations, and flow of an application handled by the backend (often in a service layer)

What does it mean to develop the “backend” of a web application?

HTTP

HTTP, or Hypertext Transfer Protocol, is the foundational protocol of the web. It allows a client like a browser or a developer in a terminal to communicate with servers.

You work with HTTP through **requests** and **responses**.



HTTP Requests

```
curl -X POST http://localhost:3000/login \
    -H "Content-Type: application/json" \
    -d '{"user": "voravich"}'
```

An HTTP request needs to know certain things:

- **Method**: Verbs describing what actions you want to perform with the request, including `GET`, `POST`, `PUT`, `PATCH`, and `DELETE`.
- **URL**: Where you want to make a request
- **Headers**: important authentication information or specifying data types
- **Body**: Used for POST/PUT to send data

HTTP Verbs

These are some best practices when using HTTP verbs:

- GET: used to **request data**, should never change the server's application state.
- DELETE: used to **request the removal of an item** on the server.

GET/DELETE
Request something

- POST: used to **create a new object** on the server
- PUT: used to **replace an existing object** with new data
- PATCH: used to **modify an existing object** with new data
  - PUT/PATCH should be idempotent: two of the same request should put the server in the same state for both.

POST/PUT/PATCH
Send data

Fetch and curl Examples

curl (cURL): command to be used to make an HTTP request

```
curl "https://qcknfszkz7.execute-api.us-east-1.amazonaws.com/pokedex/pokemon?limit=10"
```

Fetch API: JS interface for making HTTP requests and working with responses

```
async function getJoke() {
    const res = await fetch('https://official-joke-api.appspot.com/random_joke');
    const data = await res.json();
    return data;
}

getJoke().then((data) => console.log(data));
```

HTTP Responses

HTTP Responses output the following items:

- **Status Code**: Indicate whether HTTP request was successful, and various other states. (200 = OK, 404 = Not Found, 500 = Error, etc)
- **Headers**: Information about the response, like “Content-Type: application/json”
- **Body**: Often JSON with requested data

HTTP Status Codes

200 OK – Request succeeded
201 Created – Resource created
204 No Content – Successful, no response body
301 Moved Permanently – Resource has a new permanent URL
302 Found – Temporary redirect
400 Bad Request – Client request error
401 Unauthorized – Authentication required
403 Forbidden – Request refused
404 Not Found – Resource doesn't exist
500 Internal Server Error – Server encountered an error
503 Service Unavailable – Server temporarily unavailable

REST API

Backends will often use an architectural design style called **REST (Re**presentational **S**tate **T**ransfer**)**.

Using REST gives structure and conventions to using HTTP, making them predictable across many systems.

REST maps HTTP methods to CRUD (create, read, update, delete) operations to standardize how resources are managed on the web.

REST Example: API Routes

Imagine we have an backend to manage users.

Here are a few URL names in our API to show REST conventions:

- GET /users – List users
- GET /users/9057 – Fetch user with ID 9057
- POST /users – Create new user
- PUT/PATCH /users/9057 – Update user 9057
- DELETE /users/42 – Delete user 9057

HTTP & REST Overview

HTTP provides the methods,
REST provides the rules.
Together they allow for structured communication on the web.

Now, how do we write JS backend code using these ideas?

Express.js Backend

How do we use Express.js to build a backend web server and API routes?

Express.js

Express.js is the most popular web framework for Node.

It lets you build web servers and APIs easily within JS, with the following features:

- **Flexible, simple routing**: Easily map URLs and HTTP methods
- **Middleware:** Able to handle authentication, logging, and JSON with "plug-in" methods
- **Well-supported:** has a large ecosystem of compatible libraries and can run wherever Node.js does.

Sidenote: pnpm

So far we've used npm for installations. It's often quite slow and disc-inefficient.

We recommend you try pnpm (https://pnpm.io/), which solves both of these problems!

```
npm install -g pnpm
```

Now you can run anything that used "npm" with "pnpm" instead!

Creating an Express App

```
[p]npm i express
```

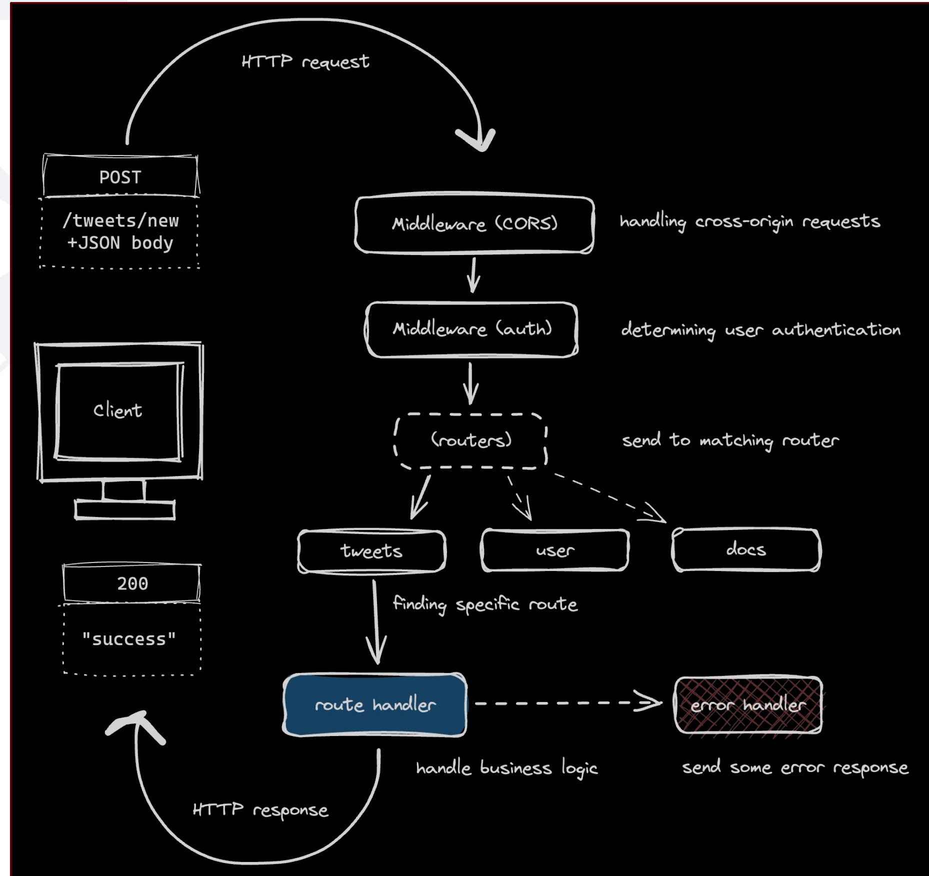
Once you import express into a script, you can create an app and let it listen to a certain port (often port 3000). This starts your Express server within the current terminal session.

```
// app.js
const express = require('express');
const app = express();

// Routes and Middleware
...

app.listen(3000, () => console.log('Server running'));
```

Anatomy of Express.js



https://imgur.com/D7SxSjT

1. HTTP Request
2. Middleware
3. Routers
4. Route/Error Handlers
5. HTTP Response

Express Routing Syntax

A route in Express defines in the server the HTTP method and URL path you want to handle, and what code to run for those requests.

Syntax:

```
app.METHOD(PATH, HANDLER)
```

METHOD: HTTP verb like `get, post, put, delete`
PATH: endpoint URL
HANDLER: function to run when route is matched

req (Request): Input

`req` lets you access input parameters to your routes. These include:

- **Path params:** req.params
- **Query string:** req.query
- **Headers**: req.headers
- **Body:** req.body (only after you add a body parser, like express.json())
- **Auth info:** often stored on req (via middleware)

```
app.use(express.json());
app.get('/api/:id', (req, res) => {
  const id = req.params.id;

  const search = req.query.search;

  const body = req.body;

  const userAgent =
req.headers['user-agent'];

  const authHeader =
req.headers['authorization'];

  res.json({ id, search, body,
userAgent, authHeader });
});
```

res (Response): Output

`res` allows you to send certain output out of your routes. Common handlers include:

- **res.send():** Sends a response of various types (string, object, buffer)
  - `res.send('Hello World!');`
- **res.json()**: Sends a JSON response.
  - `res.json({ name: ’Voravich’, age: 60 });`
- **res.status():** Sets the HTTP status code.
  - `res.status(404).send(‘Not Found’)`
- **res.redirect()**: Redirects to a different URL.
  - `res.redirect('/new-route');`

Express.js Syntax Example

```
const express = require('express');
const app = express();

app.get('/api', (req, res) => {
  res.send('Hello, Express!');
});

app.post('/api/data', (req, res) => {
  // Send the data somewhere first
  res.json({ received: req.body });
});

app.listen(3000, () => console.log('Server
running on port 3000'));
```

`app.get()` at route '/api'

- GET request
- res.send() can send a response of any type, automatically setting the `Content-Type` header.

`app.post()` at route '/api/data'

- POST request
- res.json() specifically sends a JSON, using `Content-Type: application/json`

Modularizing with express.Router()

A router object in Express can help modularize your backend code by defining subsections that only run on certain paths.

Think of it as a "mini Express app" that can group related routes together.

```
// userRoutes.js
const express = require('express');
const router = express.Router();

router.get('/', (req, res) => {
  res.send('List of users');
});
...

module.exports = router;
```

```
// app.js
const express = require('express');
const userRoutes = require('./userRoutes');
const app = express();

app.use('/users', userRoutes);

app.listen(3000, () => console.log('Server running'));
```

Middleware

Middleware functions run before any router handlers.

Common uses for middleware include logging, authentication, validation, and error handling.

You declare middleware with `app.use()` for global (before every request) middleware, or defined as a function for specific routes.

```
app.use((req, res, next) => {
  console.log('I am global!');
  next();
});


app.get('/hello', (req, res) => {
  res.send('Hello World!');
});
```

```
function requireAuth(req, res, next) {
  ...
  next();
}

app.get('/dashboard', requireAuth, (req, res) => {
  res.send('Welcome to the dashboard!');
});
```

Middleware Chaining

You can chain multiple middleware functions in the same app.use() call, or attach multiple middleware functions to routes. These will be called one after another with the next() method.

```
const setFoo = (req, res, next) => {
  req.foo = 'some value';
  next();
};

const logFoo = (req, res, next) => {
  const { foo } = req;
  console.log(foo);
  next();
};

app.use(setFoo, logFoo);
```

```
function requireAuth(req, res, next) {
  ...
  next();
}

function logAccess(req, res, next) {
  console.log(`Accessed: ${req.path}`);
  next();
}

app.get('/settings', requireAuth, logAccess, (req, res) => {
  res.send('Settings Page');
});
```

Error Handling

Sometimes errors occur in your routes. You can pass an error argument to `next()` so that error handling middleware can handle it.

```
app.get('/findUser', (req, res, next) => {
  ...
  if (user) {
     res.json(user)
  } else {
     next(new Error('Oh no! Something broke.'));
  }
});
```

Error Handling Middleware

Error-handling middleware has one difference: it includes an `err` argument.

Any error handling middleware should be written **after** all other middleware in an app.

```
app.get('/fail', (req, res, next) => {
  next(new Error('Oh no! Something broke.'));
});

app.get('/fail-miserably', (req, res, next) => {
  next(new Error('Oh no! Something broke...badly'));
});

app.use((err, req, res, next) => {
  if (err.message === "Oh no! Something broke.") {
    return res.status(400).json({ error: 'Specific fail.' });
  }
  next(err);
});

app.use((err, req, res, next) => {
  res.status(500).json({ error: 'Something went wrong.' });
});
```

Parameters & Queries

Route Parameters (`:param`): parts of a URL act as variables

```
app.get('/users/:id', (req, res) => {
  res.send(`User ID: ${req.params.id}`);
});
// GET /users/17 => 'User ID: 17'
```

Query Strings (`/?key=value`): key-value pairs that appear after a ? in the url

```
app.get('/search', (req, res) => {
  const searchQuery = req.query.q;
  const pageNum = req.query.page;
  res.send(`Results for: ${searchQuery}, page: ${pageNum}`);
});
// GET /search?q=express&page=2 => 'Results for: express, page: 2'
```

Route Matching

```
const express = require('express');
const app = express();

// In this case, /api/data would detect this route
instead!
app.get('/api/:id', (req, res) => {
  res.send(`User ID: ${req.params.id}`);
});

app.get('/api/data', (req, res) => {
  res.json({ received: req.body });
});

app.listen(3000, () => console.log('Server
running on port 3000'));
```

Order matters: routes are matched by the order in which they are written

The first matching route is executed, all others are ignored.

Thus, you should write more specific routes before generic ones.

Server-side Navigation

For multi-page applications (NOT SPAs like React), you can use express to perform server-side routing. This allows rendering of different HTML files to different routes.

```
app.get('/', (req, res) => {
  res.sendFile(path.join(__dirname, 'views', 'home.html'));
});

app.get('/about', (req, res) => {
  res.sendFile(path.join(__dirname, 'views', 'about.html'));
});

app.get('/contact', (req, res) => {
  res.sendFile(path.join(__dirname, 'views', 'contact.html'));
});
```

Note: Express & SPAs

Since SPAs often need to serve up a single index.html and static assets, Express is not sufficient for navigation in SPAs.

For instance, in React, Express would need to serve up the React app for all non-API routes (made through React Router) using the following syntax:

```
app.use(express.static(path.join(__dirname, 'dist'))); // static assets

app.get('*', (req, res) => {
  res.sendFile(path.join(__dirname, 'dist', 'index.html'));
});
```

Class Activity

https://edstem.org/us/courses/91614/lessons/161213/slides/946487

Backend Design

How do we design a backend well for maintainability, scalability, and efficiency with data handling?

Good Backend Design

A well-designed backend is made to be scalable, maintainable, secure, and performant.

It will be beneficial to use a proper backend design pattern that's been adopted by many teams.

Backend Layers

A popular pattern for organizing code on the backend involves splitting backend code into 2-3 layers:

- **Controller Layer**: handles HTTP requests and responses
- **Service Layer**: Business logic, transform data, enforce rules and validation
- **Data Access Object (DAO)**: Directly manage data storage mechanism, like through the file system or database.

This separation keeps apps maintainable and scalable.

Router

When dealing with complex backends, it's beneficial to define Routers so that you can organize routes.

This lets you apply middleware or controllers in a clean way.

```
// app.js
app.use('/user', userRoutes);
```

```
// userRoutes.js
import { Router } from 'express';
import { getUser, createUser } from
'../controllers/userController.js';
import { authenticateToken } from '../auth.js';

const router = Router();

router.use(authenticateToken);
router.get('/', getUser);
router.post('/', createUser);

export default router;
```

Controller Layer

The **controller** is responsible for receiving HTTP requests to send to the service layer, and outputting responses.

This is one of the first points of contact for the backend, where you define how to deal with requests and responses.

```
import { getUserDataService } from '../services/userService.js';

export async function getUser(req, res) {
  const user = req.user;
  const data = await getUserDataService(user);
  res.json({ msg: `Got user: ${user}`, data });
}
...
```

Service Layer

The **service layer** handles any business logic. This should include either functions to directly fetch data, or to call data access/DAO methods to acquire the data.

You may also handle logic like validation and data cleaning here, anything to transform the contents of the request or response.

```
import { getUserData, setUserData } from '../DAO/userDAO.js';

export async function getUserDataService(user) {
  return getUserData(user);
}

export async function setUserDataService(user, data) {
  return setUserData(user, data);
}
```

DAO Layer

DAO, or a Data Access Object, separates the direct database or data access code from the business logic.

While DAO is often optional for the pattern, it is beneficial to encapsulate the access to the data source for testing.

This makes it easier to say, swap databases easily.

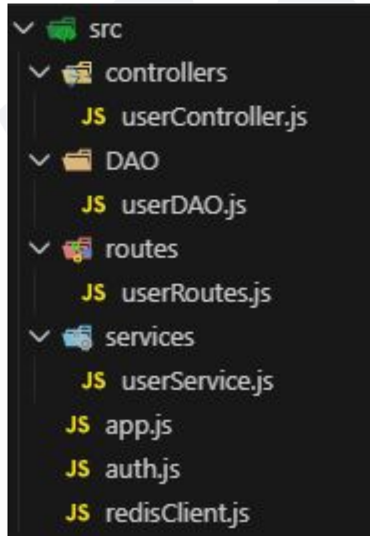
```
import redisClient from '../redisClient.js';

export async function getUserData(user) {
  const str = await
redisClient.get(`${user}:data`);
  return str ? JSON.parse(str) : null;
}

export async function setUserData(user,
data) {
  await redisClient.set(`${user}:data`,
JSON.stringify(data));
}
```

Backend Illustration

```
curl http://localhost:3000/user
     -H [Authorization Details]
```



app.js

/user

userRoutes.js

GET

userController.js

res.json({data})

req.user
(from auth)

userService.js

user data

req.user
(from auth)

userDAO.js

user data

Authorization

How do we use authorization such as JWT to secure our routes?

Authentication vs Authorization

Authentication: Who are you?

- Example: Login

Authorization: What are you allowed to do?

- Example: Accessing specific resources, admin privileges, dashboards only logged-in users can see

Authorization in APIs

We want to be able to protect certain routes by only allowing access to certain people with permissions.

We can enforce these permissions by writing authorization middleware that requires certain tokens with permission.

"Can I
GET /api/box/clx1234567890?"

"No, gimme your JWT Token
in your header!!!"

JWT Authorization

JWT (JSON Web Token) is a compact way to transmit info & permissions as a signed token.

Each token has the following structure:

```
HEADER.PAYLOAD.SIGNATURE
```

For instance:

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJ1c2VyIjoidm9yYXZpY2giLCJpYXQiOjE3NjMyNz
kxMjksImV4cCI6MTc2MzM2NTUyOX0.y58QBdd7THJCf7CupPp4Ca11gtdRp_7iik6u9TzUX5k
```

Anatomy of a JWT Token

The **header** describes the token itself, including type (“`typ`”: “`JWT`”), and signing algorithm (`e.g. "alg": "HS256"`)

The **payload** contains the data, the user identity and permissions, that you want to transmit.

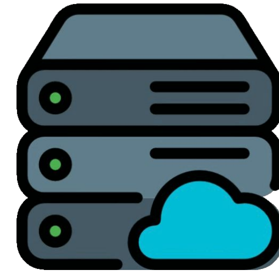
The **signature** ensures data integrity (that the info hasn’t been tampered with) by encrypting the header and payload with a secret.

Example JWT Flow

1. User logs in, backend validates credentials against database/user storage

“My username and password are…”

“Approved!”

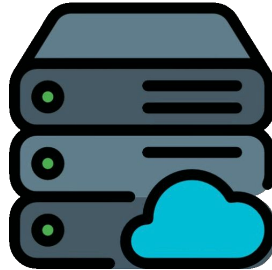


Example JWT Flow

2. Server generates a JWT token with user's identity and roles. This involves attaching a payload, a secret key (for encryption), and other options, like an expiration time.

```
const JWT_SECRET = process.env.JWT_SECRET || 'my_secret_dont_steal_pls';

jwt.sign({ user }, JWT_SECRET, { expiresIn: '24h' });
```



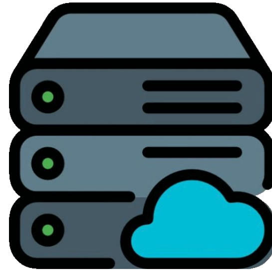
Example JWT Flow

3. User should now have the JWT token, which can be used in future requests that need it (Authorization header)

Example JWT Flow

4. The server will authenticate the user by verifying the token and the permissions granted to the user.

```
jwt.verify(token, JWT_SECRET, (err, payload) => {
     … // Check errors before returning
     req.user = payload.user; // use the payload
     next(); // this is middleware, move to the next one!
}
```



Example JWT Flow

5. The server allows or denies the action. If allowed, the action is performed.

“Thank you!”

“Here is your requested response:”

The .env file

The .env file stores environment variables in your application, so that you can keep your sensitive configurations and secrets out of your codebase. Items like:

- Database Credentials
- API/Secret keys
- App/Environment settings

```
PORT=3000
JWT_SECRET=supersecret
REDIS_URL=redis://localhost:6379
```

The file is loaded on app startup, often through libraries like `dotenv`, into the app's `process.env`.

You should **not** commit a `.env` file to a git repo. (use `.env.example` as a template)

Intro to Databases

What is a database and how do they integrate into our backend development?

What is a Database?

A database is an organized collection of data that is stored and accessed electronically.

They allow for storing, querying, updating, and securing data.

In a backend, you will use a client/driver to connect to some database using some credentials.

- `pg/postgres` for postgres
- `mongoose` for MongoDB
- `redis` for Redis

Traditional vs. Cloud DBs

Traditional Databases

- Self-hosted, requires hosting on a local machine, data center, or virtual machine.
- You are responsible for setup, installation, updates, etc.

Cloud Databases

- Managed by cloud vendors (AWS, Google)
- Runs on their infrastructure, just requires your credentials
- Pay per use

Database Types

Relational (SQL)

- Tables, schemas, relationships (e.g., PostgreSQL, MySQL)

NoSQL (Non-relational)

- Key-Value Stores (e.g., Redis)
- Document Stores (e.g., MongoDB)
- Wide Column, Graph, Time-Series, etc.

Each type optimized for different use-cases.

Redis

Redis (**Re**mote **Di**ctionary **S**erver) is a NoSQL key-value store database.

It is extremely fast due to keeping data in RAM (both for local and for cloud versions!)

It's useful for tasks like caching, session management, and real-time analytics that require fast access.

Setting up Redis (Cloud)

Create a Redis Cloud account (https://redis.io/cloud/)

Create a cloud database on their servers

Connect to the database endpoint in your code:

```
const redisUrl = process.env.REDIS_URL || 'redis://localhost:6379';

const client = createClient({
    url: redisUrl,
});

client.on('error', (err) => console.log('Redis Client Error', err));

await client.connect();
```

Using Redis

Once you have your client, you can use the get/set methods achieve data persistence.

Common convention is to use colon (:) separators to organize, define namespaces, and avoid collisions.

```
import redisClient from '../redisClient.js';

export async function getUserData(user) {
  const str = await redisClient.get(`${user}:data`);
  return str ? JSON.parse(str) : null;
}

export async function setUserData(user, data) {
  await redisClient.set(`${user}:data`, JSON.stringify(data));
}
```

Class Demo: Putting it All Together

https://edstem.org/us/courses/91614/lessons/161213/slides/946454

Let's demonstrate an Express.js backend with authorization using a Redis database.

We will need to make a cloud database (https://redis.io/cloud/) or a local database on Redis to use this code.