How to Set Up a TypeScript Monorepo

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In this Series

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The article discusses the advantages of a monorepo approach. Earthly streamlines the build process and guarantees uniformity in builds across multiple projects. Check it out.

In recent years, monorepos have become a trending topic in the IT community. When using a monorepo, an organization stores all its projects in the same repo. Monorepos are particularly popular among web developers, since most of their projects use JavaScript or TypeScript and rely on the same npm dependencies.

In this tutorial, we'll go over what a monorepo is, why, and when you should consider adopting it, and how to set up a TypeScript monorepo with npm.

What Is a Monorepo?

A **monorepo** is a software-development approach in which one repository contains the code and assets of several projects. It is a global project that contains smaller projects. Each of these projects can be anything from a single application to reusable packages of components or utility functions. Within a monorepo, these packages are typically called *local packages*.

A **monorepos** generally includes many applications and several packages; a package can depend on other packages. For example, the `ui` package may use functions exposed by the `utils` package. On the other hand, the apps are usually not dependent on each other.

> *Monorepo* is not to be confused with a *monolithic application*! A **monolith** is a single project whose components must be deployed together. A monorepo, on the other hand, consists of several independent applications that live in the same repository and share code through local packages, but can be deployed on their own. Thus, monorepos allow greater deployment flexibility than monoliths.

What Are Some Benefits of a Monorepo?

There are three specific reasons to consider adopting a monorepo approach:

1. **It's easier to standardize code and tooling across teams.** Because all code is stored in the same place, it's easier to apply the same rules for indentation and linting. Every team relies on the same code linting and formatting libraries, which are part of the monorepo.
2. **It enables better visibility and collaboration across teams.** Developers have access to all projects, which makes it easier to reuse and share code.
3. **It facilitates file organization and easier management of code dependencies.** In a monorepo, there's one version for each dependency. This means that you no longer have to worry about incompatibilities or conflicting versions of external libraries.

When Should You Start Using a Monorepo?

The perfect time to adopt a monorepo approach is when you're starting a project. This way, you can take advantage of all its benefits from day one.

A monorepo strategy is particularly appealing if you have a large number of projects or plan to scale quickly. With a monorepo, you're not starting from scratch when you create a new project; all you have to do is add it to the monorepo, and you immediately have access to several packages and an existing CI setup. Monorepos are especially worthwhile if your projects are based on the same technologies as this enables code sharing. Even tech giants like **Google rely on a huge monorepo**.

At the same time, the monorepo approach has its pitfalls.

First, don't forget that **setting up a build pipeline for your monorepos may not be easy**. This is especially true if your monorepo consists of several apps that should be deployed in a particular order. If your pipeline isn't perfectly configured, your deployments could lead to downtime or malfunction.

Second, coordinating the versioning of all products, services, and libraries that are part of a monorepo is a complex process. If you adopt a monorepo, you need to pay even more attention to each commit. Also, every member on the development team should be highly skilled with Git or a similar version control system.

So if your teams use very different technologies, a polyrepo might be the best approach. But keep in mind that migrating from a **polyrepo to a monorepo** can be cumbersome, challenging, and time consuming. While this migration might sometimes be worth the effort, the earlier you adopt a monorepo, the better.

How to Build a TypeScript Monorepo With NPM

Building a monorepo in TypeScript isn't a simple task, which is why several monorepo build tools are on the market these days to **make** things easier. The most popular monorepo build tools are **Lerna**, **Nx**, and **Turborepo**. With these, you can set up a monorepo in TypeScript with a bunch of npm commands. However, you may not be able to understand what these tools do behind the scenes or why.

The only way to master monorepos in TypeScript is to understand how they work. So let's learn how to implement a TypeScript monorepo based on npm workspaces.

You can take a look at the final result by cloning the **GitHub repository that supports this tutorial** with the following command:

```
git clone https://github.com/Tonel/typescript-monorepo
```

Now let's build a TypeScript monorepo from scratch!

Prerequisites

To build a TypeScript monorepo with npm workspaces, you'll need:

- **Node.js >= 14**
- npm >= 7

Note that you need `npm >= 7` because npm workspaces were introduced in version 7. We'll go over why you need them and what they are soon.

Initialize the Directory Structure

This is what your monorepo directory structure should look like:

```
typescript-monorepo
├── src
├── node_modules
├── ...
└── packages
```

The `src` folder stores a Node.js TypeScript application, while `/packages` contains the shared local libraries defined as npm workspaces. Note that there is only one `node_modules` folder in the entire codebase. This means that each package has its npm dependencies stored in the global `node_modules` folder.

Let's create this basic folder setup with the following commands:

```
# create the monorepo root directory
mkdir typescript-monorepo

# enter the newly created directory
cd typescript-monorepo

# creating the subdirectory
mkdir src
mkdir packages
```

Define the Global `package.json` File

Inside the `monorepo-typescript` directory, launch the following command:

```
npm init -y
```

This initializes a `package.json` file for you. Note that the `-y` flag tells `npm init` to automatically say yes to all questions npm would otherwise ask you during the initialization process.

Now, let's update the `/package.json` as follows:

package.json Copy

```
{
  "name": "monorepo-typescript",
  "version": "1.0.0",
  "description": "A monorepo in TypeScript",
  "private": true,
  "workspaces": [
    "packages/*"
  ]
}
```

In detail, make sure the **`workspaces`** property is present and configured as above. **Npm workspaces** allow you to define multiple packages within a single root package. With this configuration, every folder inside **`/packages`** with a **`package.json`** file is considered a local package.

When you run **`npm install`** in the root directory, folders within **`packages/`** are symlinked to the **`node_modules`** folder. For example, let's assume you have a **`ui`** local package. After running **`npm install`**, your monorepo project should have the following folder structure:

```
typescript-monorepo                                    >_
├── ...
├── node_modules
│   ├── ui -> ../packages/ui
│   └── ...
├── package.json
├── package-lock.json
└── packages
    └── ui
        ├── ...
        └── package.json
```

As you can see, the **`ui`** package folder also appears in the **`node_modules`** directory. Specifically, the **`ui`** folder inside **`node_modules`** links to the **`ui`** folder inside **`./packages`**.

Add the Core Dependencies

Since you're setting up a TypeScript monorepo, you need to install `typescript` as a root dependency with the following command:

```
npm install typescript
```

Note that the libraries installed here should be considered a core dependency of the project.

You also need `ts-node` and its types. Install them as dev dependencies with the npm command below:

```
npm install --save-dev @types/node ts-node
```

`ts-node` transforms TypeScript into JavaScript and allows you to execute TypeScript on Node.js without precompiling. Since `src` contains a Node.js app, you need `ts-node` to run the files placed in the `src` folder.

All packages in your application should follow the same linting and indentation rules. This is why you should add `eslint` and `prettier` to your root project's dependencies. Since this is a TypeScript codebase, you also need `@typescript-eslint/eslint-parser` and `@typescript-eslint/eslint-plugin`. These are the TypeScript parser and plugin for eslint, respectively.

Install them all as dev dependencies with the npm command below:

```
prettier @typescript-eslint/eslint-parser @typescript-eslint/eslint-p
```

Then, create an **eslint configuration file**. For example, you can initialize a `.eslintrc.json` file as follows:

eslintrc.json Copy

```
{
  "extends": [
    "eslint:recommended",
    "plugin:@typescript-eslint/recommended"
```

```
    ],
    "parser": "@typescript-eslint/parser",
    "plugins": [
      "@typescript-eslint"
    ]
  }
```

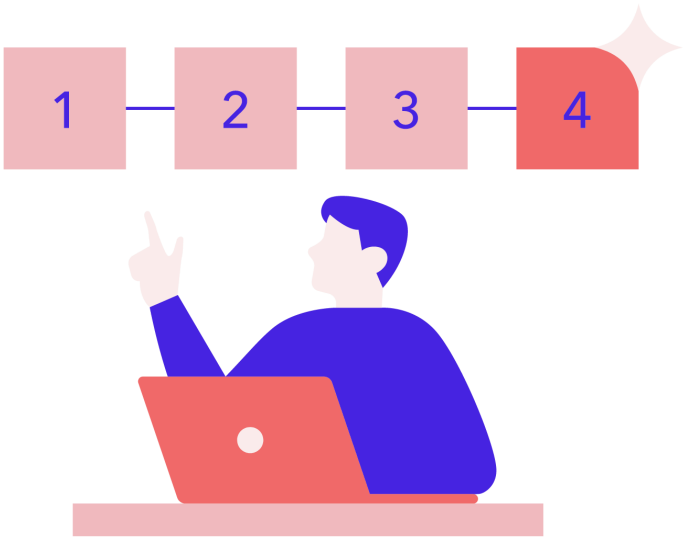
Similarly, create a **prettier configuration file**. Again, you can define a `.prettierrc.json` file as below:

prettierrc.json Copy

```
{
  "trailingComma": "all",
  "tabWidth": 2,
  "printWidth": 120,
  "semi": false,
  "singleQuote": false,
  "bracketSpacing": true
}
```

Now, all code within the monorepo codebase have the same style and follow the same rules.

Add a Local Package



Now let's set up a local package. The `@monorepo/utils` package includes all the utility functions to use across the entire monorepo.

First, create the `utils` folder inside `/packages`:

```
mkdir utils
```

Initialize a `package.json` file inside `utils` with this npm command:

```
npm init --scope @monorepo --workspace ./packages/utils -y
```

The `--scope` flag specifies an **npm scope name** in the package name.

> You should adopt the same npm scope name for all your local packages. This keeps your monorepo `node_modules` directory cleaner, as all your local packages will appear as links in the same `@<scope_name>` folder. Also, it makes local imports more elegant and easy to recognize from global npm libraries.

Make sure `package.json` contains the following content:

package.json Copy

```
{
  "name": "@monorepo/utils",
  "version": "1.0.0",
  "description": "The package containing some utility functions"
  "main": "build/index.js",
  "scripts": {
    "build": "tsc --build"
  }
}
```

Here, you're simply defining a basic `package.json` file with a custom `build` script that runs `tsc --build`. If you're not familiar with this command, `tsc` is

the TypeScript compiler. In detail, `tsc` compiles TypeScript to JavaScript according to the rules defined in `tsconfig.json`. This is why you also need a `tsconfig.json` file. Initialize it as follows:

tsconfig.json Copy

```
{
    "compilerOptions": {
        "target": "es2022",
        "module": "commonjs",
        "moduleResolution": "node",
        "declaration": true,
        "strict": true,
        "incremental": true,
        "esModuleInterop": true,
        "skipLibCheck": true,
        "forceConsistentCasingInFileNames": true,
        "rootDir": "./src",
        "outDir": "./build",
        "composite": true
    }
}
```

This is a basic `tsconfig.json` template. In particular, notice the last three options.

To make the package cleaner, put all your code in the `src` local directory under `ui`. With the `rootDir` option, you can define the package root directory where you intend to place your code. Similarly, the `outDir` option makes sure that the package is built in the local `./build` directory inside `ui`.

As explained in the **TypeScript documentation**, set the `composite` option to `true`. Since you're likely to reference this project in other parts of the monorepo, this enables you to reference this package in other `tsconfig.json`. As you're about to learn, this will be useful in the next few steps.

Now, define the logic of the package by creating an `src` directory:

```
cd packages/ui
mkdir src
```

>_

This folder contains all your code. Then, initialize an `index.ts` file as follows:

index.ts Copy

```
// ./packages/utils/index.ts

export function isEven(n: number): boolean {
    return n % 2 === 0
}
```

> ***Note that this is just a simple example. In a real-world scenario, define all your utility functions in the `./src` folder.***

This is what the file structure of the `@monorepo/utils` local package looks like:

```
utils
└── src
|   └── index.ts
├── package.json
└── tsconfig.json
```

You just learned how you can define a local package for your monorepo. Repeat this process as many times as you need, depending on the number of local packages you want to define.

As explained earlier, npm automatically processes any `package.json` file under `/packages` to create a link between the local package folder and the package folder in `node_modules`. This is also why each package requires a `package.json` file. So, every time you define a local package, you should run `npm install` in the root folder of your directory.

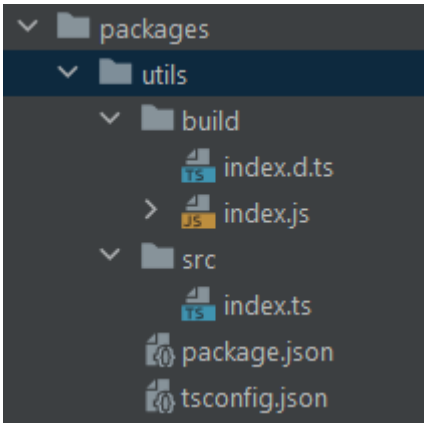
Verify That the Local Package Works

You can build the local package to see if it works with the command below:

```
npm run build --workspace ./packages/utils
```

Make sure to launch it in the root directory of the monorepo. This command executes the `build` script defined in the local `package.json` of the package specified with the `--workspace` flag. Don't forget that a local package is nothing more than an npm workspace, which is why you need to use the `--workspace` flag.

At the end of the compilation process, if everything worked as expected, you can find the compilation results in the `.packages/utils/build` folder as follows:



packages/utils/build folder

Define a Global `tsconfig.json` File

Initialize a `tsconfig.json` file in the root directory with the following content:

tsconfig.json Copy

```
{
  "compilerOptions": {
    "incremental": true,
    "target": "es2022",
    "module": "commonjs",
    "declaration": true,
    "strict": true,
    "moduleResolution": "node",
    "esModuleInterop": true,
    "skipLibCheck": true,
    "forceConsistentCasingInFileNames": true,
    "rootDir": "./src",
    "outDir": "./build"
  },
  "files": [
```

```
  ],
  "references": [
    {
      "path": "./packages/utils"
    }
  ]
}
```

Thanks to **TypeScript references**, you can split a TypeScript project into smaller parts. With the `references` option, you can define the list of packages your TypeScript monorepo consists of. When running `tsc -- build` in the root directory, the TypeScript compiler accesses all packages defined in `references` and compiles them one by one in order.

For example, let's assume you also added a `ui` package. In that case, the `references` option of `./tsconfig.json` looks like this:

tsconfig.json Copy

```
"references": [
  {
    "path": "./packages/utils"
  },
  {
    "path": "./packages/ui"
  }
]
```

Add a new `build` script in the global `./package.json` file:

package.json Copy

```
"scripts": {
  "build": "tsc --build --verbose"
}
```

The `--verbose` flag to make `tsc` log what it's doing in the terminal.

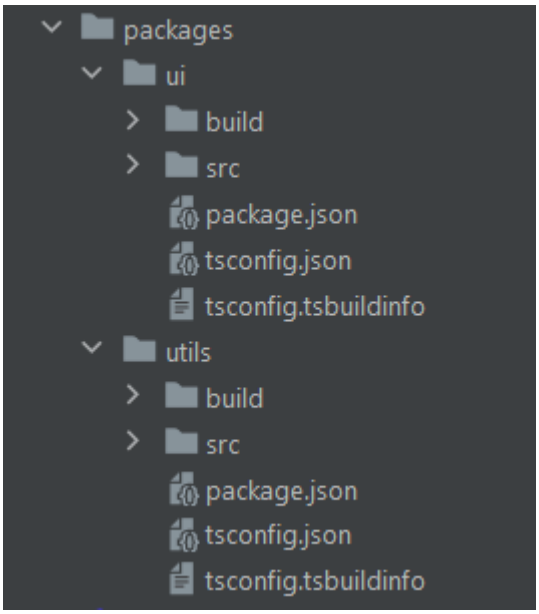
Now, if you run `npm run build` in the root directory, `tsc` should print:

```
Projects in this build:                                    Output
  * packages/utils/tsconfig.json
  * packages/ui/tsconfig.json
  * tsconfig.json
```

As you can see, `tsc` builds the projects in the order specified in the `references` field.

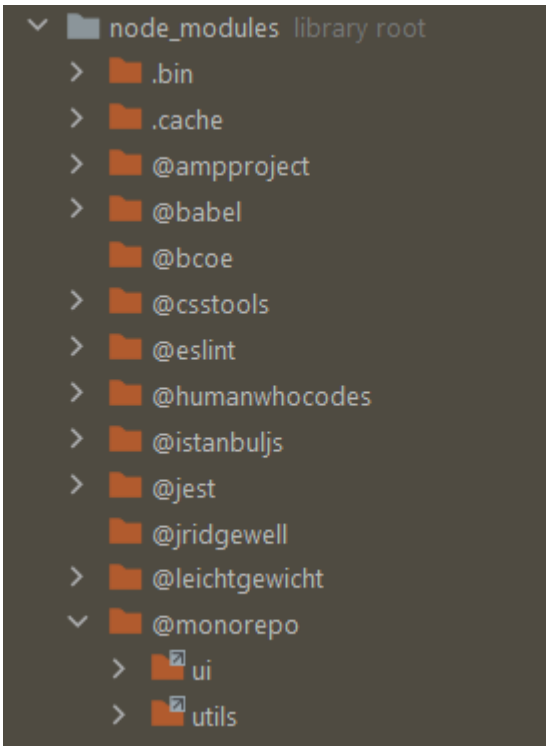
At the end of the compilation process, for each local package, you'll have:

- A `./packages/<package-name>/build` folder



Local package folder

- A link from `node_modules/@<scope_name>/<package-name>` to `./packages/<package-name>`



Link between node modules folder and package folder

Use a Local Package Inside Another Local Package

Now, let's assume you want to use some utility functions from the `@monorepo/utils` in the `@monorepo/ui` package. All you have to do is run the following npm command in the root directory:

```
npm install @monorepo/utils --workspace ./packages/ui
```

This adds `@monorepo/utils` as a dependency in `@monorepo/utils`.

Take a look at the local `package.json` file inside `./packages/ui` and you'll see:

package.json Copy

```
"dependencies": {
  "@monorepo/utils": "^1.0.0"
}
```

This means that `@monorepo/utils` was correctly added as a dependency.

Now, in `./packages/ui/index.ts`, you can access the utility functions exposed by `@monorepo/utils` as follows:

index.ts Copy

```
// ./packages/ui/index.ts

import { isEven } from "@monorepo/utils"

export function FooComponent() {
  // giving a random integer number between 0 and 5
  const randomNumber = Math.floor(Math.random() * 5)
  console.log(`FooComponent: ${randomNumber} -> isEven: \
  ${isEven(randomNumber)}`)

  // UI component implementation ...
}
```

In detail, you can import the functions from the **`@monorepo/utils`** package with the following line:

```
import { isEven } from "@monorepo/utils"
```

>_

Add an External npm Package to a Local Package

Your local packages may require external npm libraries. In this case, don't run an **`npm install`** command inside the package folder; that would add the dependency to the local **`package.json`** file and consequently generate a locale **`node_modules`** folder. This violates the core idea that a monorepo has only one **`node_modules`**.

Instead, follow this procedure to add an external npm package to a local package of your monorepo.

Let's assume you want to add **`[moment](https://www.npmjs.com/package/moment)`** to the **`@monorepo/ui`** package. Run the following **`npm install`** command in the root folder of your monorepo:

```
npm install moment --workspace ./packages/ui
```

>_

This installs `moment` in the monorepo's `node_modules` folder and adds the following section to the local `packages.json` inside `./packages/ui`:

package.json Copy

```
"dependencies": {
  // ...
  "moment": "^2.29.4"
}
```

You can verify that everything went as expected by checking that there's only one `node_modules` folder in the entire monorepo project.

Then, you can use `moment` as below:

index.ts Copy

```
// ./packages/ui/index.ts

import { isEven } from "@monorepo/utils"
import moment from "moment"

export function FooComponent() {
  // giving a random integer number between 0 and 5
  const randomNumber = Math.floor(Math.random() * 5)
  console.log(`[${moment().toISOString()}] FooComponent: \
  ${randomNumber} -> isEven: ${isEven(randomNumber)}`)

  // UI component implementation ...
}
```

In detail, you can import `moment` and use it in `@monorepo/ui` with the following `import` statement:

package.json Copy

```
import moment from "moment"
```

Putting It All Together

Now, add **`@monorepo/utils`** and **`@monorepo/ui`** as project dependencies in the global **`./package.json`** file with this npm command:

```
npm install @monorepo/utils @monorepo/ui
```

Then, create a **`./src/index.ts`** file and make it use the functions exposed by your local packages:

index.ts Copy

```
import { FooComponent } from "@monorepo/ui"
import { isEven } from "@monorepo/utils"

console.log(isEven(4))
FooComponent()
```

Now, test if the Node.js **`./src/index.ts`** file works:

```
# building the monorepo and all its packages
npm run build

# running the compiled index.js
node src/index.js
```

This prints:

```
true
[2022-11-23T14:28:14.220Z] FooComponent: 4 -> isEven: true
```


Conclusion

As you know, a monorepo consists of several applications, with each application relying on many packages that may depend on each other. So to ensure that you can correctly deploy an application that's part of a monorepo, it's essential to

build and deploy each package in the right order. Therefore, you need to define a monorepo pipeline.

Earthly can help you with that. It's a build automation tool that enables you to run all your builds in containers. Earthly runs on top of the most popular CI systems, such as **Jenkins**, **CircleCI**, GitHub Actions, and AWS CodeBuild, and you can easily adopt it to set up your monorepo pipeline.

Antonello Zanini

I'm a software engineer, but I prefer to call myself a Technology Bishop. Spreading knowledge through writing is my mission.

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Bala is a technical writer who enjoys creating long-form content. Her areas of interest include math and programming. She shares her learning with the developer community by authoring tutorials, how-to guides, and more.

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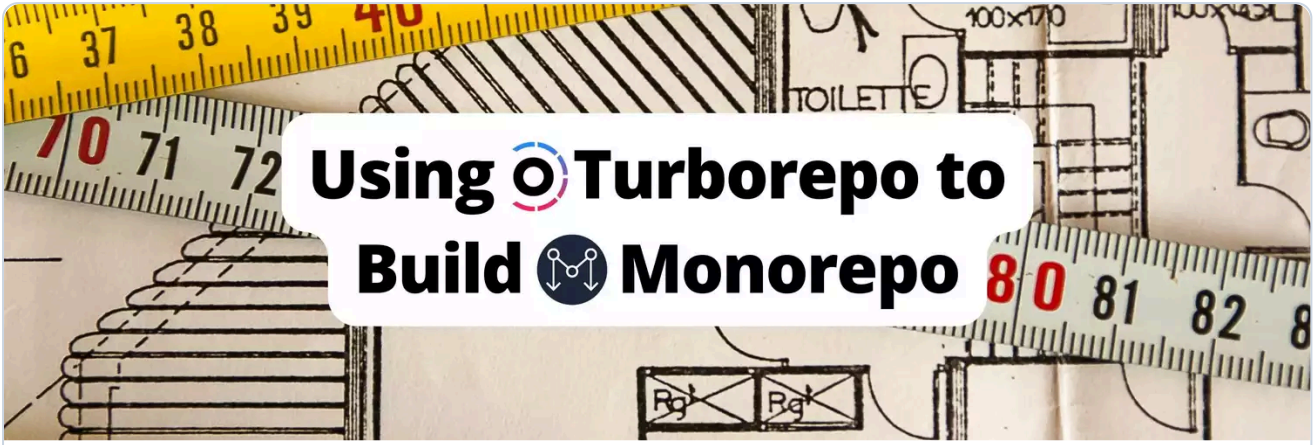

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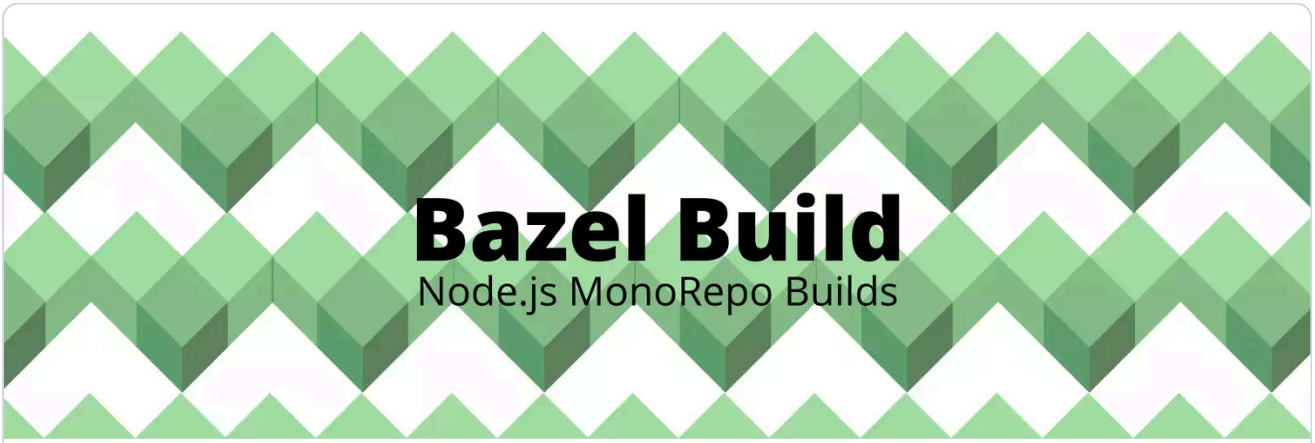

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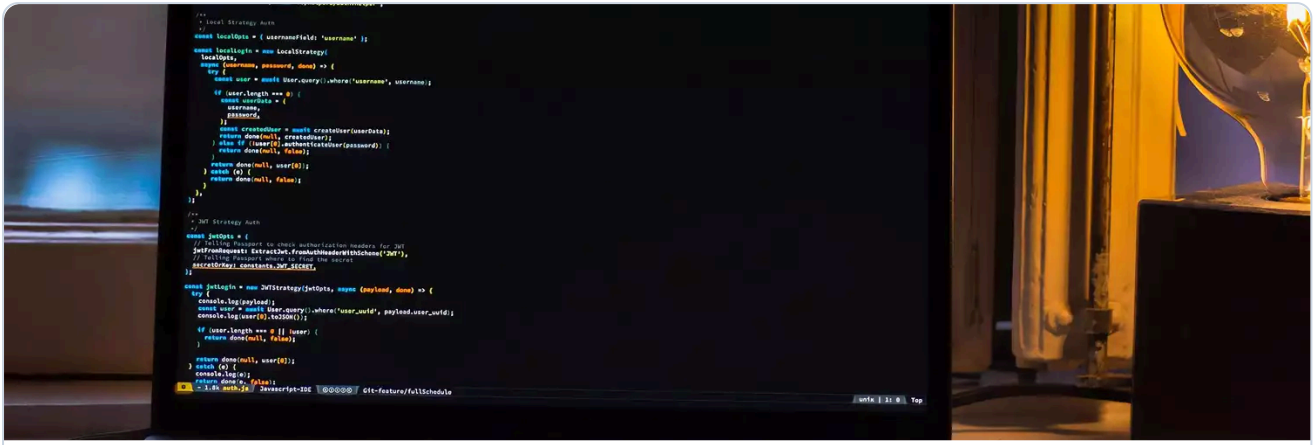

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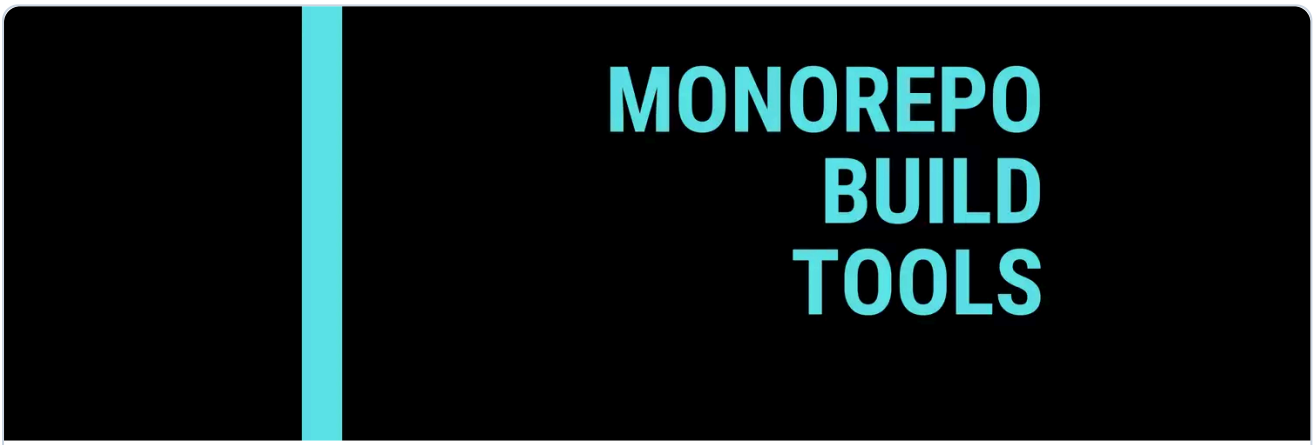

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