Harnessing The Power of

Hexagonal Architecture

Note: Hyperlinks are not active when viewed from GitHub's file viewer. Either navigate back to the main ReadMe for the project and click the link for this document in the Design Notes section or type this link into your browser ***https://woodyb.github.io/vending-machine-project/design/Harnessing-The-Power-of-Hexagonal-Architecture.pdf***

Benefits of Hexagonal Architecture

Hexagonal architecture, with its emphasis on testability and modularization, stands out as a powerful design pattern. However, it's essential to recognize that hexagonal architecture need not exist in isolation – It can be seamlessly integrated with other architectural paradigms to unlock even greater benefits. It’s not an all or nothing decision when you add hexagonal architecture.

Hexagonal Architecture: A Foundation for Testability

Hexagonal architecture, also known as **ports and adapters** architecture, provides a solid foundation for building software systems that are both flexible and testable. By decoupling application logic from external dependencies, it enables thorough testing and promotes independent development of components. The benefits of hexagonal architecture extend beyond testability to include flexibility, separation of concerns, and enhanced collaboration.

Embracing Integration

While hexagonal architecture offers numerous advantages on its own, it can also be combined with other architectural patterns to amplify its benefits. Integrating hexagonal architecture with microservices, event-driven architecture, or serverless architecture to name a few enables teams to achieve a more versatile and powerful software design.

Microservices Architecture

Pairing hexagonal architecture with microservices facilitates the development of independently deployable services with modularized internal components. This combination enhances agility and reliability while ensuring testability and flexibility at the architectural level. Having worked before as a SDET responsible for testing microservices I often found there was some testing that I wanted to conduct that was very difficult because I could not isolate the core logic in the microservice. Some ports and adapters in the microservices would have made this work so much easier. What I've come to realize over the years is you don't need SDETs that can perform heroics to find ways to test your product if you are creating testable software, which will be better designed software.

Event-Driven Architecture

In event-driven systems, hexagonal architecture can be applied within individual components to ensure testability and independence from infrastructure concerns. This approach enables the development of resilient, scalable systems that can evolve over time while benefiting from the isolation provided by hexagonal architecture.

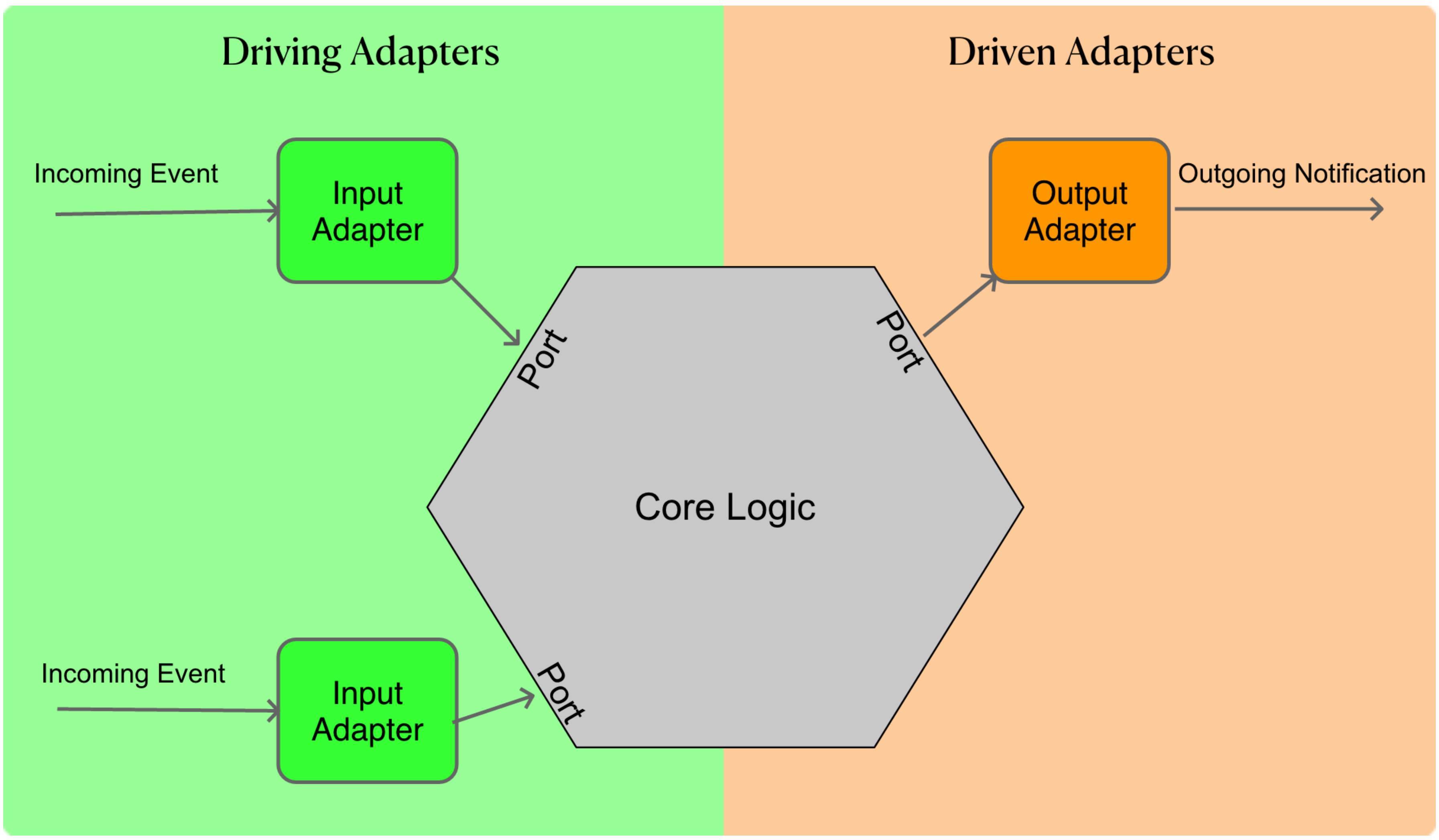
Serverless Architecture

Combining hexagonal architecture with serverless functions enhances modularity and testability within serverless applications. By encapsulating business logic and dependencies, developers can achieve greater agility and reliability in their serverless deployments.

Embracing A Hybrid Approach

The integration of hexagonal architecture with other architectural patterns represents a hybrid approach that leverages the strengths of each paradigm. By embracing this approach, teams can unlock the full potential of their software designs, achieving greater flexibility, maintainability, and testability in an ever-changing technological landscape. I recently discovered Tech Excellence led by Valentina Cupać. Here's a good LinkedIn talk on TDD in Hexagonal Architecture and Clean Architecture from Valentina.

Hexagonal Architecture In The Vending Machine Project



Basic Idea

I'll leave it to you to dig in on hexagonal architecture but at a high level it looks something like this. Here's a link to Dr. Alistair Cockburn's website which is a good place to start.

The core logic is inside the hexagon and only interacts with outside entities through a port. What's a port in this context? It's an agreed upon way for the core logic to communicate with an adapter. In software terms this will usually be an interface if the language supports them. We are using Typescript and it does support Interfaces. So we can think Port equals Interface for this project.

Now, what are adapters? Adapters are kind of glue code. Driving adapters take incoming events and convert the information as necessary in order to send it through a port to the core logic. Code-wise, in this project these will normally be implemented as classes. Driven adapters just do the inverse in that they take output from the core logic and convert it so it can be used by whatever is connected to the other side of the adapter.

Vending Machine Logic Controller

The Logic Controller is our core logic. It is being implemented as a FSM (Finite State Machine) for now. However, if we decide to implement the core logic another way as long as we don't change the ports (Interfaces) our tests should still function.

Port Example

Let's look at an example of a port and adapter in our project. Here's an input port for getting how much money the user has put into the vending machine before making a selection. I don't know how real vending machines work but I do know they have something called a coin mechanism. I don't know if real coin mechanisms typically keep such a balance but I also know there has to be some way to find out if the user has inserted enough money. So I've created the interface to make it easy for my core logic to get the information it needs. It will be the adapter's job to interact with a coin mechanism however it works so that the core logic can consume it through the port. In our case the core logic will be calling `readPendingTransactionTotal()`

```
export interface CoinMechanismInsertedCoinsInterface {

    insertCoin(coin: Coins): void;

    readPendingTransactionTotal(): number;

}
```

Adapter Example

Ok so we've got a port, how about the adapter. We don't have a real coin mechanism but we do have a simulator in this project. The vending machine software along with the simulator is our shipping "product." The simulator is being created to allow a user to interact with the vending machine in ways like inserting coins. The core logic has no idea of what's on the other side of the interface nor should it. Let's have a look at two adapters that implement the `CoinMechanismInsertedCoinsInterface`.

1) CoinMechanismInsertedCoinsSimulatorAdapter

2) CoinMechanismInsertedCoinsUnitTestAdapter

My hope is the long names give you a good clue to what the other side of the adapter is connected to. The first one is our simulator and the second one is being used for unit tests when we are testing the core logic. Sometimes adapters used by tests are just implemented in the test code and not in an individual file.

Since both of these adapters implement the `CoinMechanismInsertedCoinsInterface` they must provide methods as described in the interface or they will not compile. However, that's not the only methods they may implement. We can augment the class to have additional methods. This allows us to create a test doubles which can be a stubs, mocks, spies etc. This is exactly what `CoinMechanismInsertedCoinsUnitTestAdapter` does.

`CoinMechanismInsertedCoinsSimulatorAdapter` is sent a coins (quarters, dimes, etc) from our simulator. It has logic to convert these coins into values.

`CoinMechanismInsertedCoinsUnitTestAdapter` exists so tests can control what the what the adapter will return to the core logic when it calls `readPendingTransactionTotal().` This is why it has this extra method in addition to the ones it had to implement to satisfy the interface contract.

```
    public updatePendingTransactionTotal(amount: number) {

        this.pendingTransactionTotal = amount;

    }
```

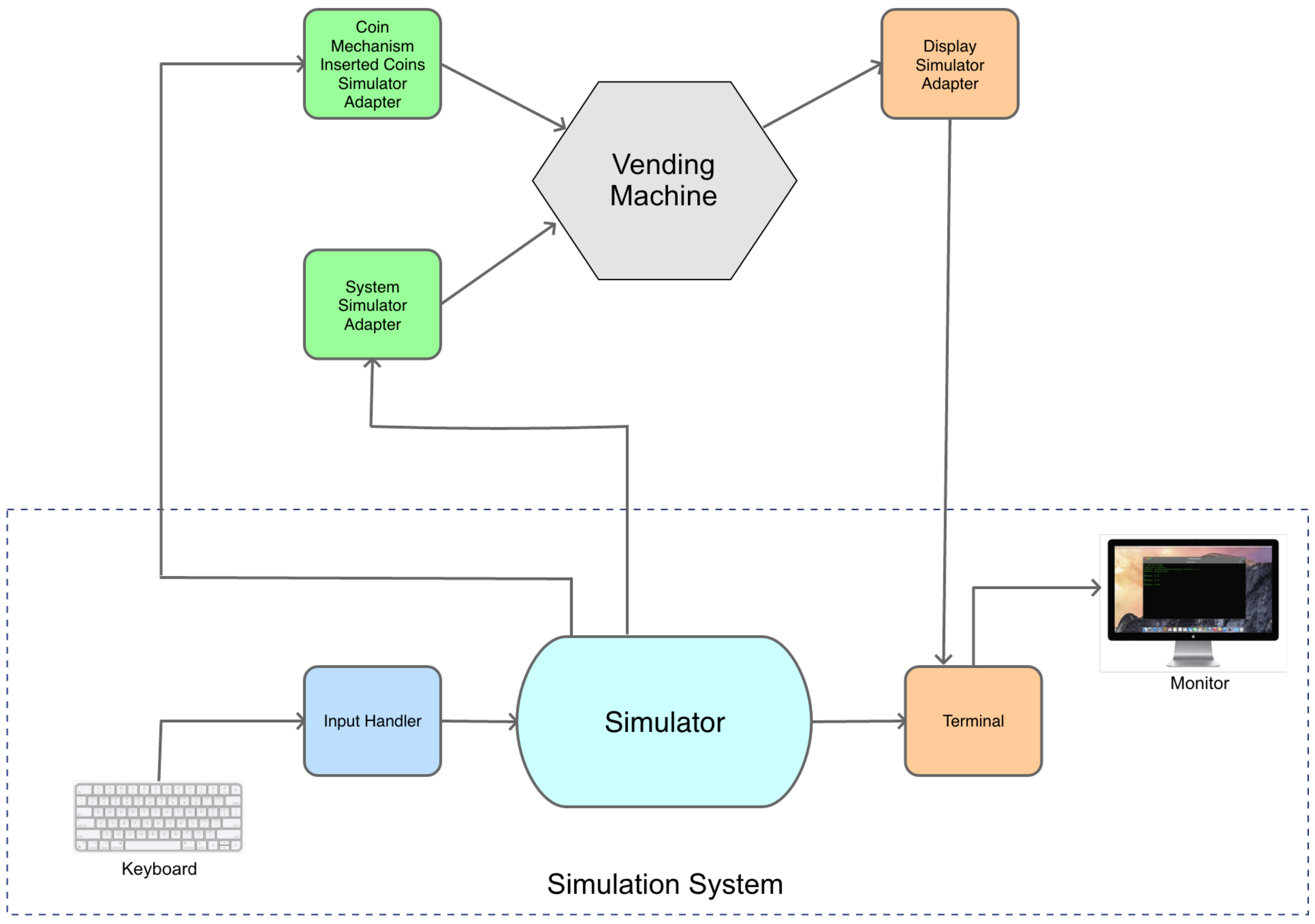
This method allows us to set whatever amount we want in the adapter so that we can write tests like this.

```
it('Should display 0.25 after a quarter is inserted', async () => {

      await powerOnSystem();

      mockCoinMechanismInsertedCoins.updatePendingTransactionTotal(.25);

      const found25Cents = await waitForVendingMachineToDisplay('0.25');

      expect(found25Cents).toBe(true);

      await powerOffSystem();

    });
```

Having complete control over all the adapters (control inputs / capture outputs) allows us to completely control the core logic's environment and thoroughly test it. To see more of these tests have a look at the commit test VendingMachine.spec.ts

The Vending Machine With Simulator Diagram

Note: This diagram is a work in progress and will be updated as functionality is added to the Vending Machine. You may need to refresh your browser a few times in order to see the most up to date version.



Walk Through

Scenario: User starts up the simulation (i.e. `node bin/index`) and once the Vending Machine and Simulator are up and running, presses **"q"** then **Enter**.

- The ***Vending Machine*** starts and begins watching for a **`POWER_ON`** event
- The ***Simulator*** starts up and sends a start up message to ***Terminal***
- ***Terminal*** simply displays the message on the monitor

- The ***Simulator*** sends a `POWER_ON` event to the ***System Simulator Adapter***
- The ***Vending Machine*** detects the `POWER_ON` event and starts up
- The ***Vending Machine*** sends its start up message which includes its version to the ***Display Simulator Adapter***
- The ***Display Simulator Adapter*** prepends "DISPLAY: " to the message to indicate this message is from the Vending Machine and intended for the Display on the machine. It then sends message on to ***Terminal*** which as before will display it on the monitor
- The ***Vending Machine*** settles into its **IDLE** state and sends the "**Insert Coin**" message to the ***Display Simulator Adapter*** (prepends "DISPLAY: ") => ***Terminal*** => monitor
- The user then presses the "**q**" key followed by **Enter**
- The ***Input Handler*** sends the key sequence data to the ***Simulator***
- The ***Simulator*** process the "***q***" key and sends a **Coins.QUARTER** to the ***Coin Mechanism Inserted Coins Simulator Adapter***
- The ***Coin Mechanism Inserted Coins Simulator Adapter*** updates its internal *Pending Transaction Total* to 0.25
- The Vending Machine reads the Pending Transaction Total from the ***Coin Mechanism Inserted Coins Simulator Adapter*** and sends "0.25" to the ***Display Simulator Adapter*** (prepends "DISPLAY: ") => ***Terminal*** => monitor

Why All This Abstraction?

Couldn't this be much simpler just to demonstrate the necessary logic and tests for the Vending Machine code kata? Yes of course but that's not the whole goal of the project. If you look at our diagram above we could completely throw away our simulator, replace the simulator adapters with new adapters that interface with real hardware components and not change our core logic in Vending Machine. This separation of concerns not only allows us to move the core logic to a whole new world with high confidence it also allows us to throughly test it since we can control its inputs and capture its outputs. If you look at the unit test for the Vending Machine (commit test VendingMachine.spec.ts) you will see that's exactly what we are doing. We also have separate tests for our Simulator so it can be tested independently of the Vending Machine.