Clean Architecture in Java / SpringBoot

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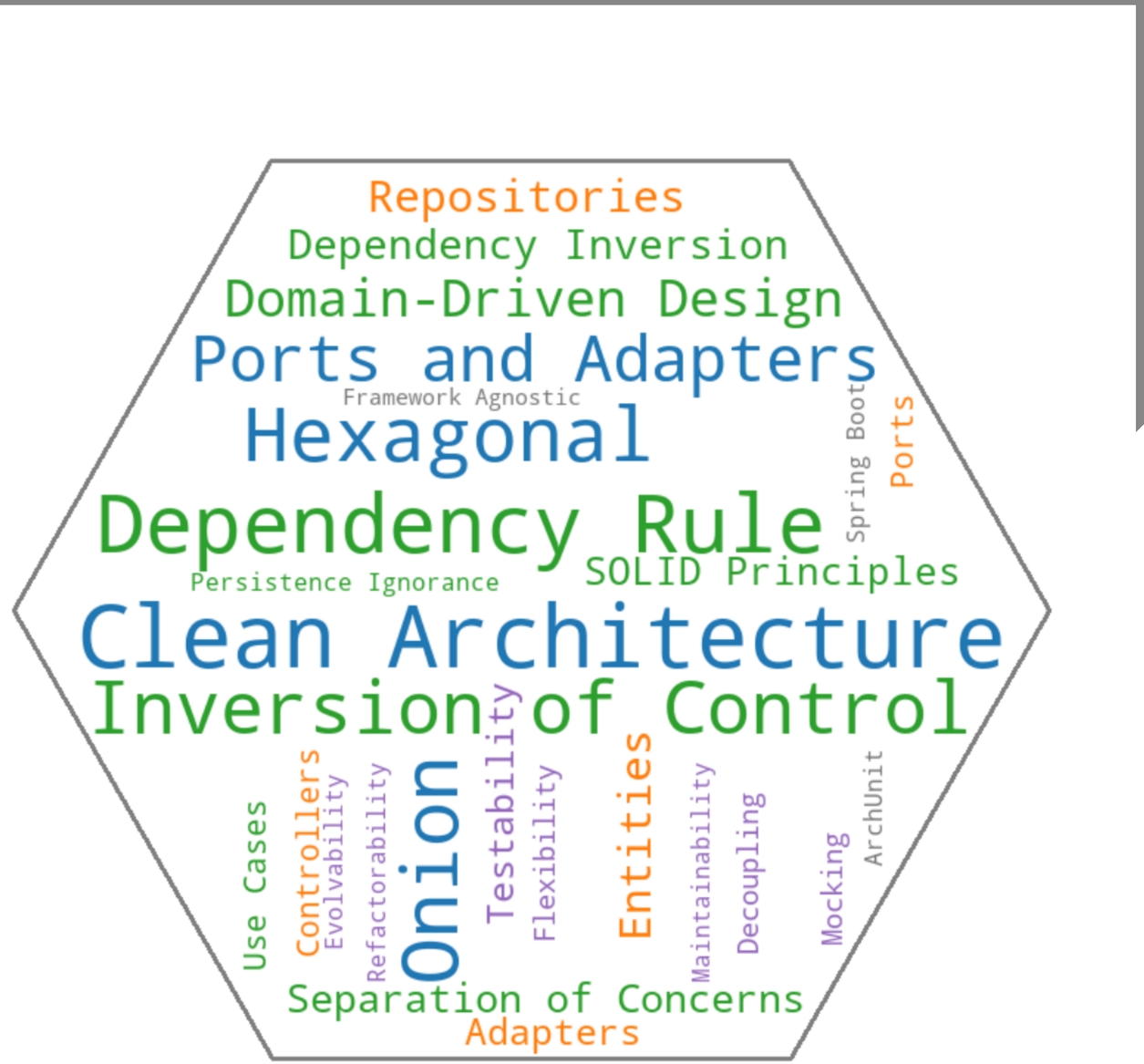
How to approach such a broad topic?



So, let's learn from a bad example ...

```java
@Service
public class CustomerScoreService {

  private final JdbcTemplate jdbcTemplate;
  private final Logger logger =
                    LoggerFactory.getLogger(CustomerScoreService.class);

  public CustomerScoreService(JdbcTemplate jdbcTemplate) {
    this.jdbcTemplate = jdbcTemplate;
  }

  public int calculateScore(Long customerId) {
    logger.info("Calculating score for customer {}", customerId);

    List<Order> orders = jdbcTemplate.query(
        "SELECT * FROM orders WHERE customer_id = ?",
        new Object[]{customerId},
        (rs, rowNum) -> new Order(rs.getLong("id"),
                                  rs.getBigDecimal("amount"))
    );

    List<Return> returns = jdbcTemplate.query(
        "SELECT * FROM returns WHERE customer_id = ?",
        new Object[]{customerId},
        (rs, rowNum) -> new Return(rs.getLong("id"),
                                   rs.getDate("return_date").toLocalDate())
    );

    int score = (int) (orders.size() * 10 - returns.size() * 20);

    logger.info("Customer {} has score {}", customerId, score);
    return score;
  }
}
```

- **It's a big ball of mud:** Spring Boot Service, dependency injection, business logic and data access are all mixed together in one class.
- **Tightly Coupled**: The service is directly coupled to the database schema and the specific SQL queries, making it hard to change or test.
- **No Separation of Concerns**: Business logic is mixed with data access logic, violating the Single Responsibility Principle.
- **Hard to Test**: Service and the business rules can't be tested in isolation.
- **No Abstraction**: There are no abstractions for the data access layer, making it hard to mock or replace with a different implementation.

Our excuses

- **"It's just a prototype!"**: Prototypes can become production code, and poor design will haunt us later.
- **"We had to get it done quickly!"**: Rushing leads to poor design and maintainability issues.
- **"We can refactor later!"**: Refactoring is often harder than we think, especially with tightly coupled code (and missing unit tests).
- **"It's not that bad!"**: We often downplay the issues, but they can grow into significant problems.
- **"We can just add more comments!"**: Comments do not replace good design; they can even hide poor code quality.
- **"Requirements were poor!"**: requirements will always be vague and incomplete, but we can still design our code to be flexible and adaptable.
- **"We don't have the budget for it!"**: Investing in good design pays off by reducing technical debt and improving maintainability.

... Nice try, but it still is poor design. And it will haunt us!

So, let's try to improve!

Traditional 3-tier Architecture

```java
@Service
public class CustomerScoreService {

  private final OrderRepository orderRepository;
  private final ReturnRepository returnRepository;
  private final Logger logger = LoggerFactory.getLogger(CustomerScoreService.class);

  public CustomerScoreService(OrderRepository orderRepository
                              ReturnRepository returnRepository) {
    this.orderRepository = orderRepository;
    this.returnRepository = returnRepository;
  }

  public int calculateScore(Long customerId) {
    logger.info("Calculating score for customer {}", customerId);

    List<Order> orders = orderRepository.findByCustomerId(customerId);
    List<Return> returns = returnRepository.findByCustomerId(customerId);

    int score = orders.size() * 10 - returns.size() * 20;

    logger.info("Customer {} has score {}", customerId, score);
    return score;
  }
}
```

```java
public class Order {
  private final Long id;
  private final BigDecimal amount;

  public Order(Long id, BigDecimal quantity) {
    this.id = id;
    this.amount = quantity;
  }
  //... getters and setters ...
}
```

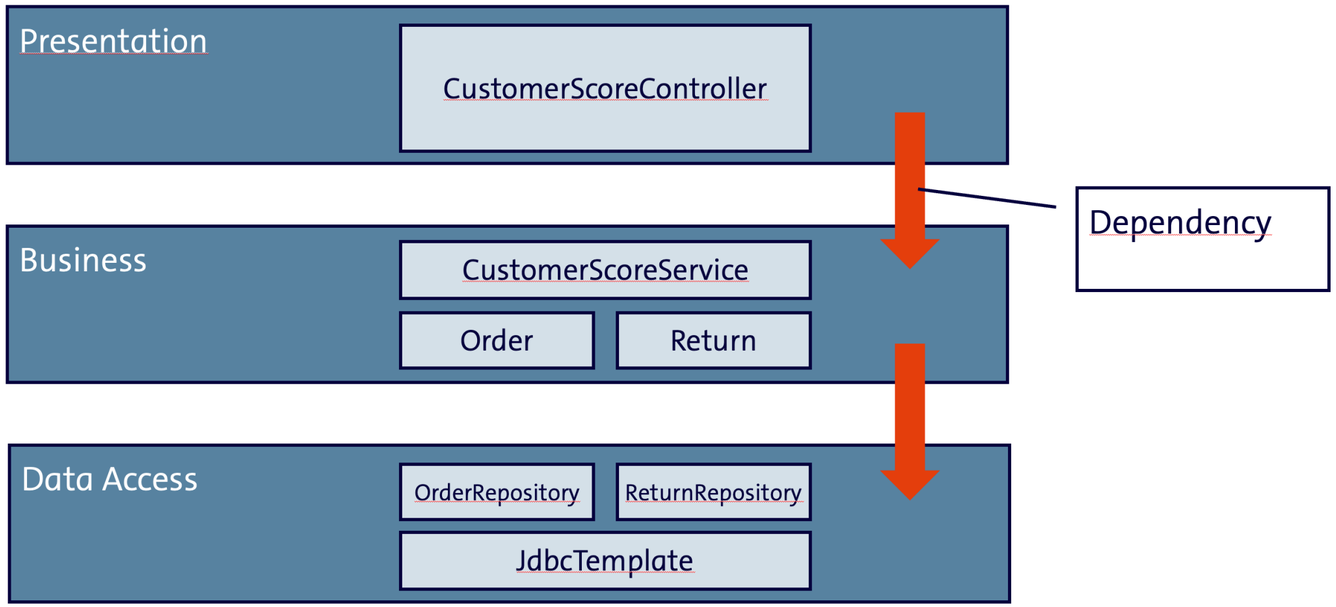
```java
@RestController
public class CustomerScoreController {

  private final CustomerScoreService customerScoreService;

  public CustomerScoreController(CustomerScoreService customerScoreService) {
    this.customerScoreService = customerScoreService;
  }

  @GetMapping("/customers/{id}/score")
  public ResponseEntity<Integer> getCustomerScore(@PathVariable Long id) {
    int score = customerScoreService.calculateScore(id);
    return ResponseEntity.ok(score);
  }
}
```

```java
@Repository
public class OrderRepository {

  private final JdbcTemplate jdbcTemplate;

  public OrderRepository(JdbcTemplate jdbcTemplate) {
    this.jdbcTemplate = jdbcTemplate;
  }

  public List<Order> findByCustomerId(Long customerId) {
    return jdbcTemplate.query(
        "SELECT * FROM orders WHERE customer_id = ?",
        new Object[]{customerId},
        (rs, rowNum) -> new Order(rs.getLong("id"), rs.getBigDecimal("amount"))
    );
  }
}
```

Problems with the 3-tier Architecture

- **No clear separation of concerns:** the service layer is still responsible for both business logic and data access.
- **Business logic in the service layer is still tightly coupled** to the data access layer, as it contains data access calls.
- **Simple junit tests not possible:** you'll either need to mock the repositories or use an in-memory database.
- **How to test the actual business logic (the score calculation) in isolation?**
- **Anaemic domain model:** the domain model (Order, Return) is just a data structure without any behavior or business logic.

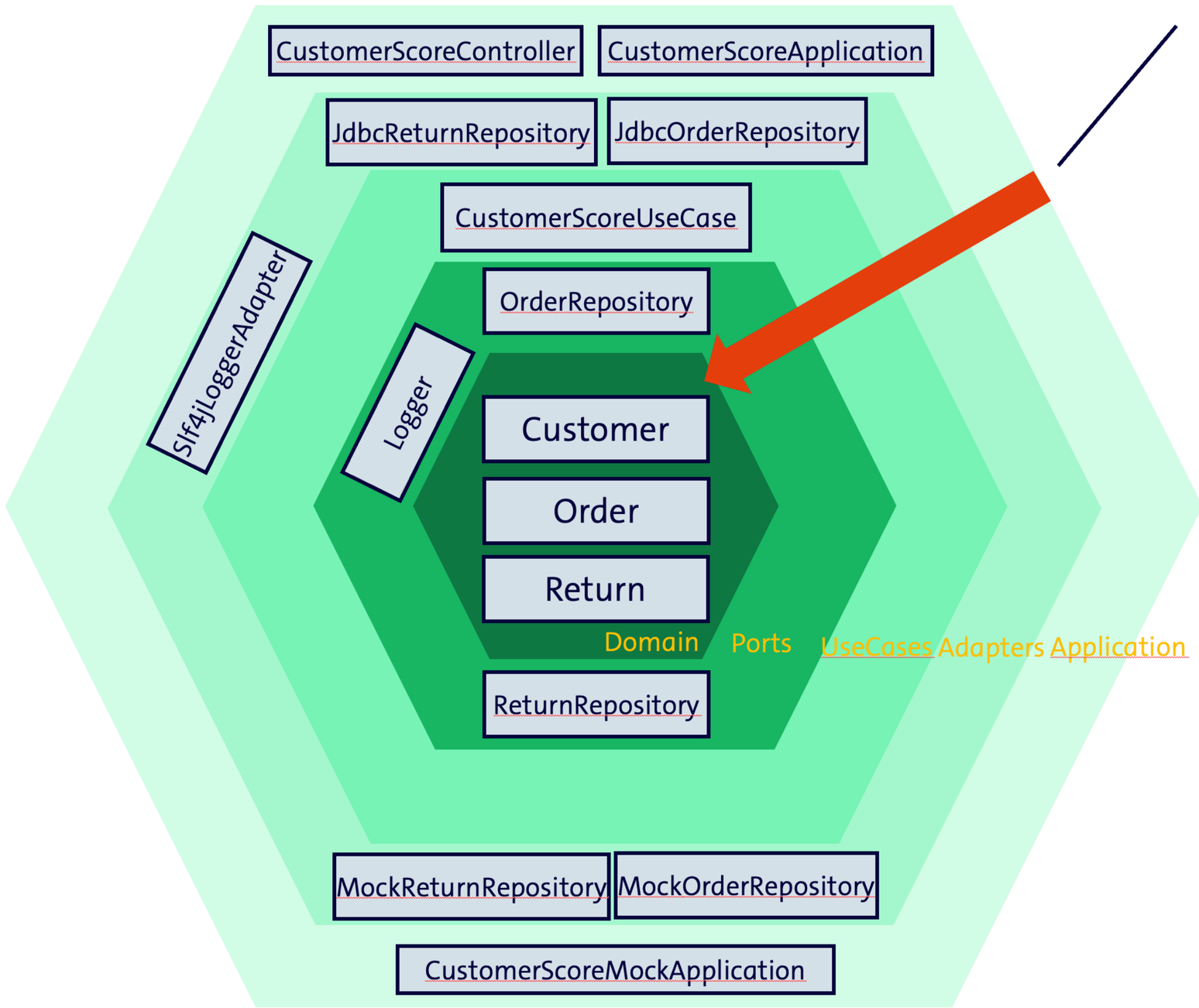
blame it on the dependency graph!



Let's try to fix it with an onion-like architecture

- Take domain driven design seriously: put the **domain** model at the center of our architecture.
  - Have business rules (like `calculateScore`) in the domain model.
  - The domain model will be **independent** of any frameworks, libraries or infrastructure code.
- Specific **use cases** are implemented around the domain model. They can access the domain model and use it to implement the business logic.
  - If use cases need to access data, services or API's, they will call against interfaces (aka. **ports**), avoiding any direct dependencies. Thus the business logic does not call infrastructure code or frameworks, like Spring, JPA, etc.
- Around the use cases, we will implement the actual infrastructure code (e.g. DB access, API access, messaging, logging). This code is organized in **interface adapters**, which implement the interfaces (ports).
- In the most external layer, we will implement the **external interface**, like REST controllers, which will delegate to the use cases to execute the business logic. SpringBoot will be used to assemble the **application**, wiring the adapters and use cases.
- Apply a strict **outside-in dependency rule**:
  - the **domain model** does not depend on anything,
  - the **use cases (and ports)** depend on the domain model,
  - the **adapters** depend on the use cases (and ports), and
  - the **application** (aka. frameworks and drivers) depends on the adapters and the use case layer.

Clean Architecture: The Big Picture



Dependency Rule:
Only inward
Dependencies allowed!

Let's have a look at the code

```java
// Domain Model
public class Customer {

  public int calculateScore(List<Order> orders,
                            List<Return> returns) {
    BigDecimal totalOrderValue = orders.stream()
        .map(Order::getAmount)
        .filter(Objects::nonNull)
        .reduce(BigDecimal.ZERO, BigDecimal::add);

    BigDecimal totalReturnValue = returns.stream()
        .map(Return::getAmount)
        .filter(Objects::nonNull)
        .reduce(BigDecimal.ZERO, BigDecimal::add);

    if (totalReturnValue.equals(BigDecimal.ZERO)
     || totalOrderValue.equals(BigDecimal.ZERO)) {
      return 100;
    } else {
      return totalOrderValue
          .subtract(totalReturnValue)
          .divide(totalOrderValue)
          .multiply(BigDecimal.valueOf(100))
          .intValue();
    }
  }
}
```

```java
// Use Case
public class CustomerScoreUseCase {

  private final OrderRepository orderRepo;
  private final ReturnRepository returnRepo;
  private final Logger logger;

  public CustomerScoreUseCase(OrderRepository orderRepo,
                              ReturnRepository returnRepo,
                              Logger logger) {
    this.orderRepo = orderRepo;
    this.returnRepo = returnRepo;
    this.logger = logger;
  }

  public int calculateScore(long customerId ) {
    logger.info("Calculating score for customer " + customerId);

    List<Order> orders = orderRepo.findOrdersByCustomerId(customerId);
    List<Return> returns = returnRepo.findReturnsByCustomerId(customerId);

    Customer customer = new Customer(customerId);
    int score = customer.calculateScore(orders, returns);

    logger.info("Customer " + customerId + " has score " + score);
    return score;
  }
}
```

```java
// Adapter
@Repository
public class JdbcOrderRepository implements OrderRepository {

  private final JdbcTemplate jdbcTemplate;

  public JdbcOrderRepository(JdbcTemplate jdbcTemplate) {
    this.jdbcTemplate = jdbcTemplate;
  }

  @Override
  public List<Order> findOrdersByCustomerId(Long customerId) {
    return jdbcTemplate.query(
        "SELECT * FROM orders WHERE customer_id = ?",
        (rs, rowNum) -> new Order(
          rs.getLong("id"),
          rs.getBigDecimal("amount")),
        customerId
    );
  }
}
```

Benefits of Clean Architecture

- **Domain-Driven Design**: Encourages a rich domain model with behavior, avoiding anaemic models.
- **Inversion of Control**: The architecture promotes inversion of control, as the use cases depend on interfaces (ports) rather than concrete implementations, allowing for better decoupling and flexibility. Leading to:
  - **Testability**: Use cases and domain logic can be tested in isolation without any dependencies on frameworks or infrastructure.
  - **Flexibility**: Easy to change or replace adapters without affecting the core business logic. As interface contracts are decoupled from implementation details.
  - **Maintainability**: Clear separation between domain logic, use cases, and infrastructure code, making it easier to re-use, refactor and evolve the codebase.
- **Technology Agnostic**: The core business logic is independent of any frameworks or libraries, making it easier to switch technologies if needed.
- **Verifiable**: The architecture can be automatically verified as it follows a strict dependency rule. This can be enforced by tools like ArchUnit to ensure the architecture is maintained over time.

Sounds good, but ...

- **Learning Curve**: Clean Architecture can be complex and may require a shift in mindset for developers who are used to traditional architectures.
- **Potential for Over-Engineering**: There is a risk of over-engineering, especially if the architecture is applied to small or simple projects where a simpler design would suffice.
- **Initial Setup**: Setting up the architecture can take more time initially, as it requires defining interfaces, adapters, and use cases.

Further Readings annd Links

- Clean Architecture by Robert C. Martin
- Implementing Domain-Driven Design by Vaughn Vernon
- Organizing Layers Using Hexagonal Architecture, DDD, and Spring
- ArchUnit - Testing Java Architecture
- ArchUnit Onion Architecture template
- GitHub Repo for my slides

Any Questions?

Thanks for your attention!