Lesson 2: Android Advanced Development

Architecture, Navigation & Modern UI

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Agenda

1. **Advanced UI & Navigation**
2. **MVVM & UDF**
3. **Dependency Injection**
4. **Deep Dive**
5. **Challenge Lab**

1. Advanced UI & Navigation

Type-Safe Navigation

Traditional Android navigation relied on Strings (`"profile/{id}"`). This was fragile:

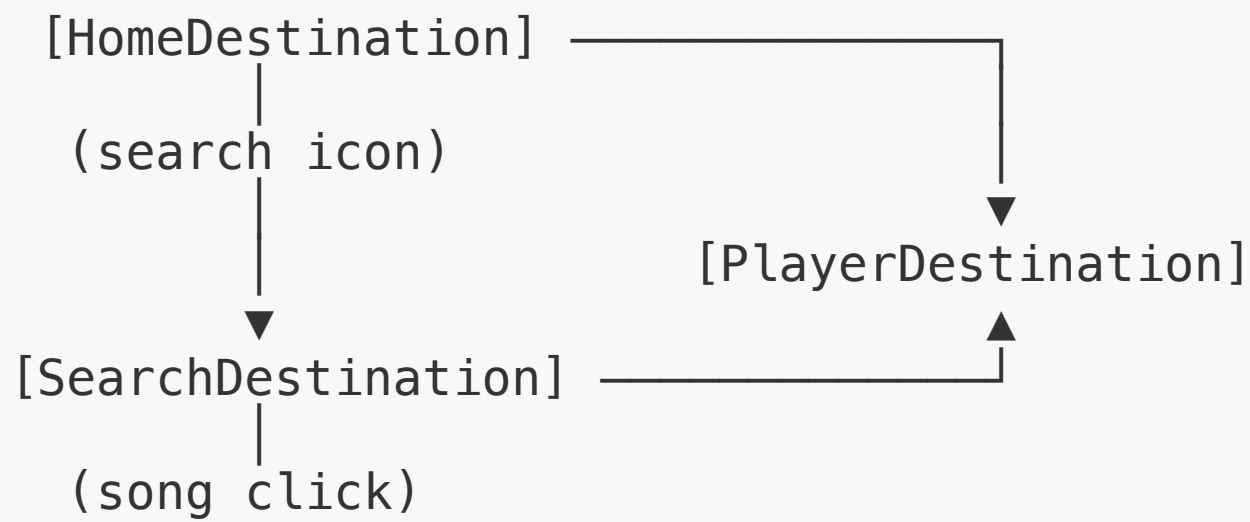
- Typos caused runtime crashes.
- Arguments were untyped (everything is a String).
- Refactoring was a nightmare (Find & Replace).

Navigation Compose 2.8+ introduces **Type Safety**:

- Define destinations as **Objects** or **Data Classes**.
- Compiler verifies types at build time.
- Arguments are typed (Int, Boolean, Custom Objects).

The Navigation Graph

The `PlayerDestination` screen is reused by both screens (Home & Search).



Defining Destinations

Key concept: `@Serializable` allows the library to turn this class into a route automatically.

```
//ui/navigation/Destinations.kt
// 1. Simple Destination (No args)
@Serializable
data object HomeDestination

// 2. Simple Destination (No args)
@Serializable
data object SearchDestination

// 3. Destination with Arguments
@Serializable
data class PlayerDestination(
    val songId: String // Type-safe argument!
)
```

Under the Hood: Serialization in Navigation

How does it work?

`kotlinx.serialization` converts your Objects into a URL format internally.

- Arguments are mapped to URL parameters.
- Primitives (Int, Bool) and Strings are supported out-of-the-box.
- Complex objects can be passed (though IDs are recommended).

Example Mapping:

`PlayerDestination(songId = "rock_1")`

⬇️

`android-app://androidx.navigation/com.example.PlayerDestination/rock_1`

The NavHost

```
//MainActivity.kt:
// Define the Graph using Types
NavHost(navController = navController, startDestination = HomeDestination) {

    // Define composable for a specific Type
    composable<HomeDestination> {
        HomeScreen(
            onSongClick = { song ->
                // Compile-time check!
                navController.navigate(PlayerDestination(song.id))
            }
        )
    }

    // Extract arguments safely
    composable<PlayerDestination> { backStackEntry ->
        val dest = backStackEntry.toRoute<PlayerDestination>()
        // destination.songId IS a String. Guaranteed.
        PlayerScreen(songId = dest.songId)
    }
}
```

The Back Stack & Pop Behavior

Navigation Compose manages a "LIFO" (Last-In, First-Out) stack.

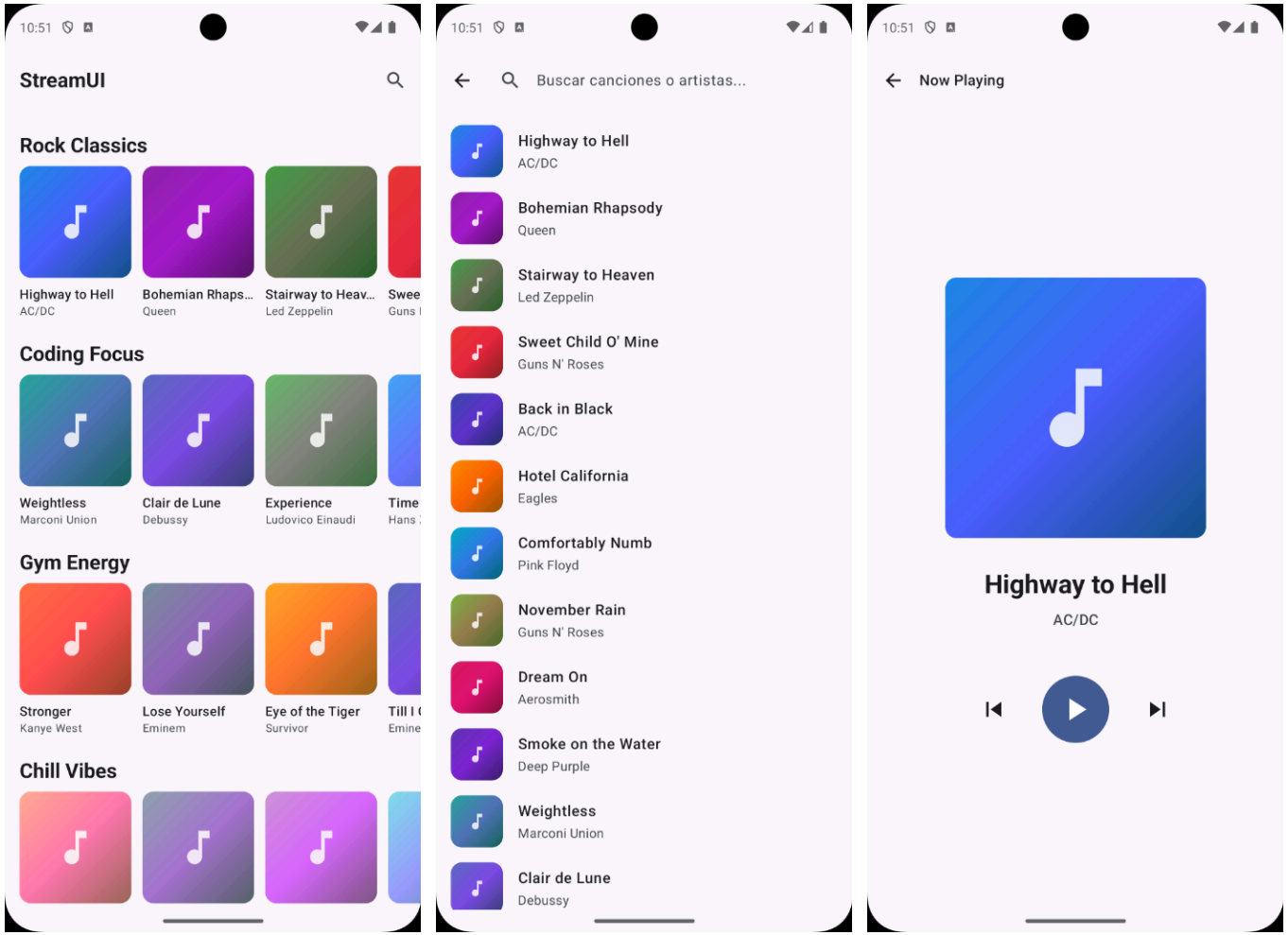
Scenario:

1. Home (`Start`)
2. Navigate to Search (`Push Search`) -> Stack: `[Home, Search]`
3. Click Song (`Push Player`) -> Stack: `[Home, Search, Player]`
4. Press Back (`Pop Player`) -> Stack: `[Home, Search]`

Cyclic Navigation?

Use `popUpTo` to avoid infinite stacks (e.g., Home -> Search -> Home -> Search...).

Visuals: Project Overview



(Home | Search | Player)

Navigation with Tabs

Tabs allow switching between top-level destinations.

Components:

1. **Scaffold**: Provides the slot for `bottomBar`.
2. **NavigationBar**: The container for items.
3. **NavigationBarItem**: Each clickable tab.

State Management:

You need to know *which* tab is selected.

```
val currentRoute =
navController.currentBackStackEntryAsState().value?.destination
```

The Graphs Hierarchy

Usually, `BottomNavigation` lives **outside** the child NavHost, or wraps it.

```
MainActivity
 └── Scaffold
      ├── bottomBar (NavigationBar)
      └── content (NavHost)
           ├── HomeRoute
           └── HighlightsRoute (New!)
```

Resources: Navigation

1. **Official Guide: Type Safety in Kotlin DSL**
2. **Now in Android: Navigation Compose**
3. **Kotlin Serialization Setup**
4. **Codelab: Navigation in Jetpack Compose**
5. **Medium: Migrating to Type-Safe Navigation**

2. MVVM & Basic UDF

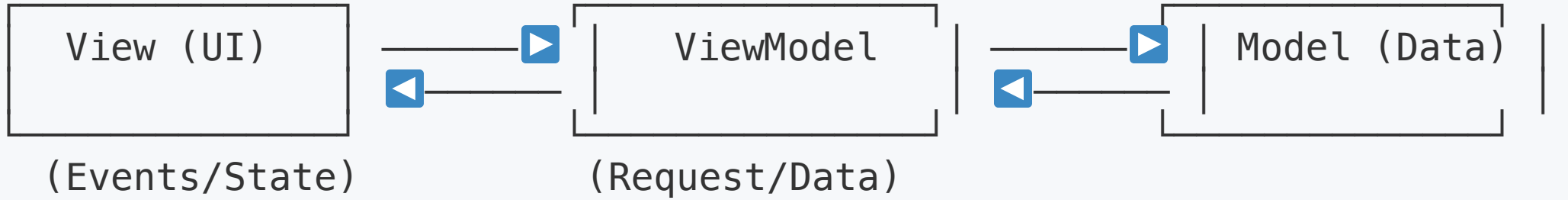
Bringing order to chaos

MVVM & UDF

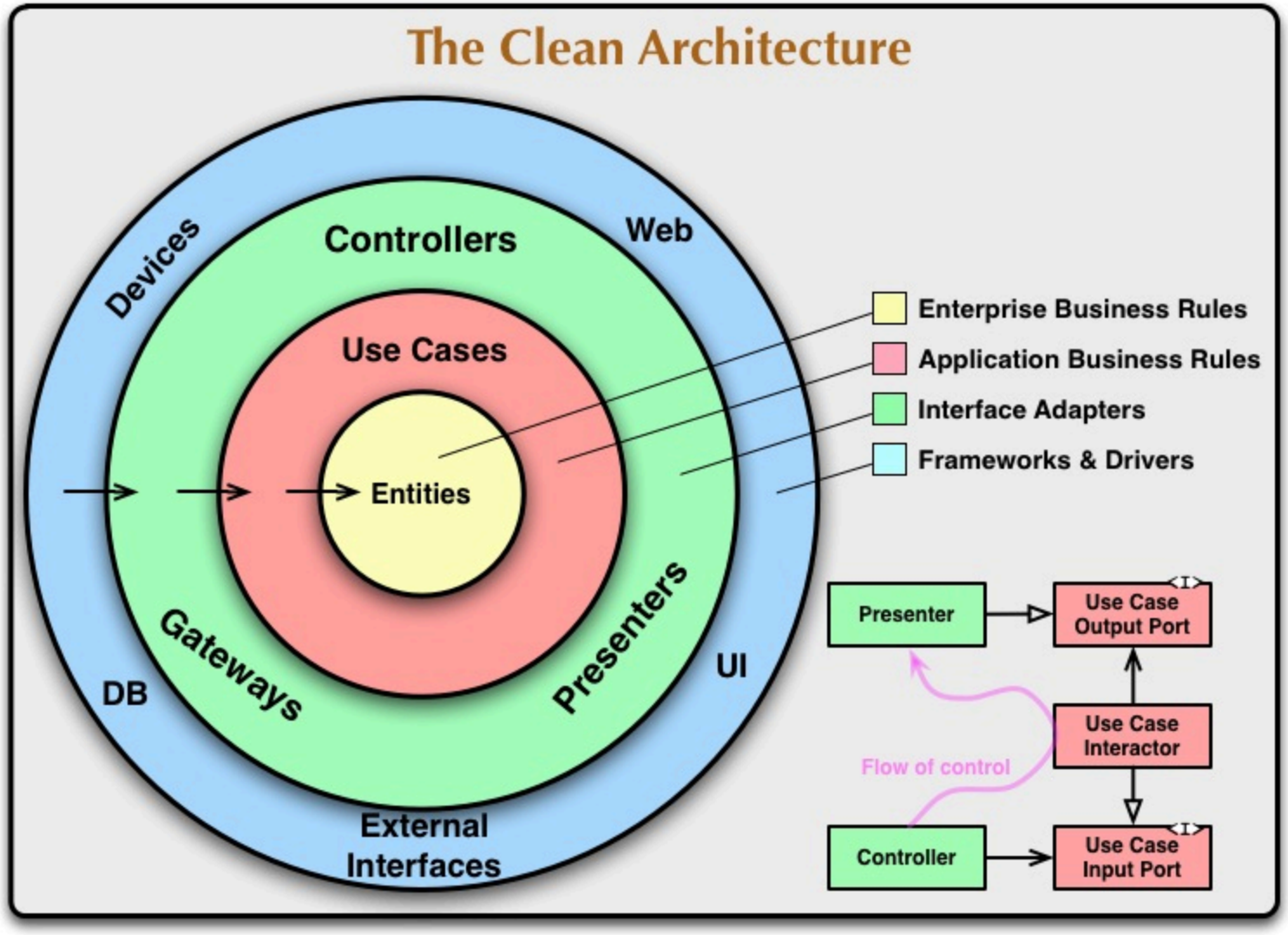
Definitions

- **MVVM (Model-View-ViewModel)**: An architectural pattern that separates the UI (View) from the business logic and data (Model) using a mediator (ViewModel).
- **UDF (Unidirectional Data Flow)**: A design pattern where state flows down and events flow up. This guarantees consistency and simplifies debugging.

MVVM Components Diagram



What is Clean Architecture?



What is Clean Architecture?

A software design philosophy that separates the elements of a design into ring levels.

Dependency Rule
Source code dependencies can only point **inwards**.

- Nothing in an inner circle can know anything at all about something in an outer circle.
- The Domain (Business Logic) knows nothing about the Database or the UI.

Clean Architecture Layers

1. **Presentation Layer (UI + ViewModel)**
    - Handles user interaction and state display.
    - *Depends on:* Domain (or Data if Domain is skipped).
2. **Domain Layer (Optional)**
    - Pure business logic (Use Cases).
    - *Depends on:* Data (Interface).
3. **Data Layer (Repository + Source)**
    - Handles data retrieval (API, DB).
    - *Depends on:* Nothing (Frameworks).

Project Structure (Clean Architecture)

How we organize code to support MVVM:

```
app/src/main/java/com/curso/...
├── data/
│   ├── model/          (Immutable Data Classes: Song, Category)
│   └── repository/     (Data Fetching: MockMusicRepository)
├── di/                 (Dependency Injection: AppModule)
└── ui/
    ├── navigation/     (Routes: Destinations)
    ├── screens/        (Composables: HomeScreen)
    └── viewmodel/      (State Holders: HomeViewModel)
```

Why MVVM?

Putting all logic in the UI (Activity/Composable) leads to "God Classes" that are impossible to test or maintain.

What for?
MVVM moves decision-making to a `ViewModel`.
UDF (Unidirectional Data Flow) ensures data flows strictly one way:

1. **Events** flow UP (UI -> ViewModel)
2. **State** flows DOWN (ViewModel -> UI)

The Restaurant Kitchen (Arch)

Problem (No Architecture):
The Waiter (UI) takes the order, goes to the kitchen, cooks the burger, pours the drinks, and calculates the bill.

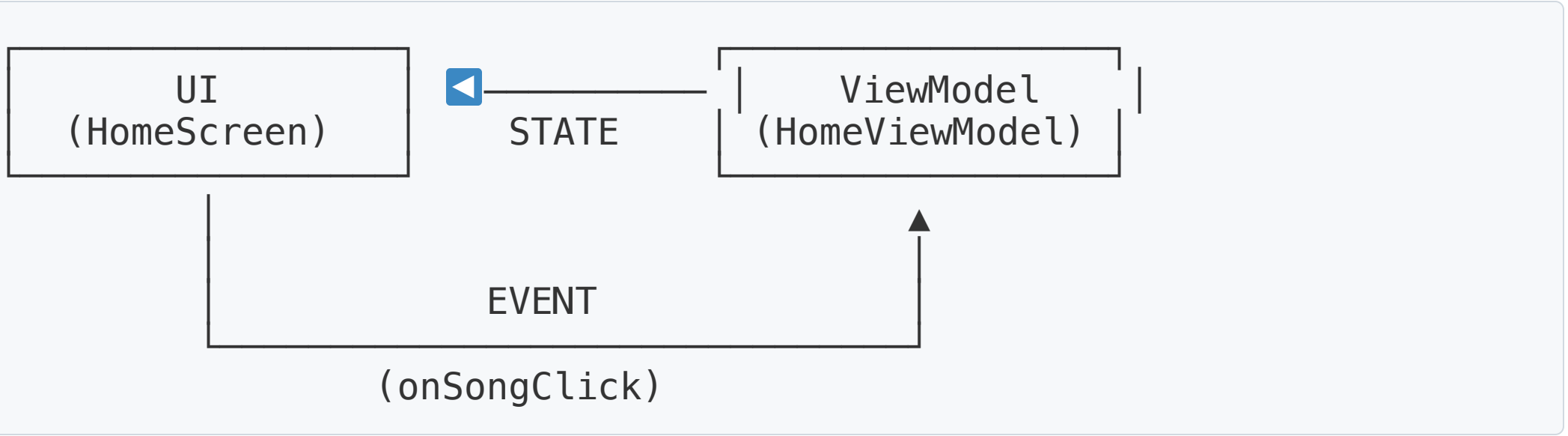
- **Result:** Chaos. Waiter is overwhelmed. If the Waiter quits (Screen Rotation), the order is lost.

Solution (MVVM):

- **Waiter (UI):** Only takes orders and serves food. Doesn't know how to cook.
- **Chef (ViewModel):** Receives the order (Event), cooks using ingredients (Repository), and puts the plate on the counter (State).
- **Result:** Efficient. Chef keeps cooking even if the Waiter goes on break.

Visualization: UDF Cycle

The UI *never* changes the state directly. It asks the ViewModel to do it.



The ViewModel

From `ui/viewmodel/HomeViewModel.kt`:

```
class HomeViewModel(private val repository: MockMusicRepository) : ViewModel() {

    // 1. State Holder (Private Mutable)
    private val _uiState = MutableStateFlow<HomeUiState>(HomeUiState.Loading)

    // 2. Exposed State (Public Immutable)
    val uiState: StateFlow<HomeUiState> = _uiState.asStateFlow()

    init {
        loadData()
    }

    private fun loadData() {
        // ViewModel decides WHEN and HOW state changes
        val data = repository.getCategories()
        _uiState.value = HomeUiState.Success(data)
    }
}
```

The View

```
//ui/screens/HomeScreen.kt
@Composable
fun HomeScreen(viewModel: HomeViewModel = koinViewModel()) {

    // 1. Observe State (Waiter watches the counter)
    val state by viewModel.uiState.collectAsState()

    // 2. React to State
    when (state) {
        is HomeUiState.Loading -> LoadingView()
        is HomeUiState.Success -> {
            HomeContent(
                songs = (state as HomeUiState.Success).songs,
                // 3. Send Events (Waiter passes order to kitchen)
                onSongClick = { song -> viewModel.onSongSelected(song) }
            )
        }
    }
}
```

Resources: MVVM

1. Guide to App Architecture
2. State Holder Pattern
3. Unidirectional Data Flow in Compose
4. ViewModel Overview
5. Codelab: State in Jetpack Compose

3. Dependency Injection

Dependency Injection (DI)

What is it?

A design pattern where a class receives the objects it depends on (dependencies) from an external source rather than creating them itself.

Inversion of Control (IoC):

Instead of the App controlling the creation of dependencies, a Container controls it and provides them when asked.

S.O.L.I.D. Principles

- **S**ingle Responsibility: One class, one job.
- **O**pen/Closed: Open for extension, closed for modification.
- **L**iskov Substitution: Subtypes must be substitutable for base types.
- **I**nterface Segregation: Many client-specific interfaces are better than one general-purpose interface.
- **D**ependency Inversion: **Depend on abstractions, not concretions.** (This is the core of DI!).

Manual vs Automated DI

Manual DI:

You create a container class by hand that holds references.

- *Pros:* No libraries, transparent.
- *Cons:* Boilerplate code, hard to manage scopes.

Automated DI (Koin/Hilt):

A library manages the container.

- *Pros:* Less code, lifecycle awareness, easy testing.
- *Cons:* Learning curve, "magic" behavior.

Koin

Why?

If `HomeViewModel` creates its own `MockMusicRepository`, they are glued together forever. You can't test the ViewModel with fake data, and you assume the Repository is easy to create.

What for?

Dependency Injection (DI) means asking for what you need instead of creating it. A centralized "Container" (Koin) provides the dependencies.

Real World Analogy

Problem (No DI):
Every time you need a car, you personally forge the steel, mold the tires, and refine the gasoline.

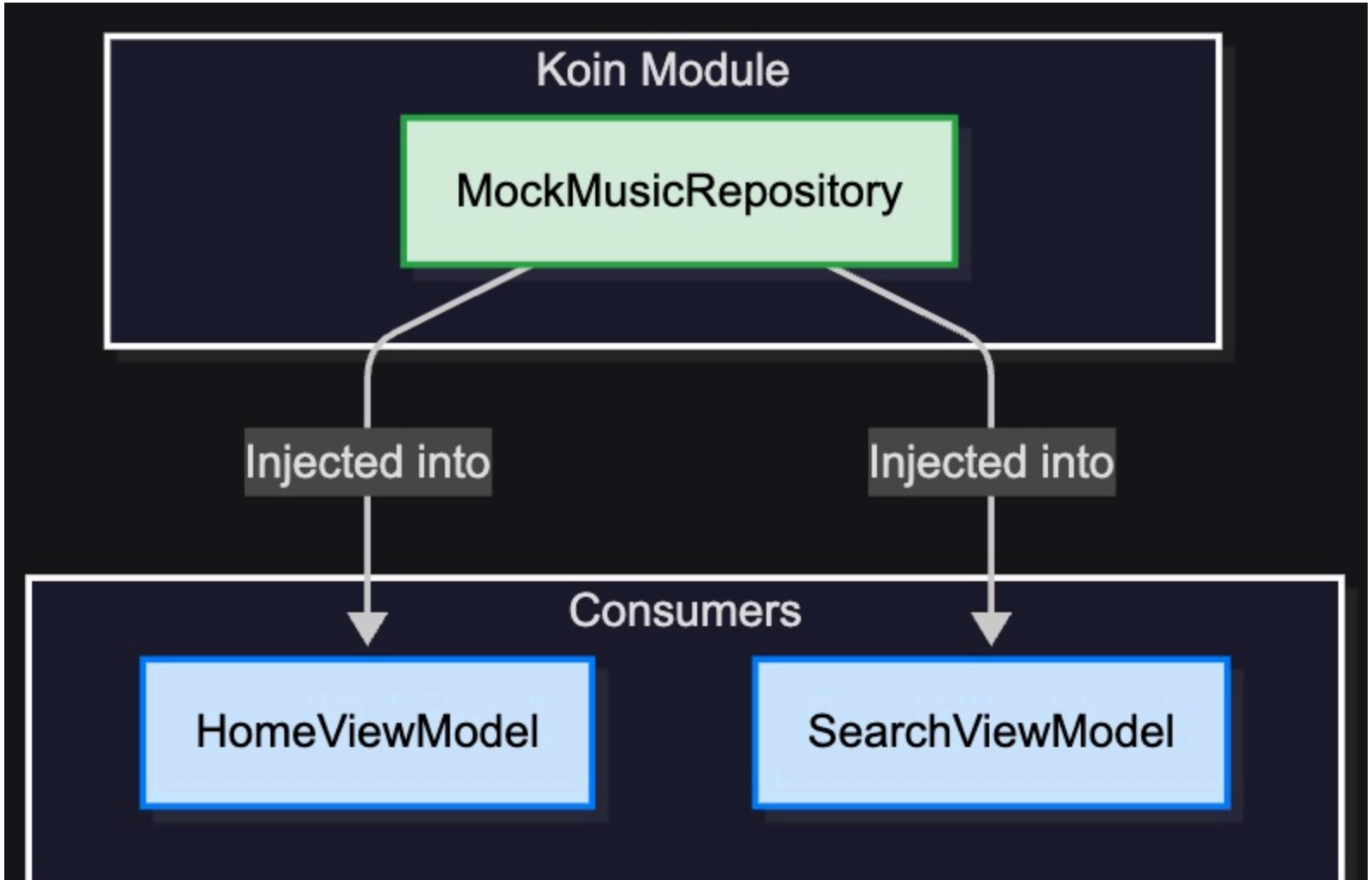
- **Result:** Inefficient. You need to know how to build *everything*.

Solution (DI):
You act as an Assembly Line. You say: *"I need an Engine and 4 Wheels."*

- **Container (Koin):** Provides the Engine and Wheels (maybe from a stockpile, maybe new).
- **Result:** You just assemble. You don't care where the Engine came from.

Dependency Graph

Both ViewModels share the **same** Repository instance



The Module

```
//di/AppModule.kt
val appModule = module {
    // 1. Define the Singleton (The Stockpile)
    // "Create one MockMusicRepository and keep it forever"
    singleOf(::MockMusicRepository)

    // 2. Define ViewModels (The Consumers)
    // "When someone asks for HomeViewModel, give them one"
    // "Koin automatically finds the Repository it needs"
    viewModelOf(::HomeViewModel)
    viewModelOf(::SearchViewModel)
}
```

Injection point

```
//MainActivity.kt
// 1. Start Koin (The Turnkey)
startKoin {
    androidContext(this@StreamApplication)
    modules(appModule)
}

// 2. Inject in Composable (The Ask)
@Composable
fun HomeScreen(
    // "Hey Koin, give me the HomeViewModel!"
    viewModel: HomeViewModel = koinViewModel()
) {
    // ...
}
```

Resources: Koin

1. **Koin Official Docs for Android**
2. **Koin with Jetpack Compose**
3. **Manual Dependency Injection**
4. **Hilt vs Koin**
5. **Video: DI in a Nutshell**

Deep Dive

Recomposition

The Core Concept:

Recomposition is calling your Composable functions again with new data.

When does it happen?

When the **inputs** of a Composable change.

- State variables (`MutableState`)
- Function parameters

The Golden Rule:

Composable functions can run in any order, in parallel, and very frequently. **Keep them Side-Effect Free!**

Stability

Compose needs to know if a type is "Stable" to decide whether to skip it.

Stable Types:

- Primitives & Strings.
- Classes where all properties are `val` and Stable.
- Classes marked with `@Immutable` or `@Stable`.

Unstable Types:

- Classes with `var` properties.
- Lists/Maps from the standard library (use `Kotlinx Immutable Collections` to fix this).

Skippability

If Compose sees that inputs haven't changed, it **Skips** the function.

```
@Composable
fun SongCard(song: Song) { ... }
```

1. First composition: `song = Song("A")` -> **Draw**.
2. Next frame: `song` is still `Song("A")`?
    - If `Song` is Stable -> **Skip**.
    - If `Song` is Unstable -> **Recompose** (even if data is same!).

Lesson: Use Data Classes with `val` for maximum performance.

Side Effects

Sometimes we need to escape the Composable lifecycle (e.g., Log analytics, Start a timer).

Side Effects Handlers:

1. `LaunchedEffect(key)`: Runs a coroutine when `key` changes.
2. `DisposableEffect(key)`: Runs cleanup code when the Composable leaves the screen.
3. `SideEffect`: Runs on every successful recomposition (rare).

Example:

```
LaunchedEffect(Unit) {
    analytics.logScreenView("Home")
}
```

State Management Strategies

`remember`:
Saves a value across recompositions.

- *Lost on:* Configuration change (Rotation).

`rememberSaveable`:
Saves a value across recompositions AND configuration changes (via Bundle).

- *Essential for:* TextFields, check boxes, simple UI state.

`ViewModel`:
Saves state across configuration changes and survives until the screen is destroyed.

- *Essential for:* Business logic, screen data.

Architecture & UDF

Single Source of Truth (SSOT):

- The `ViewModel` is the SSOT for the UI state.
- The `Repository` is the SSOT for the data.

State Hoisting:

- Moving state up to make a component stateless.
- *Example:* `SongCard` doesn't know *how* to be a favorite, it just tells `HomeViewModel` (via `HomeScreen`) that it was clicked.

DI Scopes

Singleton (`single`):

- Created once, lives as long as the container (App).
- *Use for:* Repositories, Retrofit clients, Databases.

Factory (`factory`):

- Created every time it's asked for.
- *Use for:* Helper classes, heavy objects that shouldn't be kept in memory when not used.

Scoped (`viewModel`):

- Lives as long as the associated Scope (Activity/Fragment/NavGraph).
- *Use for:* ViewModels.

Challenge Lab

Part 1: Refactoring (Guided)

Objective: Enhance `SongCard` to support a "Favorite" action.

1. **Modify Model**: Add `isFavorite: Boolean` to `Song` data class.
2. **Modify UI**: Add a `HeartIcon` to `SongCard`.
3. **Lift State**: Explain why `SongCard` shouldn't handle the click internally.
    - Add `onFavoriteClick: (String) -> Unit` to `SongCard`.
    - Pass it up to `HomeScreen` and then `HomeViewModel`.
4. **Implement Logic**: Add `toggleFavorite(id: String)` in `HomeViewModel`.
   (Hint: You might need to make the Repository mutable or fake it in the VM)

Part 2: Create a Highlights Screen

1. **Create Route**: Define `HighlightsDestination` in `Destinations.kt`.
2. **Create Screen**: `HighlightsScreen.kt`.
    - Should display a grid of "Favorite" songs.
3. **Navigation**: Add a "Star" icon in the `TopAppBar` of `HomeScreen` to navigate there.
4. **Dependency**: Reuse `HomeViewModel` or create `HighlightsViewModel`?
    - *Constraint*: Try sharing the `HomeViewModel` first to see shared state in action.
5. **Bottom Navigation**:
    - Implement a `Scaffold` with `bottomBar` in `MainActivity`.
    - Add tabs for "Home" and "Highlights".
    - Connect the tabs to the Navigation Graph.