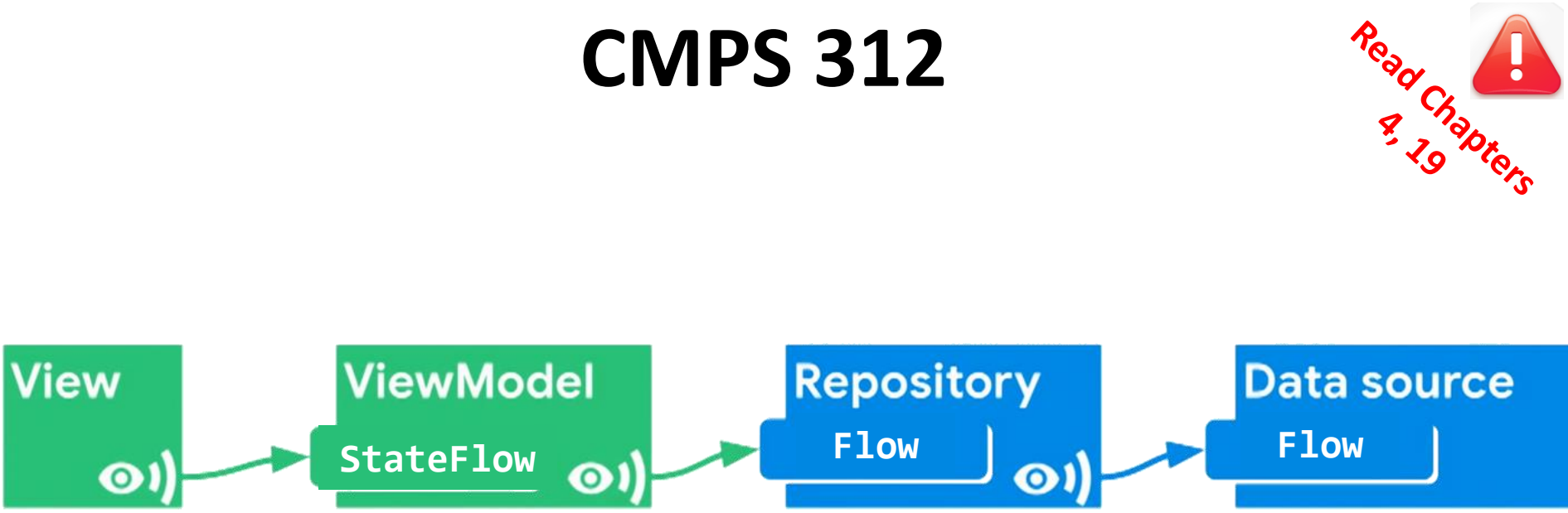
CMPS 312



Model-View-ViewModel (MVVM) Architecture

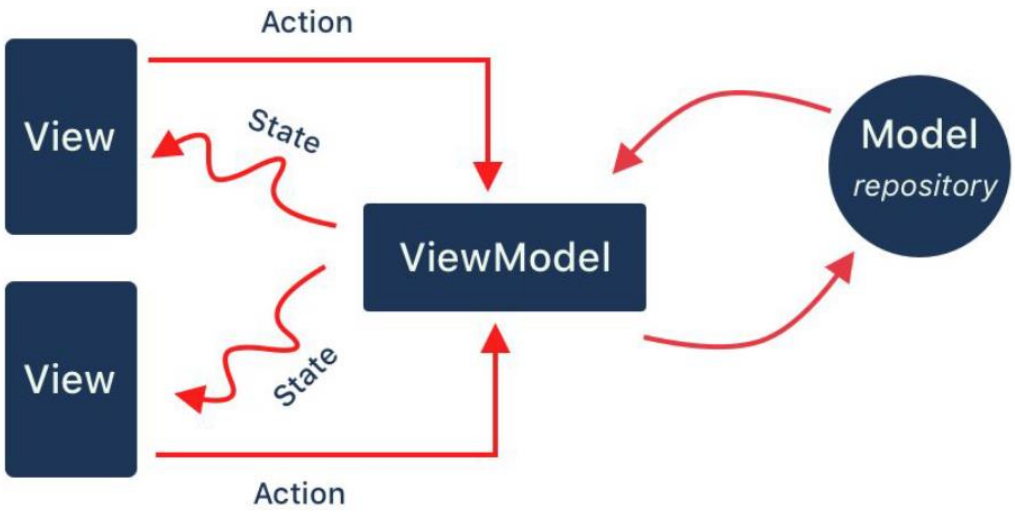
Dr. Abdelkarim Erradi

CSE@QU

Outline

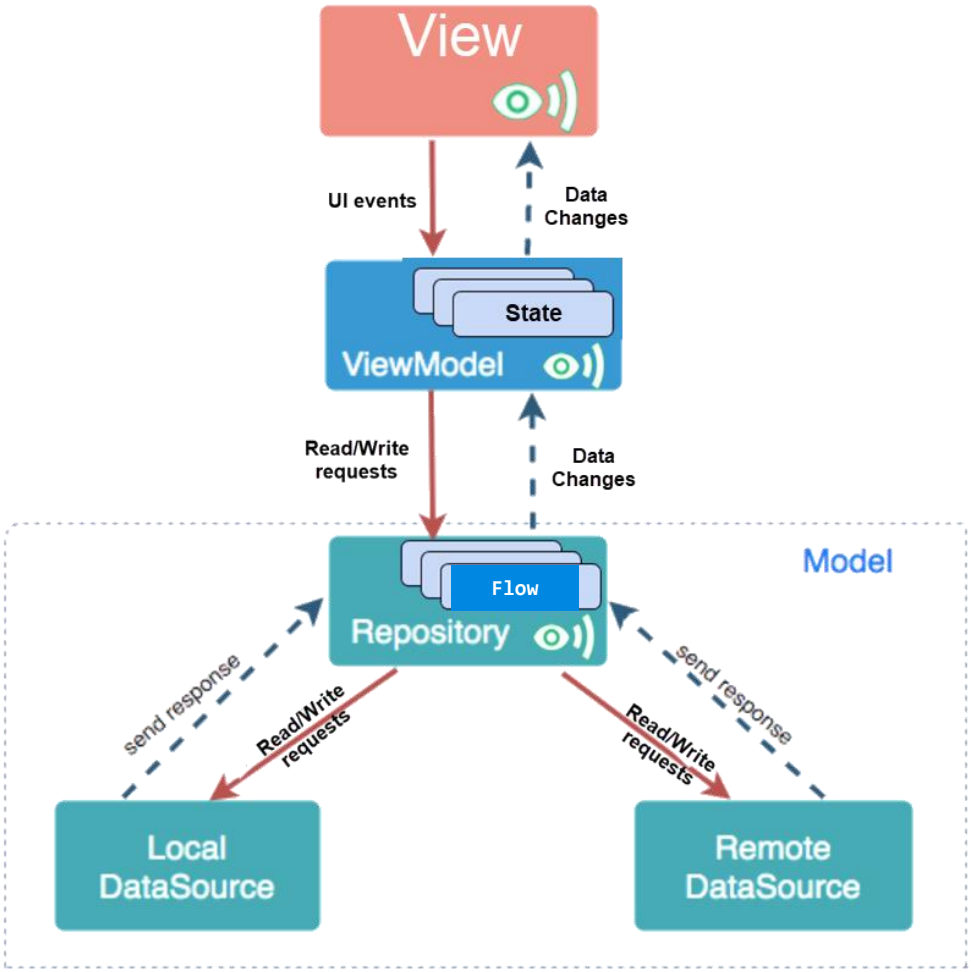
1. Model-View-ViewModel (MVVM)
2. ViewModel
3. State variables
4. Flow

MVVM Architecture



Back

Model-View-ViewModel (MVVM) Architecture



View = UI to display state & collect user input

- It **observes** state changes from the ViewModel to update the UI accordingly

- Calls the ViewModel to handle events such as button clicks, form input, etc.

ViewModel

- Manages **state** (i.e, data needed by the UI)
  - Interacts with the Model to read/write data based on user input
  - Expose the state as **Observables** that the UI can subscribe-to to get data changes
- Implements UI logic / computation (e.g., data validation)

Model - handles data operations

- Model has **entities** that represent app data
- **Repositories** read/write data from either a Local Database (using **Room** library) or a Remote Web API (using **Ktor** library)
- Implements data-related logic / computation

MVVM Key Principles

- Separation of concerns:
  - View, ViewModel, and Model are **separate components** with distinct roles
- Loose coupling:
  - ViewModel **has no direct reference to the View**
  - View never accesses the model directly
  - Model unaware of the view
- Observer pattern:
  - View observes the ViewModel (to get data changes)
  - ViewModel observes the Model (to get data changes)

- Inversion of Control:
  - Uses Dependency Injection instead of direct instantiation of objects

e.g., `val scoreViewModel = viewModel<ScoreViewModel>()`

Advantages of MVVM

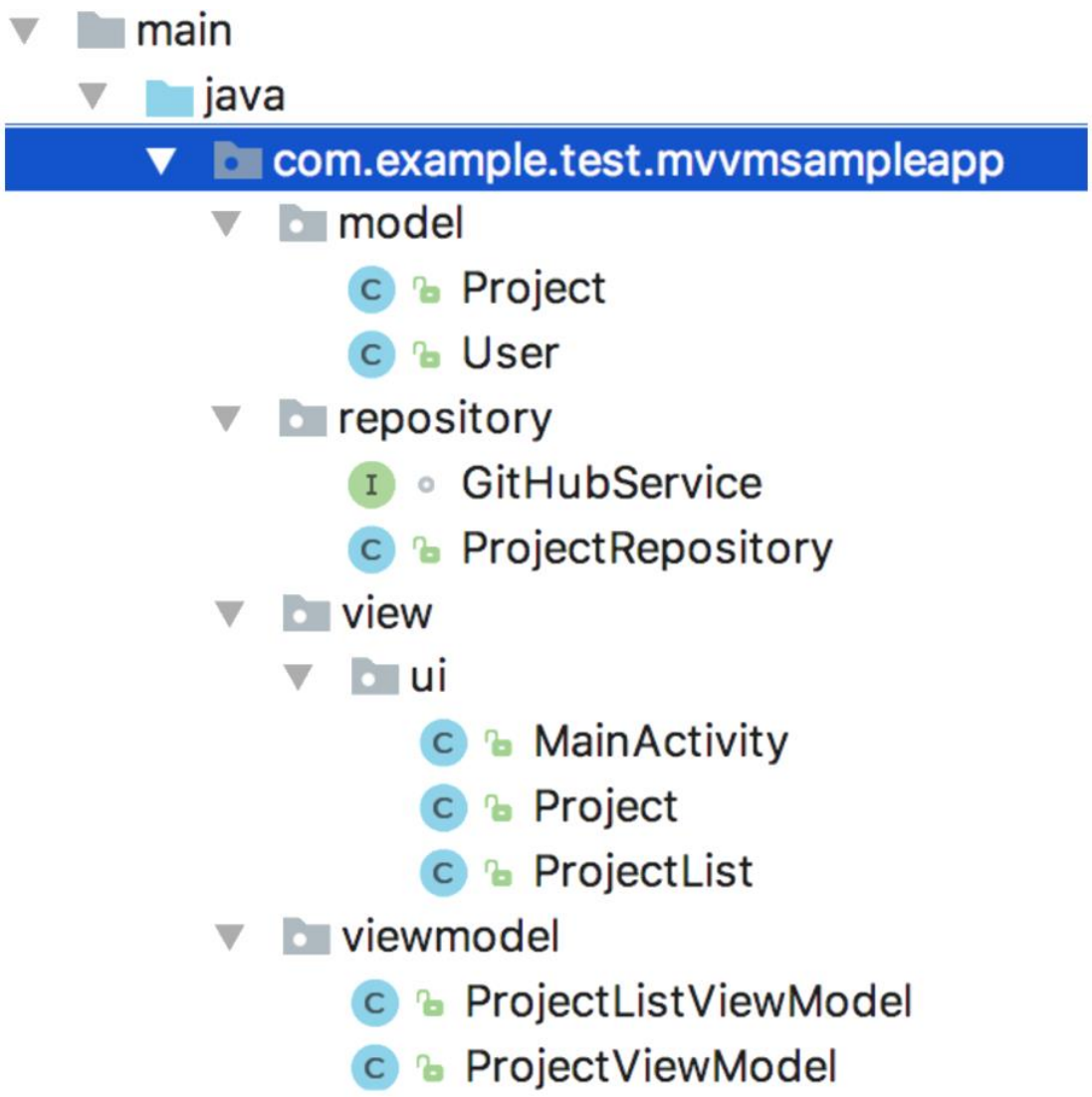
- ***Separation of concerns* = separate UI from app logic**
  - App logic is not intermixed with the UI. Consequently, code is cleaner, flexible and easier to understand and change
  - Allow changing a component without significantly disturbing the others (e.g., View can be completely changed without touching the model)
  - Easier **testing** of the App components

MVVM => Easily maintainable and testable app

Android Architecture Components

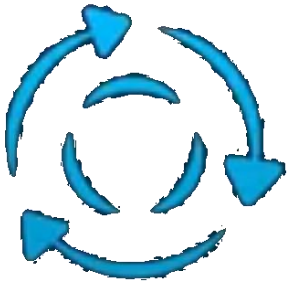
- Android architecture components are a collection of libraries to ease developing MVVM-based Apps
- Part of Android Jetpack  They include:
  - ViewModel stores UI-related data that isn't destroyed on screen rotation
  - StateFlow data holder that notifies the View when the model data changes
  - Room to read / write data to local SQLite database

Recommended Project Structure



You may organize the view by feature

ViewModel



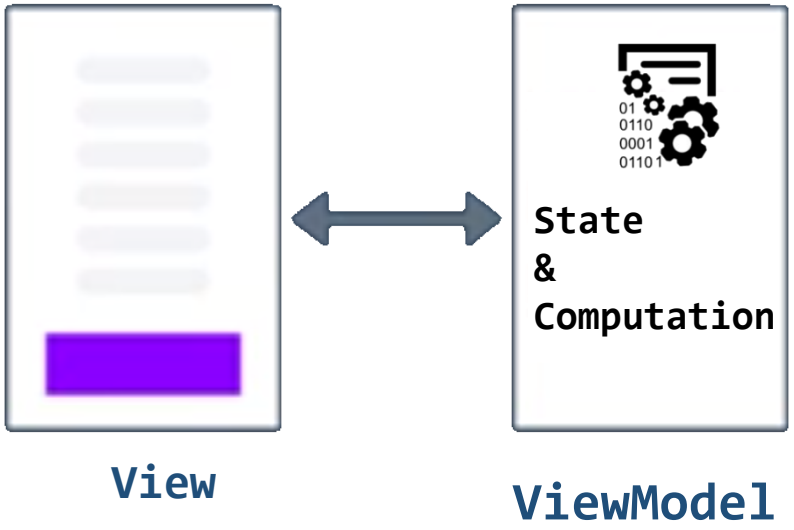
Lifecycle Aware

Survives Config Changes

Back

ViewModel

- ViewModel is used to **store and manage state** (i.e., data needed by the UI)
  - in a lifecycle conscious way
  - allows **state** to survive device configuration changes such as *screen rotations* or *changing the device's language*

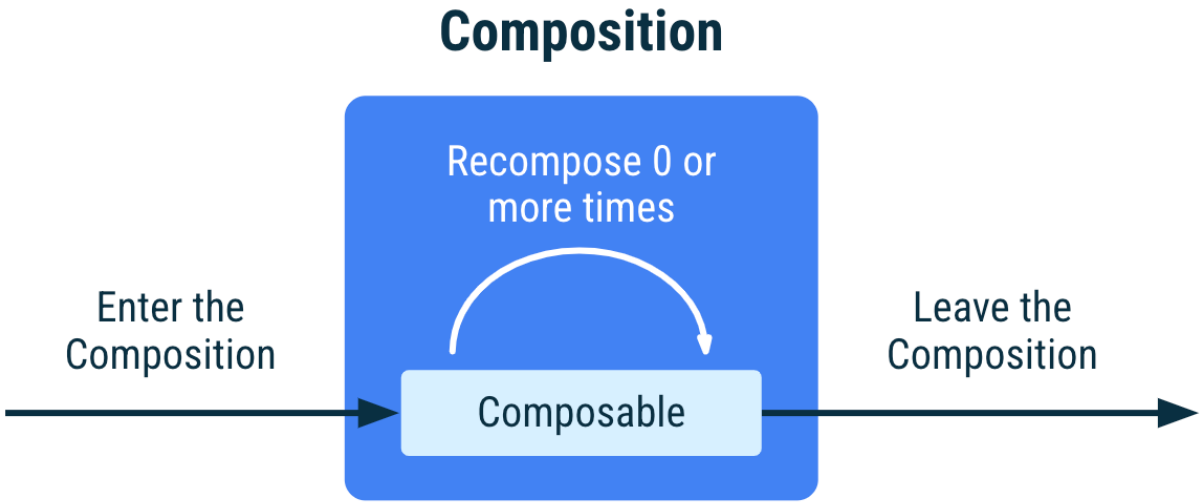


- If the system destroys or re-creates a UI component (e.g., when the screen rotates), any state stored in the View is lost
  - State is NOT retained across configuration changes (landscape/portrait)

Use **ViewModel**:

- Manages state
- Read/write data from a Repository

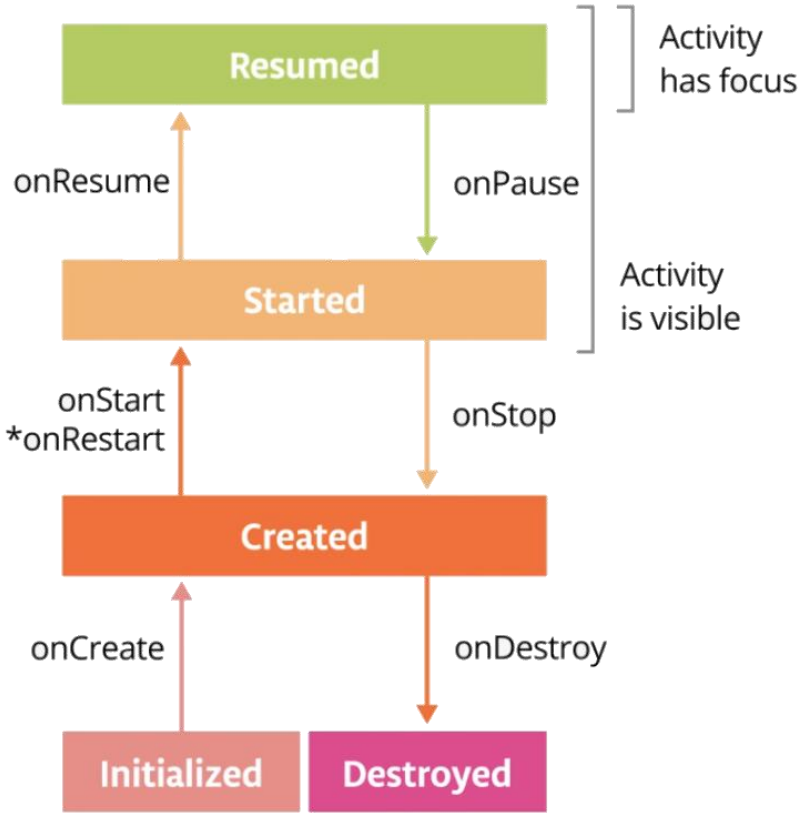
Composable Lifecycle



- When the screen is displayed for the first time, the Composable **enters** the Composition, gets **recomposed** 0 or more times, and **leaves** the Composition
- Recomposition is triggered by a change to a State<T> object. Compose tracks these and runs all composables in the Composition that read that particular State<T>

https://developer.android.com/jetpack/compose/lifecycle

Activity Lifecycle

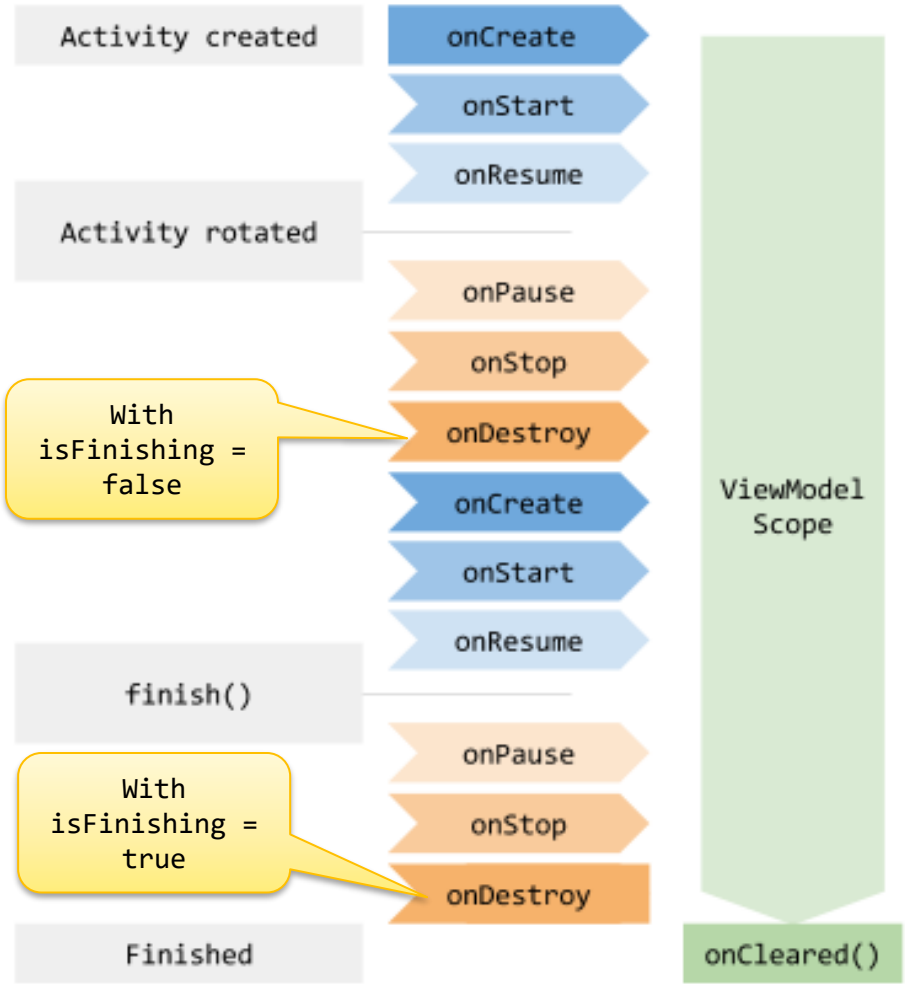


An activity has essentially **four states**:

- ***Resumed*** if the activity in the foreground of the screen (has focus)
- ***Started*** if the activity has lost focus but is still visible (e.g., beneath a dialog box).
  - When the user returns to the activity, it is **resumed**
- **Created** if the activity is completely obscured by another activity.
  - When the user navigates to the activity, it must be **restarted** and restored to its previous state.
- **Destroyed** when the user closes the app or if the activity is killed (when memory is needed or due to `finish()` being called on the activity)

ViewModel Lifecycle

- ViewModel object can be scoped to the main activity
- However, it has a **longer lifespan** compared to the associated Activity which may undergo a rotation and get recreated
- It remains in memory until the activity is `completely destroyed`
  - When the activity is recreated (after a screen rotation) the associated ViewModel remains alive



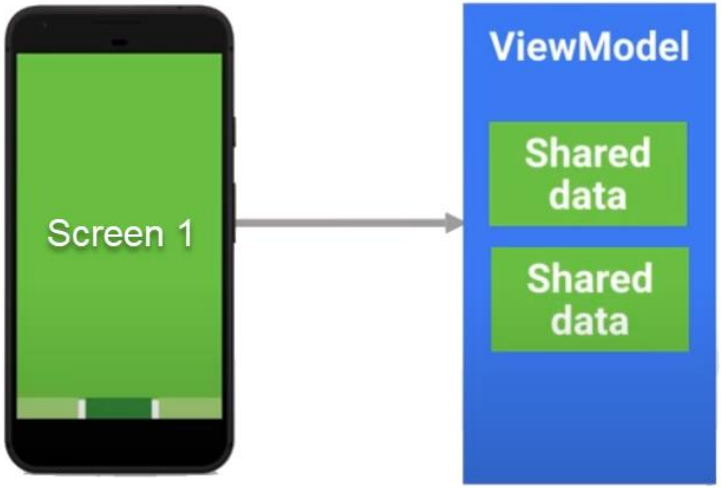
ViewModel Example

```
class ScoreViewModel : ViewModel() {
    // Private mutable state variables
    private var _team1Score = mutableStateOf(0)
    // Public State variables
    val team1Score : State<Int> = _team1Score
    fun onIncrementTeam1Score() { _team1Score.value++  }
```

```
@Composable
fun ScoreScreen() {
    // Get an instance of the ScoreViewModel
     val scoreViewModel = viewModel<ScoreViewModel>()
    Text(text = scoreViewModel.team1Score.value)
    Button(onClick = { scoreViewModel.onIncrementTeam1Score() }) {
       Text(text = "+1")
    }
    ...
}
```

Shared data between Screens using ViewModel

- Screens can **share** data using a shared **View Model** class that extends `ViewModel()`




```
@Composable
fun ProfileScreen(userId: Int) {
 /* Get an instance of the shared viewModel
    Make the activity the store owner of the viewModel
    to ensure that the same viewModel instance is used for all screens */
 val userViewModel = viewModel<UserViewModel>()
 val user = userViewModel.getUser(userId)
... }
```

“no contexts in ViewModels” rule

- ViewModel should **not be aware of the View** who is interacting with
  => It should be decoupled from the View

  - ViewModel should not hold a reference to Activities or Views (i.e. Composables)
  - Should not have any Android framework related code
  - As this defeats the purpose of separating the UI from the data
  - Can lead to memory leaks and crashes (due to null pointer exceptions) as the ViewModel outlives the View
    - if you rotate an Activity 3 times, 3 three different Activity instances will be created, but you only have one ViewModel instance

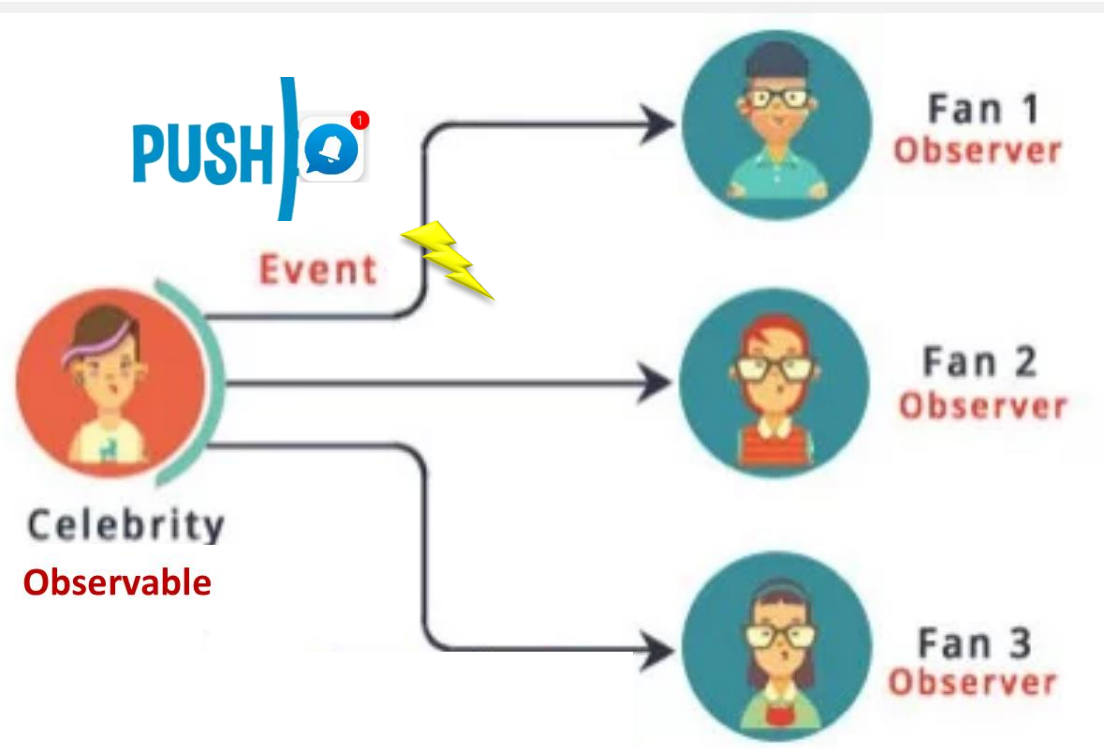
State variables

State variables

- State in an app is any value that can change over time
- A **State** variable is an **observable data holder** whose reads and writes are observed by Compose to trigger UI recomposition
  - State variable warps around an object and allows the view to **observe** it
- The ViewModel exposes **State** variables that the View observes and update the UI accordingly
  - This decouples the ViewModel from the View: the ViewModel does NOT have any direct reference to the View
  - The View can observe the ViewModel State variables for changes then update the UI (aka recomposition)

Observable - Real-Life Example

- A celebrity who has many fans on Instagram. Fans want to get all the latest updates (photos, videos, posts etc.). Here fans are **Observers** and celebrity is an **Observable**



Example - State variable

```
class ScoreViewModel : ViewModel() {
    // Private mutable state variables
    private var _team1Score = mutableStateOf(0)
    // Public State variables
    val team1Score : State<Int> = _team1Score
    fun onIncrementTeam1Score() { _team1Score.value++  }
```

```
@Composable
fun ScoreScreen() {
    // Get an instance of the ScoreViewModel
     val scoreViewModel = viewModel<ScoreViewModel>()
    Text(text = scoreViewModel.team1Score.value)
    Button(onClick = { scoreViewModel.onIncrementTeam1Score() }) {
       Text(text = "+1")
    }
    ...
}
```

Other Observable Types

- `mutableStateListOf()` creates an instance of MutableList that is observable
- `mutableStateMapOf()` creates an instance of MutableMap<K, V> that is observable
- **Flow**: a flow is a type that can emit a stream of values overtime
  - e.g., you can use a flow to receive live updates from a database
- **StateFlow** is lifecycle-aware observable data holder class that notifies the View when the model data changes
  - Meaning that StateFlow only sends updates to app component observers that are in an active lifecycle state

Flow

What is Flow?

- Stream of values (produced one by one over time instead of all at once)
  - as opposed to functions that return only a single value
  - Values could be generated from network requests or database calls
- Can transform a flow using operators like map, filter, etc.

```
fun stream(): Flow<String> = flow {
    emit("🌊") // Emits the value upstream ☝
    emit("⚽")
    emit("🎉")
}
```


```
object WeatherRepository {
    private val weatherConditions = listOf("Sunny", "Windy", "Rainy", "Snowy")
    fun getWeather(): Flow<String> =
        flow {
              var counter = 0
              while (true) {
                  counter++
                  delay(3000)
                  emit(weatherConditions[counter % weatherConditions.size])
               }
         }
}
```

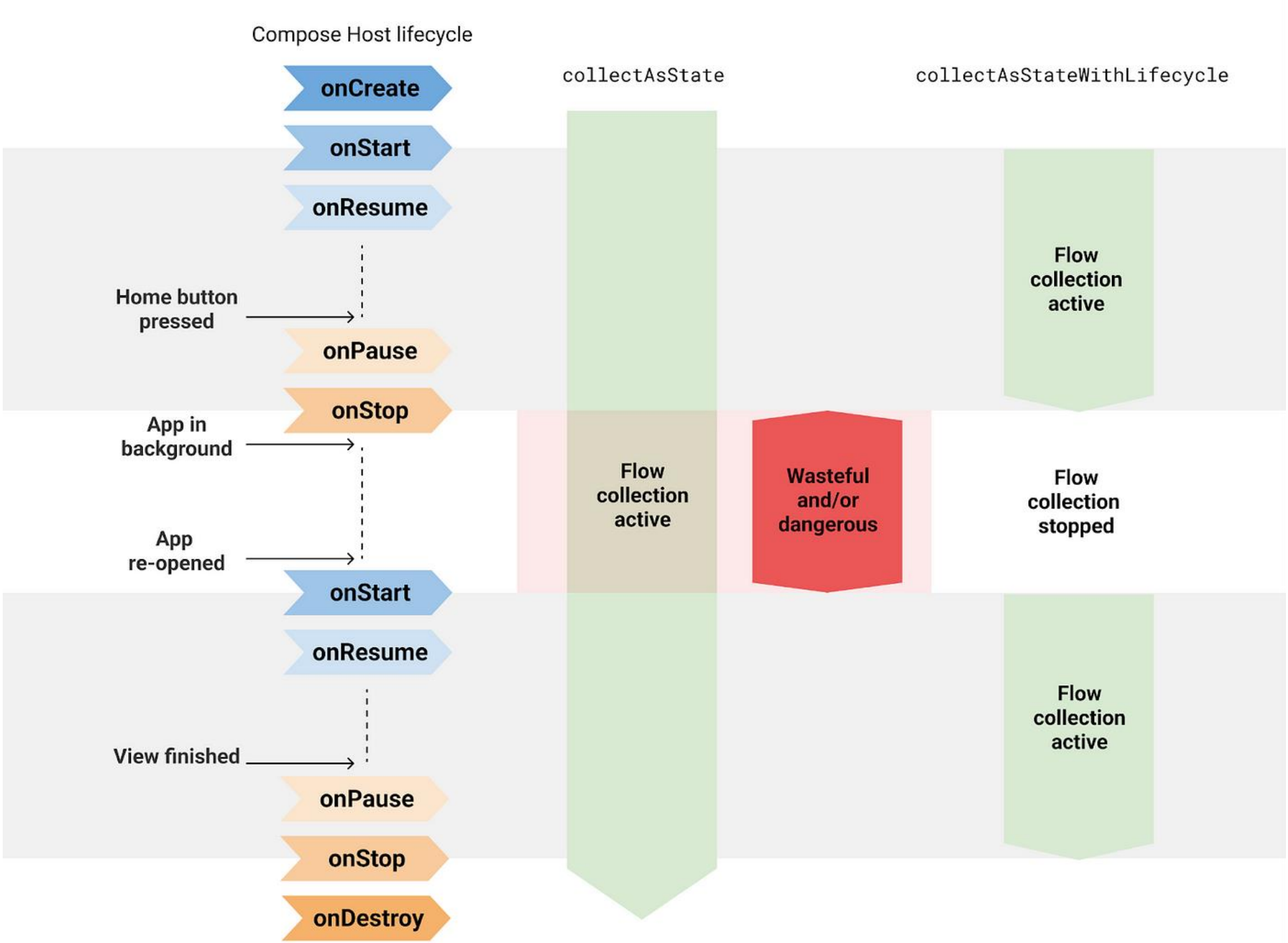
```
class WeatherViewModel : ViewModel() {
    val weatherFlow: Flow<String> = WeatherRepository.getWeather()
}
```

```
@Composable
fun ScoreScreen() {
    val weatherViewModel = viewModel<WeatherViewModel>()
    val weatherFlow = weatherViewModel.weatherFlow.
         collectAsStateWithLifecycle (initialValue = "")
    // Recomposes whenever weatherFlow changes
    Text(
      text = "Weather: ${weatherFlow.value}" )
    }  ... }
```

collectAsStateWithLifecycle

- `collectAsStateWithLifecycle()` collects values from a Flow and transforms its latest value into a Compose State. Causing recomposition when a new value is received from the Flow
  - Every time a new flow emission occurs, the returned State will be updated causing recomposition
- It does so in a lifecycle-aware manner, allowing the app to save unneeded app resources when the app is in the background
  - collectAsStateWithLifecycle start collecting values from the flow only when the composable in an active lifecycle state and stop collecting values from the flow when the composable is stopped (UI is not visible on the screen)
- Requires adding this dependency to build.gradle

```
implementation("androidx.lifecycle:lifecycle-runtime-compose:2.6.2")
```


Compose Host lifecycle
collectAsState
collectAsStateWithLifecycle
onCreate
onStart
onResume
Home button pressed
onPause
onStop
App in background
App re-opened
onStart
onResume
View finished
onPause
onStop
onDestroy
Flow collection active
Wasteful and/or dangerous
Flow collection active
Flow collection stopped
Flow collection active

.stateIn

- In the View, consume the UI state using **collectAsStateWithLifecycle**
- The ViewModel can convert a Flow returned by the model into StateFlow using **stateIn**
  - This enables the app to free up resources when not needed

```
val newsFlow: StateFlow<String> = DataRepository.getNews().stateIn(
    scope = viewModelScope,
    started = WhileSubscribed(5000),
    initialValue = ""
)
```

You can use WhileSubscribed(5000) to keep the upstream flow active for 5 seconds more after the disappearance of the last collector. That avoids restarting the upstream flow after a configuration change

Flow Operators

- Flow has operators similar to collections such as map, filter and reduce

```
(1..5).asFlow()
    .filter { it % 2 == 0 }
    .map { it * it }
    .collect { println(it.toString()) }

val result =(1..5).asFlow()
                  .reduce { a, b -> a + b }
println("result: $result")
```

Resources

- State and Jetpack Compose
  - https://developer.android.com/jetpack/compose/state
- Kotlin flows on Android
  - https://developer.android.com/kotlin/flow
- MVVM
  - https://developer.android.com/topic/architecture