Lab on apps development for tablets, smartphones and smartwatches

Week 5: ViewModels and System Services

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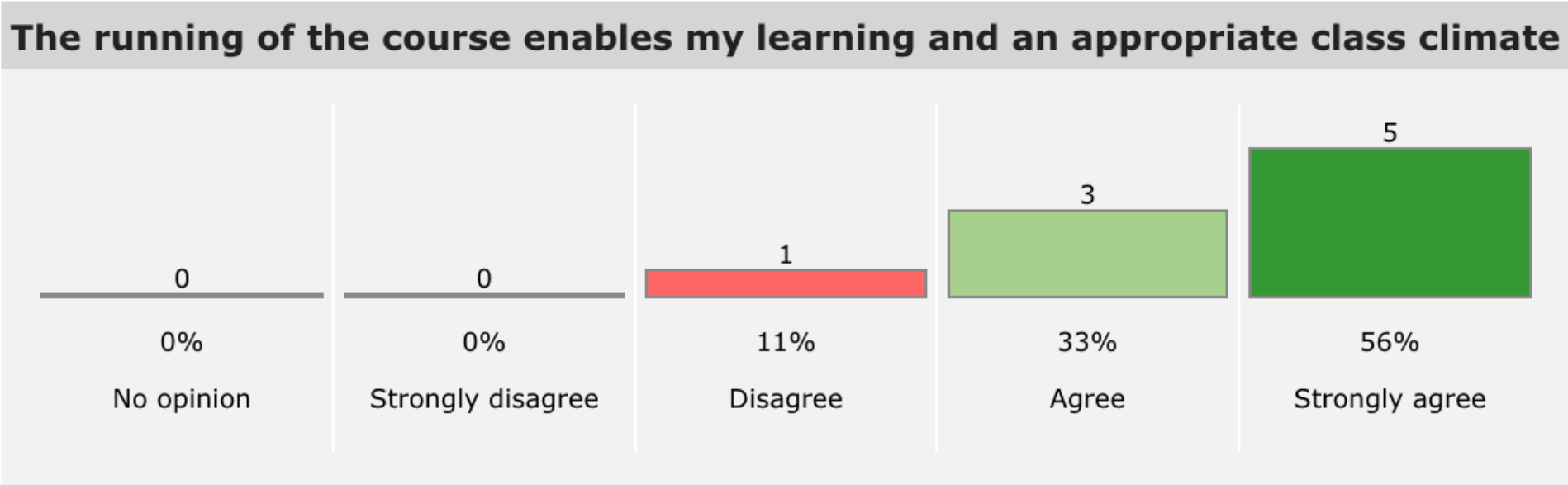
Course Feedback



- Participation: **47%**
  (8 over 17)

Course Feedback

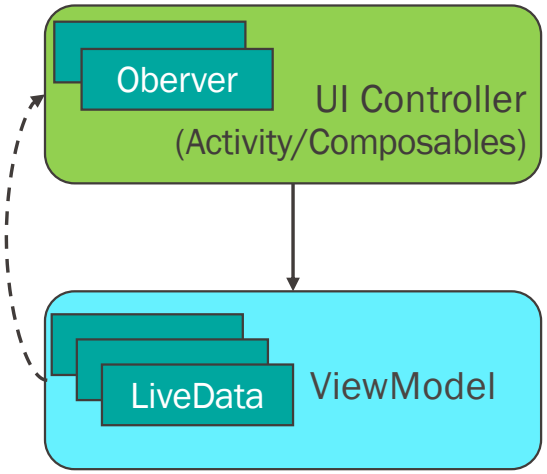
- Great TAs
- Interesting course (x3)
- Good material /presentation (x2)

- Slides late on Moodle
- More details

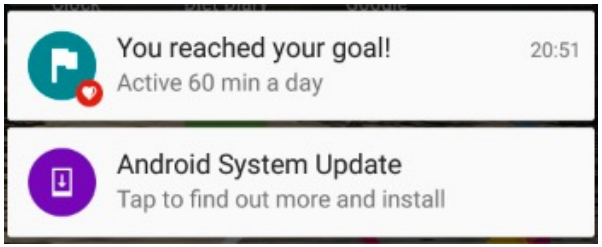
- Theory is presented in a more complicated way than it actually is.
- Add more examples / more explanation (line by line).
- Labs can’t be finished in 3 hours.
- Chairs are uncomfortable.

Class outline

- **ViewModels and Livedata**



- System Services
  - Sensor services
  - Notifications
  - Alarms



- Broadcast receivers

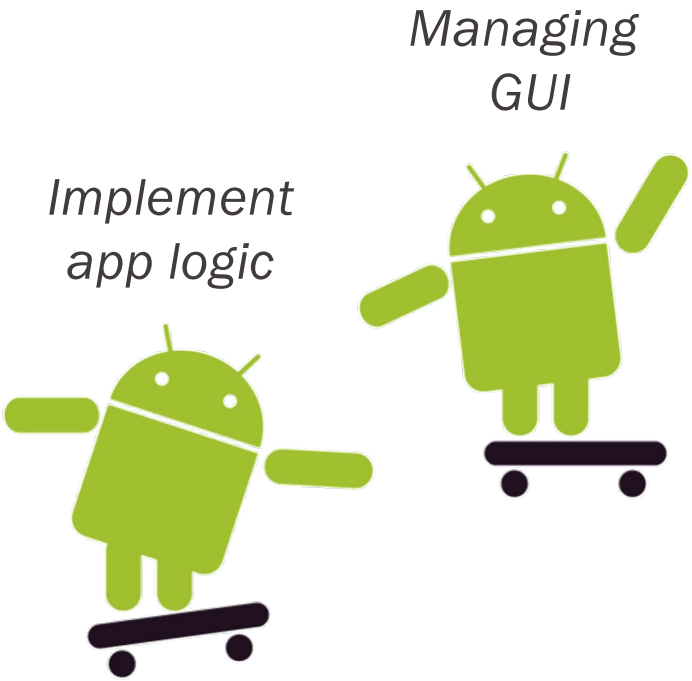
Where are we?

- Our Composables are becoming increasingly complicated
  - Listeners, navigation, menus, …

- Are Composable functions doing too much?

  1. Management of the Composables GUI
     - displaying views, listening to user actions

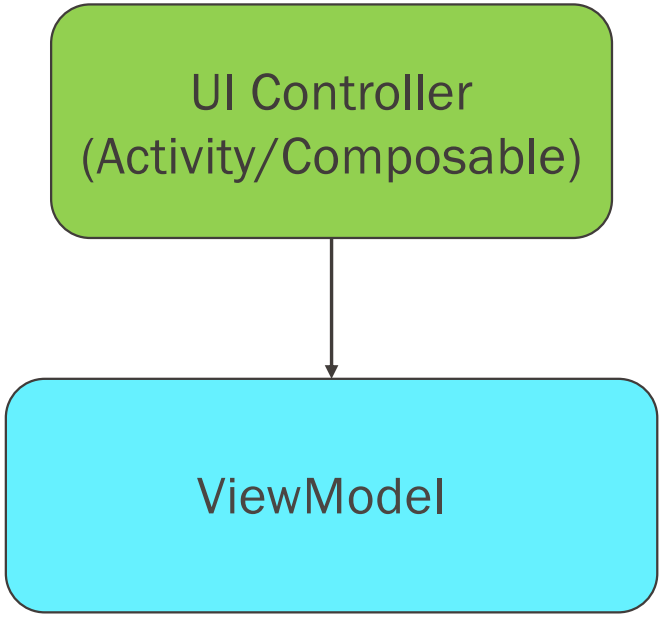
  2. Holding and manipulating data



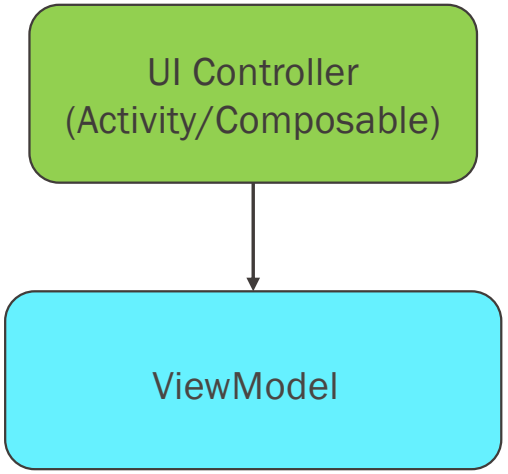
Separation of concerns

1. UI controllers → Composables, Activities
   - Manage the GUI
     → displaying/updating Composables

2. ViewModels
   - Hold and manipulate data
     → implement the app “logic”



ViewModels



- extend the ViewModel class

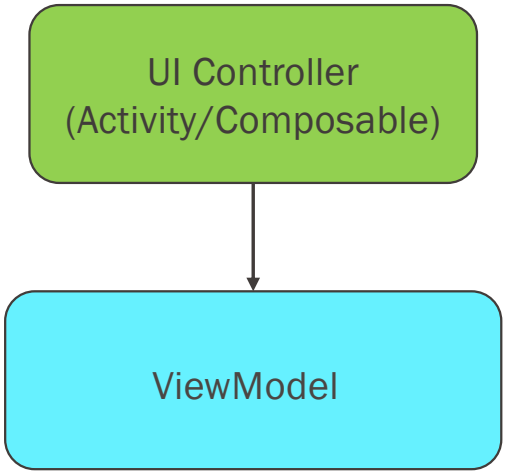
```
class MyViewModel : ViewModel(){...}
```

- linked to and by a UI controller
  - in the UI Controller class:

```
private lateinit var viewModel: MyViewModel
```

Referencing ViewModels

- UI controllers are re-created during configuration changes
  - rotations, …
- ViewModels persist during configuration changes
- ViewModels are referenced by ViewModelProvider
  - ViewModelProvider returns existing ViewModel if exists

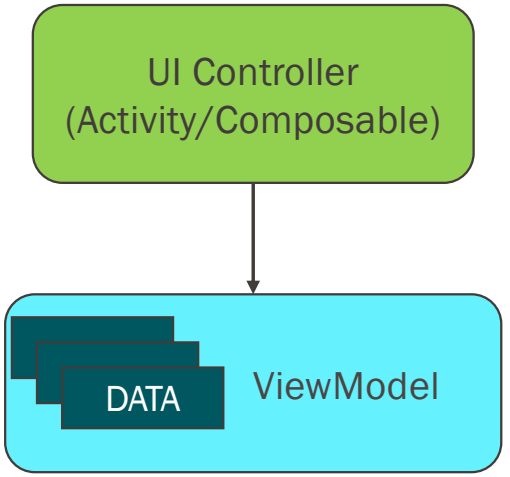



```
viewModel = ViewModelProvider(this)
            .get(MyViewModel::class.java)
```

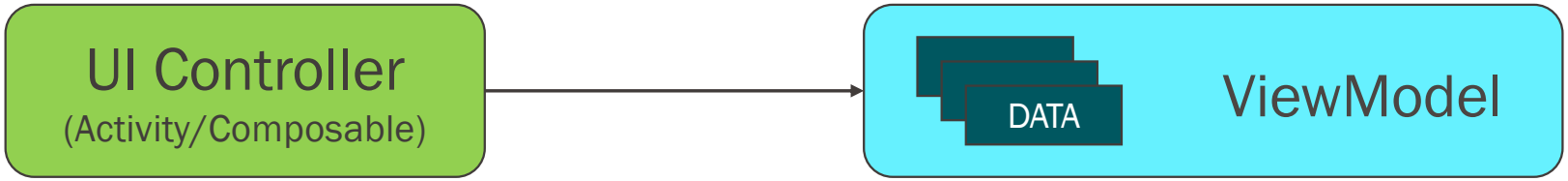
UI-controller vs ViewModel

- UI controller: everything (and only) what is related to GUI
  - declaration/references to Activities/Composables
  - events
    - e.g. onClick()
- ViewModel
  - all other variables, methods etc.. implementing the app logic
- UI Controllers can access methods in ViewModels

```
viewModel.viewModelFun()
```



UI controllers and ViewModels



- Does not manipulate data to be displayed in the UI
- Contain code for displaying data, managing listeners
- Does contain a reference to the associated ViewModel
- Destroyed and re-created at configuration changes

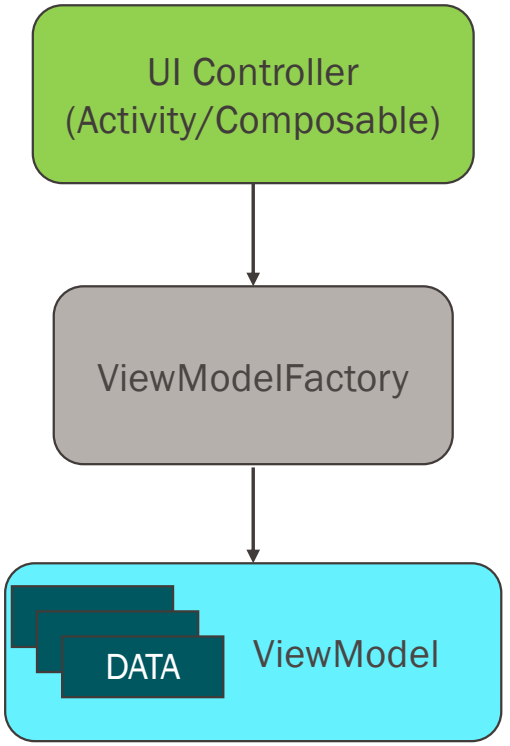
- Does contain the data the UI controller displays
- Contains code for data processing
- Does not contain reference to the associated UI controller
- Destroyed only when the associated Activity goes away permanently

Initialize ViewModels with a Factory class

- The initial state of ViewModel can be parametric
  - i.e. depends on the Arguments that started the corresponding Activity
- ViewModel using parameters such as:

```
class MyViewModel(myParameter: Int) : ViewModel(){
```

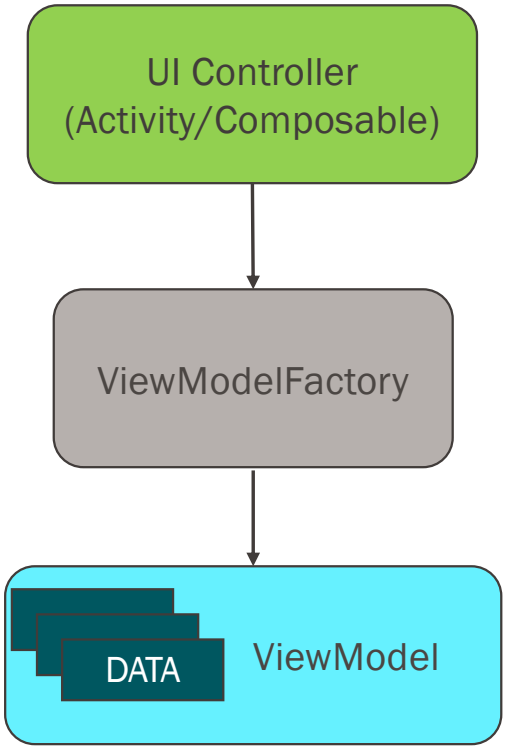
...are created using a ViewModelFactory



Initialize ViewModels with a Factory class

- ViewModelFactory creates the ViewModel()

```
class MyViewModelFactory(private val myParameter: Int) :
ViewModelProvider.Factory {

    override fun <T : ViewModel?> create(modelClass: Class<T>): T {
            return MyViewModel(myParameter) as T
    }
}
```



- As instructed by the UI controller

```
viewModelFactory = MyViewModelFactory(initParamValue)

viewModel = ViewModelProvider(this, viewModelFactory)
        .get(MyViewModel::class.java)
```

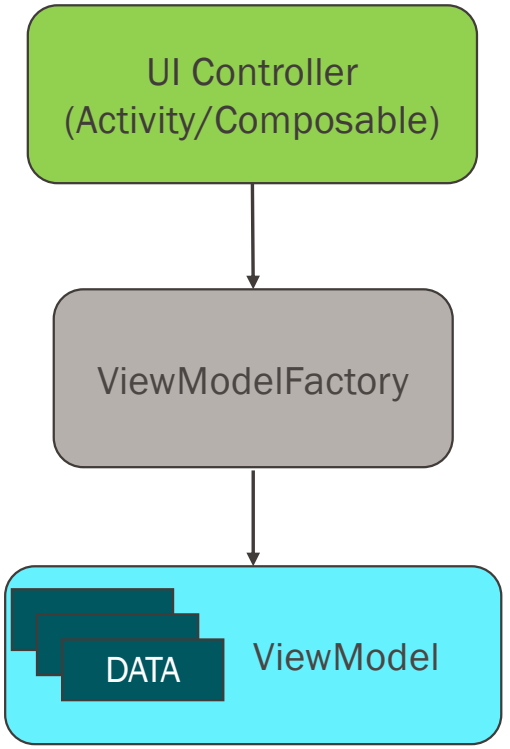
Initialize ViewModels in Composables

- Commonly provided as a last default parameter in the constructor
- Scope is
  - enclosing destination (Screen) if in a navigation graph
  - Activity otherwise

```
@Composable
fun MyScreen(
    modifier: Modifier = Modifier,
    myViewModel: MyViewModel = viewModel()
) {
```

equivalent in Activity

```
viewModel = ViewModelProvider(this)
            .get(MyViewModel::class.java)
```

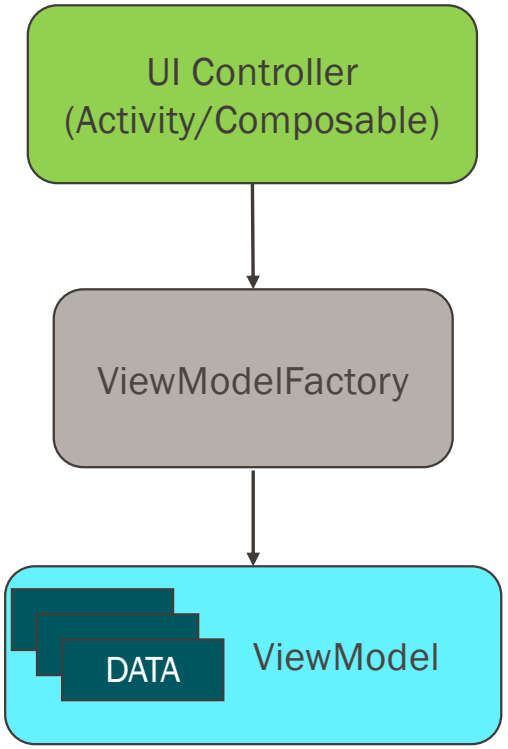


Documentation: https://developer.android.com/topic/libraries/architecture/viewmodel/viewmodel-apis#viewmodels-scoped

Initialize ViewModels in Composables

- Commonly provided as a last default parameter in the constructor
  - Parameters passed via Factory

```
@Composable
fun MyScreen(
    modifier: Modifier = Modifier,
    myViewModel: MyViewModel = viewModel(
       factory = MyViewModelFactory(myParameter))
) {
```



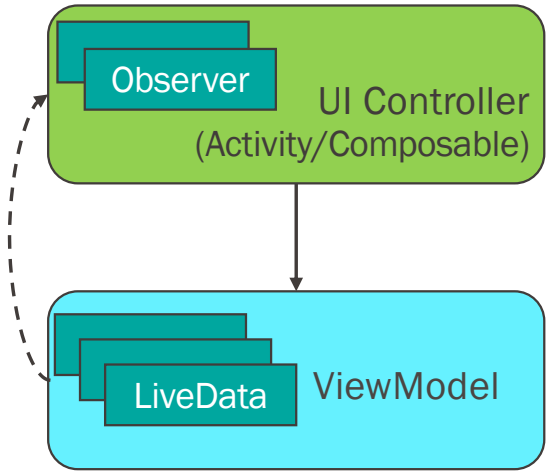
- Factory is the same as in the Activity case

REMINDER

```
class MyViewModelFactory(private val myParameter: Int) :
ViewModelProvider.Factory {

    override fun <T : ViewModel?> create(modelClass: Class<T>): T {
            return MyViewModel(myParameter) as T
    }
}
```

LiveData and Observers

- Data values are stored in ViewModels,
  but the UI controller should be aware of (some of) them



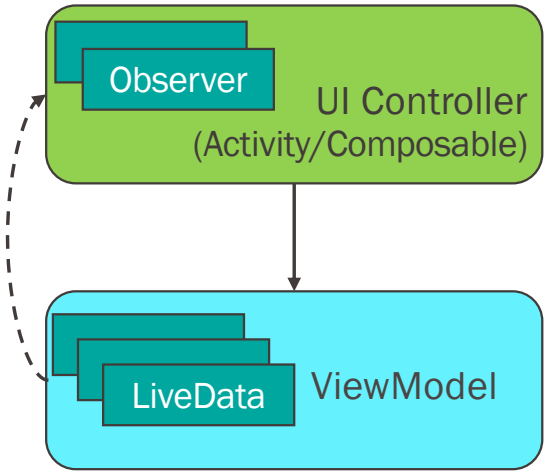
- When should the UI Controller update the GUI?
  - Reflecting changes in the ViewModel

- Android provides for
  - LiveData in ViewModel Classes
    - changes in LiveData are notified to the UI controller
    - lifeCycle-aware, notify only if UI controller (e.g. Composable) is active and/or becomes visible
  - Observers in UI controllers

LiveData

- LiveData are declared in ViewModels
  - Wrapper that can contain any kind of object or primitive type
    - Examples:

```
val score: LiveData<Int>

val word: LiveData<String>
```

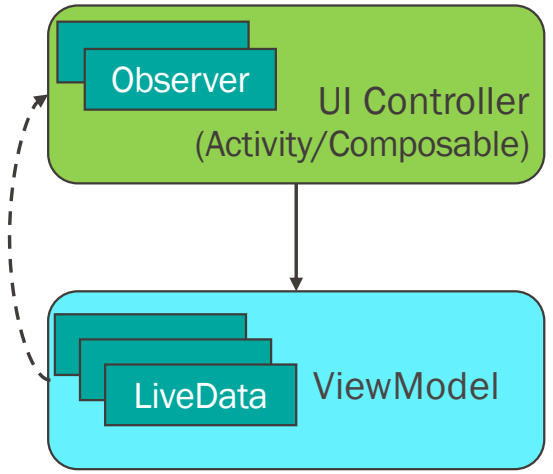


- Observers in UI Controller link Activity/Composable and LiveData

Observers in Activities

- Activities are notified when LiveData changes

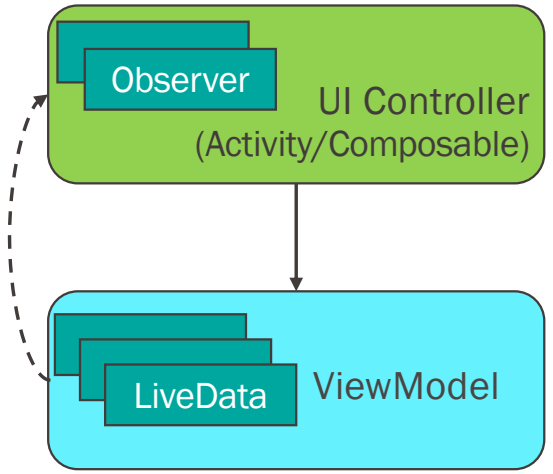
```
override fun onCreate(savedInstanceState: Bundle?) {
    super.onCreate(savedInstanceState)

    // link viewModel
    viewModel =
ViewModelProvider(this).get(GameViewModel::class.java)

    //set an observer for the "word" LiveData
    viewModel.word.observe(this, Observer { newWord ->
        //handle the word update
    })
    …
}
```



Observe the "word" Livedata in Viewmodel.
When it changes, notify as soon as the Activity is active according to its LifeCycle
The new value for "word" is "newWord"

Observers in Composables

- observeAsState observe LiveData from the ViewModel and transforms it into state
  - Every time the LiveData updates, the UI that depends on ”word” is recomposed.




```
@Composable
fun GameScreen(
    modifier: Modifier = Modifier,
    gameViewModel: GameViewModel = viewModel()
) {
    val word by gameViewModel.word.observeAsState(initial = "")

    …
}
```

MutableLiveData and LiveData

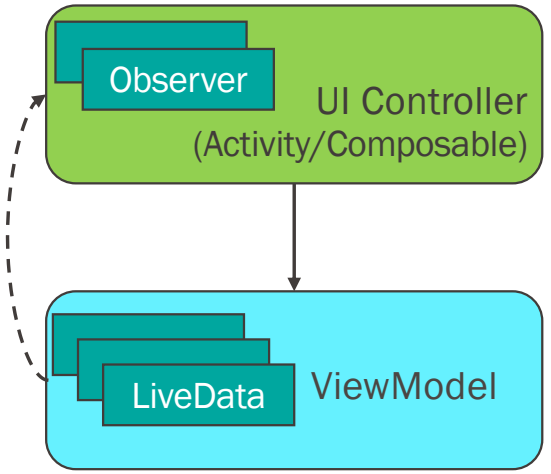
- LiveData should be readable,
  but not writable by the UI controller
  → separation of concerns

- Use MutableLiveData in ViewModels
  - declare it private to make it writable only inside the class

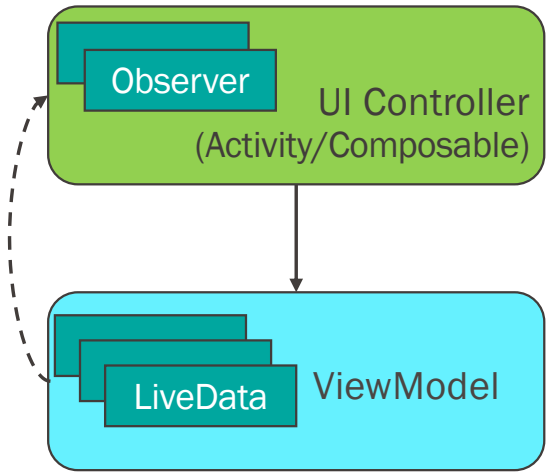
```
private val _word = MutableLiveData<String>()

_word.value = "myWord"
```

- Associate LiveData with MutableLiveData with getter

```
val word: LiveData<String>
    get() = _word
```



Summing up



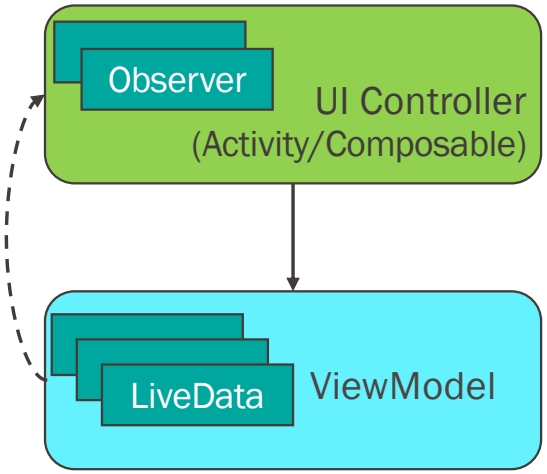
- Separation of concerns
  - UI Controller vs. ViewModel
- ViewModels can be parametrized via ViewModelFactory
- LiveData/MutableLiveData incapsulates observed data
  - MutableLiveData → readable/writable, private of ViewModel
  - LiveData → readable by UI controller
- Observers automatically update the UI when LiveData changes
  - Activities → `viewModel.<VAR>.observe(...{...})`
  - Composables → `viewModel.<VAR>.observeAsState()`

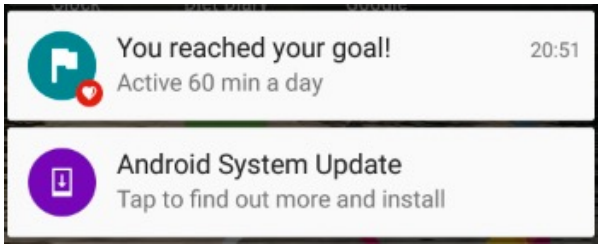
Class outline

- ViewModels and Livedata

- **System Services**
  - Sensor services
  - Notifications
  - Alarms

- **Broadcast Receivers**





System Services

- Allows applications to access OS and hardware features
  - **Sensor Service**
  - **Notification Service**
  - **Alarm Service**
  - Power Manager Service
  - Vibrator Service, Audio Service
  - Telephony Service, Connectivity Service, Wi-Fi Service
  - …
- Available via Service Managers

```
val sensorMgr = app.getSystemService(SENSOR_SERVICE) as SensorManager

val alarmMgr = app.getSystemService(Context.ALARM_SERVICE) as AlarmManager

val notificationMgr = app.getSystemService(Context.NOTIFICATION_SERVICE)
                                                    as NotificationManager
```

System Services

- Service Managers require an application Context
  - Handle to characteristics of application, OS, and device
    → AndroidViewModel instead of ViewModel

```
class myViewModel(private val app: Application, <MY_OTHER_INPUTS>) :
AndroidViewModel(app) {
```

- AndroidViewModel is supported by viewModelFactory

```
class myViewModelFactory(private val application: Application,
                         <MY_OTHER_INPUTS>) : ViewModelProvider.Factory {

    override fun <T : ViewModel?> create(modelClass: Class<T>): T {
            return myViewModel(application, <MY_OTHER_INPUTS>) as T
    }
}
```

Sensor service

- Many types of sensors:
  - Accelerometer, Gyroscope, Light, …
  - GPS
  - Heart Rate
  - …
- Each Sensor contains information about the vendor, type, …

- List of sensors on a device:

```
var sensorlist = sensorMgr.getSensorList(Sensor.<TYPE>)
```

  - *<TYPE>* → TYPE_ACCELEROMETER, TYPE_LIGHT, TYPE_ALL

- Handle to a sensor of a given type

```
val slightSens = sensorMgr.getDefaultSensor(Sensor.TYPE_LIGHT)
```

Monitoring sensor events

- To get sensor data, we need to implement two callbacks, via the SensorEventListener interface
  - the accuracy of a sensor changes: onAccuracyChanged()
  - a sensor reports a new value: onSensorChanged()

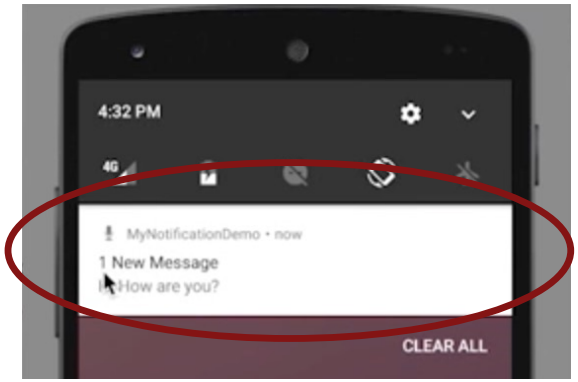
- Steps:
  1. Implement SensorEventListener
  2. Creating the sensor manager
  3. Provide methods to register/unregister the listener → called in onPause()/onResume of the corresponding Activity
  4. Doing something when sensor accuracy/value changes

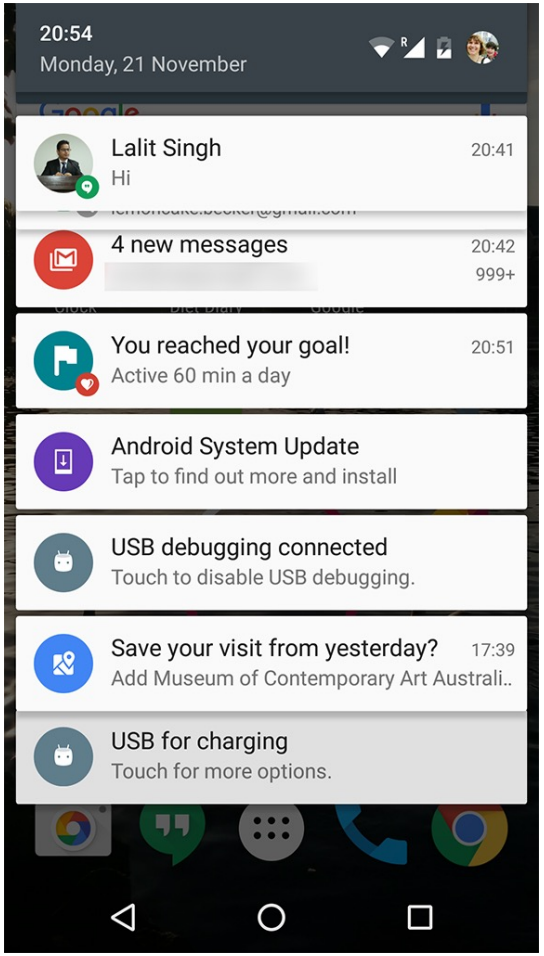
```
class myViewModel(private val app: Application) :
                    AndroidViewModel(app), SensorEventListener{          1.

    val  sensorMgr = app.getSystemService(SENSOR_SERVICE) as SensorManager   2.

    fun registerSensor() {
        val lightSens = sensorMgr.getDefaultSensor(Sensor.TYPE_LIGHT)
        sensorMgr.registerListener(this, lightSens,
                                   SensorManager.SENSOR_DELAY_NORMAL);
    }

    fun unregisterSensor() {                                             3.
        sensorMgr.unregisterListener(this)
    }

    override fun onSensorChanged(event: SensorEvent?) {
        //read value to be incapsulated in LiveData variable
        val flux: Float = event?.values?.get(0) ?: 0F
    }

    override fun onAccuracyChanged(sensor: Sensor?, accuracy: Int) {     4.
        //Do something if sensor accuracy changes
    }
```

(try to) listen every 3us

Notification service

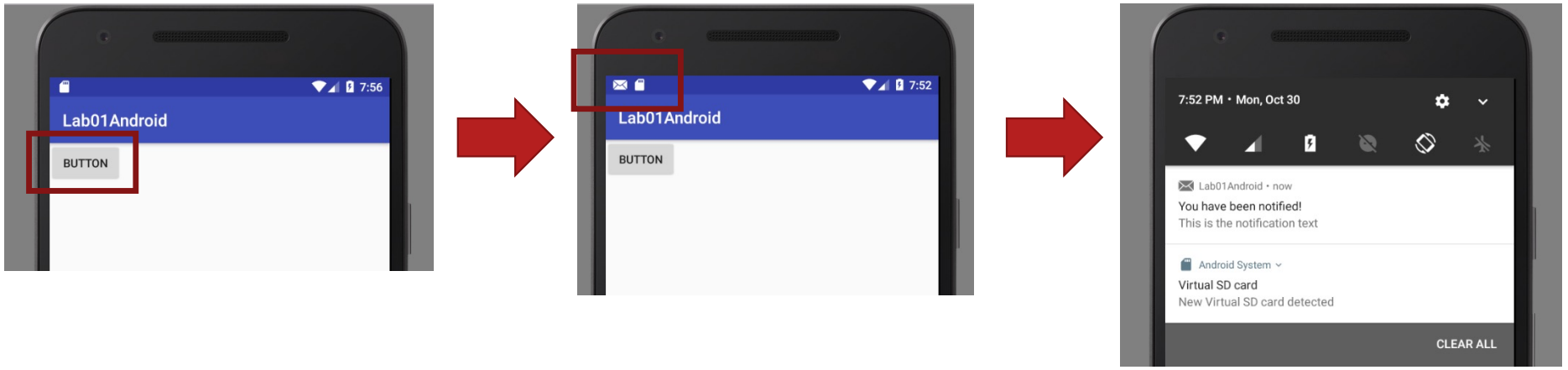
- What is a notification?
  - A message displayed outside of the regular app UI
    - Does not interrupt operations on the foreground app
  - To see details, user opens the notification drawer
  - At minimum, consists of
    - Small icon
    - Title
    - Detail text





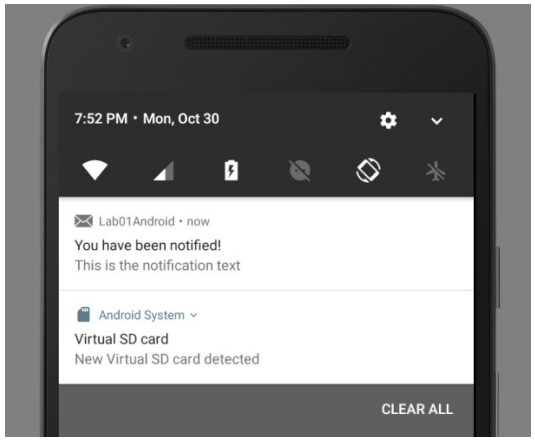
A very simple example

- ViewModel that launches a notification



How to create a Notification - setup

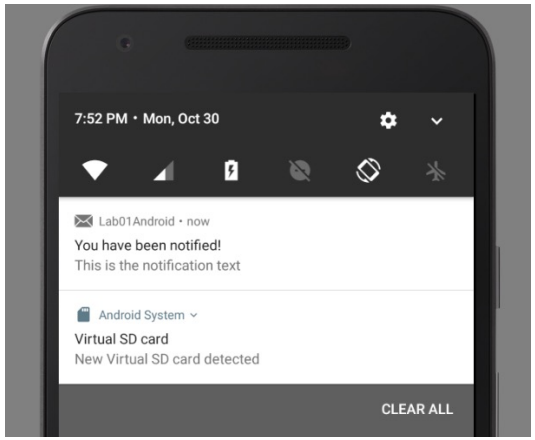
1. Getting a reference to NotificationManager SystemService
2. Creating a communication channel and attach it to the NotificationManager
   - required for Android version >= 8 (Oreo)




```
class myViewModel(private val app: Application) :
                        AndroidViewModel(app) {

1.  private val notificationManager =
    app.getSystemService(Context.NOTIFICATION_SERVICE) as NotificationManager
    init{
        if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.O) {
2.      val notificationChannel = NotificationChannel(
                "myChannelID", "myChannel",
                NotificationManager.IMPORTANCE_HIGH)
        notificationManager.createNotificationChannel(notificationChannel)
        }
    }
```

How to create a Notification – display

3. Build the Notification message
   - Title / Content / Icon
4. Send the notification to the Notification Manager




```
fun displayNotification() {
    val notifyBuilder = NotificationCompat.Builder(app, "myChannelID")
            .setSmallIcon(R.drawable.cooked_egg)
            .setContentTitle("My notification")
            .setContentText("Time to work!")

    notificationManager.notify(NOTIFICATION_ID, notifyBuilder.build())
}
```

3.

4.

Notifications and pending intents

- Notifications can be interactive, responding when user tap on them
  - Notification may have buttons (e.g. “reply”)
    - *https://developer.android.com/training/notify-user/build-notification.html*

- Behavior of tapping on notification is specified in “PendingIntent” object
  - e.g. “app is opened when notification is tapped”
  - Described as part of notification

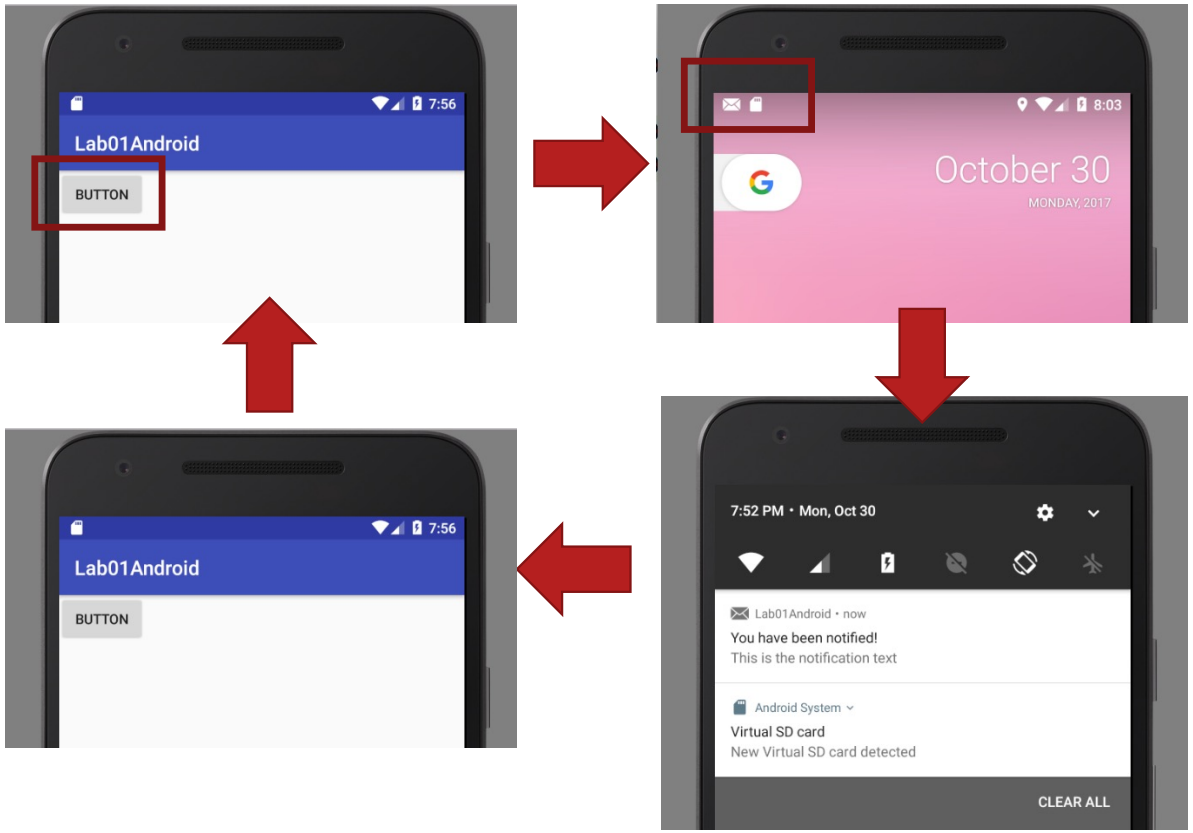
Creating a PendingIntent

1. Create an intent
2. Create a PendingIntent
3. Add it to notification builder
   - And then call notify()
4. Call *activity*!!.finish()
   to force-quit an app

```
fun displayNotification() {
   val contentIntent = Intent(app, MainActivity::class.java)                    1.

   val restartPendingIntent = PendingIntent.getActivity(                        2.
        app,
        NOTIFICATION_ID,
        contentIntent,
        PendingIntent.FLAG_UPDATE_CURRENT
   )

   val notifyBuilder = NotificationCompat.Builder(app, "myChannelID")
        .setSmallIcon(R.drawable.cooked_egg)
        .setContentTitle("My notification")
        .setContentText("Time to work!")
        .setContentIntent(restartPendingIntent)                                 3.
   notificationManager.notify(NOTIFICATION_ID, notifyBuilder.build())}
```

How does our example change now?

- When you launch the Notification, the app finishes
- When you click on the notification, the app is relaunched



Notification priorities

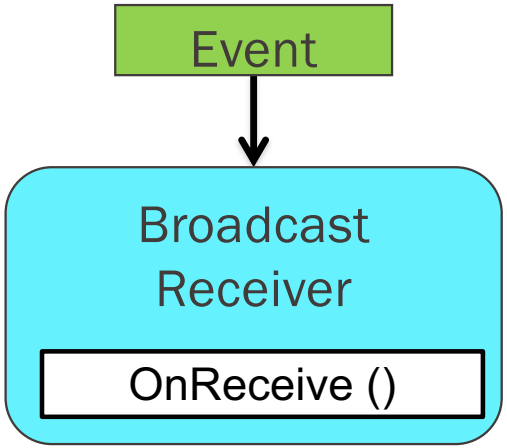
- Determines how the system displays the notification with respect to other notifications

- Use <mNotifyBuilder>.setPriority()
  - .setPriority(NotificationCompat.PRIORITY_HIGH)
  - PRIORITY_MIN (-2) to PRIORITY_MAX (2)

- Priority above 0 triggers heads-up notification on top of current UI
  - Used for important notifications such as phone calls
  - Use lowest priority possible

Broadcast receivers

- Broadcast Receivers respond to events
  - independent from Activity/Composables
  - even when app is closed
- Here, we will see them in conjunction to Alarms
  - Alarm service *setups* alarm event
  - Broadcasts receiver *captures* event
- Other patterns exists
  - Example: System broadcasts: delivered under certain events
    - After the system ends booting:
      android.intent.action.BOOT_COMPLETED
    - When the WiFi state changes:
      android.intent.action.WIFI_STATE_CHANGED



Creating Broadcast Receivers

1. Create a new class that extends BroadcastReceiver

2. Implement onReceive()
   - Receives the event Intent
   - Handles the event

3. Registration of the Broadcast Receiver to the event
   - Registration in Android Manifest

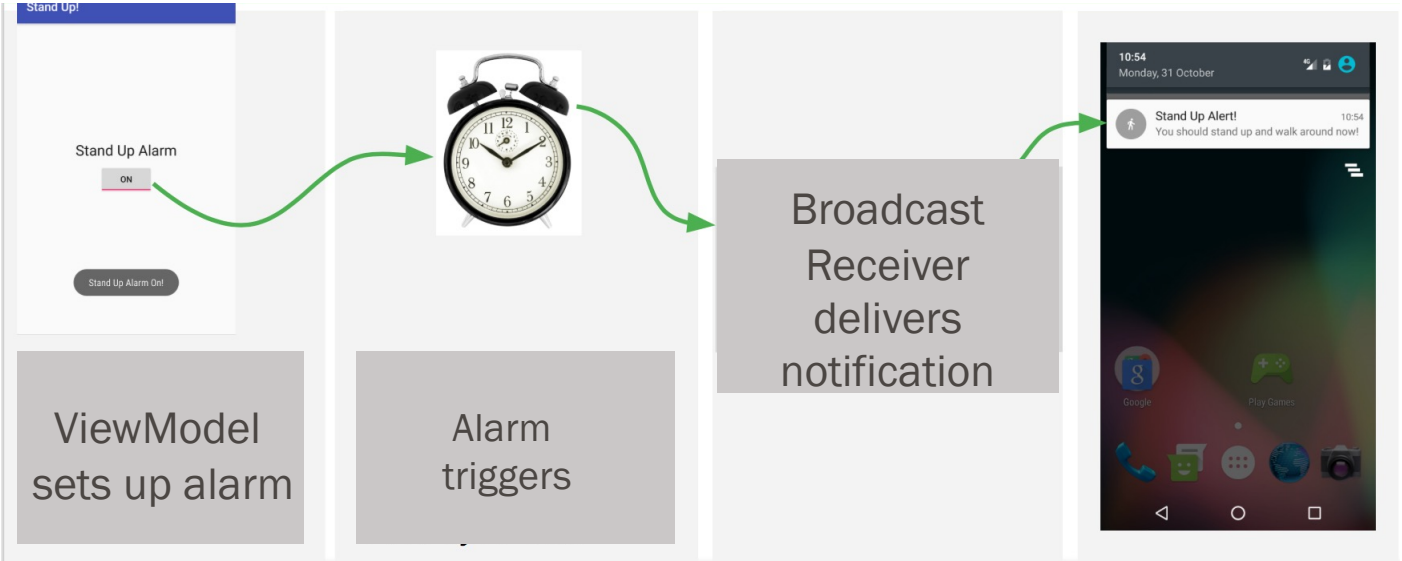
```
class AlarmReceiver: BroadcastReceiver() {

    override fun onReceive(context: Context, intent: Intent) {
        //Do something to deal with the alarm
    }

}
```

```
<application
    ...
    <activity android:name=".MainActivity">
        ...
    </activity>

    <receiver
        android:name=".receiver.AlarmReceiver"
        android:enabled="true"
        android:exported="false">
    </receiver>

</application>
```

Alarms

- An Alarm in Android schedules something to happen at a set time
  - Fire intents at set times or intervals
  - App does not need to run for alarm to be active

→ Use with BroadcastReceiver



Types of Alarms and behaviors

- Measuring time
  - Elapsed Real Time: time since system boot → Use when possible!
    - Independent of time zone
    - Used to measure intervals and relative time
    - Elapsed time includes time device was asleep
  - Real Time Clock (RTC)—UTC (wall clock) time
    - When time of day at local time zone matter

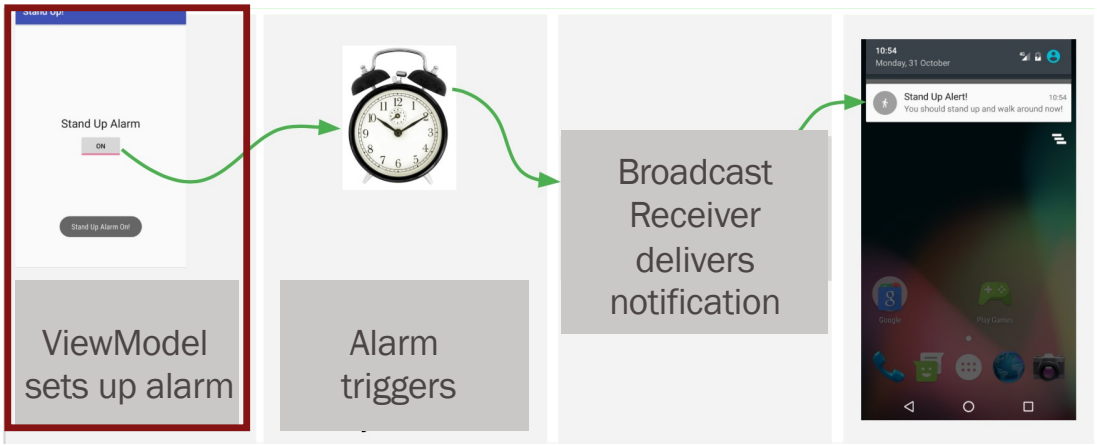
- Wake up behavior
  - Wakes up device if screen is off
    - Use only for critical operations
    - Can drain battery!
  - Does not wake up device
    - Fires next time device is awake

	Elapsed Real Time (ERT)—since system boot	Real Time Clock (RTC)—time of day matters
Do not wake up device	`ELAPSED_REALTIME`	`RTC`
Wake up	`ELAPSED_REALTIME_WAKEUP`	`RTC_WAKEUP`

Setting up an Alarm

1. Create AlarmManager in the ViewModel

```
class myViewModel(private val app: Application) :
                        AndroidViewModel(app) {

    val alarmMgr = app.getSystemService(Context.ALARM_SERVICE)
                    as AlarmManager
```



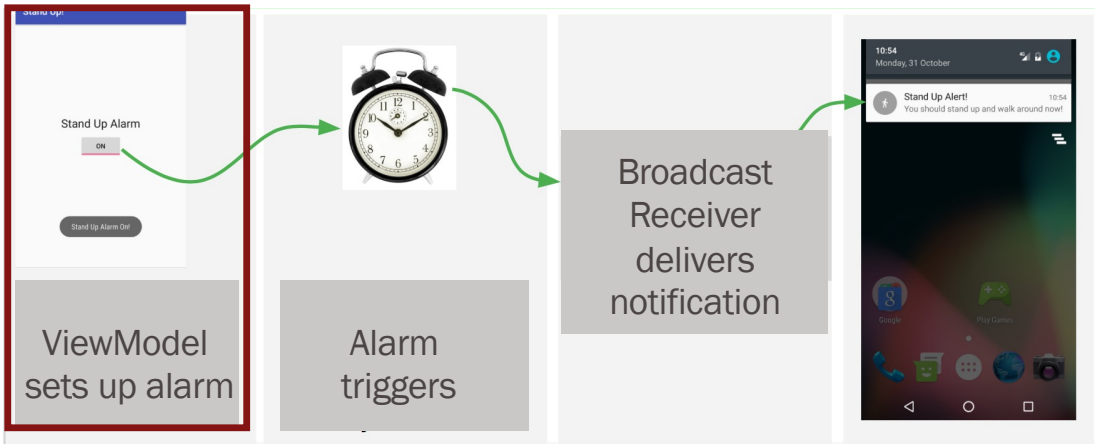
5

Setting up an Alarm

2. Also in ViewModel, set up a PendingIntent
   - associated to BroadcastReceiver
   - containing Intent processed by onReceive() in BroadcastReceiver

Broadcast Receiver name

```
fun onSetAlarm() {
        val alarmIntent = Intent(app, MyAlarmReceiver::class.java)
        val pd = PendingIntent.getBroadcast(app, REQUEST_CODE, alarmIntent, 0)
        alarmMgr.setExact(AlarmManager.ELAPSED_REALTIME_WAKEUP,
                          SystemClock.elapsedRealtime() + 60 * 1000,
                          pd)
```

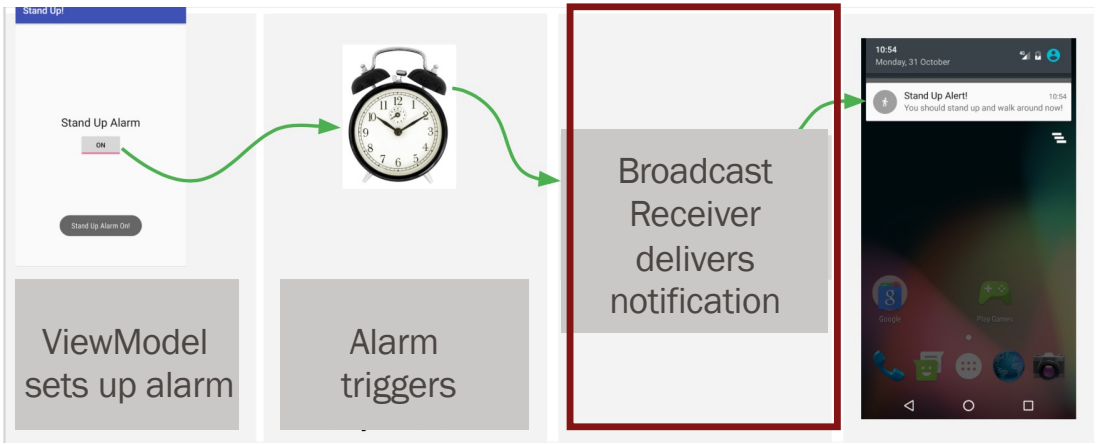


Setting up an Alarm

3. Advertise the Receiver in the Manifest XML file

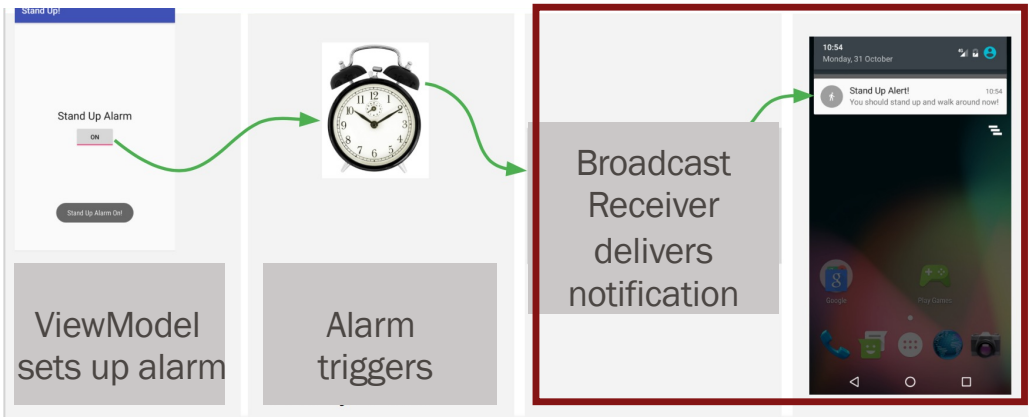
```
<application
  ...
  <activity android:name=".MainActivity">
     ...
  </activity>

  <receiver
    android:name=".MyAlarmReceiver"
    android:enabled="true">
  </receiver>

</application>
```

Broadcast Receiver name



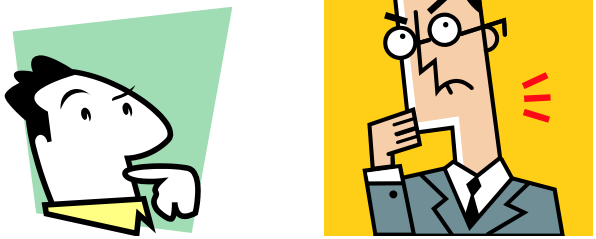
Setting up an Alarm

4. Create a BroadcastReceiver
   - Do something in onReceive()
   - In this example, the broadcast receiver displays a notification when triggered by the alarm



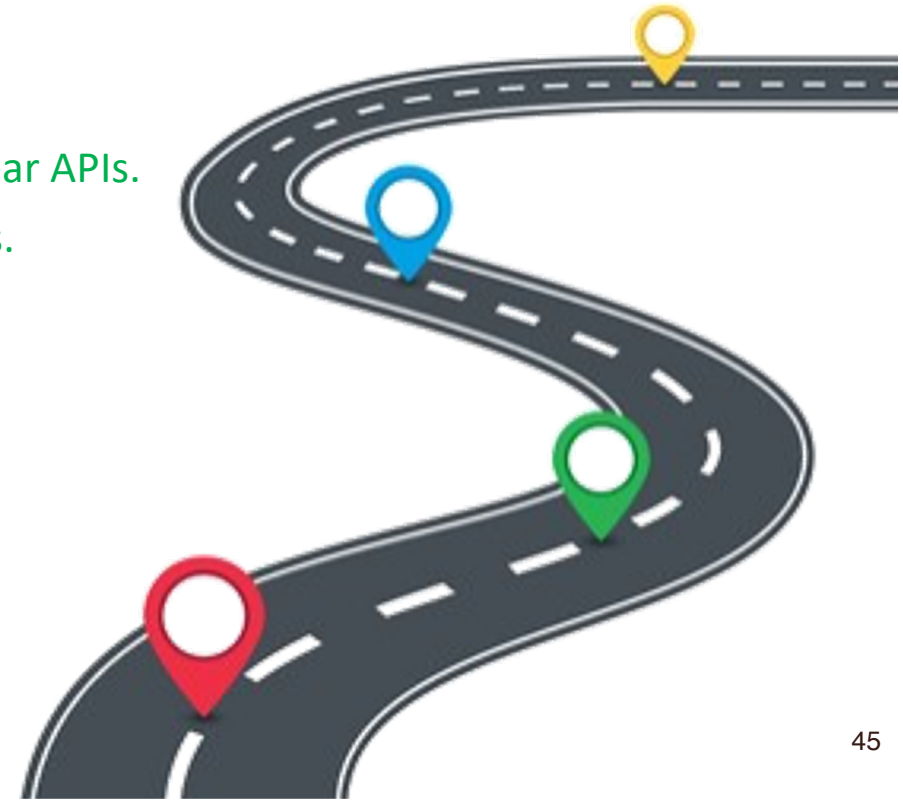

```
class Alarmreceiver : BroadcastReceiver() {

    private val NOTIFICATION_ID = 0

    override fun onReceive(context: Context, intent: Intent) {

        val notificationManager = getSystemService(
                context,
                NotificationManager::class.java
        ) as NotificationManager

        //create channel if
        // Build.VERSION.SDK_INT >= Build.VERSION_CODES.O

        val notifyBuilder = NotificationCompat
                .Builder(context,"myChannelID")
                .setSmallIcon(R.drawable.cooked_egg)
                .setContentTitle("My notification")
                .setContentText("Notification on time!")

        notificationManager
                .notify(NOTIFICATION_ID, notifyBuilder.build())
    }
}
```

Questions?



Where are we?

0. Course presentation. Introduction to Kotlin.
1. Android overview. Defining a GUI.
2. Dynamic applications: State and interactivity.
3. Complex GUIs: Screens and menus.
4. Apps under the hood: Life cycles
   Communication between Android and AndroidWear devices: Wear APIs.
5. Separating concerns: UI controllers and viewModels.
   Interfacing with sensors: System Services.
6. Interfacing with the cloud: Firebase.
   Displaying structured data: Lists.
7. Local databases: Room library.
   Integrating Google maps.
8. Bluetooth Low Energy.



Today's Lab

- Restructure tablet app
  - ViewModels
  - LiveData
  - Observers
- Acquire data from watch HR sensor
- Send HR data to tablet
- HR plot on tablet