Lab on apps development for tablets, smartphones and smartwatches

Week 1:
Android overview. Defining a GUI.

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Outline of the course

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.

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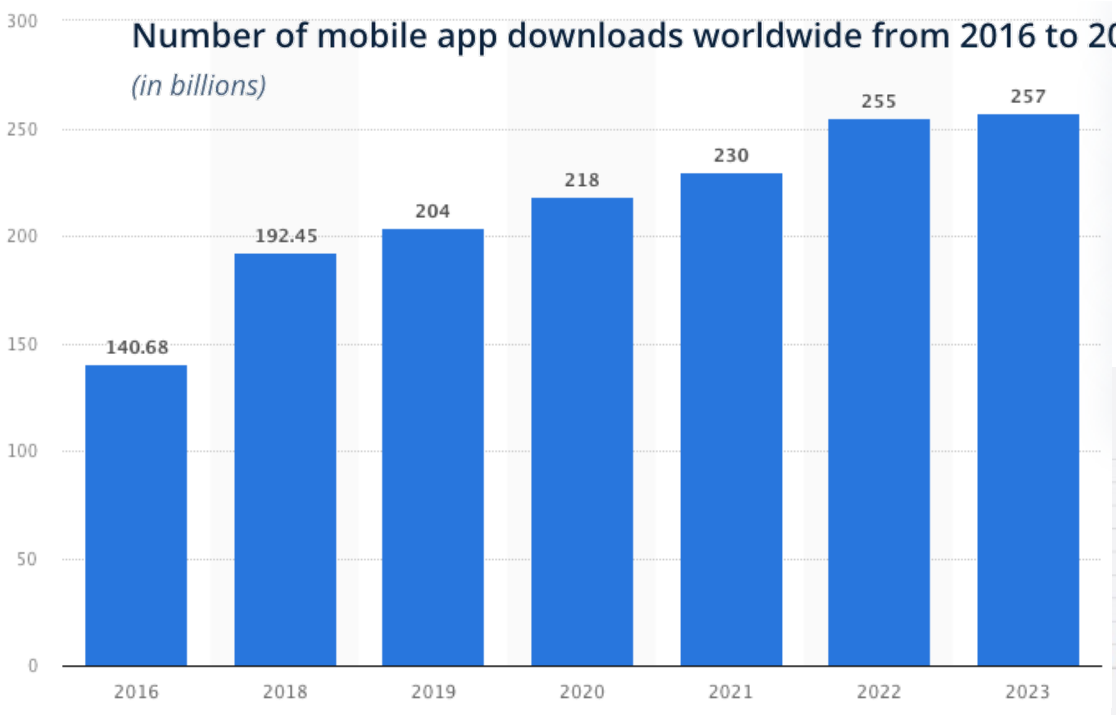
Growth of the mobile app economy



source: Statista, 2025

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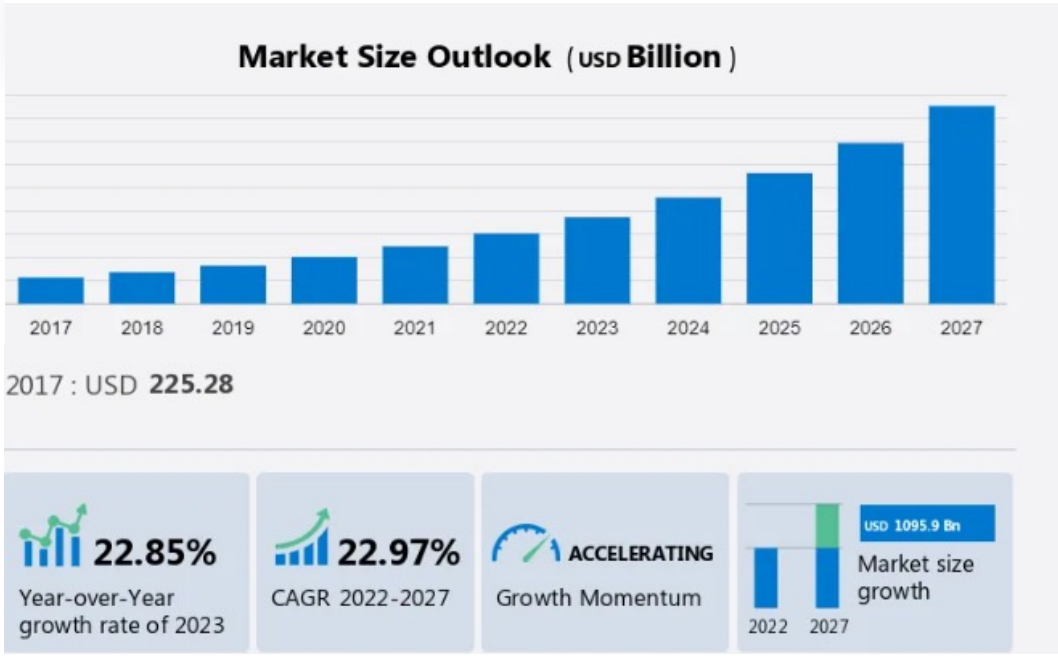

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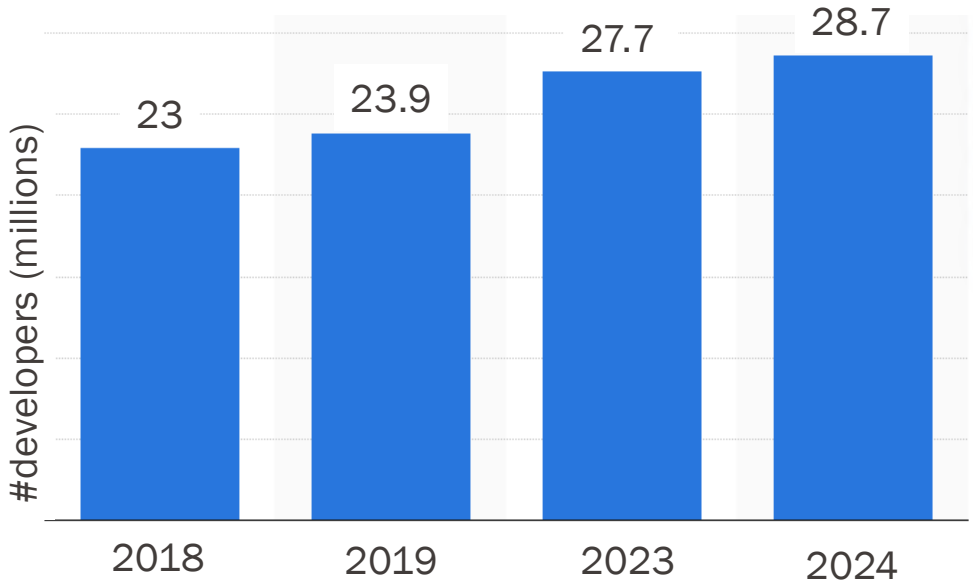
Apps market

- ~24M developers in 2019, 900K new developers per year
- 2% of developers earn 54% of all app. revenue
- 64% of Android developers are below the app. poverty line (<500$/month)



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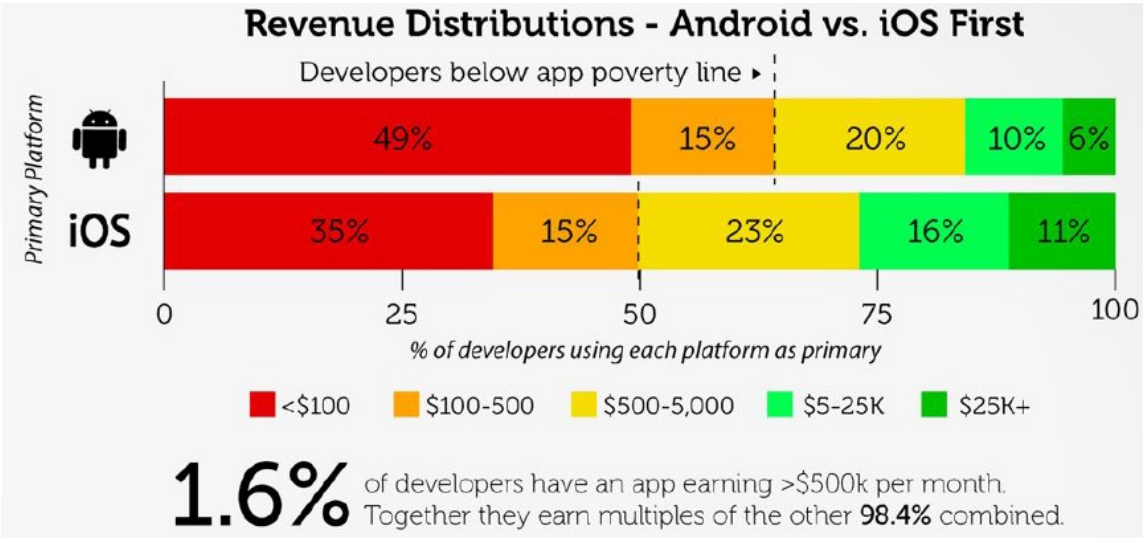

Source: GlobalVision, 2019

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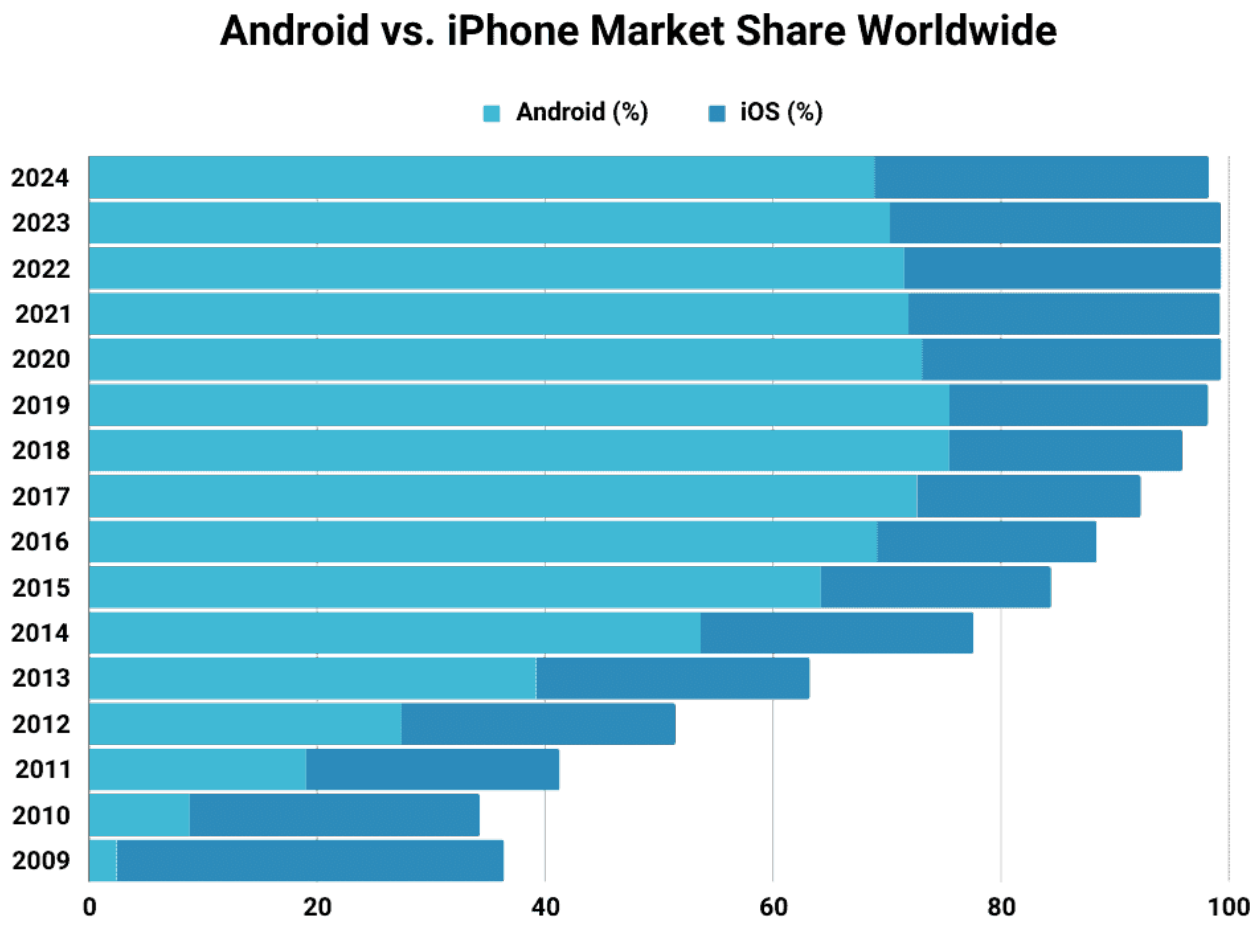
Android & iOS are the last two standing



source:
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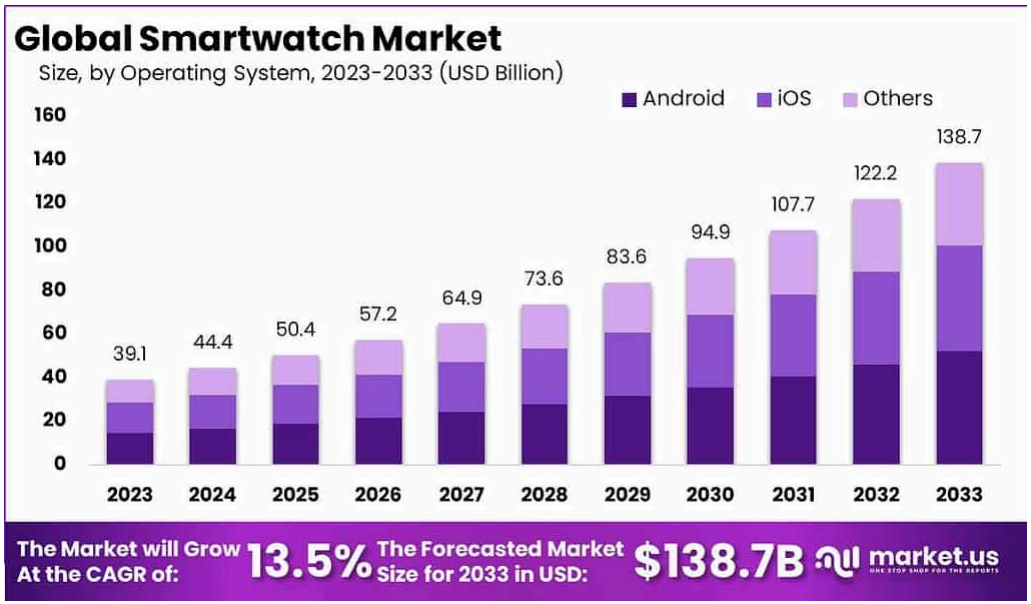
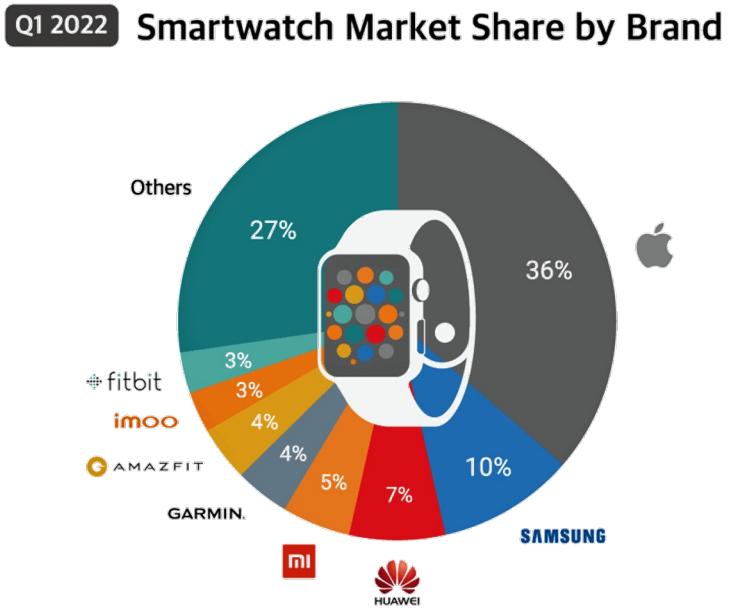
Developers are conquering… the wrist

- The same “Android vs. Apple” game
  - but with more players





Source: Market.us, 2025

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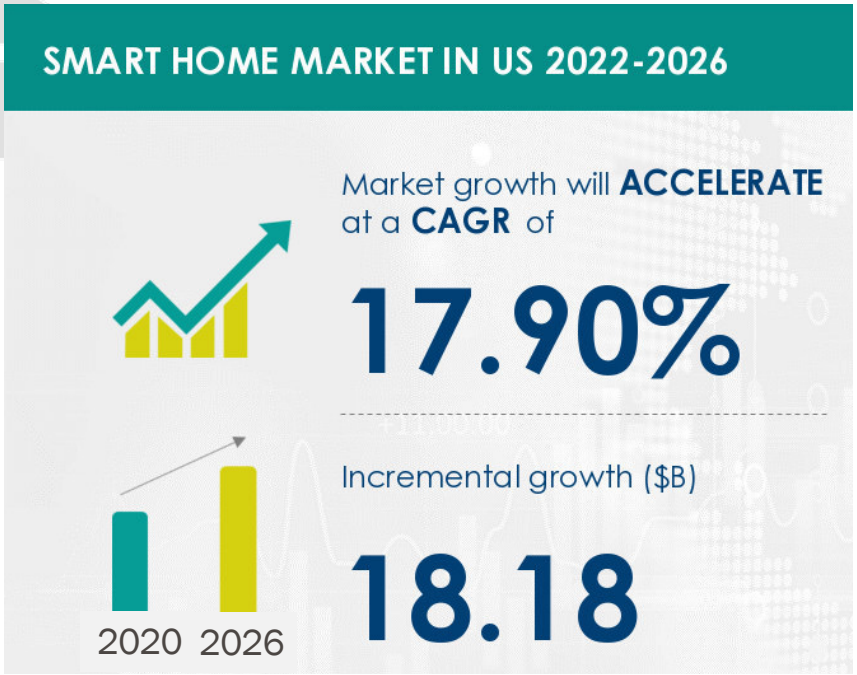
Developers are conquering… the home

Source: Developer Megatrends

- Entertainment
- Security
- Speakers
- Lighting
- Thermostats
- …



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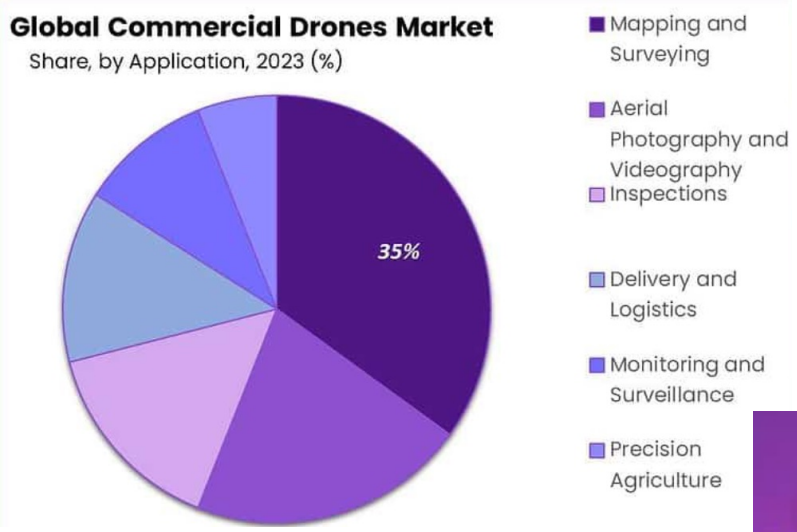
Developers are conquering… the sky

- Drones SDKs



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dji DEVELOPER

3D Robotics

Airware

Source:
Developer Megatrends

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Developers are conquering…

- cars
- cities
- healthcare
- clothing
- factories
- …

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Android development Opportunities

- 17B IoT devices (2024), and growing
  - 32B devices in 2030 [1]
- Smart* are an increasing market
  - * = watches, drones, cities, cars, ...
- Endless application landscape
  - No dominant 3rd party developers.... yet
- **You can develop for them today!**

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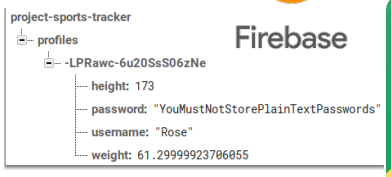
[1] “Number of IoT connections worldwide 2022-2033, with forecasts to 2030”, statista.com

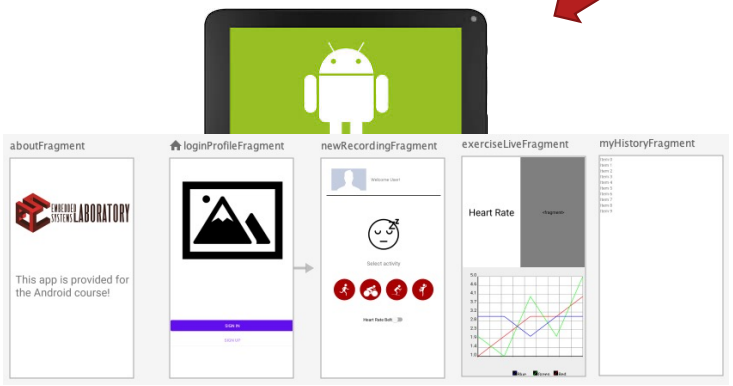
Distributed app across devices, sensors and the cloud

CLOUD



Firebase

TABLET



WEARABLES

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Class outline

- **Android overview**
- Resources, Composables
- Lab of Today
  - Create and build your first app for tablet & watch!

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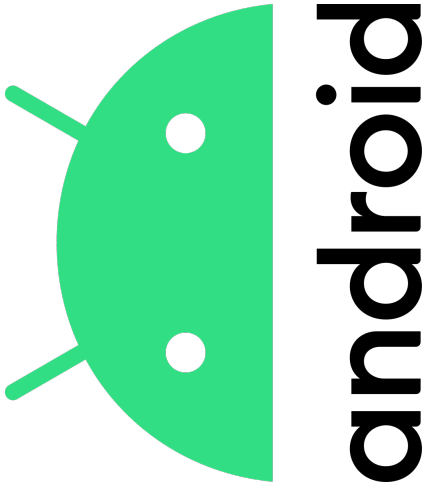
What is Android?

- Android is a **full ecosystem** used on over 80% of all smartphones
- Mobile operating system based on Linux Kernel
- User Interface (UI) for touch screens
- Multi-platform system:
  - powers devices such as watches, TVs, and cars
- Highly customizable for devices / by vendors
- Open source



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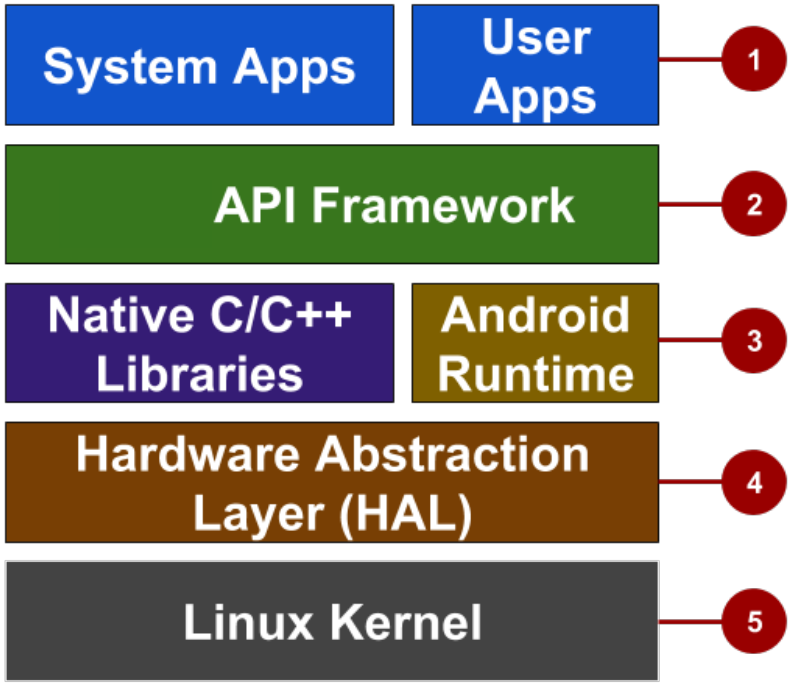
Android platform architecture

The Android stack is composed of layers:

1. System and user apps
2. Android OS API framework
   - Feature set of the Android-OS available via **Kotlin** APIs
3. Android runtime
   - Each app runs its own process with its own instance of the runtime
4. Hardware Abstraction Layer (HAL)
   - Standard interfaces that expose hardware as a library
5. Linux Kernel



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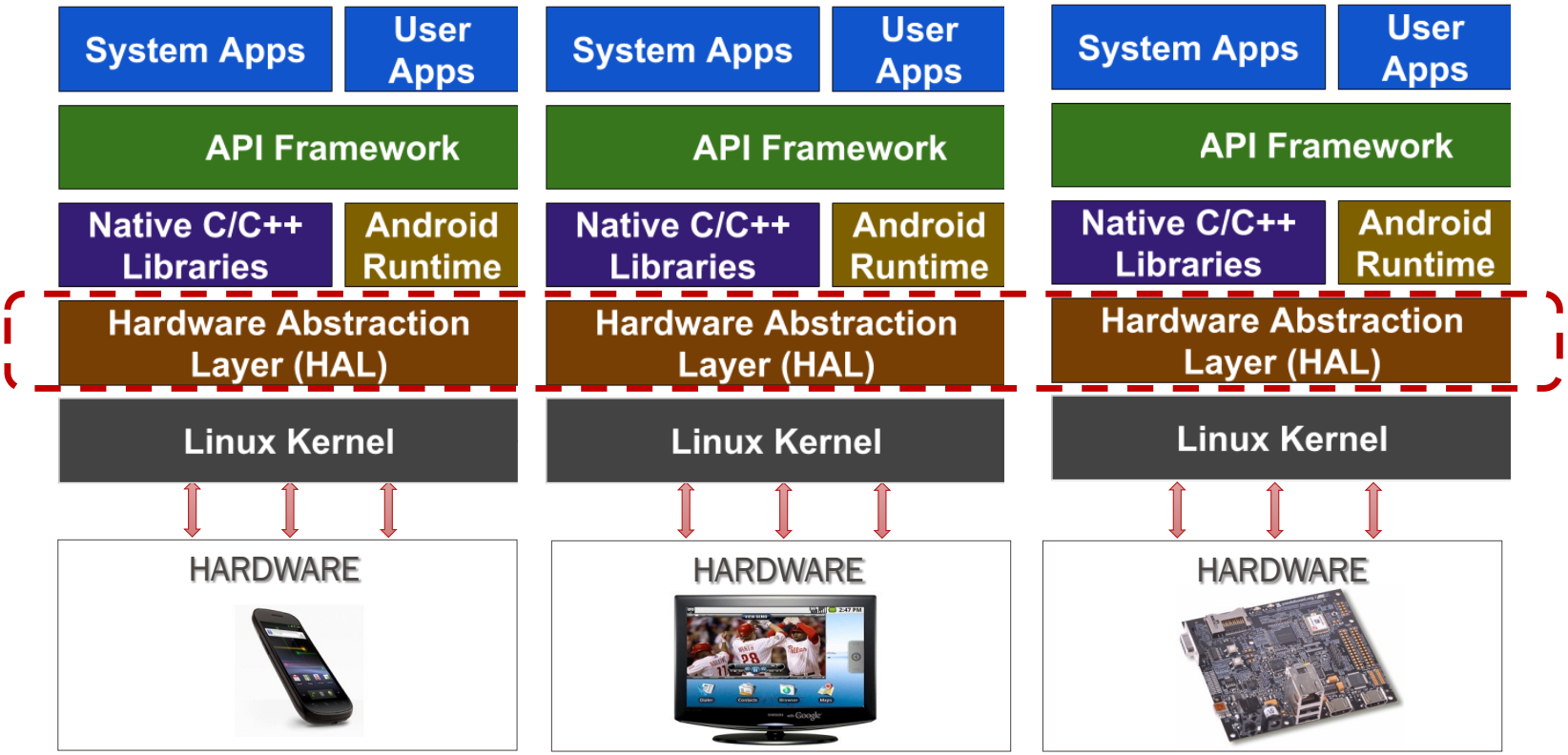
Multi Platform Support



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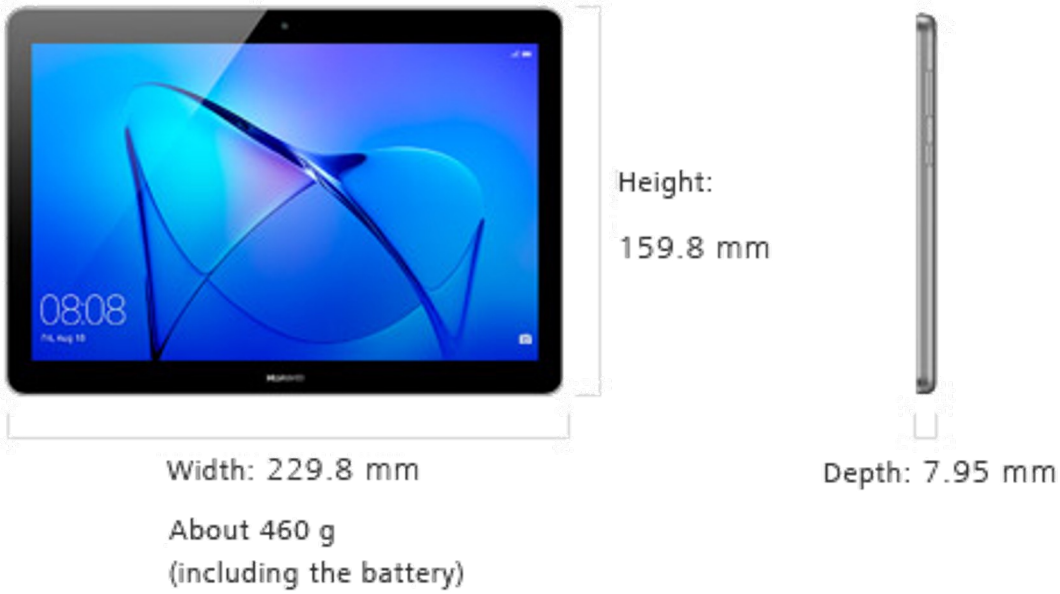
Huawei MediaPad T3 10”

- Chipset:
  - Qualcomm Snapdragon 425
    - 4 core Cortex A53 @1.4GHz
  - 3GB RAM
  - Built-in storage: 16GB
- Sensors
  - Ambient light sensor
  - Gyroscope
  - Accelerometer
  - Magnetometer
- Camera: 5MP (frontal 2MP)
- Bluetooth 4.0, A2DP
- WiFi 802.11 b/g/n
- 2G/3G/4G
- LCD Capacitive touchscreen
  - 9.6”, 16million colors, 800x1280px, 157ppi



Huawei Watch 2

- Chipset:
  - CPU: Qualcomm Snapdragon 2100
  - 768MB RAM and 4GB Flash
- Sensors:
  - 6-axis a+G sensor
  - 3-axis compass
  - Heart Rate Sensor (PPG)
  - Barometer
  - Capacitive sensor
  - Ambient light sensor
- GPS
- WiFi 2.4GHz 802.11b/g/n
- Bluetooth 4.1
- Display:
  - 1.2-inch circular AMOLED display
  - 390x390 pixels w. 326 PPI

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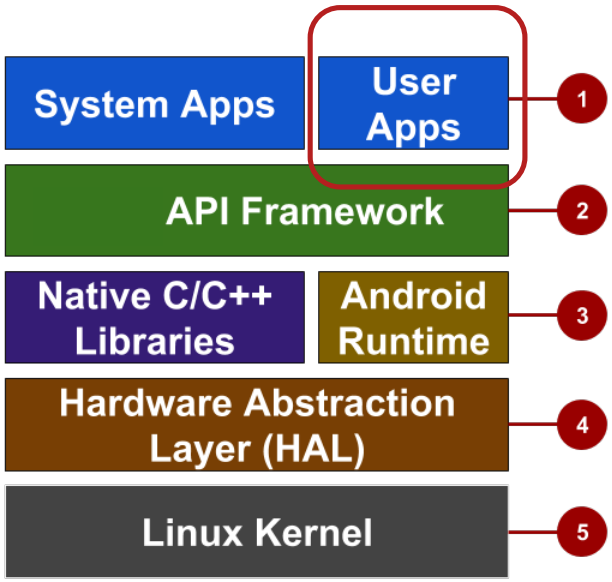
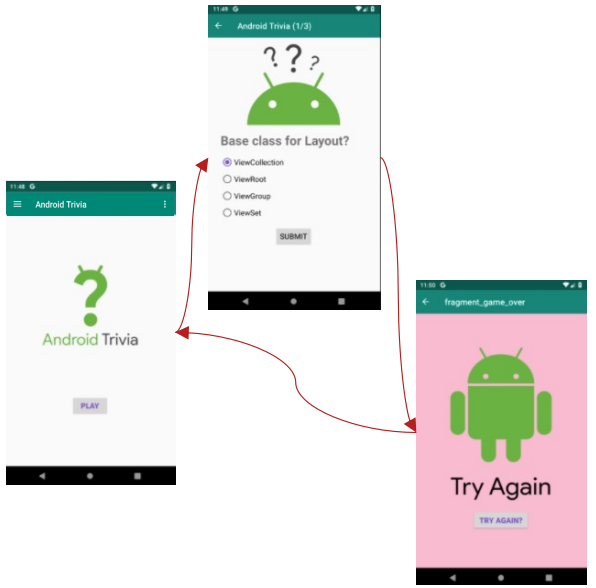
What is an Android app?

- A set of interactive screens
- GUI and behavior described in Kotlin Programming Language
- Developed with Android SDK (Android Studio)
- Using Android API Framework (2)
- Executed by Android Runtime Virtual machine (ART) (3)





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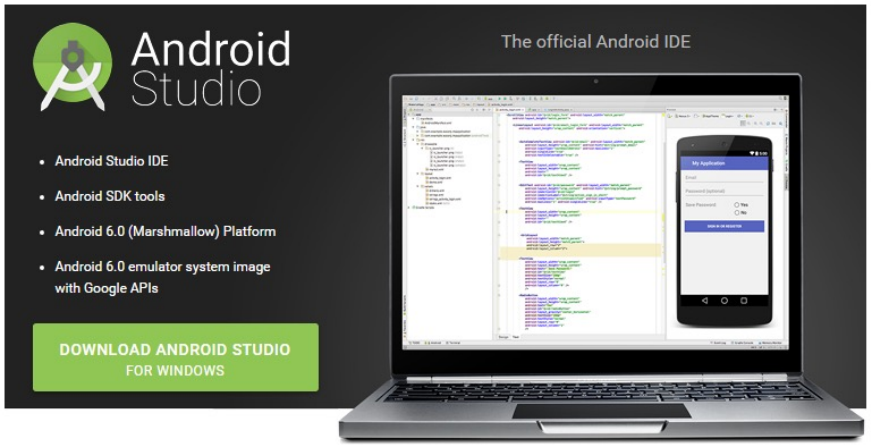
Android Studio

- Developers can download Android Studio for free: https://developer.android.com/studio/archive
  - Development tools (debugger, monitors, editors)
  - Libraries (maps, wearables)
  - Virtual devices (emulators)
  - Documentation (http://developers.android.com)
  - Sample code

- Android itself is an Open Source Project: http://source.android.com/



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Android versions

Source, Statcounter, July 2025

- Android 11 – 15 (2020-2025)
  → ~ 83% of devices
- App Developer specifies target and minimum version

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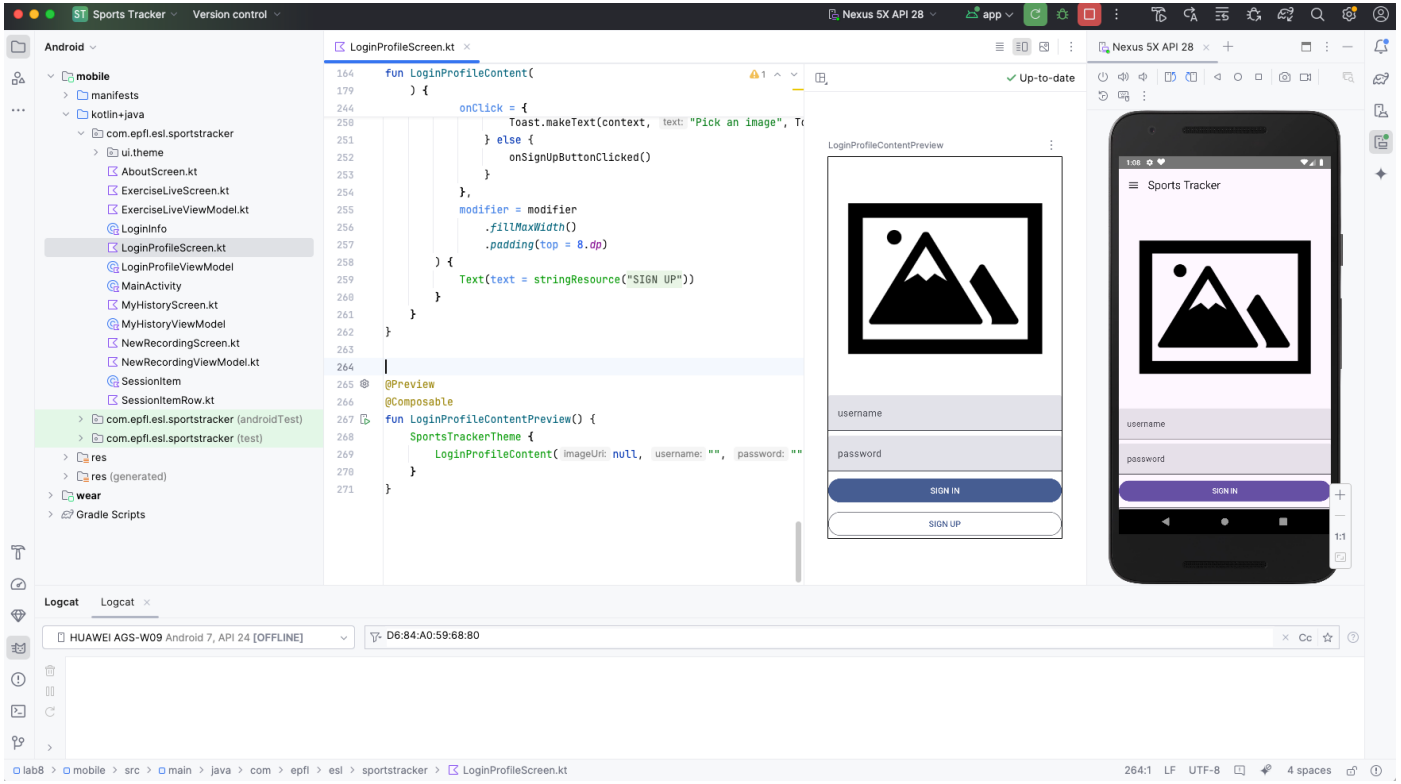
Android Studio

- Official Android IDE
  - Kotlin code for app logic and GUI layout
  - Configurations in XML
- Develop, run, debug apps …
  - Visual layout preview
  - Virtual devices (emulators)



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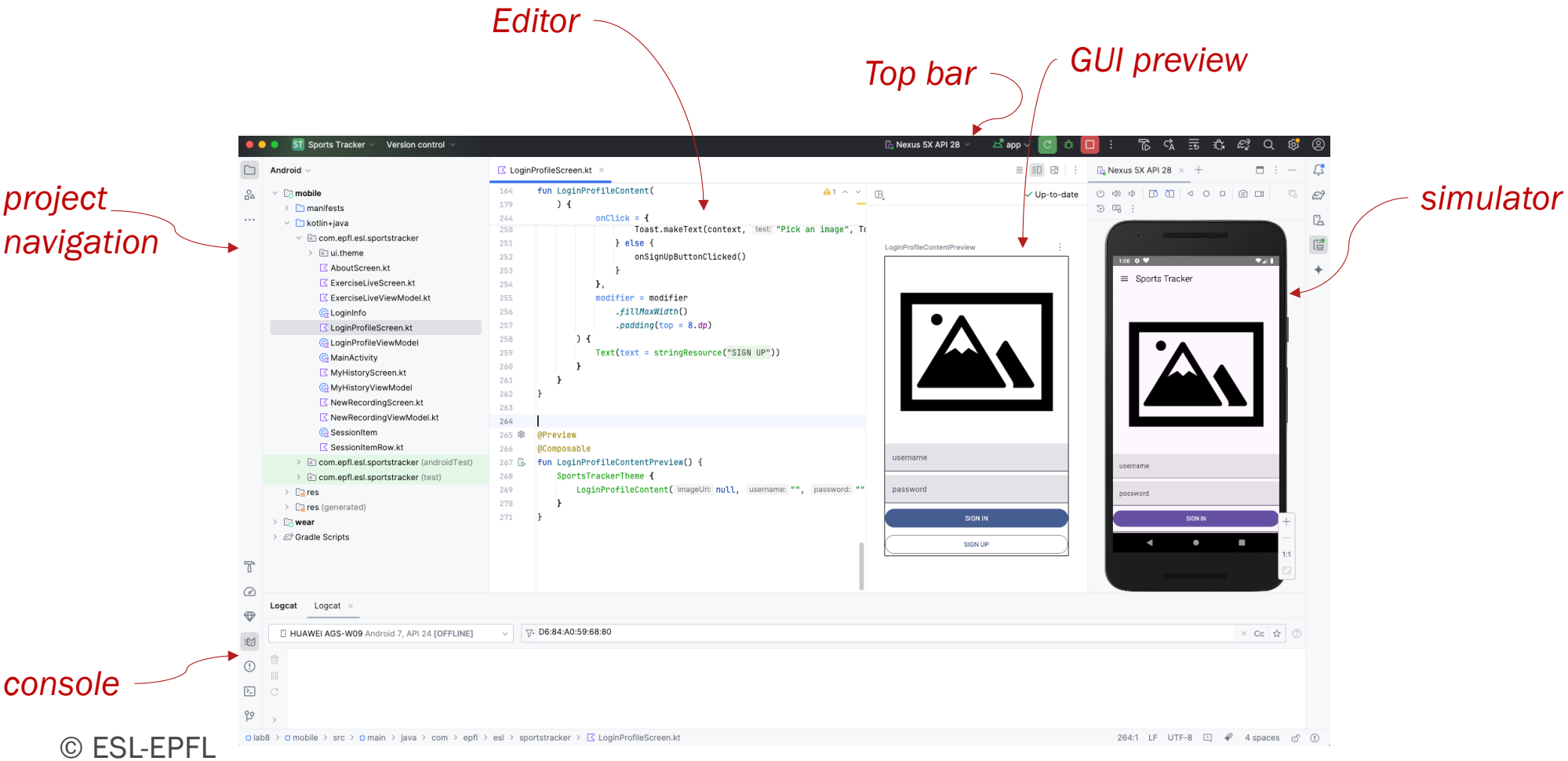
Android Studio



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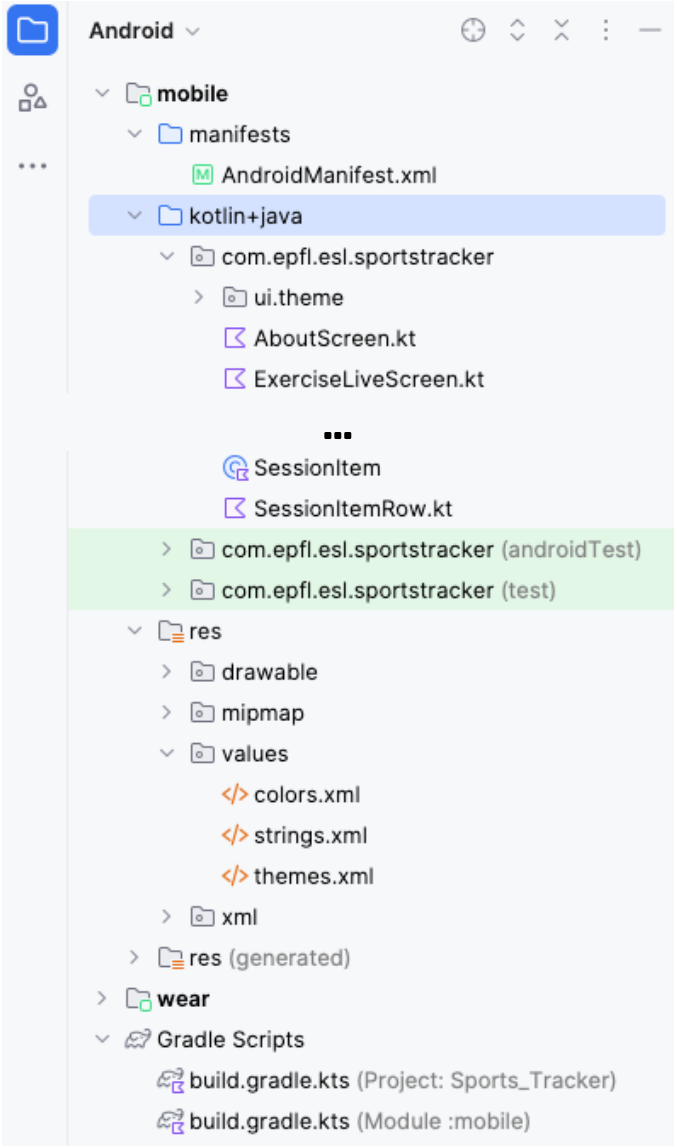
Android application building blocks

- manifests:
  - Characteristics of the app and component definition
- kotlin+java :
  - code of your app
  - Activities and VieModels → functionality
  - Composables → GUI
  - Helper classes
- res(ources):
  - images, strings, colors, XML and media files
- Gradle Scripts:
  - Scripts used to build the application



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Class outline

- Android overview
- **Resources, Composables**
- Lab of Today
  - Create and build your first app for tablet & watch!

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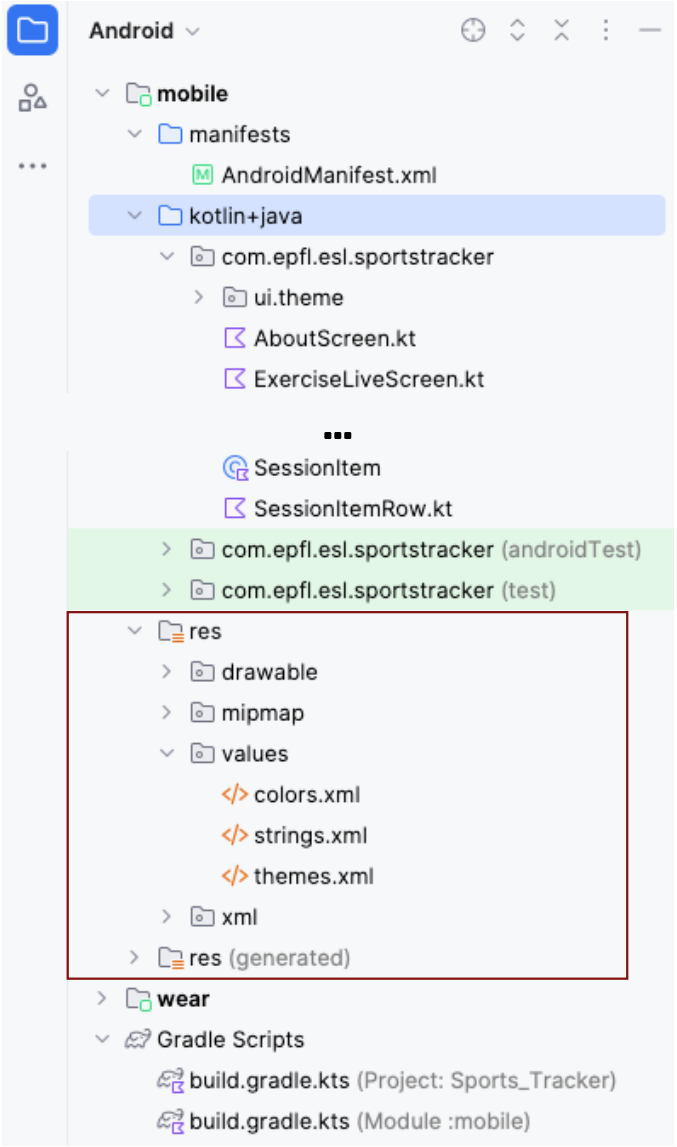
Application Resources

- Resources → everything that is not code

Resources… why?

- Provide alternative resources to support specific device configurations
  - different language packs, different screen size images
  - re-compile only when needed



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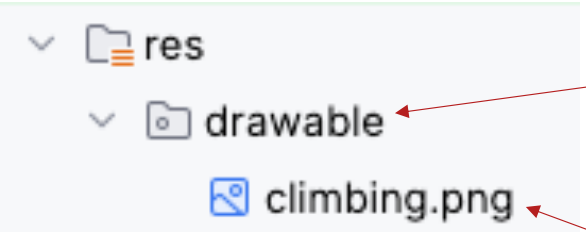
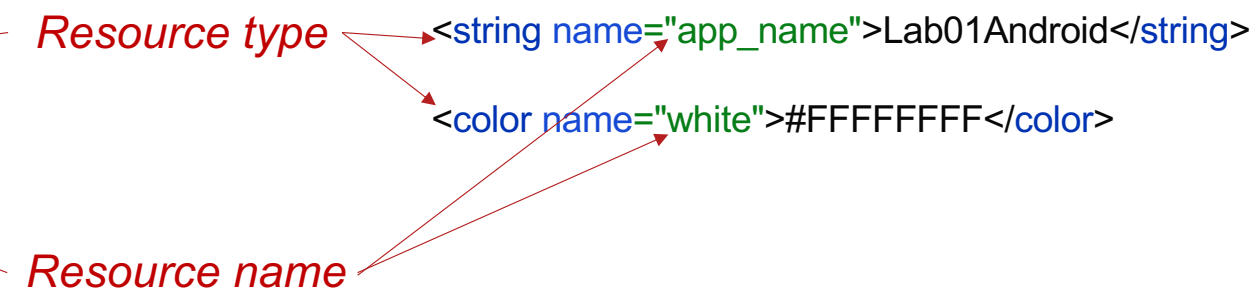
Application Resources

- Each Resource is associated with an **Identifier** (ID)
  - Identifiers must be unique!
- ID is composed of two parts:
  - The resource **type** (e.g. string, drawable, color, etc…)
  - The resource **name**, either:

- Media



- Values



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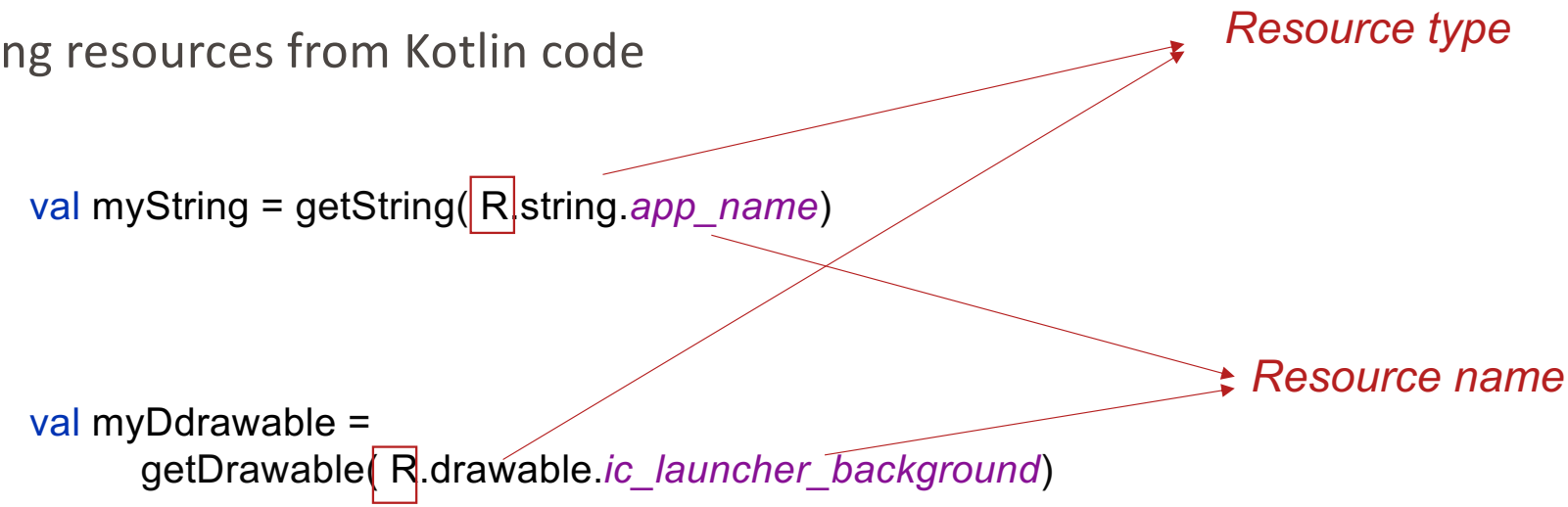
Access to Application Resources

- Referencing resources from Kotlin code



- **R** class: glue between Kotlin and resources

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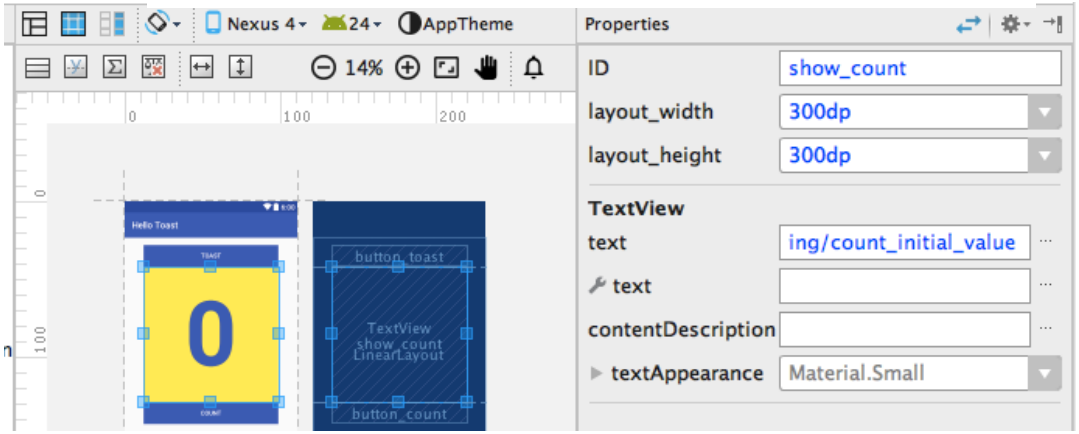
GUI design in XML
(the old way)

- Using View resources
  - Text, buttons, ...
  - parameters for size, color, ...
- ViewGroups resources as ”Views containers”
  - To organize GUI elements in columns, grids...
- Views-based GUI development
  - directly in XML code
  - graphically with Android Studio

```
<TextView
    android:id="@+id/my_text"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:text="Hello World!"
    android:textSize="36sp"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintLeft_toLeftOf="parent"
    app:layout_constraintRight_toRightOf="parent"
    app:layout_constraintTop_toTopOf="parent" />
```



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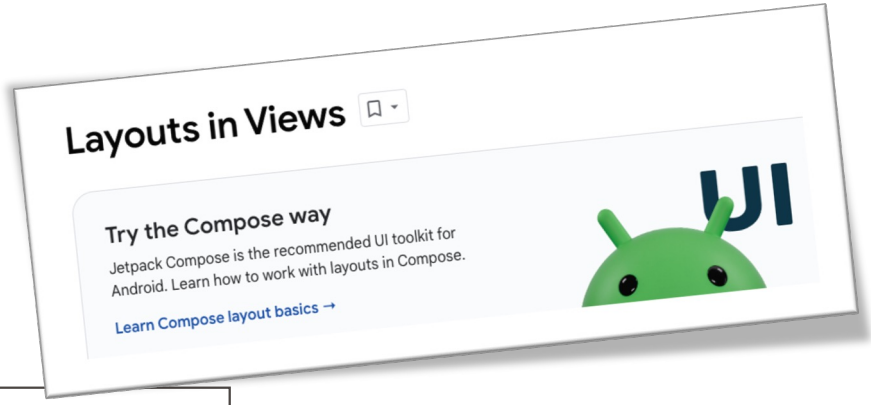
GUI design in XML
(the old way)

- More information on views:
  https://developer.android.com/develop/ui/views/layout/declaring-layout

- View can be wrapped in Composables with AndroidView
  - Composables → modern way of building Android GUIs



AndroidView composable

View linked here

```
AndroidView(factory = { ctx ->
   TextView(ctx).apply {
      layoutParams = ViewGroup.LayoutParams(
         ViewGroup.LayoutParams.MATCH_PARENT,
         ViewGroup.LayoutParams.WRAP_CONTENT
      ),
      it.text = "Hello World!"
})
```

- More information on Views in Composables:
  https://developer.android.com/codelabs/basic-android-kotlin-compose-view-interop

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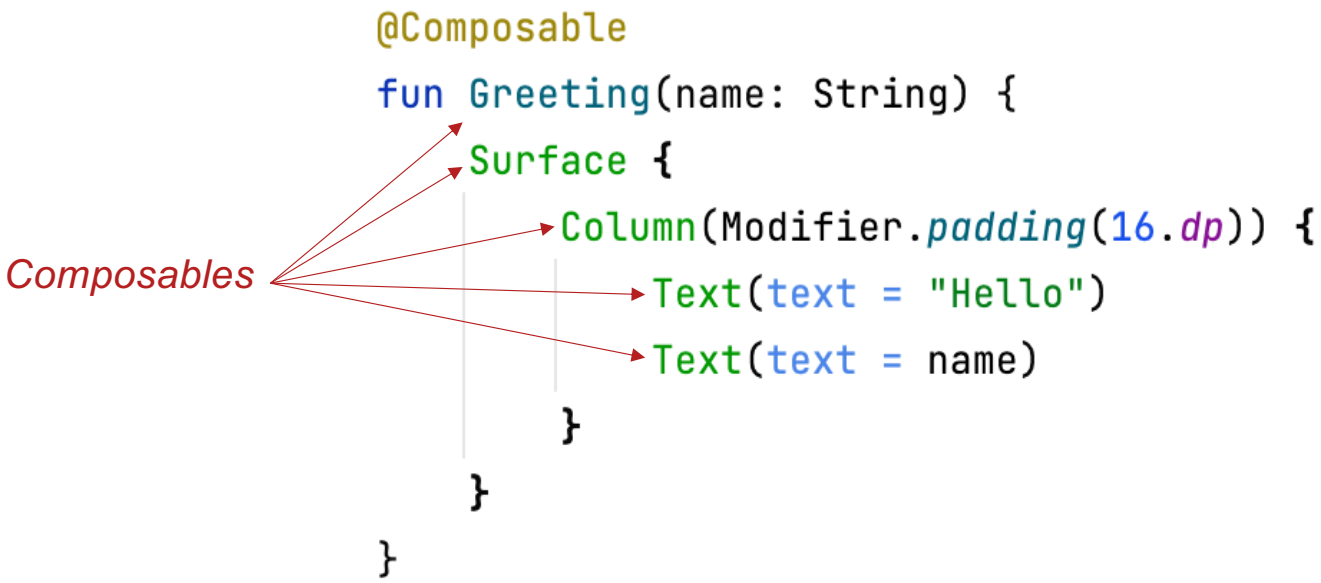
GUI design with Jetpack Compose

- GUI elements declared as Kotlin @Composable functions



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GUI design with Jetpack Compose

- Top composables called inside the setContent method in a ComponentActivity class
  - Activities are the “entry point” of an app (more on Activities next week)

- OnCreate() callback
  - call to super
  - inflate layout
  - inflate theme
    - color scheme, typography, shapes
  - MyApp() ***composable*** function

```
class MainActivity : ComponentActivity() {
    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContent {
            MaterialTheme {
                MyApp(modifier = Modifier.fillMaxSize())
            }
        }
    }
}

@Composable
fun MyApp() {
    ...
}
```

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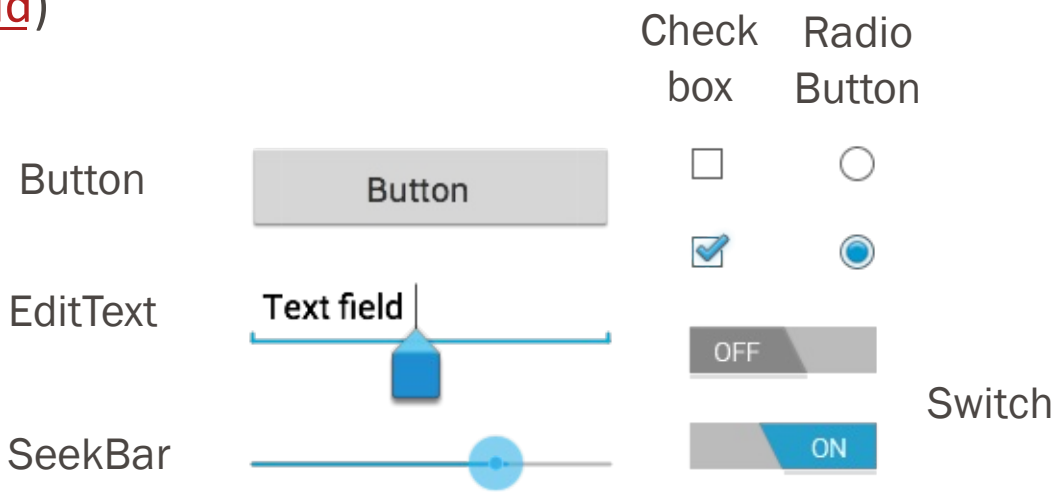
Composables

- **Composable** is the basic building block to create user interfaces
  - Everything the app user sees, is a composable

- Default/standard provided composables:
  - text display (Text), text edit (TextField)
  - Buttons, menus and other controls
  - scrollable lists:
    LazyColumn, LazyRow, LazyGrid
  - Images
  - ...



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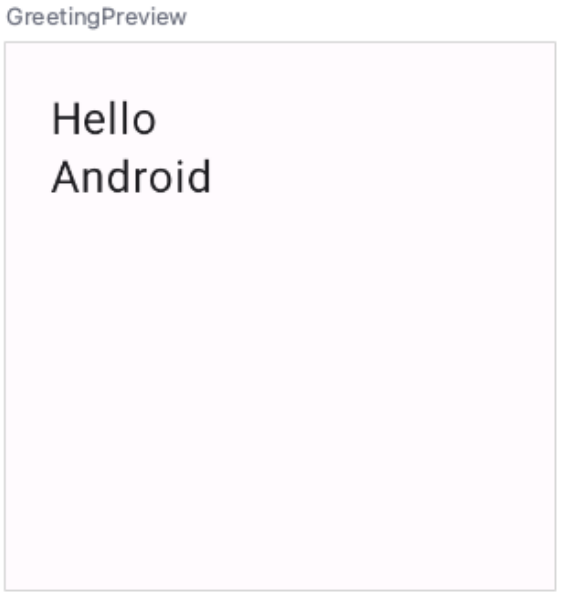
Composables previews

- Composable can be @Previewed
  - previews can parameterized to test specific scenarios or layout dimensions

```
@Composable
fun Greeting(name: String){
   Surface{
      Column(Modifier.padding(16.dp)) {
         Text(text = "Hello")
         Text(text = name)
      }
   }
}

                @Preview(widthDp = 320, heightDp = 320)
                @Composable
                fun GreetingPreview() {
                   MaterialTheme {
                      Greeting("Android")
                   }
                }
```

Preview size



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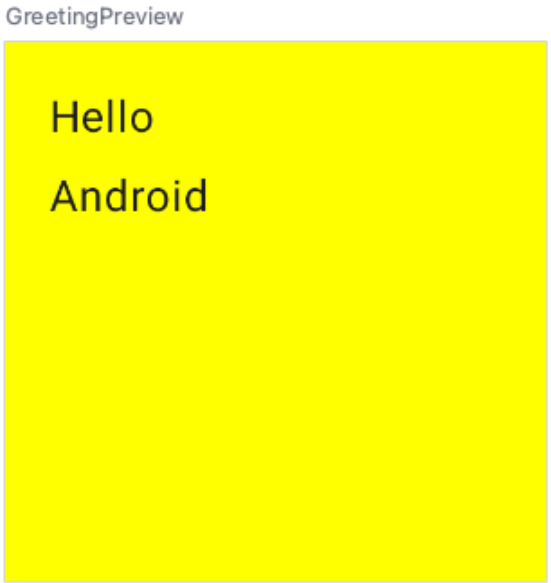
Custom composables

- Composables can be
  - created
  - reused
  - combined

```
@Composable
fun Greeting(name: String, modifier: Modifier = Modifier)
{
Surface{
   Column(
      modifier = Modifier
         .background(color = Color.Yellow)
         .padding(16.dp)
      ) {
         Text(text = "Hello")
         Spacer(modifier = Modifier.size(8.dp))
         Text(text = name)
      }
   }
}
```



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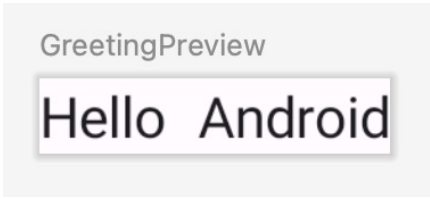
Composable layouts

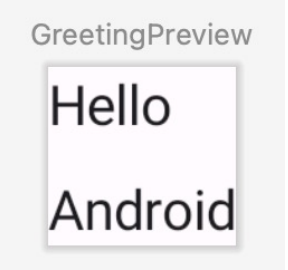
- Organize composables positions
  - Row

```
Row { this: RowScope
    Text(text = "Hello")
    Spacer(modifier = Modifier.size(8.dp))
    Text(text = name)
}
```



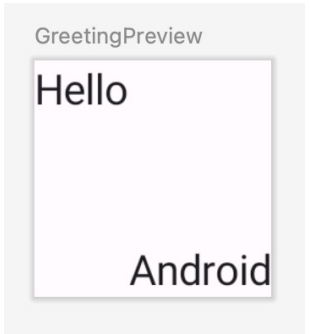
  - Column

```
Column { this: ColumnScope
    Text(text = "Hello")
    Spacer(modifier = Modifier.size(8.dp))
    Text(text = name)
}
```



  - Box – put elements on top of another

```
Box(modifier = Modifier.size(80.dp)) { this: BoxScope
    Text(text = "Hello", modifier =  Modifier.align(Alignment.TopStart))
    Text(text = name, modifier = Modifier.align(Alignment.BottomEnd))
}
```



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Modifiers

- Change composables size, layout, behavior and appearance
- Also, make composables clickable, animate them
  - next lectures!

```
Column(
    modifier = Modifier
        .background(color = Color.Yellow)
        .padding(16.dp)
        .fillMaxWidth()
        .clickable { /* Handles click event */ }
) { this: ColumnScope
    Text(text = "Hello")
    Spacer(modifier = Modifier.size(8.dp))
    Text(text = name)
}
```

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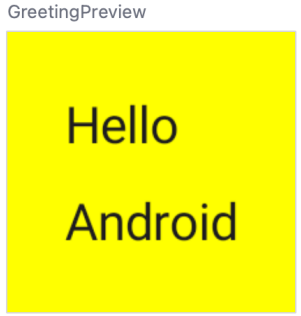
Modifiers

- The order of modifier functions is significant (left to right)

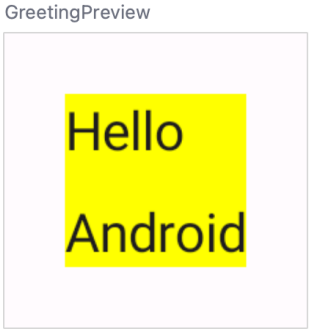
Example 1:

```
Column(
    modifier = Modifier
        .background(color = Color.Yellow)
        .padding(16.dp)
) { this: ColumnScope
    Text(text = "Hello")
    Spacer(modifier = Modifier.size(8.dp))
    Text(text = name)
}
```



Example 2:

```
Column(
    modifier = Modifier
        .padding(16.dp)
        .background(color = Color.Yellow)
) { this: ColumnScope
    Text(text = "Hello")
    Spacer(modifier = Modifier.size(8.dp))
    Text(text = name)
}
```



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Modifiers scope

- Some modifiers are specific for one type of composable scope
  - E.g. *Modifier.align(Alignment.BottomEnd)* can only be applied inside a BoxScope
  - Attending to add a modifier to a wrong scope results in a compilation error

```
Box(modifier = Modifier.size(80.dp)) { this: BoxScope
    Text(text = "Hello", modifier =  Modifier.align(Alignment.TopStart))
    Text(text = name, modifier = Modifier.align(Alignment.BottomEnd))
}
```

- Full list of modifiers and their scopes:
  https://developer.android.com/jetpack/compose/modifiers-list

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Passing modifiers between composables

- Best practice: add a modifier parameter at the end of custom Composables.
  - Makes reusing Composables easier and avoids code duplication

```
@Composable
fun Message(message: String, modifier: Modifier = Modifier) { … }

@Preview
@Composable
fun WinMessagePreview() {
   MaterialTheme {
     Message("You win", Modifier.background(Color.Green).padding(16.dp))
   }}

@Preview
@Composable
fun LoseMessagePreview() {
   MaterialTheme {
     Message("You lose", Modifier.background(Color.Red).padding(16.dp))
   }}
```

Same composable

Different modifiers

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Constraint layouts

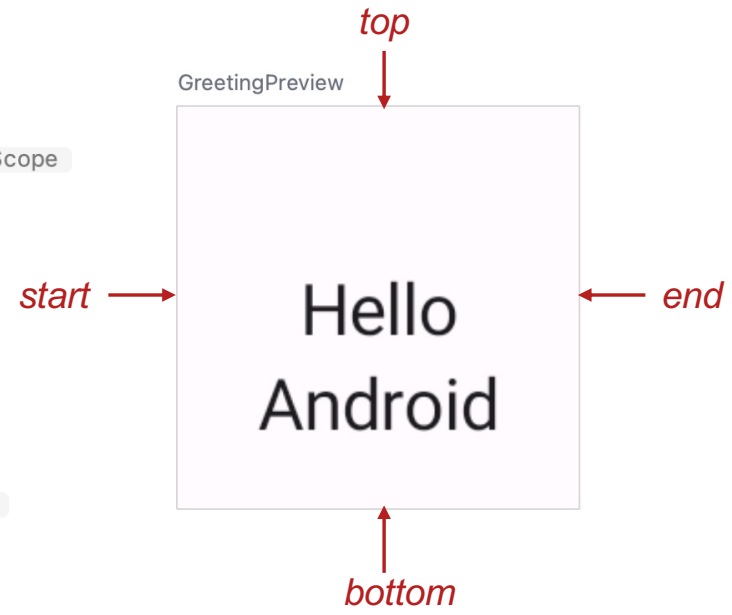
- Allows placement of composables relative to other composables on the screen
  - Avoids nesting multiple Rows and Column
  - Modifiers anchor composables to other composables

reference for each composable in the layout

```
ConstraintLayout(modifier = Modifier.size(80.dp)) { this: ConstraintLayoutScope
    val (greetingRef, nameRef) = createRefs()

    Text(text = "Hello",
        modifier = Modifier.constrainAs(greetingRef) { this: ConstrainScope
            top.linkTo(parent.top)
            start.linkTo(parent.start)
            end.linkTo(parent.end)
            bottom.linkTo(parent.bottom)
        })

    Text(text = name,
        modifier = Modifier.constrainAs(nameRef) { this: ConstrainScope
            top.linkTo(greetingRef.bottom)
            start.linkTo(parent.start)
            end.linkTo(parent.end)
        })
}
```



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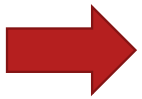
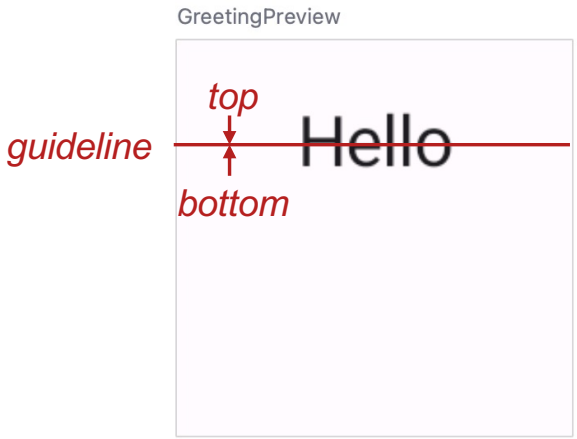
Constraint layouts guidelines

- Guidelines are invisibles lines that help to position composables
  - can be created at a certain point (dp) or certain percentage inside the parent composable.
- Two types:
  - Horizontal -> start and end
  - Vertical -> top and bottom

```
val topGuideline = createGuidelineFromTop( fraction: 0.25f)

Text(text = "Hello",
    modifier = Modifier.constrainAs(greetingRef) { this: ConstrainScope
        top.linkTo(topGuideline)
        bottom.linkTo(topGuideline)
        start.linkTo(parent.start)
        end.linkTo(parent.end)
    }
)
```





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Recomposition

- Recomposition is performed at run-time anytime the GUI needs to be updated
  - Drawing the screen is costly

- → Jetpack compose only redraws the GUI parts that needs updating
  - Composable functions can execute in any order depending on changes in internal state

```
@Composable
fun ButtonRow() {
   MyFancyNavigation {
      TopScreen()      ← TopScreen() does not have to execute before MiddleScreen()
      MiddleScreen()
      BottomScreen()
   }
}
```

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Class outline

- Android overview
- Resources, Composables
- **Lab of Today**
  - Create and build your first app for tablet & watch!

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Today's Lab – Your first app

1. Creating your first Android project
2. A static screen displaying text and images
3. Use Column and ConstraintLayout
4. Running your app (on real device and emulator)
   1. on the Phone/Tablet
   2. on the Watch

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Class outline

- Android overview
- Resources, Views and Layouts
- Lab of Today
  - Create and build your first app for tablet & watch!
- **Gentle reminder: groups and material**

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Questions?

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