Développement d'Applications Android
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1 Kotlin

1.1 Data class

auto getter/setter/toString/properties/copy
`data class Artist(var id: Long, var name: String)`
destructure : `val(name,surname,age) = p`

1.2 Null safety

— `a?.name` → a.name else null / compile seulement avec `val n: String? = a?.name`
— `!!` → KotlinNullPointerException si b est null
— `?:` → `c?.name ?: "Unknown"` default if null

1.3 Extension functions

Ability to add any function to any class

1.4 Classes

— inherit of Any and are final()
— `class Person(private var name: ...)` → set private attribute
w/o `private` → public
— multiple constructors → use 'init' and 'constructor()'
— default getter/setter → can't be modified if created by default constructor

1.5 Inheritance

Use `open class...` → `class Student(name:String,var uni:String): Person(name,surname)` (you have to specify super constructor)

1.6 Collections

— `List, Set, Map` and `MutableList/Set/Map`
— `any, count, max, filter, map, partition, +` `(concatenate lists)`
— `.partition { it % 2 == 0 } = Pair(List<2,4>, List<1,3>)`

1.7 Operator overloading

- `==` is Java `equals`, `===` is Java `==`

1.8 When

Similar to switch case

```
when(view) {
  is TextView -> view.text = "Hello"
}
val res = when(x){
  0, 1 -> "binary"
  else -> "error"
}
```

1.9 Exceptions

Not mandatory to handle exceptions

1.10 Scope functions

1.10.1 let

block executed only if p is non null, no return value

```
var p : Person? = null
p?.let { it.age = 23 }
```

1.10.2 apply

block executed returning the edited value

```
Calendar.getInstance().apply{ set(Calendar.MONTH, 4) }
```

1.10.3 use

For closeable objects, automatically closes after

```
Writer("file").use { it.appendLine("stuff") }
```

1.11 Companion objects

Equivalent to static, has values, variables, methods...

2 Android Resources

2.1 Manifest File

Build tools, smartphone OS + store requirements :
— App components : activities, services, broadcast receiver, content providers
— Permissions
— Hardware/software functionalities needed

2.2 Resources

Will contain all files and static content used by app.
Best practice : separate resources from code → better maintenance

2.2.1 Values

— Textual (string.xml) with Plural management possible (one/other)
— dimension.xml, use `dp`
— colors.xml
— themes.xml

2.2.2 Drawables

— Bitmap fields : each image has multiple sizes/definitions (+ optimization depending on a phone, we want to avoid a high def for a 'small' phone or the opposite)
— Vector
— Nine-patch : controlled resizing (we don't want to distor the folder image)
— State list (pressed/focused/hovered)
— Level list multi images (e.g 1-4 wifi bars)

2.2.3 Layout

ViewGroups organize the display of views (**Layout**, e.g., LinearLayout)
— Views : graphical elements (**widgets**, e.g., Button)
Main types :
— LinearLayout : horizontal/vertical
— RelativeLayout : relative to parent and Views/ViewsGroups
— ConstraintLayout : better performance and integration compared to Relative
— ScrollView : no nesting

2.2.4 Resource Contextualization

Resources adapt to device configuration at **runtime** (language, screen size/orientation, Android version, etc.) by using qualified directories :

```
res/
    values/strings.xml          # Default
    values-fr/strings.xml       # French
    values-fr-land/strings.xml  # French landscape
    layout-sw600dp/main.xml     # 7" tablets
```

Key points :
— Multiple qualifiers must follow strict ordering
— **Default** resources (without qualifiers) **must always be provided**
— System selects best match, falling back by removing qualifiers right-to-left

2.3 R Class

During build time, the Android Gradle Plugin generates a final class `R` containing static references to all application resources. The class is generated in the app's root package.

2.3.1 Package Structure

— App resources : generated in app's package (e.g., `com.example.myapp.R`)
— Library resources : each library has its own `R` class in its package
— Android framework resources : accessible via `android.R`

2.3.2 Resource References

From XML :
— App resources : `@id/my_view`
— Android resources : `@android:id/text1`
From code :

```
// App resources
setContentView(R.layout.activity_main)
findViewById<Button>(R.id.my_button)

// Android framework resources
textView.setTextColor(android.R.color.black)

// Library resources (e.g., Material components)
Snackbar.make(view, R.string.ready, LENGTH_SHORT)
```

2.3.3 Build Process

— `R` class is generated during resource compilation phase
— Each resource gets a unique integer ID
— IDs remain constant during app execution but may change between builds
— Resource references are replaced with these IDs at compile time

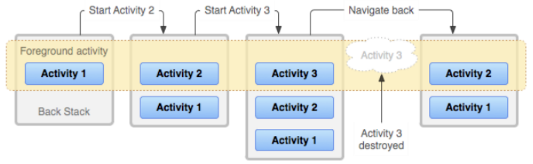
2.3.4 Build Scripts

— Gradle : manage package/deps, compilation
— 2 build.gradle files : 1 for whole project, 1 for app (project module)
— Packages retrieved using maven (groupId, artifactId, version)

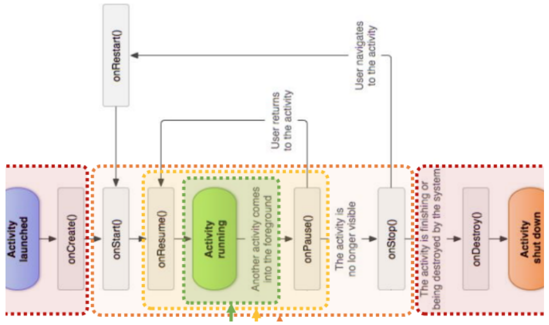
3 Activity, Fragments, Services

3.1 Activity

Represents a layout of an app
— Must be in Manifest file
— activity in a stack



3.1.1 Lifecycle


onRestart()
User navigates to the activity
User returns to the activity
Activity launched
onCreate()
onStart()
onResume()
Activity running
Another activity comes into the foreground
onPause()
The activity is no longer visible
onStop()
The activity is finishing or being destroyed by the system
onDestroy()
Activity shut down

Activities have a specific lifecycle managed by the system (inversion of control). Never instantiate activities directly with constructors.

3.1.1.1 Lifecycle Methods

— `onCreate()` : Called when activity created or recreated after being killed by system. Setup UI, initialize data.
— `onStart()` : Activity becoming visible but not yet interactive.
— `onResume()` : Activity gains focus, can interact with user.
— `onPause()` : Activity losing focus but still visible (e.g., split-screen).
— `onStop()` : Activity no longer visible.
— `onDestroy()` : Activity being destroyed.

3.1.1.2 Common Triggers

— User navigates between apps : `onPause()` → `onStop()`
— Screen rotation : `onPause()` → `onStop()` → `onDestroy()` → `onCreate()`
— Split-screen activation : `onPause()` (activity remains visible)
— Back button : `onPause()` → `onStop()` → `onDestroy()`
— System kills background activity : `onDestroy()`
— Dialog opens : `onPause()` (activity partially visible)

3.1.1.3 Activity States

— **Active** : Top of stack, visible and interactive
— **Paused** : Visible/partially visible, no focus
— **Stopped** : Not visible, in memory
— **Inactive** : Temporary state when created/killed

Note : The system can kill paused or stopped activities to reclaim resources. Activities must save their state in `onSaveInstanceState()`.

3.1.2 First Steps

Override onCreate (mandatory) :

```
override fun onCreate(savedInstanceState: Bundle?) {
    super.onCreate(savedInstanceState)
    setContentView(R.layout.activity_main)
}
```

— Inherit from Activity/AppCompatActivity
— complexity hidden from inheritance
Interactions :
— `findViewById<Button>(R.id.my_btn)` : searches item and will return corresponding view and return the object reference. Search can be heavy. → use **`lateinit var`** to avoid call findViewById for each view interaction
— `btn.setOnClickListener{}`

3.1.3 Intents

Mechanism to ask the system to start an activity : By default, in Manifest the **app entry** will use an Intent

```
val i = Intent(this, MySecondActivity::class.java)
startActivity(i)
```

Intent types and behavior :
— Launch activities : added to stack. When ended, pop from stack and return to previous one
— End activity : `back` button - default behavior should be preserved
  — Overrideable using `addCallback {}`
  — Can use `finish()` to end activity
— Explicit (same app, e.g., MySecondActivity)
— Implicit (other app), e.g. Open web page, send mail/message, use camera

3.1.4 Activity Key/Value Data

Intents can carry data between activities using key-value pairs :
— Put extras using `putExtra()`
— Retrieve using appropriate getter method (`getStringExtra()`, etc.)
— Bundle for complex data structures

3.1.5 Contracts

Activity result contracts provide a type-safe way to :
— Pass data between activities
— Handle activity results
— Register for callbacks
— Manage permissions

3.1.6 Activity Save/Restore

Use `onSaveInstanceState(outState: Bundle)` and `onRestoreInstanceState(savedState: Bundle)`. Autosaves widgets with **ID**. The bundle will be passed to the new instance to `onCreate(savedSte: Bundle)`. E.g save a counter value and on rotate will destroy the activity but with onCreate will retrieve the saved counter value.

3.2 Fragments

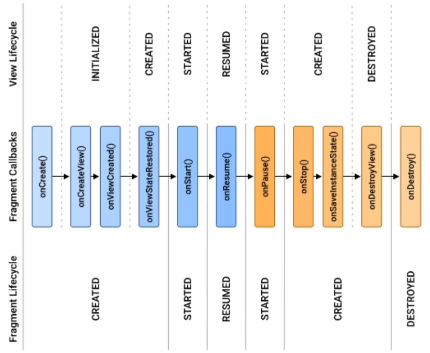
Reuse GUI, divide interface with multiple Fragments. Fragments will berun in a host Activity.

3.2.1 Fragment Lifecycle

Fragment lifecycle includes additional states and callbacks compared to activities. The fragment manager handles state transitions and manages the fragment backstack.

Key lifecycle states :

— Created	— Resumed	— Stopped
— Started	— Paused	— Destroyed



Managed by `FragmentManager` (transactions) :
- Different state transitions
- Add/pop in main activity + manage stack

3.2.2 Fragments Overview

Add fragment :

```
<androidx.fragment.app.FragmentContainerView
  android:id="@+id/framelayout"
  android:name="package.MyFragment"/>
supportFragmentManager.beginTransaction()
  .replace(R.id.framelayout, MyFragment.newInstance())
  .commit()
```

Screen rotation : recreates but preserves internal state

3.2.3 Data Exchange Activity/Fragment

- Activity → Fragment : Fragment can use Activity public methods
- Fragment → Activity : Fragment can use `getActivity`, activity can be **null**
- Fragment → Fragment : Via Activity : Frag1 → Act → Frag2

3.3 Services

For long operations in background, executed **only** in main thread (UI-Thread)

Types :
- Foreground : linked to visible notification (download, player)
- Background : no UI, time limited (server sync, save)
- Bounded : linked to app (activity), destroyed when no more links

3.3.1 Background and Foreground

- `startForegroundService()` and `startService()`
- `startFService` has 5 sec to be in front using `startF`
- `stopService` with Intent and `stopSelf()`
- Background service lives only minutes after app is in background

3.3.2 Bounded

`bindService()` + `unbindService()`, can bind to fg/bg service. Enables Service-Activity communication, otherwise use LocalBroadcast.

Example Background :

```
val i = Intent(this, MyService::class.java)
startService(i)
```

`onStartCommand()` flags :
- START_STICKY : restart service ASAP (null intent)
- START_NOT_STICKY : no restart
- START_REDELIVER_INTENT : restart with original intent

Example Bounded :

```
override fun onStart() {
    super.onStart()
    val i = Intent(this, MyService::class.java)
    bindService(i, connection, BIND_AUTO_CREATE)
}
override fun onPause() {
    super.onPause()
    unbindService(connection)
    mBound = false
}
```

When bound : `if(mBound) mService.startThread()`

4 Broadcast Receiver

Pub/sub system for messages. Register in Manifest :

```
<receiver android:name=".MyBroadcastReceiver"
↪  android:exported="true">

class MyBroadcastReceiver : BroadcastReceiver() {
    override fun onReceive(context: Context, intent:
    ↪  Intent) {
        when(intent.action) {
            Intent.ACTION_LOCALE_CHANGED -> {} (...)
```

5 Content Providers

- Access to centralized DB data
- Standardized communication between apps
- Data identified by URI (e.g., `content://contacts/people/1`)
- CRUD operations
- Can impose permissions

5.1 File Provider

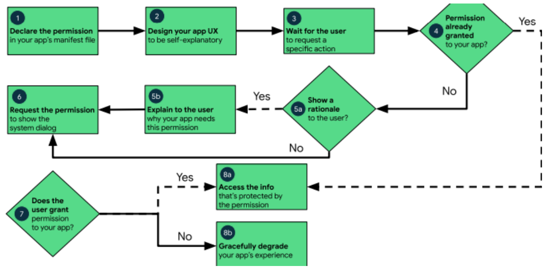
- Access to non-structured data (files)
- Shared storage : all apps access, `READ_EXTERNAL_STORAGE`
- Private storage : app-only (sandboxing)
- Temporary access via URI to private storage files

6 Permissions

Levels :
- Installation : in Manifest, auto-granted
- Execution : 'dangerous' permissions, **requires user grant**
- Special : system apps or manufacturers only

Best practices :
- Control : user choice to grant
- Transparency : clear permission purpose
- Minimal : necessary permissions only

Example :
- Download image : requires `<uses-permission android:name="android.permission.INTERNET" />`
- List mobile : `READ_PHONE_STATE` (dangerous) requires explicit grant


1 Declare the permission in your app's manifest file
2 Design your app UX to be self-explanatory
3 Wait for the user to request a specific action
4 Permission already granted to your app?
Yes
No
5a Show a rationale to the user?
Yes
5b Explain to the user why your app needs this permission
No
6 Request the permission to show the system dialog
7 Does the user grant permission to your app?
Yes
8a Access the info that's protected by the permission
No
8b Gracefully degrade your app's experience

7 Graphical Interface

7.1 View Visibility

Three possible states :
- **VISIBLE** : Default state, view is visible
- **INVISIBLE** : View not displayed but space reserved in layout
- **GONE** : View hidden and no space reserved (as if never added, size = 0)

Modification through XML or code :

```
<TextView
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:visibility="gone" />
view.visibility = View.GONE
```

7.2 Main View Types

7.2.1 TextView and EditText

7.2.1.1 TextView for displaying text

- Formatting : bold, italic, size, color
- Basic HTML support (`<b>`, `<i>`, etc.)
- `android:textIsSelectable` for text copying

7.2.1.2 EditText for user input

- `inputType` : `text`, `textPassword`, `number`, `phone`
- `hint` for input guidance
- Listeners : `TextWatcher` for input events

7.2.2 Button and ImageButton

- Click handling :

```
button.setOnClickListener { // Action on click }
button.setOnLongClickListener {
    // Action on long click
    true // return mandatory
}
```

- Icon support with `drawableLeft/Right/Top/Bottom` or Material Design

7.2.3 ImageView

- Displays images from resources or memory
- `scaleType` to control resizing :
  - `fitCenter` : Resizes to fit within bounds
  - `centerCrop` : Fills by cropping if necessary
  - `fitXY` : Stretches to fill
- Asynchronous loading required for online images

7.2.4 Selection Components

7.2.4.1 CheckBox, Switch, ToggleButton

```
switch.setOnCheckedChangeListener { _, isChecked ->
    if (isChecked) {
        // Enabled
    } else {
        // Disabled
    }
}
```

7.2.4.2 RadioGroup and RadioButtons

- Non-cancellable single choice
- Group management via `RadioGroup`
- Events via `setOnCheckedChangeListener`

7.2.4.3 Spinner

- Dropdown list
- Data source : `string-array` or `Adapter`
- Adapter enables dynamic list and updates

7.2.5 Progress Bars

7.2.5.1 ProgressBar

- Indeterminate mode : continuous animation
- Determinate mode : progress 0-100
- Horizontal or circular

7.2.5.2 SeekBar (inherits from ProgressBar)

- User interaction to set value
- `setOnSeekBarChangeListener` for events

7.2.6 WebView

- Displays web content in app
- Requires Internet permission for online content
- JavaScript configuration :

```
webView.settings.javaScriptEnabled = true
```

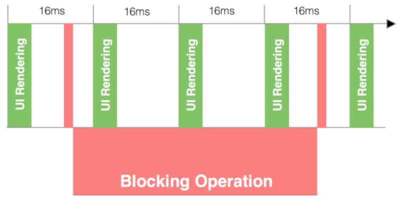
- JavaScript-Android interface possible

7.3 UI-Thread and Background Operations

- UI-Thread : main thread for user interface
- Long operations must run in background

Example :

```
val imageView = findViewById<ImageView>(R.id.image)
thread {
  val url = URL("https://example.com/image.jpg")
  val bmp = BitmapFactory.decodeStream(
    url.openConnection().getInputStream()
  )
  runOnUiThread {
    imageView.setImageBitmap(bmp)
  }
}
```



7.4 Custom Views

7.4.1 Creation

- Inherit from `View` or subclass
- `@JvmOverloads` for multiple constructors
- Implement `onDraw()` and `onTouchEvent()`

7.4.2 Custom Attributes

```
<declare-styleable name="CustomView">
    <attr name="customAttribute" format="string" />
</declare-styleable>
```

7.5 Material Components

Enhanced TextField :

— Error handling	— Hint animation
— Start/end icons	

7.6 User Feedback

- Toast : simple temporary message
- Snackbar : message with possible action
- Dialog : user decision or input

7.7 Notifications

- Asynchronous, outside application
- Require channel since Android 8.0
- Actions via `PendingIntent`
- Can be expandable

Notification channel :

```
val channel = NotificationChannel(CHANNEL_ID, name,
↪  importance).apply {
    description = descriptionText
}
```

7.8 ActionBar

Main navigation with configurable icons and text

```
override fun onCreateOptionsMenu(menu: Menu): Boolean
↪  {
    menuInflater.inflate(R.menu.main_menu, menu)
    return true
}
```

7.9 ListView vs RecyclerView vs ScrollView

7.9.1 ScrollView

- Single child container allowing content to scroll
- No view recycling (all content loaded in memory)
- Cannot be nested with itself
- Use `NestedScrollView` (AndroidX) for nesting support
- Best for static content that exceeds screen size

7.9.2 ListView

Pros :
- Simpler implementation
- Built-in `OnItemClickListener`
- Easier header/footer management
- Default item animations

Cons :
- No enforced ViewHolder pattern
- Single layout type for all items
- Poor performance with large datasets
- Limited customization
- All data updates require full refresh

7.9.3 RecyclerView

Pros :
- Enforced ViewHolder pattern
- Multiple view types support
- Better memory efficiency through view recycling
- Customizable item animations
- Layout managers (`Linear`, `Grid`, `Staggered Grid`)
- `DiffUtil` for efficient updates
- Supports both vertical and horizontal scrolling
- Item decorations and spacing

Cons :
- More complex implementation
- No built-in click listeners
- Requires more boilerplate code
- Header/footer implementation more complex

When to use each :
- **ScrollView** : Static content, forms, or detail views
- **ListView** : Simple lists with single layout type
- **RecyclerView** : Complex lists, multiple view types, or large datasets

7.10 Additional Widgets

7.10.1 Floating Action Button (FAB)

- Material Design floating button
- Customizable animations
- Typical position at bottom right

7.10.2 Gesture Detection

- Via `GestureDetectorCompat`
- Detects : single/double tap, scroll, fling, long press

```
val detector = GestureDetectorCompat(this, object :
↪  GestureDetector.SimpleOnGestureListener() {
    override fun onDoubleTap(e: MotionEvent): Boolean
    ↪  {
        // Handle double tap
        return true
    }
})
```

8 LiveData and MVVM Architecture

8.1 LiveData

LiveData is a Jetpack lifecycle-aware observable data holder class.

8.1.1 Key benefits

- Automatic UI updates when data changes or observer becomes active
- No memory leaks (automatic cleanup)
- Thread-safe : Observers called on main thread
- Survives configuration changes
- LiveData created in ViewModel : replace state save of a re-created Activity and can share data/events between several components (Activity + Fragments)
- LiveData **immutable**, use MutableLiveData if changes needed
- Update value : **sync** if **UI-Thread**, asyn if any thread (data.postValue(1))

8.1.2 Observation

8.1.2.1 From activity

```
data.observe(this) { value ->
textview.text = "$value"}
```

- lifecycleOwner : activity itself
- Callback called in UI-Thread, for each value changes and when the activity is or becomes active/visible

8.1.2.2 From fragment

```
data.observe(viewLifecycleOwner) { value ->
↪  textview.text = "$value" }
```

- lifecycleOwner : viewLifecycleOwner → returns Fragment's view lifecycle.

8.1.3 Implementation

```
private val _data = MutableLiveData<Type>()
val data: LiveData<Type> = _data // Public immutable
↪  exposure
```

8.1.4 Advanced features

- **Transformations** : Map or switchMap operations
- **MediatorLiveData** : Merge multiple LiveData sources
- **List handling** : Full list decapsulation required for modifications

8.2 MVC in Android

Traditional MVC pattern doesn't directly map to Android architecture :

8.2.1 Basic Android MVC Structure

- **Model** : Data and business logic
- **View** : XML layouts and widgets
- **Controller** : Activities/Fragments

Key differences from canonical MVC :
- Views cannot directly interact with Model
- Controller (Activity/Fragment) must mediate all interactions
- Tight coupling between View and Controller

8.2.2 Controller Responsibilities

Activities/Fragments accumulate multiple responsibilities :
- View management (instantiation, updates)
- User action handling
- System API calls (sensors, Bluetooth, permissions)
- Data loading and processing
- Lifecycle management

8.2.3 Lifecycle Challenges

Major issues with Android's MVC implementation :
- **State Management** :
  - UI state lost on configuration changes
  - `savedInstanceState` inadequate for complex data
  - Temporary data destroyed without control
- **Async Operations** :
  - Ongoing operations may outlive Activity
  - Complex cleanup required
  - Resource waste from interrupted requests
  - Difficult to handle rotation during async operations

8.2.4 Architectural Problems

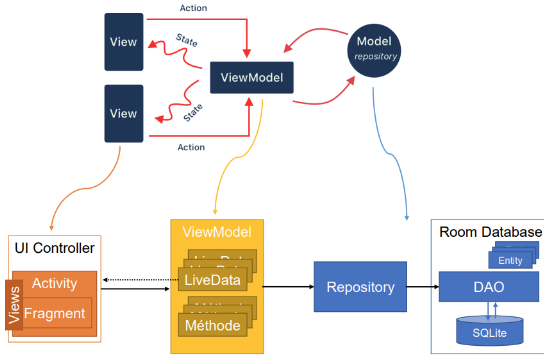
- Monolithic Activities
- Poor separation of concerns
- Difficult to test
- Complex state management
- No clear data ownership
- Lifecycle-dependent business logic

This leads to :
- Complex, hard to maintain code
- Difficult unit testing
- Poor reusability
- Lifecycle-related bugs

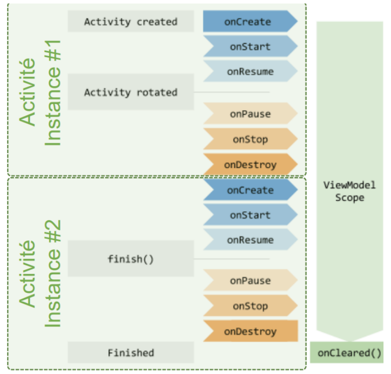
8.3 MVVM Architecture

MVVM separates concerns into :
- **View** : UI layer (Activities/Fragments)
- **ViewModel** : UI logic and state holder
- **Model** : Business logic and data operations

Advantages over MVC :
- Clear separation of concerns
- Better testability (ViewModel has no Android dependencies)
- Survives configuration changes
- Handles async operations safely



8.4 ViewModel Lifecycle



Key characteristics :
- Survives Activity/Fragment recreation
- Destroyed only when Activity finished or Fragment detached
- Scope larger than Activity but smaller than Application
- ViewModel is link to one and only Activity and its fragments. Using another Activity with ViewModel will result to create a new VieModel instance
- Created lazily on first request

```
class MyViewModel : ViewModel() {
    override fun onCleared() {
        // Called when ViewModel is being destroyed
        // Clean up resources
    }
}
```

8.5 SavedState with ViewModel

While ViewModel survives configuration changes, it doesn't survive process death. Solutions :
- **SavedStateHandle** : For simple data
- **RemoteMediator** : For complex data requiring reload
- **Room** : For persistent data

```
class MyViewModel(private val savedStateHandle:
↪  SavedStateHandle) : ViewModel() {
    var state: Type
        get() = savedStateHandle.get<Type>(KEY) ?:
        ↪  defaultValue
        set(value) = savedStateHandle.set(KEY, value)
}
```

8.6 Architecture Best Practices

8.6.1 LiveData Placement

- Repository : Use Flow/Coroutines
- ViewModel : Convert to LiveData
- UI : Observe LiveData only

8.6.2 ViewModel Best Practices

- No View/Activity/Context references
- Expose immutable LiveData
- Handle process death with SavedStateHandle
- Use Coroutines for async operations
- Factory for dependency injection

8.6.3 Common pitfalls to avoid

- Storing View references
- Using Activity context
- Exposing MutableLiveData
- Heavy operations in ViewModel constructor

8.7 Jetpack Integration

Benefits of using Jetpack MVVM :
- Lifecycle awareness built-in
- SavedState handling
- Coroutines integration
- Room compatibility
- Navigation component support
- Easy testing with ViewModelScope

9 Android Data Persistence

9.1 Overview

Android offers multiple data persistence options :
- File storage (private or shared)
- Preferences
- local DB SQLite

Storage Type	Permissions	App Access	Removal
Private Files (Internal)	None	Private	On uninstall
Private Files (External)	None (API 19+)	Private	On uninstall
Media Files	RD_EXT_STRG	Shared	Persists
Shared Files	None (SAF)	Shared	Persists
Preferences	None	Private	On uninstall
Local Database	None	Private	On uninstall

9.2 File Storage

9.2.1 Private Storage

Internal storage :
- Accessed via `filesDir` and `cacheDir`
- Automatically encrypted since Android 10
- Limited space, careful management needed

External storage :
- May be emulated if no physical SD card
- Check availability with `Environment` methods
- Multiple external volumes possible
- Access via `getExternalFilesDir(null)` and `externalCacheDir`
- **Never store** absolute path since it can change

9.2.2 Shared Media File

- shared files (images, videos,...) which can be used for other app have centralized storage.
- needs `READ_EXTERNAL_STORAGE` if images are not created from app.
- API MediaStore uses query for finding content.

9.3 SharedPreferences

Key-value storage for **simple** data :
- XML-based storage
- Synchronous (`commit()`) or asynchronous (`apply()`) → preferred usage is apply
- Supports primitive types
- Accessible through high-level API

Example usage :

```
val prefs = getSharedPreferences("filename",
↪  Context.MODE_PRIVATE)
prefs.edit {
    putString("key", "value")
    putInt("counter", 42)
}
```

9.4 Room Database

Modern database solution with :
- ORM capabilities
- Compile-time verification
- LiveData/Flow integration
- Relationship support between entities

9.4.1 Components

- **Entities** : Data classes representing tables
- **DAO** : Interfaces defining data access methods (rw)
- **Database** : Abstract class defining database configuration
- **Repository** : Single source of truth for data operations. DAO encapsulation and calling IO methods has to be done in a dedicated thread or coroutine

9.4.1.1 Data Access Objects (DAO)

DAOs define the interface for database operations. Methods are annotated to specify SQL operations :

```
@Dao
interface UserDao {
    @Transaction
    @Query("SELECT * FROM user")
    fun getAll(): LiveData<List<User»
    @Insert
    fun insert(user: User): Long
    @Update
    fun update(user: User)
    @Delete
    fun delete(user: User)
    @Query("SELECT * FROM user WHERE age > :minAge")
    fun getOlderThan(minAge: Int): List<User>
}
```

Room generates all necessary code at compile time using KSP (Kotlin Symbol Processing).

9.4.1.2 Type Converters

Converters handle complex types that Room can't store directly :

```
class DateConverter {
    @TypeConverter
    fun fromTimestamp(value: Long?): Date? {
        return value?.let { Date(it) }
    }
    @TypeConverter
    fun dateToTimestamp(date: Date?): Long? {
        return date?.time
    }
}
```

Register converters at database level with `@TypeConverters` annotation.

9.4.1.3 Entity Relationships

Room supports various relationship types :

9.4.1.3.1 Embedded Objects

```
data class Address(
    val street: String,
    val city: String
)
@Entity
data class User(
    @PrimaryKey val id: Int,
    val name: String,
    @Embedded val address: Address
)
```

9.4.1.3.2 One-to-One

```
data class UserAndLibrary(
    @Embedded val user: User,
    @Relation(
        parentColumn = "id",
        entityColumn = "userId"
    )
    val library: Library
)
```

9.4.1.3.3 One-to-Many

```
data class UserWithPets(
    @Embedded val user: User,
    @Relation(
        parentColumn = "id",
        entityColumn = "ownerId"
    )
    val pets: List<Pet>
)
```

9.4.1.3.4 Many-to-Many

```
@Entity
data class PlaylistSongCrossRef(
    @PrimaryKey val playlistId: Long,
    val songId: Long
)

data class PlaylistWithSongs(
    @Embedded val playlist: Playlist,
    @Relation(
        parentColumn = "playlistId",
        entityColumn = "songId",
        associateBy =
        ↪  Junction(PlaylistSongCrossRef::class)
    )
    val songs: List<Song>
)
```

9.4.1.4 Database Migration

Room handles schema changes through migrations :

```
val MIGRATION_1_2 = object : Migration(1, 2) {
    override fun migrate(database:
    ↪  SupportSQLiteDatabase) {
        database.execSQL(
            "ALTER TABLE User ADD COLUMN last_update
            ↪  INTEGER"
        )
    }
}
Room.databaseBuilder(context, MyDb::class.java,
↪  "database")
    .addMigrations(MIGRATION_1_2)
    .build()
```

Migrations are crucial for preserving user data across app updates.

9.4.1.5 Database Creation

Database instance typically follows singleton pattern : → DB creation is a heavy operation, so we want to create only one instance and keep a reference. Singleton will be stored in app level.

```
@Database(
    entities = [User::class, Pet::class],
    version = 1,
    exportSchema = true
)
@TypeConverters(DateConverter::class)
abstract class AppDatabase : RoomDatabase() {
    abstract fun userDao(): UserDao
    abstract fun petDao(): PetDao

    companion object {
        @Volatile
        private var INSTANCE: AppDatabase? = null

        fun getDatabase(context: Context): AppDatabase
        ↪  {
            return INSTANCE ?: synchronized(this) {
                Room.databaseBuilder(
                    context.applicationContext,
                    AppDatabase::class.java,
                    "app_database"
                ).build().also { INSTANCE = it }
            }
        }
    }
}
```

9.4.1.6 Performance Considerations

Key points for optimal Room usage :
- Use Suspend functions or LiveData for async operations
- Implement paging for large datasets
- Use transactions for multiple operations
- Cache complex query results
- Consider indices for frequently queried columns

9.4.2 Relationships

Supports :
- One-to-One
- One-to-Many
- Many-to-Many (with cross-reference table)
- Embedded objects

9.4.3 Best Practices

- Use Kotlin coroutines for async operations
- Implement Repository pattern
- Handle migrations properly
- Consider pagination for large datasets
- Use `distinctUntilChanged()` for LiveData queries
- Consider encryption needs (SQLCipher)

9.5 Architecture Overview

Recommended MVVM structure with Room :
- UI Controllers (Activities/Fragments) (e.g button to create a person)
- ViewModel with LiveData (e.g create entity person)
- Repository mediating data operations (**async** insert → prevent UI-Thread/coroutine lock)
- Room Database with DAOs
- Entities representing data structure

9.6 Alternative Solutions

Other database options :
- Couchbase Mobile (NoSQL)
- Firebase Realtime DB
- Nitrite-Java
- SQLCipher for encryption