Android lecture 3

Fragments, Notifications, Data persistence

Agenda

- Fragments
  - Inflating
  - Lifecycle
- Notifications
- Data persistence
  - File
  - SharedPreferences
  - Database
  - Content provider

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TargetSdk requirements

API level requirement	Starting date
Android 8.0 (API level 26)	• August 1, 2018: Required for new apps • November 1, 2018: Required for app updates
Android 9 (API level 28)	• August 1, 2019: Required for new apps • November 1, 2019: Required for app updates
Android 10 (API level 29)*	• August 3, 2020: Required for new apps • November 2, 2020: Required for app updates
Android 11 (API level 30)*	• August 2, 2021: Required for new apps • November 1, 2021: Required for app updates

* Wear OS apps are not subject to the API level 29 or API level 30 requirements.

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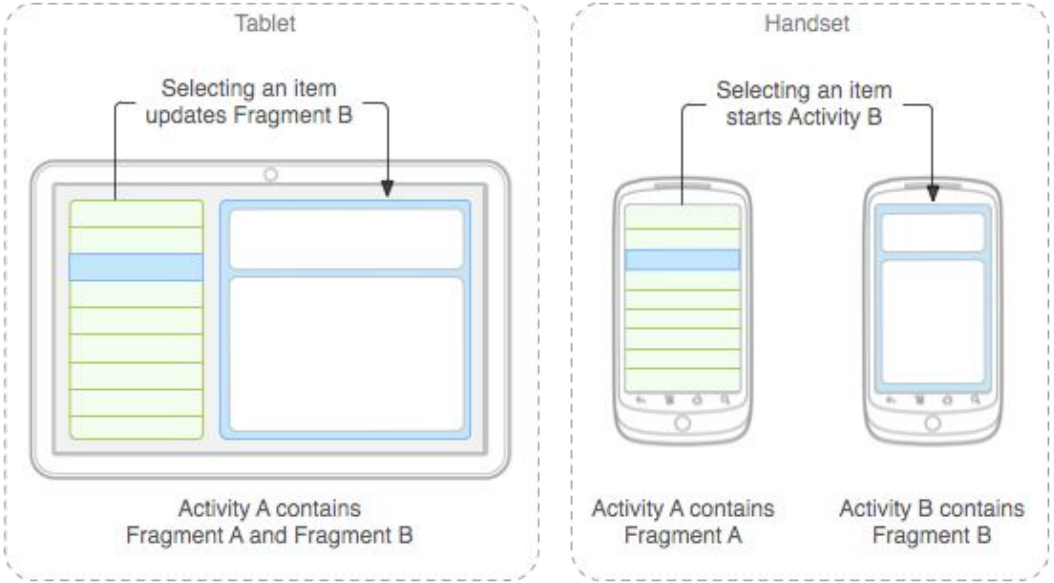
Fragment

- Simplify create UI for phones and tablets
- ~~`android.app.Fragment`~~ - Added API 11, deprecated API 28
- ~~android.support.v4.app.Fragment~~ - replaced by jetpack
- androidx.fragment.app.Fragment - jetpack



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Fragment - add statically

activity_main.xml

```
<?xml version="1.0" encoding="utf-8"?>
<FrameLayout xmlns:android="http://schemas.android.com/apk/res/android"
   xmlns:tools="http://schemas.android.com/tools"
   android:layout_width="match_parent"
   android:layout_height="match_parent">

   <androidx.fragment.app.FragmentContainerView
       android:id="@+id/fragment_id"
       android:tag="some_string"
       android:name="packagename.class"
       android:layout_width="match_parent"
       android:layout_height="match_parent" />

</FrameLayout>
```

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Fragment - Activity.kt

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

    supportFragmentManager.beginTransaction()
            .add(R.id.fragment_container, MyFragment.newInstance())
            .addToBackStack(null)
            .commit()
}
```

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Fragment - states

- Is in same state as host activity
- Resumed
  - Fragment is visible in the running activity
- Paused
  - Another activity in foreground, but hosting activity is still visible
- Stopped
  - Fragment is not visible
  - Hosting activity is stopped or fragment is removed from the activity, but added to backstack.
  - Alive, can be killed by hosting activity

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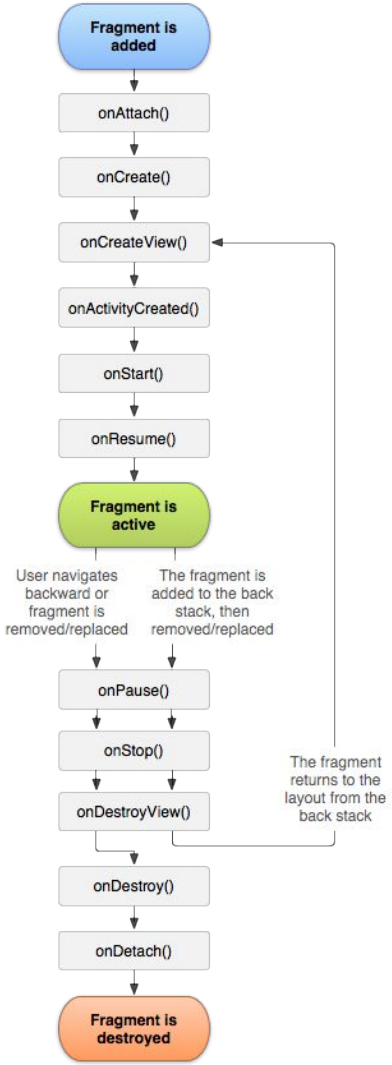
Fragment - lifecycle



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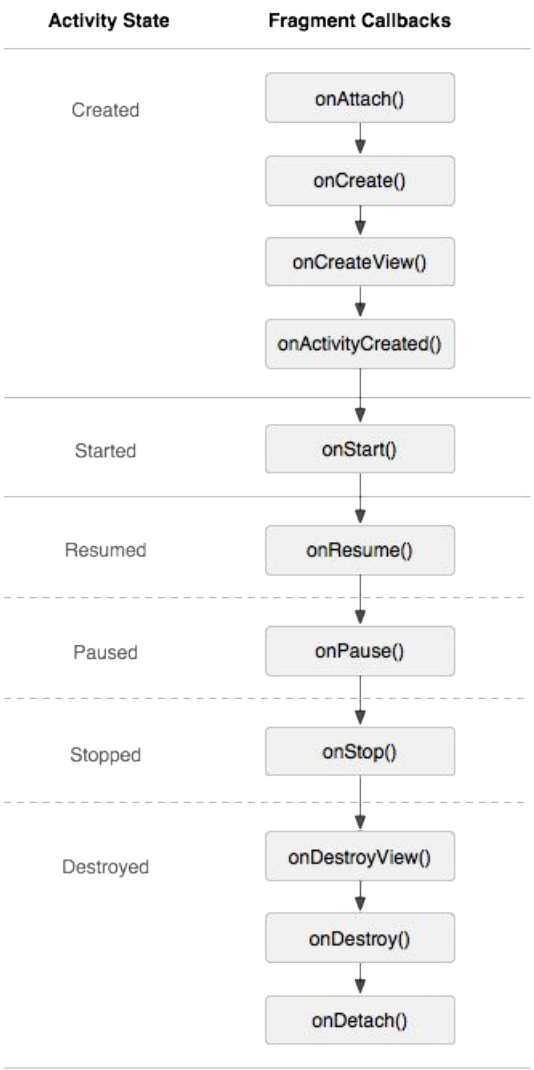
Fragment inside Activity lifecycle



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Fragment - lifecycle

- onAttach(Activity)
  - Fragment is associated with the activity
  - Set activity as a listener
- onCreate(Bundle)
  - Initial creation of fragment
  - Process fragment extras
  - Not called when fragment is retained across Activity re-creation
- onCreateView(LayoutInflater, ViewGroup, Bundle)
  - Called when view hierarchy needs to be created

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Fragment - lifecycle

- onActivityCreated(Bundle)
  - Activity onCreate() completed
  - Get references to views
- onViewStateRestored(Bundle)
  - All saved state of the view hierarchy was restored
- onStart()
  - Fragment visible to user (same as Activity.onStart())
- onResume()
  - Fragment interact with user (based on hosting container)
  - Same as Activity.onResume()

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Fragment - lifecycle

- onPause()
  - Not interact with user anymore
  - Paused activity or fragment manipulation
- onStop()
  - No longer visible
  - Stopped activity or fragment manipulation
- onDestroyView()
  - Disconnect fragment from view hierarchy created in onCreateView()
- onDestroy
  - Fragment going to be destroyed
  - Cleanup all resources
  - Not called for retained fragments
- onDetach
  - Detach fragment from activity
  - Remove activity listeners

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Retained fragment

- Call `Fragment#setRetainInstance(true)`
- Survive configuration change
- Views needs to be recreated
- `Fragment#onCreate()` is not called for retained instances
- Usually for background work or data caching

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Headless fragment

- Fragment without UI
- Often retained fragment
- `Fragment#onCreateView()` returns null

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Fragment and Activity

- Fragment is not working without activity
- Activity can call fragment methods directly
- Fragment defines interface to be implemented by Activity to handle fragment requirements

Fragment - passing data

```
class DemoFragment: Fragment() {

    companion object {
        @JvmStatic
        fun newInstance(username: String): DemoFragment {
            val fragment = DemoFragment()
            fragment.arguments = bundleOf(
                "Username" to username,
                "id" to 1001
            )

            return fragment
        }
    }
}
```

- Android calls non-params constructor when restoring fragments
- Constructor with parameters will not be called

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Exercise

1. Inflate LoginFragment in LoginActivity statically
2. Inflate UserFragment in UserActivity dynamically
3. Fill UserFragment data

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Persistence

Persisting data - files

- Standard Java API for file operations

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Internal storage

- Always available
- For private data
- Removed with application uninstall
  - https://medium.com/inloopx/samsung-tablets-are-not-removing-application-files-after-uninstall-45cc22ace56a
- Cache

Internal storage

- `Context.getFilesDir()`
  - File representing internal directory for your app
- `Context.openFileOutput(filename: String, mode: Int)`
  - Filename - name of file
  - Mode - specify access to file
    - `MODE_PRIVATE` - accessible by apps with same UID
    - `MODE_APPEND` - append data instead of erasing file
    - `MODE_WORLD_READABLE` - Deprecated API 17, SecurityException API 24
    - `MODE_WORLD_WRITEABLE` - Deprecated API 17, SecurityException API 24
- `Context.openFileInput(filename: String)`
  - Filename - name of file

Internal storage - cache

- `Context.getCacheDir()`
  - File representing internal directory for app temporary files
  - System can delete these files, when is running low on storage
  - 3rd party cleaner apps often clear cache
  - Delete these files when are not longer needed
  - Presence of these files should not affect your application
    - It can just slow down app, need to download some resources

Internal storage - sharing data

- Data can be shared via `FileProvider`
  - Allows to specify shared directories
  - Implicit intent to pick specific files

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External storage

- External storage != SD Card
- Not always available
- World readable
- Uninstall remove files in `Context.getExternalFilesDir()`
- Lot of API changes between android versions
- Often modified by vendors

External storage

- Requires permissions
  - `android.permission.WRITE_EXTERNAL_STORAGE`
  - `android.permission.READ_EXTERNAL_STORAGE`
  - Since API 19 permissions are not needed for private files
- Developer responsibility to check if the external storage is available
- Public files
  - Available to the other apps and user
  - Downloaded files
- Private files
  - Files to be deleted with app uninstall
  - Accessible to other, but no value for them
  - Temp downloaded files, ringtones, ….

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External storage

- `Environment.getExternalStoragePublicDirectory(type: String): File`
  - Type - type of files to access `Environment.DIRECTORY_*`
  - File representing top-level shared/external directory for files of particular type
  - Multi user devices - access only to current user
- `Environment.getExternalFilesDir(type: String): File`
  - Type - type of files to access `Environment.DIRECTORY_*`
  - `File` representing where app place internal files
  - Files are deleted after app uninstall
- `Environment.isExternalStorageEmulated(): Boolean`
- `Environment.isExternalStorageRemovable(): Boolean`
- `Environment.getExternalStorageState(): String`

External storage - SD card

- < API-19 guess where the sdcard is mounted
- = API-19 not possible write shared data on sd card, when primary external storage is available
  - Or using storage access framework, but access is granted per file
- >=API-21 Storage access framework allows to grant access for directories
  - New APIs for accessing media folders on SD card
  - Context.getExternalMediaDirs(): Array<File>

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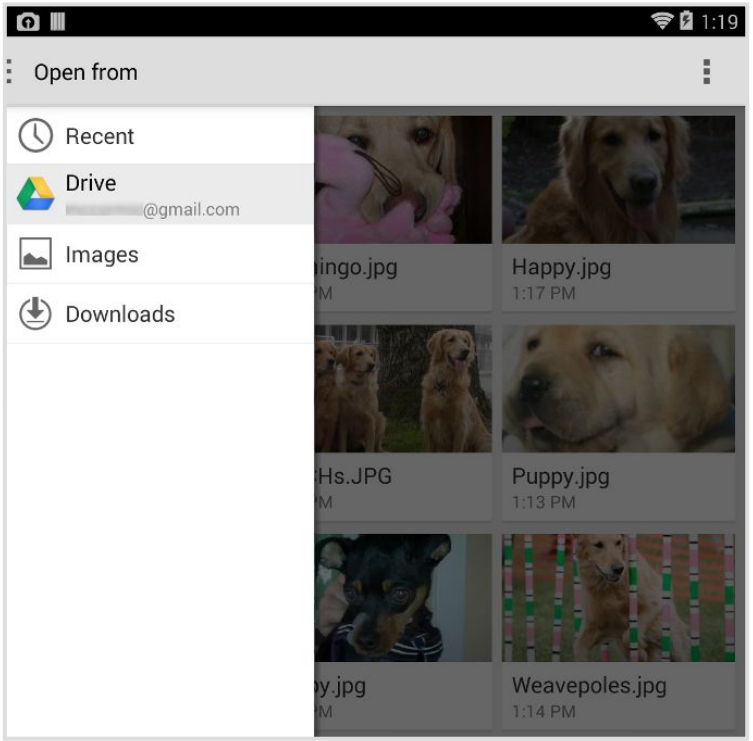
Storage access framework



- Let user pick a file
- Allows to plug-in custom service (cloud services like Dropbox, Google drive, …)
- Since API 19

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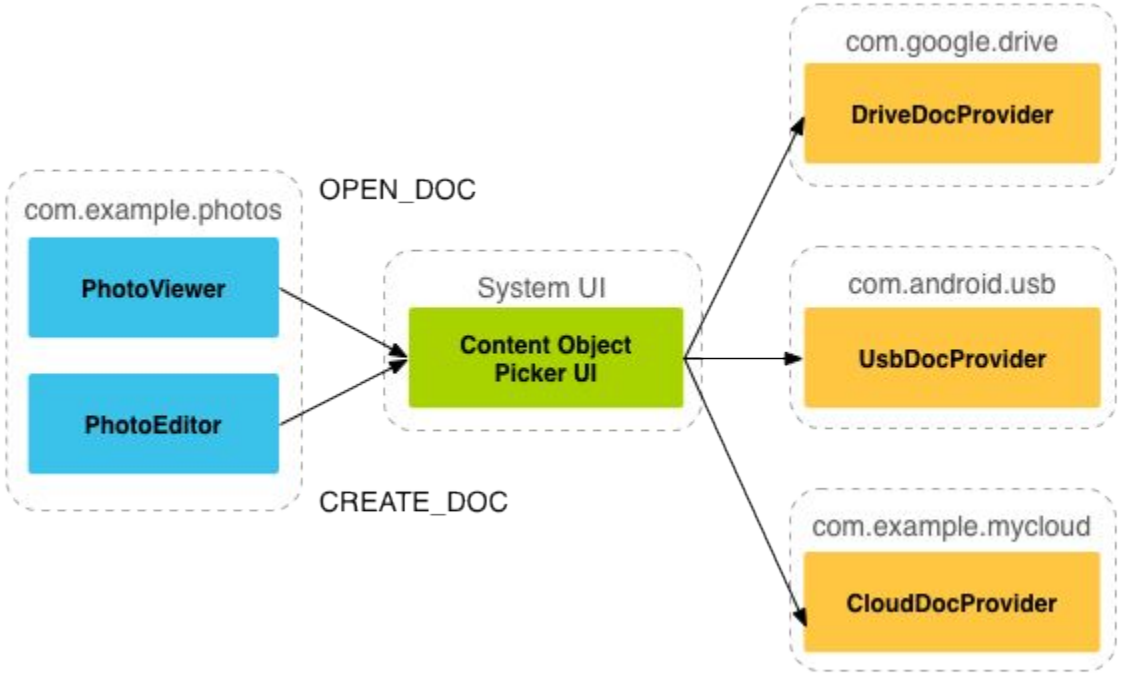
Storage access framework



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Scoped storage - Android 10 (API-29)

- Restrict access to files on external storage
- App has access to app-specific directory
- Files are in collections - no permission needed for contribution
  - Pictures
  - Videos
  - Music/Audio
  - Download
- Modify/Delete files created by other app requires explicit user consent

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Scoped storage - Android 10 (API-29)

- Access to documents, downloaded file use storage access framework
- Read/write outside of the collections requires storage access framework
- Photo location metadata permission

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Scoped storage - Android 10 (API-29)

- Possible to opt-out by AndroidManifest.xml flag

Scoped storage - Android 11 (API-30)

- Files API for files accessible through MediaStore API
  - 3rd party libraries, C/C++ code
- API for bulk options over media files
- Special app access for selected use case
  - Antivirus
  - Backup&Restore
  - File managers
  - ...
  - Manually reviewed by google
  - User have to explicitly grant the access in Android settings
- Managed by TargetSdk

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Scoped storage

https://developer.android.com/training/data-storage/use-cases

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SharedPreferences

- Key value storage
- Backed by XML
- `Context.getSharedPreferences(name: String, mode: Int)`
  - Name - name of file with preferences
  - Mode - operating mode
    - `MODE_PRIVATE` - only apps with same UID have access
    - `MODE_WORLD_READABLE` - API 17 Deprecated, API 24 SecurityException
    - `MODE_WORLD_WRITEABLE` - API 17 Deprecated, API 24 SecurityException
- `Activity.getPreferences(int mode)`
  - Preferences associated with activity
- `PreferenceManager.getDefaultSharedPreferences (Context)`
  - Default preferences used by Preference framework

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SharedPreferences

```
val sharedPrefs = getSharedPreferences("preferences",
Context.MODE_PRIVATE)
val intVal = sharedPrefs.getInt("int_key", 42)
val stringVal = sharedPrefs.getString("string_key", "Default")
```

```
val editor = sharedPrefs.edit()
editor.putString("string_key", "new value")
editor.commit() //Synchronous
editor.apply()  // Async
```

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SharedPreferences

- Editor.commit()
  - Notifies about result
  - Synchronous operation, waits until changes are written to disk
- Editor.apply()
  - Async variant
  - Atomically stores values
  - ANRs bugs (fsync() on main thread)
- If multiple editors modifying preferences at she same time, last calling apply() wins
- Debugging - rooted device or flipper/stetho

http://facebook.github.io/stetho/ - old, not maintained
https://fbflipper.com/ - new, multiplatform

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Data store

- Shared preferences replacement
- Shared preferences async API has some design flaws
  https://engineering.avast.io/how-we-fought-with-anr-rate-in-android-vitals/

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Data store

Feature	SharedPreferences	Preferences DataStore	Proto DataStore
Async API	✅ (only for reading changed values, via listener)	✅ (via `Flow`)	✅ (via `Flow`)
Synchronous API	✅ (but not safe to call on UI thread)	❌	❌
Safe to call on UI thread	❌*	✅ (work is moved to `Dispatchers.IO` under the hood)	✅ (work is moved to `Dispatchers.IO` under the hood)
Can signal errors	❌	✅	✅
Safe from runtime exceptions	❌**	✅	✅
Has a transactional API with strong consistency guarantees	❌	✅	✅
Handles data migration	❌	✅ (from SharedPreferences)	✅ (from SharedPreferences)
Type safety	❌	❌	✅ with Protocol Buffers

https://android-developers.googleblog.com/2020/09/prefer-storing-data-with-jetpack.html

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Data store

- Completely asynchronous approach
- RxJava/Kotlin coroutines API
- Google protocol buffer type safe API
- API for migration from shared preferences

Exercise

6. Count app launches
7. Prefill login with last used one
8. Flipper for debug shared preferences

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Database -SQLite

- Full-featured SQL
- Single-file database
- Source code is just 1 file
- Small footprint
- ACID transactions
- Well documented
- Supports most of the SQL92 standard

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SQLite on Android

- Foreign keys disabled by default
- Internal storage
- Collation
  - BINARY - SQLite default
  - LOCALIZED - changes with system locale
  - UNICODE - Unicode collation algorithm
- Thread safe
- Create/upgrade on background thread
- Take care about opening/closing from different threads
- Use `BaseColumn._ID` for primary keys, some components rely on it
- Stetho tool for debugging

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Database

- `android.database.sqlite.SQLiteOpenHelper`
  - Database creation
  - Version management
  - Sqlite configuration
    - Enable write ahead log
    - Enable support for foreign keys
- `android.database.sqlite.SQLiteDatabase`
  - Exposes methods to manage a SQLite databases
  - CRUD methods
  - Manage transactions

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SQLiteOpenHelper

- `onCreate(db: SQLiteDatabase)`
  - Called when the database is created for the first time
- `onUpgrade(db: SQLiteDatabase, oldVersion: Int, newVersion: Int)`
  - Upgrade logic
- `getReadableDatabase/getWriteableDatabase`
  - creates/open database
- `close()`
  - Close open database object

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SQLiteDatabase

- `insert(table: String, nullColumnHack: String, values: ContentValues)`
  - Table - name of table
  - nullColumnHack - optional, allows to insert empty row
  - Values - inserted values
  - Returns ID of newly inserted row
- `long insertOrThrow`
- `long insertWithOnConflict`

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SQLiteDatabase

- ```
  query(boolean distinct,
        table: String,
        columns: Array<String>,
        selection: String,
        selectionArgs: Array<String>,
        groupBy: String,
        having: String,
        orderBy: String,
        limit: String): Cursor
  ```
  - `Selection` - WHERE clausule, values replaced by ?
  - `selectionArgs` - values to replace ? in selection
- Multiple variants of query, with different possibilities
- `rawQuery(sql: String, selectionArgs: Array<String>): Cursor`
- Close returned cursors

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  ```

SQLiteDatabase

- `update(table: String,`
  `values: ContentValues,`
  `whereClause: String,`
  `whereArgs: Array<String>): Int`

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SQLiteDatabase

- ```
  delete(table: String,
         values: ContentValues,
         whereClause: String,
         whereArgs: Array<String>): Int
  ```

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  ```

SQLiteDatabase

- Every CRUD operation is a transaction
- For inserting more rows in one time use transactions
- `beginTransaction()`
- `endTransaction()`
- `setTransactionSuccessful()`

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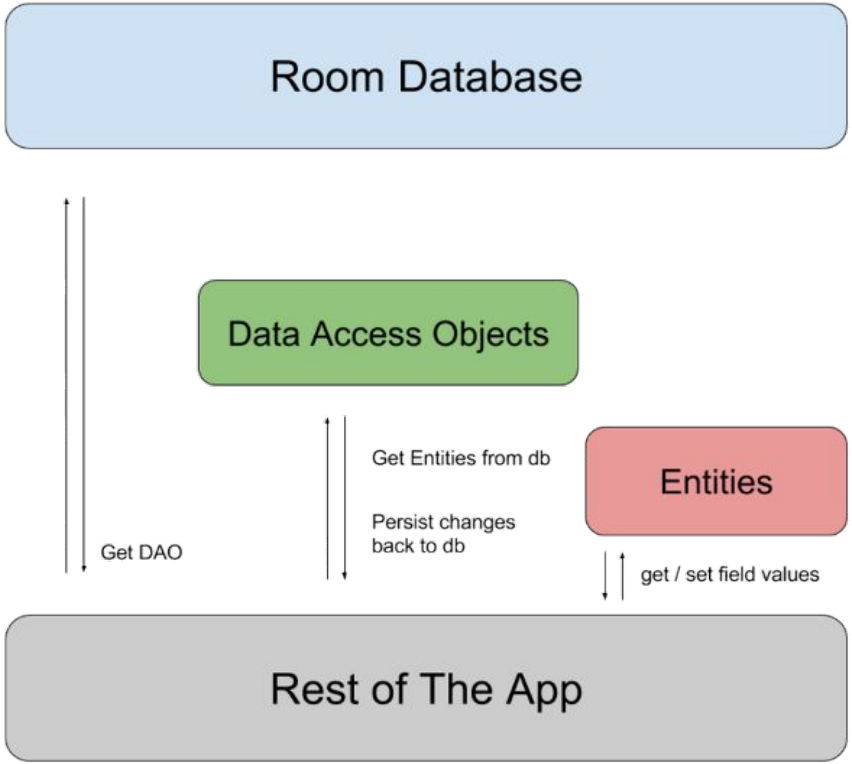
Room

- Part of the Android Jetpack
- Abstraction over SQLite
- Compile time validation of SQL queries
- Full integration with other Architecture components (LiveData, LifecycleObserver)
- RxJava bindings

Room


Room Database
Data Access Objects
Get DAO
Get Entities from db
Persist changes
back to db
Entities
get / set field values
Rest of The App

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Room - entities

- Represents a table

```
@Entity
data class Car(
    @PrimaryKey val id: Int,
    @ColumnInfo(name = "manufacturer") val manufacturer: String?,
    @ColumnInfo(name = "model") val model: String?,
    @ColumnInfo(name = "nubmer_of_wheels") val numberOfWheels: String?
)
```

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Room - DAO

- Defines operations on top of entities

```
@Dao
interface CarDao {
    @Query("SELECT * FROM car")
    fun getAll(): List<Car>

    @Query("SELECT * FROM car WHERE id IN (:carIds)")
    fun loadAllByIds(carIds: IntArray): List<Car>

    @Query("SELECT * FROM car WHERE manufacturer LIKE :manufacturer AND " +
           "model LIKE :model LIMIT 1")
    fun findByModel(manufacturer: String, model: String): Car

    @Insert
    fun insertAll(vararg cars: Car)

    @Delete
    fun delete(car: Car)
}
```

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Room database

- Defines database

```
@Database(entities = arrayOf(Car::class), version = 1)
abstract class CarDatabase : RoomDatabase() {
    abstract fun carDao(): CarDao
}


val db = Room.databaseBuilder(
            applicationContext,
            CarDatabase::class.java, "car-database"
        )
    .addMigrations(...)
    .build()
```

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ContentProvider

- Access to structured set of data
- Define data security
  - Via permissions
    - Global
    - Read/Write permissions
    - For single URI
- Connects data from one process to code running in another process
- ContentResolver for access data

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ContentProvider

- Used by system aps
  - SMS
  - Contacts
  - Calendar
- Allows to share data between apps
- Data specified via Uri
- Allows to use CursorLoader

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ContentProvider

- Can be backed up by different data sources
  - SQLite database
  - Network
  - Files
  - …

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ContentProvider

- Initializes early
  - In priority order
- Application component start order
  - Content resolvers
  - Application
  - Invoked component by intent
- https://firebase.googleblog.com/2016/12/how-does-firebase-initialize-on-android.html

ContentProvider - implementation

- Design data storage
- Design content URIs
  - `content://com.example.app.provider/table1`
  - `content://com.example.app.provider/table2/dataset1`
  - `content://com.example.app.provider/table3/#`
- Define UriMatcher
  - Translates Uris to number constant
- Extend ContentProvider class
  - query(), insert(), update(), delete()
  - getType()
  - onCreate() - fast operations, postpone db creation
- Register provider in manifest

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ContentResolver

- `context.getContentResolver()`
- CRUD operations similar params as SQLiteDatabase
- Specify data by URI

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Strict mode

Strict mode

- Developer tool
- Detects application bad behaviour

```
if (DEVELOPER_MODE) {
    StrictMode.setThreadPolicy(StrictMode.ThreadPolicy.Builder()
            .detectDiskReads()
            .detectDiskWrites()
            .detectNetwork()   // or .detectAll() for all detectable problems
            .penaltyLog()
            .build())
    StrictMode.setVmPolicy(new StrictMode.VmPolicy.Builder()
            .detectLeakedSqlLiteObjects()
            .detectLeakedClosableObjects()
            .penaltyLog()
            .penaltyDeath()
            .build())
}
```

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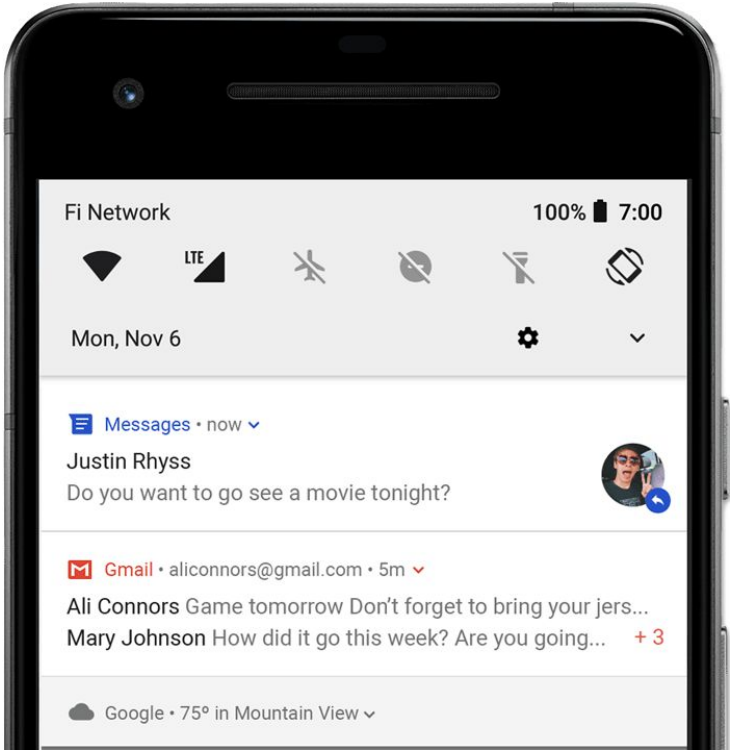
Notifications

Notifications

- Notify user, when not use your app
- Mandatory
  - Small icon
  - Content title
  - Content text
  - Notification channel - Android 8.0+



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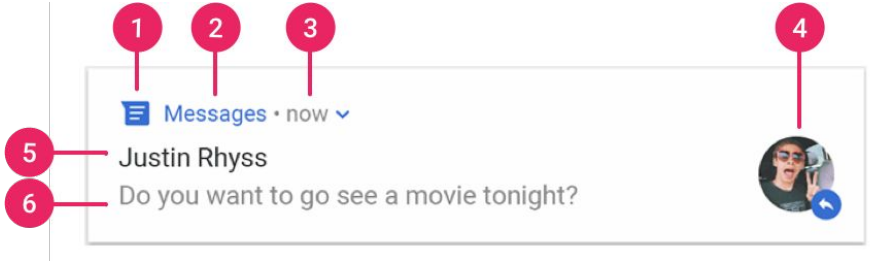
Notification

1. Small icon - mandatory parameter
2. App name - provided by system
3. Time stamp: provided by system,
   - override by setWhen()
   - Hide setShowWhen(false)
4. Large icon - optional
5. Title - optional
6. Text - optional



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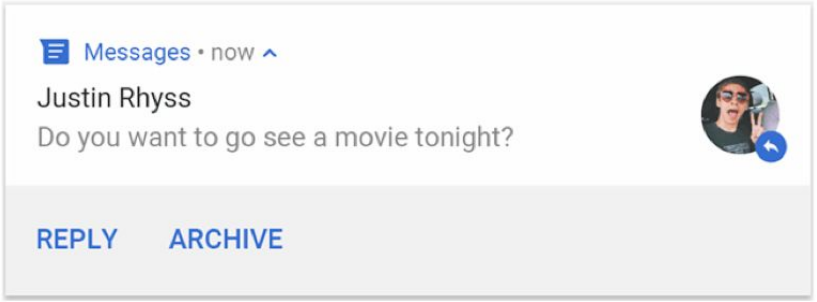
Notification actions

- Quick actions
- Inline reply action Android 7.0+



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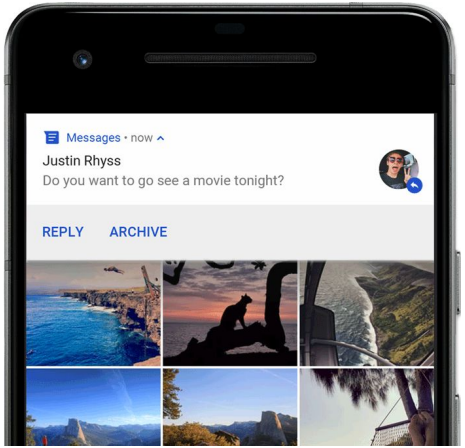
Heads-up notifications

- Heads-up notifications
  - Small floating window
  - Shows action buttons to handle action without leaving app
  - Only for high priority notifications
    - If the user's activity is in full screen mode (app uses fullScreenIntent)
    - Notification has high priority and uses ringtones or vibrations
- Android 5.0+



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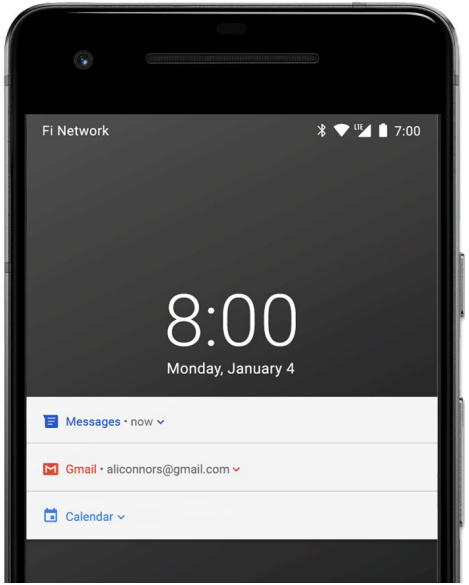
Lock screen notifications

- Possibility to set which informations when device is locked
  - VISIBILITY_PUBLIC - Shows full content
  - VISIBILITY_SECRET - Do not show at all
  - VISIBILITY_PRIVATE - Show icon and title, hide content
- Android 5.0+



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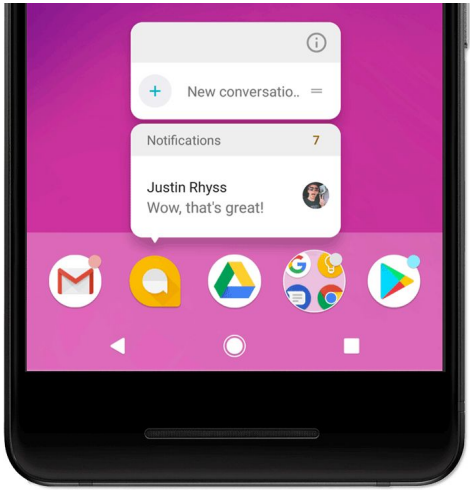
Notifications dots

- Dots on launcher app icons
- Shows notification content on long click
- Android 8.0+



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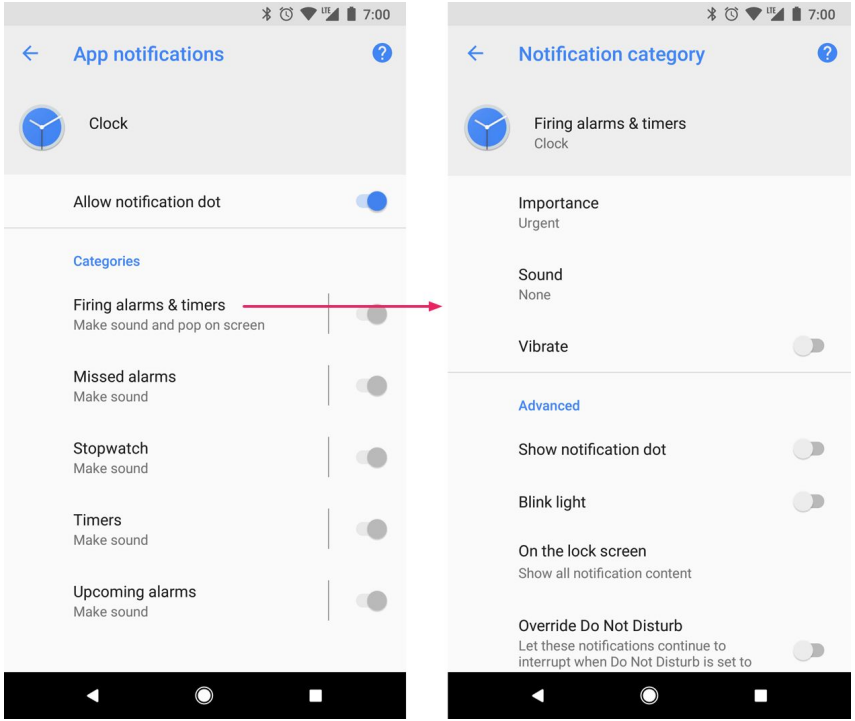
Notification channels

- Notification categories
- User can manage notifications in single category
- Override DnD
- System show number of deleted channels
- Android 8.0+



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Key classes

- android.app.Notification
- ~~android.support.v4.app.NotificationCompat~~
  - ~~Action~~
  - ~~Builder~~
  - ~~*Style~~
- androidx.core.app.NotificationCompat
  - Action
  - Builder
  - *Style
- android.app.NotificationManager
- ~~android.support.v4.app.NotificationManagerCompat~~
- androidx.core.app.NotificationManagerCompat
- android.app.NotificationChannel

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Notification

- Use `NotificationCompat.Builder`
  - Handles compatibility
- `NotificationManagerCompat.notify(int id, Notification)`
- Possible to set pending intent for actions
- Priority affects position in drawer
- Developer responsibility to handle navigation when user opens application from notification

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Create notification

```
var builder = NotificationCompat.Builder(this, CHANNEL_ID)
        .setSmallIcon(R.drawable.notification_icon)
        .setContentTitle("My notification")
        .setContentText("Much longer text that cannot fit one line...")
        .setStyle(NotificationCompat.BigTextStyle()
                .bigText("Much longer text that cannot fit one line..."))
        .setPriority(NotificationCompat.PRIORITY_DEFAULT)
```

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Create channel

```
private fun createNotificationChannel() {
    // Create the NotificationChannel, but only on API 26+ because
    // the NotificationChannel class is new and not in the support library
    if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.O) {
        val name = getString(R.string.channel_name)
        val descriptionText = getString(R.string.channel_description)
        val importance = NotificationManager.IMPORTANCE_DEFAULT
        val channel = NotificationChannel(CHANNEL_ID, name, importance).apply {
            description = descriptionText
        }
        // Register the channel within the system
        val notificationManager: NotificationManager =
            getSystemService(Context.NOTIFICATION_SERVICE) as NotificationManager
        notificationManager.createNotificationChannel(channel)
    }
}
```

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Setup notification action

```
// Create an explicit intent for an Activity in your app
val intent = Intent(this, AlertDetails::class.java).apply {
    flags = Intent.FLAG_ACTIVITY_NEW_TASK or Intent.FLAG_ACTIVITY_CLEAR_TASK
}
// Create the TaskStackBuilder
val resultPendingIntent: PendingIntent? = TaskStackBuilder.create(this).run {
    // Add the intent, which inflates the back stack
    addNextIntentWithParentStack(intent)
    // Get the PendingIntent containing the entire back stack
    getPendingIntent(0, PendingIntent.FLAG_UPDATE_CURRENT)
}
val builder = NotificationCompat.Builder(this, CHANNEL_ID)
        ....
        // Set the intent that will fire when the user taps the notification
        .setContentIntent(pendingIntent)
        .setAutoCancel(true)
```

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Fire notification

```
with(NotificationManagerCompat.from(this)) {
    // notificationId is a unique int for each notification that you must define
    notify(notificationId, mBuilder.build())
}
```

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Notifications - Android 12

- No longer possible to control full content of notification
- https://developer.android.com/about/versions/12/behavior-changes-12#custom-notifications

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Thank you
Q&A

Feedback is appreciated

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