# From Containerization to Modularity

by @oasisfeng

# Modular Future of Mobile Ecosystem

Modular hardware lead to modular software

# Modular Hardware

- Smartphones become modular
  - Prototypes: Project Ara, Phonebloks
  - Products: LG G5, Moto Z
- More devices are connected
  - Smart accessories (wristband, BT devices)
  - Connected devices (smart watch, home kits)
  - External hardware
    - Secondary display
    - Dock-hub with keyboard & track-pad (or mouse)

# Modular Software

- Software becomes even more modular in an open ecosystem.
- Android itself becomes more and more modular.
  - Assembly: Android Wear & TV, 3rd-party ROM
  - Pluggable: IME, TTS, Doc Provider, Notification Listener
  - Forkable: Shared Library (Services & Shared), System UI*
- Modular app ecosystem
  - Launcher, Widget, Lock Screen, Live Wallpaper, Complication (Wear)
  - Google Docs & Sheets Addons
  - Community-driven: Tasker, Xposed, Nevolution, Island...
  - The future of mobile belongs to the union of small teams and individuals.

# Modular App Architecture

Every modular is a tiny app

# What is Modularity?

- Modules separated by certain level of isolation
- Characteristics
  - Independent
  - Interchangeable
  - Interoperable
- The price
  - Confine
  - Contract
  - Compatibility

# Why Modular?

- Engineering
  - Enforced decoupling for high-cohesion code.
  - Module-independent (parallel) development and testing
  - Flexible integration, deployment & upgrade
  - The infamous "64K methods limit"
- Product
  - Selective installation (light-weight initial install)
  - Hybrid-friendly (web & native, mix and match)
  - Open to (3rd-party) extensions

# Basic Solutions

- Java packages
  - Pros:  lowest cost
  - Cons: loose isolation
- Gradle library modules
  - Pros:  tool-chain support
  - Cons: build efficiency
- Multiple APKs
  - Pros: build & install time (development productivity)
  - Cons: Less user-friendly

# In-House Modular Frameworks

Mainstream approaches in the wild:

- **Multi-Dex**: Inject dex-elements
  - Pros: Easy to implement, taking full advantage of AOT & JIT
  - Cons: Weak isolation
- **Container**: Proxy components by hooking. (DroidPlugin)
  - Pros: Direct APK loading
  - Cons: Massive reflective hooking (prone to compatibility issues)
- **Semi-container**: Transparent merge with class-loader proxy. (Atlas)
  - Pros: Light-weight, modest hooking, minimal module constraints
  - Cons: Runtime AndroidManifest lock-in

# The Adventure of Project Atlas (Taobao)

- 1st gen (2012 - 2013): **Container**-based
  - Goal: Fast and easy (business) plug-in integration across BUs.
  - Challenge: Compatibility (both ROM and plug-in)
- 2nd gen (2013 - 2014): **Semi-container**
  - Goal: Compatibility, reliability, maintainability.
  - Benefits: 50% less code, 80% less reflective-hooking.
- 3rd gen: (2014-): Semi-container with **flexible module management**
  - Goal: Deploy by module » Deploy-on-demand by UI pagelet (like web)
  - Benefits: Agile development, fast deployment, incremental installation.

# The Problem

- A complex framework for mixed purposes
  - Modularity, incremental deployment, runtime upgrade and even hot-fix
- The reality
  - A big mess of compromise and inefficiency
- The way out – Layered frameworks for separate purpose
  - Modularity framework, to modularize the project structure.
  - Runtime container, to manage deployment and upgrade.
  - Hot-fix mechanism, for highly efficient and fast bug-fix.

# Well-Known Open Source Containers

- They are actually much more complex beyond your imagination.
- Despite open sourced, it is still hard to evaluate.
  - Check out its compatibility list (Android versions, Dalvik / ART, Devices)
  - Check out its issue tracker
  - Check out the KNOWN ISSUES in README or wiki
  - Check out the LIMITATIONS in README or wiki

Be careful about projects with few KNOWN ISSUES and LIMITATIONS.

# The Future of Runtime Container

- The Android infrastructure
  - Split-APK (Android 5+): Requires modular project
  - Instant App (Google Play services): Requires **highly** modular project
  - Ephemeral App (Android 7+): Possibly requires modular project *
- Runtime container as a platform (Virtual App)
  - Hack existent app (like Xposed for apps, without root)
  - App automation (like UiAutomator for user)
  - Privacy concerns (that's why it should be open sourced)

# Life is hard, don't waste your time!

Talk is cheap, show me the code!

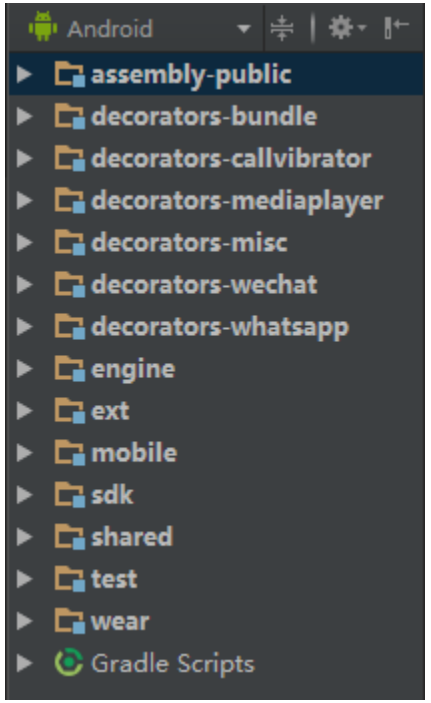
# Advice for Practice

- If you are a small team or developing a fast-iterating product
  - Modularize your project **as early as possible**.
  - Avoid developing in-house runtime container.
  - Adopt open-source hot-fix solutions.

- If you are a large team, focus on shared low-level platform.
  - Layer your frameworks, **do modularization first**.
  - Avoid container-based approach, unless it's your product model.
    - The forbiddance enforced by developer agreement of Google Play Store
    - Plan the exit route of containerization within its core design.

# Our Practice - Bare Modularization

- Project: Regular Gradle project with modules
- Module: Hybrid (Sample: github.com/oasisfeng/nevolution)
  - Act as application module in debug, but as library module in release.
- Build
  - Debug: One APK for each module with shared UID
  - Release: Single APK for all modules together




**AndroidManifest.xml** of module assembly-public

```
<manifest ... tools:remove="android:sharedUserId,android:sharedUserLabel" />
```

**build.gradle** of module assembly-public

```
ext.assembly = gradle.startParameter.taskNames.find { it.startsWith(":assembly-public") } != null;
if (ext.assembly) {
    configure(subprojects.findAll { ! it.name.startsWith("assembly-public") }) { apply plugin:'com.android.library' }
} else configure(subprojects.findAll { it.name.startsWith("decorators-") }) { apply plugin:'com.android.application' }
```

# "Bare" means A LOT

- Minimal efforts, pure Android development experience
  - Fully managed by Android Studio & Gradle, without extra tools, plug-ins
  - Future-proof for your development investment
- Effective building and debugging in large project
  - Just build your module only, not the whole project.
  - Only install the APKs of dependent modules.
  - Only upgrade the APKs of changed modules.
- Inherently compatible and friendly with most runtime containers
  - Split APKs (Android 5+), Instant Apps (Google Play)
  - Hot-patch solutions: Tinker, Instant Run (Android Studio)

# Dependency Injection

- DI in pure Android way
  - **Intent** against **intent filter**
  - AndroidManifest – The dependency configuration
    - Gradle build types & variants – AndroidManifest override for different scenarios
- Comparison to the classic DI frameworks (JSR-330 based)
  - Share components beyond app boundary.
  - IPC (multi-process) support.
  - Completely lazy.
  - User re-configurable. (ActivityChooser, DocumentsProvider)
  - Highly interoperable. (No library required)

# Flexible UI bus

- Activity identified by URL (fragment by # within URL)

```
<activity android:name=".XxxActivity“ ... >
    <intent-filter android:priority="1" > <!-- priority higher than catch-all WebViewActivity -->
        <action android:name="android.intent.action.VIEW" />
        <category android:name="android.intent.category.DEFAULT" />
        <data android:scheme="http" android:scheme="https" android:host="www.example.com" android:path="/xxx" />
    </intent-filter>
</activity>

<activity android:name=".WebViewActivity“ ... > <!– The catch-all web container activity -->
    <intent-filter android:priority=“0" > <!-- priority lower than local Activities -->
        <action android:name="android.intent.action.VIEW" />
        <category android:name="android.intent.category.DEFAULT" />
        <data android:scheme="http" android:scheme="https" android:host="www.example.com" android:pathPrefix="/" />
    </intent-filter>
</activity>
```

- Hybrid handling: **Native if module installed, web as fallback.**

# Flexible UI bus (cont.)

- Browser → App: Capture standard HTTP links in browser

```
<activity android:name=".XxxActivity“ ... >
    <intent-filter android:autoVerify="true" android:priority="1" > <!– App Links -->
        <action android:name="android.intent.action.VIEW" />
        <category android:name="android.intent.category.DEFAULT" />
        <category android:name="android.intent.category.BROWSABLE" /> <!-- Only if to be captured in browser -->
        <data android:scheme="http" android:scheme="http" android:host="www.example.com" android:path="/xxx" />
    </intent-filter>
</activity>
```

- Fully compatible with Verified App Links (Android 6+)
- Support Deep-Link (including "android-app" schema)
- Login can be handled with URL redirection and "referer" (nav. back).
- Standard-compliant, pure Android, cross-platform and future-proof.

# Light Infrastructures on top of "Bare"

- **Services** to simplify the usage of AIDL service

```
Services.use(context, INevoEngine.class, INevoEngine.Stub::asInterface, engine -> engine.evolve(...));
```

- **AidlService** to reduce boilerplate code of AIDL service.

```
public class NevoEngine extends INevoEngine.Stub implements NevoEngineInternal, Closeable {

   @Override public StatusBarNotificationEvo evolve(...) { ... }

   public static class Service extends AidlService<INevoEngine.Stub> {
      @Override protected INevoEngine.Stub createBinder() { return new NevoEngine(getContext()); }
   }
}
```

- **LocalAidlServices** for highly efficient local AIDL service.
  - Synchronous service binding, no more hassles about ServiceConnection

```
final INevoRules rules = Services.bindLocal(context, INevoRules.class);
```

*Reference implementation: [https://github.com/oasisfeng/deagle/.../com/oasisfeng/android/service](https://github.com/oasisfeng/deagle/.../com/oasisfeng/android/service)*

# Other Hiccups You May Experience

- Where to place .aidl and related files
  - Avoid AIDL interface between independent modules. (consider broadcast)
  - Separate interface module for service module. (engine & engine-api)
- Libraries are built into every dependent modules, state not shared.
  - Redundant only in debug build, no difference in actual behaviors.
  - Library should **NEVER** share state between modules.
  - Use (wrapper) service if state needs to be shared.
- Share UI among modules
  - Consider self-contained Activity in one module.
  - Share M+V (fragment & layout) in library module.

# Thanks

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anywhere