

AppXray Reverse-Engineering Report

Target: Duolingo (com.duolingo)

Field	Value
Package	com.duolingo
Version	6.79.5 (code: 2361)
Size	246 MB (XAPK), main APK 164 MB
Min SDK	29 (Android 10)
Target SDK	36 (Android 16)
Architecture	Native Kotlin + Jetpack Compose + Unity (mini-games)
DEX Files	11 (~63 MB bytecode)
Activities	242
Services	17
Report Date	2026-05-26
Source	APK decompilation + string extraction + manifest analysis

Key Findings

- IronSource mediation at the center - Unity Ads, Vungle, Moloco, AdMob, Facebook AN, and Pangle all wired through IronSource / Unity mediation stack (3,952+ IronSource class references in bytecode).
- Facebook Audience Network loaded as hidden DEX - audience_network.dex (~5 MB) in assets/, same cold-start optimization pattern as CamScanner.
- 7+ ad networks for free-tier monetization - plus Google Play Billing for Super / Plus subscriptions (no RevenueCat detected).
- Multiple staging APIs in production - android-api-stage, goals-api-stage, goals-api-stage-2/3, infra-edge-gateway-stage-cf.
- Kotlin + Jetpack Compose main UI; Unity used for specific game experiences (UnityActivity, chess promos).
- Adjust for attribution; Sentry with dedicated duolingo-sentry.sentry.io (session replay URLs in strings).
- China split - android-api.duolingo.cn alongside global android-api.duolingo.com.
- First-party ad surfaces - CustomNativeAdActivity, FullscreenNetworkNativeAdActivity, PlusPromoVideoActivity (session-end upsell).

1. Architecture Overview

Core Architecture

Duolingo is a large native Android app built primarily with Kotlin and Jetpack Compose (4,000+ Compose references in DEX). Select experiences (chess, some interactive content) route through Unity (com.duolingo.feature.unity.UnityActivity, UnityPlayerGameActivity).

User-facing app

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+-- Kotlin / Jetpack Compose -- Lessons, profile, leagues, onboarding, Plus flows
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|   +-- OkHttp + Retrofit -- API layer
|   +-- Room -- Local persistence
|   +-- ExoPlayer -- Audio / video (lessons, promos)
|   +-- Lottie / Rive -- Animations (modular_rive_lily.json, CDN Lottie)
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+-- Unity runtime -- Chess and selected game modules
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+-- Ad mediation layer -- IronSource hub -> Unity, Vungle, Moloco, AdMob, Meta, Pangle

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Component Count

Component	Count
Activities	242
Services	17
Broadcast Receivers	17
Content Providers	12

Notable First-Party Modules (from Activity names)

Module	Activity / clue
Lessons / session	com.duolingo.app., session end flows
Super / Plus monetization	PlusPurchaseFlowActivity, duolingo.com/settings/super
Ads (free users)	feature.ads.CustomNativeAdActivity, FullscreenNetworkNativeA
Leagues	feature.leagues.interstitial.LeaderboardInterstitialActivity
Math / Music	feature.math., cloudfront score XML assets
Duolingo English Test	englishtest.duolingo.com deep links
Schools / classrooms	schools.duolingo.com/api/
Video call / AI	ai.videocall.promo.VideoCallPurchasePromoActivity
Family plan	plus.familyplan., invite.duolingo.com/family-plan/

2. Core Feature Modules

Monetization UX (Free vs Paid)

Surface	Purpose
PlusPurchaseFlowActivity	In-app subscription purchase flow
PlusPromoVideoActivity	Video ad / promo after sessions (session-end monetization)
ProxyBillingActivity / V2	Google Play Billing
VideoCallPurchasePromoActivity	AI video call upsell
LeaderboardInterstitialActivity	League screen interstitial placement

Model: Freemium - ads + upsell interstitials for free users; Google Play Billing for Super/Plus (gems, family plan). Strings reference PendingPurchase, QueryPurchasesParams - native Billing Library, not third-party subscription SDK.

Social & Growth

Feature	Evidence
Friend invites	AddFriendsFlowActivity, invite.duolingo.com
Contacts	READ_CONTACTS, AddPhoneActivity
Referral / family	invite.duolingo.com/family-plan/%s

3. API & Endpoint Analysis

Production APIs (duolingo.com)

Endpoint	Purpose
android-api.duolingo.com	Primary Android API
android-api-cf.duolingo.com	Cloudflare-fronted API variant
android-api.duolingo.cn	China region API
goals-api.duolingo.com	Goals / learning path (inferred)
birdseye.duolingo.com	Internal/analytics tooling (inferred)
drive-thru.duolingo.com	Feature flag / config delivery (inferred)
diagnostics.duolingo.com/user-summary/	Diagnostics
duolingo-maker-prod.duolingo.com/animation/lottie	Lottie asset CDN
localization-duostrings.duolingo.com	Localized strings
tts-data.duolingo.com	Text-to-speech
math-cdn.duolingo.com	Math module assets
simg-ssl.duolingo.com	Avatars, Lottie, promo videos
schools.duolingo.com/api/1, /api/2	Duolingo for Schools
englishtest.duolingo.com	DET (English Test) integration
store.duolingo.com	Merch shop deep links
stories.duolingo.com	Stories feature
zombie.duolingo.com	Internal codename endpoint

Staging / Test Endpoints (in production build)

Staging Endpoint
android-api-stage.duolingo.com
goals-api-stage.duolingo.com
goals-api-stage-2.duolingo.com
goals-api-stage-3.duolingo.com
infra-edge-gateway-stage-cf.duolingo.com
duolingotest.zendesk.com

Third-Party Service Endpoints (sample)

Endpoint	Service
duolingo-sentry.sentry.io	Sentry (error + replay)
firebaseinstallations.googleapis.com	Firebase

googleads.g.doubleclick.net	AdMob / Google Ads
gateway.unityads.unity3d.com	Unity Ads
adx.ads.vungle.com	Vungle
api16-access-sg.pangle.io	Pangle (TikTok)
config.ads.vungle.com	Vungle config
imasdk.googleapis.com/admob/sdkloader/	AdMob IMA / video

4. Advertising & Monetization

Ad Networks (7+ detected)

Network	Package / evidence	Role
IronSource	com.ironsource.mediationsdk	Mediation hub -- ControllerActivity, InterstitialActivity, T
Unity Ads	com.unity3d.services.ads	Mediated network + gateway.unityads.unity3d.com
Google AdMob	com.google.android.gms.ads	Banner, interstitial, native (MRAID v3 assets in strings)
Facebook Audience Network	com.facebook.ads + audience_network.dex	Dynamic DEX load (~5 MB in assets)
Pangle (ByteDance)	com.bytedance.sdk.openadsdk	12+ TT ad Activities (rewarded, interstitial, app open)
Vungle	com.vungle.ads	Video / MRAID
Moloco	com.moloco.sdk	MraidActivity, VastActivity, ORTB paths in SDK
AppLovin	com.applovin (lower reference count)	Present but lighter integration

Ad Format Evidence (Manifest Activities)

Format	Networks
Rewarded video	Pangle (TTRewardVideoActivity), Unity, IronSource
Interstitial	AdMob, Pangle, Vungle, IronSource, Moloco
App open	Pangle (TAppOpenAdActivity)
Native / custom	CustomNativeAdActivity, FullscreenNetworkNativeAdActivity
Fullscreen WebView	Unity FullScreenWebViewDisplay, Moloco MRAID

Monetization Strategy Analysis

1. IronSource-led mediation - Highest SDK surface area; Unity Ads tightly integrated (com.unity3d.ironsourceads). Typical setup: IronSource MAX or LevelPlay managing waterfall/bidding across networks.
2. Session-end ad pressure - PlusPromoVideoActivity, LeaderboardInterstitialActivity suggest ads tied to natural break points (after lesson, league screen).
3. Hidden Facebook DEX - Same 5 MB audience_network.dex pattern; defers Meta SDK load until needed.
4. Subscriptions separate from ads - Play Billing + duolingo.com/settings/super; gems and family plan strings. No RevenueCat / Superwall found in DEX.
5. Debug tooling left in - AdsDebugScreenActivity for internal ad QA.

In-App Purchases

SDK	Purpose
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Google Play Billing	Super, Plus, gems, family plan
com.android.billingclient	Billing Library v6+ patterns (PendingPurchasesParams, multi-

5. SDK & Third-Party Libraries (Full List)

Advertising & Mediation (8)

SDK	Notes
IronSource	Mediation core
Unity Ads	Ads + UnityPlayerGameActivity for games
Google AdMob	Primary Google stack
Facebook Audience Network	Hidden DEX
Pangle	ByteDance, full format set
Vungle	Video
Moloco	Programmatic / ORTB
AppLovin	Secondary

Analytics & Attribution (3)

SDK	Purpose
Adjust	com.adjust -- MMP / attribution
Firebase	Analytics, Installations, Crashlytics docs linked
Sentry	io.sentry, duolingo-sentry.sentry.io, replay explore URLs

Crash & Monitoring (2)

SDK	Notes
Sentry	Primary crash + session replay
Firebase Crashlytics	Settings endpoint in strings

Support & CRM (1)

SDK	Purpose
Zendesk	duolingotest.zendesk.com, help center CSS in assets

Media & UI (6)

SDK	Purpose
Jetpack Compose	Modern UI toolkit
ExoPlayer	Audio/video playback
Lottie	Animations
Rive	modular_rive_lily.json
Glide	Likely image loading (typical; verify in deeper pass)

OkHttp / Retrofit	Networking
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Payments (1)

SDK	Purpose
Google Play Billing	Subscriptions and IAP

Other

SDK	Purpose
Dagger / Hilt hints	DI (dagger strings)
Room	Local DB
WorkManager	Background tasks

6. Permissions Analysis

Total: 40 permissions

High Sensitivity

Permission	Risk	Usage Context
RECORD_AUDIO	HIGH	Speaking exercises, pronunciation
READ_CONTACTS	HIGH	Friend discovery / invites
READ_EXTERNAL_STORAGE / WRITE_EXTERNAL_STORAGE	MEDIUM	Legacy storage
USE_BIOMETRIC / USE_FINGERPRINT	MEDIUM	Account security
DETECT_SCREEN_CAPTURE	MEDIUM	Anti-cheat / content protection

Ad & Tracking (5)

Permission	Purpose
ACCESS_AD SERVICES_AD_ID	Privacy Sandbox ad ID
ACCESS_AD SERVICES_ATTRIBUTION	Attribution API
ACCESS_AD SERVICES_TOPICS	Topics API
com.google.android.gms.permission.AD_ID	GAID
BIND_GET_INSTALL_REFERRER_SERVICE	Install attribution (Adjust)

Monetization

Permission	Purpose
com.android.vending.BILLING	In-app purchases

7. Technical Implementation Details

Dynamic DEX Loading (Facebook AN)

assets/audience_network.dex (~4.8 MB)

Loaded at runtime to keep cold start lean while retaining Meta fill.

Build & Obfuscation

Property	Value
Multi-DEX	11 files
Target SDK	36
Split APKs	ABI + density splits in XAPK
Sentry debug meta	sentry-debug-meta.properties in assets
Experiments config	experiments.duostrings.json -- feature flags / A/B

Unity Integration

Unity is not the main shell - it powers specific game modules (chess promos reference DuolingoInterstitial_ChessLaunchPromo). Main app navigation remains Compose-native.

Comparison to CamScanner (same analyst)

Dimension	CamScanner	Duolingo
Ad networks	6	7+
Mediation lead	AdMob + PubMatic bidding	IronSource + Unity
UI stack	Native + FlutterBoost	Kotlin Compose + Unity games
Subscription SDK	Play Billing	Play Billing (no RevenueCat)
Hidden Facebook DEX	Yes	Yes
Staging in prod	6 endpoints	6+ endpoints

Summary

Duolingo v6.79.5 is a mature freemium education app with a heavy ad mediation stack centered on IronSource, seven monetization networks for free users, and native Play Billing for Super/Plus. The codebase is Kotlin/Compose-first with Unity for select games, Adjust + Sentry + Firebase for measurement, and regional API split (.com vs .cn). The hidden Facebook DEX and multiple staging hostnames mirror patterns seen in other top-grossing consumer apps.