



G3 - Android Internals

Android Frameworks and HAL Implementation

Objectives

- Explore the Android source code architecture
 - The Android init process
 - System services
 - The Android Binder
 - Android security and SELinux
 - The Android Application Framework
 - The Android Hardware Abstraction Layer
 - The Android Multimedia Framework and OpenMAX
- Understand the static and dynamic framework structure
 - Class structure
 - Split between Java and C++ code
 - Data flow through the frameworks
 - Control structure of the frameworks

Labs are conducted on the Android emulator

We use the last released AOSP (Android Open Source Platform) version.

For on-site trainings, if suitable Linux workstations are not available, we provide virtual machine images for VirtualBox; in all cases the requisite is a recent 64bit PC (at least 4 cores) with 64Gb of RAM (32Gb may work but is not recommended) and 600Gb of free disk space.

Who should attend this course?

- Engineers that must work on the Android port on a new platform
 - Writing the HAL for a new board
 - Debugging the HAL and Android frameworks
 - Expanding the Android platform for specific usages

Prerequisite

- Good Linux kernel and driver programming experience
- Android installation knowledge
- Basic knowledge of the structure of an Android application
- Good C++ and Java programming skills
- Basic Java knowledge

Course environment

- Printed course material (in English).
- One Linux PC for two trainees (64GB RAM, 1TB free disk, 8 cores).
- Debug on Android emulators (Goldfish or Cuttlefish)

Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

Course Outline

Android Architecture Overview

- Linux and Android
- Android Licensing

First Day

The Android Linux kernel enhancements

- Accessing the kernel source code
- The Android-specific kernel drivers
 - Ashmem
 - Logger
 - Low_memory_killer
 - Timed_output
 - Timed_gpio
 - Buttons and Keypad management
- The Android GKI kernels
- The Android Kernel debugger

Exercise: Setting up the build environment and launching the build

The Android Build system

- The Android code base
- Building Android
 - The Android build environment
 - The Android Emulators (Goldfish and Cuttlefish)
 - The Android build system
 - The Android.mk files
- Adding new components to the build system
 - Java components
 - Native components
 - Applications
- Creating a new Android platform
- Converting to Soong
 - Blueprint files
- Android Treble
 - Android Partitions
 - Android Shared System Image (SSI)
 - Interface Enforcement
- Debugging

Exercise: Creating and compiling a new Android platform

Android System Initialization

- Android properties
- The Android initialization
 - Android Initialization and Device management
 - The Android initialization language
 - The Android boot sequence
 - The “zygote” process
- Security Enhanced Android

- Security in Android and SELinux
- Toolbox commands
- Security and the build system
- SEPolicy files

Android Native Interface

- The bionic C library
 - Why a new C library
 - The bionic Android-specific features
 - What is missing in bionic
- Adding native components
 - Adding native executables
 - Defining Java methods in C++
 - JNI for Android
- Platform interface for native components
 - Accessing system properties
 - Accessing the Android log system
 - Interacting with daemon services
- The Android NDK and JNI
- SWIG

Exercise: Creating a new native component

Second Day

The Android Binder

- The Android Binder architecture
 - Why a new IPC mechanism
 - Android as a massively distributed system
 - The Binder in action
 - The Binder kernel driver
- Binder implementation
 - The AIDL language
 - The AIDL tool
 - Binder Java classes
 - C++ binder implementation classes
- Writing Services
 - Standard Java services
 - Services and the Binder
 - Service Binding
 - Stable AIDL
- Binder implementation
 - Binder Java classes
 - Reference counting in C++ Android frameworks
 - C++ binder implementation classes
 - Implementing a C++ Service
 - The AIDL NDK backend
- System services
 - What is a system service
 - Static and context-dependent services
 - Structure of a system service
 - Adding a new system service
 - The system ServiceManager process

Exercise: Coding a system service

Third Day

The Android Power Manager

- Android Power Management
- The Driver API
- The user-mode API
- The Java API

The Hardware Abstraction Layer

- Why a HAL?
- Conventional and Legacy HALs
 - Architecture
 - Main HAL components
 - The legacy Sensor HAL
- HIDL HALs
 - HAL Types
 - The Hardware Interface Definition Language
- Migrating from HIDL to AIDL

Exercise: Create a simple HAL component

Fourth Day

The Android Sensors Framework

- Sensors in Android
 - The sensor types
 - The Sensor Manager
 - Accessing Sensors
- Framework Architecture
 - Sensor discovery
 - Sensor Calibration
- The Location Manager and Geocoding

The Android Multimedia Framework

- Multimedia in an Android device
 - Data formats and File formats
 - Codec and Demux
- Multimedia for Applications
 - Audio and video playback (MediaPlayer class)
 - Audio and video capture (MediaRecorder class)
- Framework Architecture
 - General framework architecture
 - General data and control flows
 - The MediaPlayer service layer
 - Stagefright and OpenMAX

Exercise: Implementation of an mp3 playback service

Stagefright and OpenMAX for Android Multimedia

- Multimedia in an Android device
- StageFright in the Android Media Framework
 - The legacy OpenCore framework
 - The Stagefright class structure

- OpenMAX Overview
 - The Khronos Group
 - OpenMAX/DL: the Development Layer
 - OpenMAX/IL: the Integration Layer
 - OpenMAX/AL: the Application Layer
 - OpenMAX and OpenSL/ES
- OpenMAX in the Android Media Framework
 - Interface between Android and OpenMAX
 - The OpenMAX/IL Architecture
- Integration of OpenMAX/IL in Stagefright
 - Component registration
 - Component configuration
 - Component Quirks
- The OpenMAX/IL Bellagio implementation
 - OpenMAX/IL LGPL implementation of the core
 - Sample implementation of components

Fifth Day

The Surface Flinger

- Overview
- The Hardware composer

The Android Audio Manager

- Audio routing
- Architecture of Audio manager
 - Audio system
 - Audio policy manager
 - Audio policy service
- Control flow
 - Playback and recording control
 - Time source generation

The Audio Flinger

- Output/input audio flow
 - Buffer management
- Audio track
 - Overview
 - Track live cycle
 - Data flow
- Audio mixer:
 - Overview
 - Mixer life cycle
 - Fast mixer
 - Resampling
 - Volume

The HAL Audio components

- Audio policies
 - Audio Policies and policy devices
 - HAL Audio policy provided services
 - Use from the audio policy manager
 - Use of audio services by the HAL audio policy

- Output duplication
- Suspend/resume
- Audio devices
 - Audio device classes
 - Data flow
 - Interaction with audio track and record
- Audio streams and effects