



## 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)

#### Environnement du cours

- Cours théorique
  - Support de cours imprimé et au format PDF (en anglais).
  - Le formateur répond aux questions des stagiaires en direct pendant la formation et fournit une assistance technique et pédagogique.
- Activités pratiques
  - Les activités pratiques représentent de 40% à 50% de la durée du cours.

- Elles permettent de valider ou compléter les connaissances acquises pendant le cours théorique.
- Exemples de code, exercices et solutions
- Un PC (Linux ou Windows) par binôme de stagiaires (si plus de 6 stagiaires) pour les activités pratiques avec, si approprié, une carte cible embarquée.
- Le formateur accède aux PC des stagiaires pour l'assistance technique et pédagogique.
- Une machine virtuelle préconfigurée téléchargeable pour refaire les activités pratiques après le cours
- Au début de chaque demi-journée une période est réservée à une interaction avec les stagiaires pour s'assurer que le cours répond à leurs attentes et l'adapter si nécessaire

## Audience visée

- Tout ingénieur ou technicien en systèmes embarqués possédant les prérequis ci-dessus.

# 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