Android Multilib Build Cheat Sheet

Presented by

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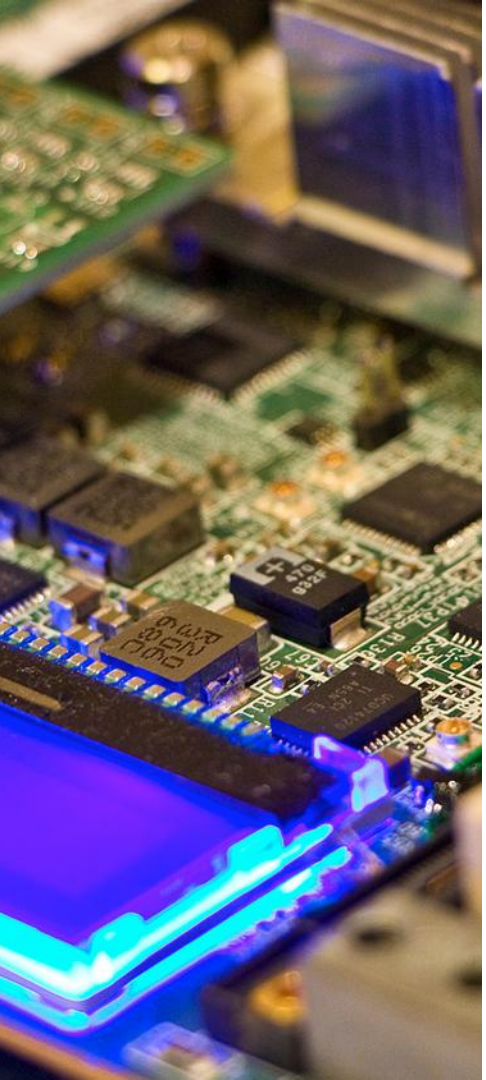

Android Multilib Build Cheat Sheet

- AOSP build configurations
  - 32-bit and 64-bit only builds
  - Multilib builds
- How to do a Multilib build?
  - Multilib platform configuration
  - Building Multilib modules
- Multilib examples from android-5.1.0_r1
  - Platform configuration example
  - Multilib module build example

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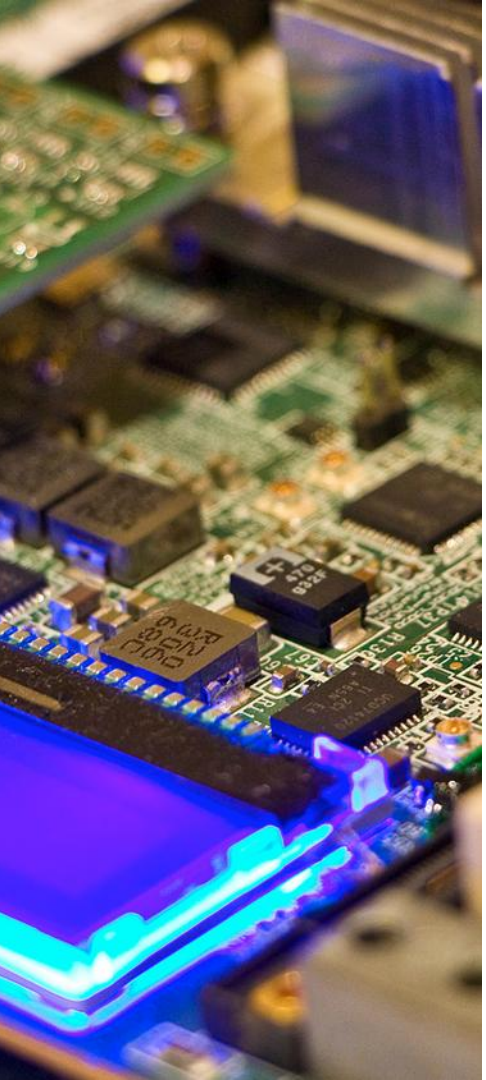

AOSP Build Configurations

- 32-bit and 64-bit only builds
  - Android build for a single target cpu arch i.e. either 32-bit or 64-bit.
- Multilib builds
  - Android build for two target cpu archs e.g. 64-bit primary and 32-bit secondary, or 32-bit primary and 64-bit secondary.

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32-bit and 64-bit only builds

- 32-bit only build
  - Target support 32-bit applications only
  - Build 32-bit Android binaries to run on 32-bit targets
  - Generate huge interest even on 64-bit targets
- 64-bit only build
  - Target support 64-bit applications only
  - Build 64-bit Android binaries to run on 64-bit targets
  - Build not yet ready for a day to day use. Builds successfully but doesn't boot up. Last tried booting on stock android-5.1.0_r1.

Multilib builds

- Multi-target build configuration for 64-bit targets
- Support building binaries for two target cpu archs in the same build, with a primary and a secondary arch configuration.
- Target can support both 32-bit and 64-bit applications

Multilib builds

- 64-bit Primary and 32-bit Secondary (aka 64_32)
  - 64-bit arch is configured as the Primary arch and 32-bit as Secondary
  - 64-bit is the default target for modules if not configured otherwise locally
  - system_server will run as a 64-bit process
- 32-bit Primary and 64-bit Secondary (aka 32_64)
  - Build configuration contrary to 64bit Primary and 32bit Secondary
  - Theoretically possible, traces still available in AOSP (system/core/rootdir/init.zygote32_64.rc)
  - Configuration might have been dropped somewhere in the development cycle. Build is broken for stock android-5.1.0_r1

art/build/Android.common.mk:42: *** Do not know what to do with this multi-target configuration!. Stop.

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Multilib builds

- Zygote configuration
  - Primary and Secondary zygotes
    - Multilib builds run two zygote processes
    - Primary zygote and Secondary zygote
    - To support both 64bit and 32bit applications
  - Starting Lollipop, zygote init config is not part of init.rc anymore.
    - init.rc include init.${ro.zygote}.rc at runtime which initialize zygotes
    - Enable/Select Multilib zygote in product config:

```
PRODUCT_DEFAULT_PROPERTY_OVERRIDES += ro.zygote=zygote64_32
PRODUCT_COPY_FILES += system/core/rootdir/init.zygote64_32.rc:root/init.zygote64_32.rc
```

Multilib builds

- Dissecting /init.zygote64_32.rc:

```
service zygote /system/bin/app_process64 -Xzygote /system/bin --zygote --start-system-server --socket-name=zygote
class main
socket zygote stream 660 root system
onrestart write /sys/android_power/request_state wake
onrestart write /sys/power/state on
onrestart restart media
onrestart restart netd
```

“service zygote” → /system/bin/app_process64 → Primary Zygote
“--start-system-server” → system_server → 64-bit process

```
service zygote_secondary /system/bin/app_process32 -Xzygote /system/bin --zygote --socket-name=zygote_secondary
class main
socket zygote_secondary stream 660 root system
onrestart restart zygote
```

“service zygote_secondary” → /system/bin/app_process32 → Secondary Zygote

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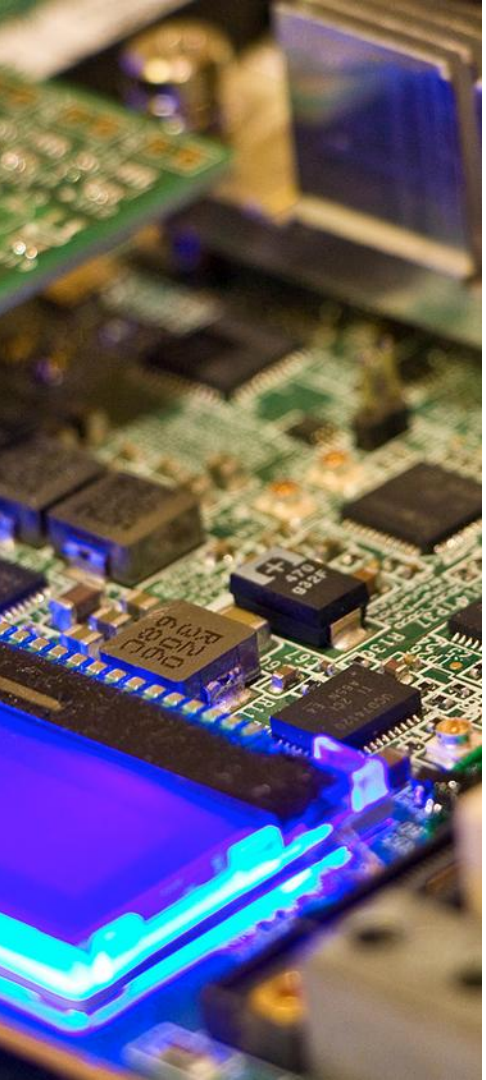

How to do a Multilib build?

- Multilib platform configuration
  - Configure target archs and abis
  - Application/Executables support
  - Custom toolchains
- Building Multilib modules
  - Local build flags
  - Building arch specific modules
  - Binary installation path
  - Handling pre-built modules
  - Dex-preopt and generated sources

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Multilib Platform Configuration

- Configure target CPU archs and ABIs in BoardConfig.mk
  - Primary arch:
    - TARGET_ARCH and TARGET_CPU_* variables defined as usual

```
TARGET_ARCH := arm64
TARGET_ARCH_VARIANT := armv8-a
TARGET_CPU_VARIANT := generic
TARGET_CPU_ABI := arm64-v8a
```

  - Secondary arch:
    - Android build system uses TARGET_2ND_* variables to set up an additional compilation environment for the secondary arch

```
TARGET_2ND_ARCH := arm
TARGET_2ND_ARCH_VARIANT := armv7-a-neon
TARGET_2ND_CPU_VARIANT := cortex-a15
TARGET_2ND_CPU_ABI := armeabi-v7a
TARGET_2ND_CPU_ABI2 := armeabi
```

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Multilib Platform Configuration

- Application/Executables Support
  - To build 32-bit executables and apps by default, set
    TARGET_PREFER_32_BIT := true
  - Set TARGET_SUPPORTS_32_BIT_APPS and TARGET_SUPPORTS_64_BIT_APPS to choose which native libraries to build for an app.
    - If both are set, it will build 64-bit apps unless TARGET_PREFER_32_BIT is set or it is overriden by module-specific local variables in Android.mk
    - If only one is set, it will only build apps that work on that particular arch.
    - If neither is set it will fall back to only building 32bit apps unless overridden by Android.mk config.

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Multilib Platform Configuration

- Set Custom Toolchains
  - Set TARGET_GCC_VERSION_EXP, if you are using a common GCC toolchain version for both the archs.
    - For example, to use custom 4.9-linaro toolchains to build both 32-bit and 64-bit binaries, set:

```
TARGET_GCC_VERSION_EXP := 4.9-linaro
```

The build system in this case will pick both 32-bit and 64-bit custom 4.9-linaro toolchains from default prebuilts toolchain path
i.e. prebuilts/gcc/linux-x86/arm/arm-linux-androideabi-4.9-linaro and prebuilts/gcc/linux-x86/aarch64/aarch64-linux-android-4.9-linaro.

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Multilib Platform Configuration

- Set TARGET_TOOLCHAIN_ROOT and 2ND_TARGET_TOOLCHAIN_ROOT to use different toolchain versions for 64-bit and 32-bit binaries.
  - For example, set custom 4.9-linaro toolchain for primary arch and stock 4.9 toolchain for secondary arch:

```
TARGET_TOOLCHAIN_ROOT := prebuilts/gcc/linux-x86/arm/arm-linux-androideabi-4.9-linaro
2ND_TARGET_TOOLCHAIN_ROOT := prebuilts/gcc/linux-x86/arm/arm-linux-androideabi-4.9
```

Building Multilib Modules

- Building an Android module with Multilib support
  - Module names in product configuration, PRODUCT_PACKAGES, together with the dependency graph decides what binaries will be built and installed to the system image.
    - For libraries pulled in by dependency, a 32-bit library is only installed if it's required by a 32-bit library or executable. The same is true for 64-bit libraries.
    - For executables, by default the build system builds only the 64-bit version, but this build rule can be overridden by TARGET_PREFER_32_BIT or LOCAL_32_BIT_ONLY module-scoped local variable.

Note: Module names on the make command line cover only the 64-bit version build. For example, after running "lunch aosp_arm64-eng", "make libc" builds only the 64-bit libc. To build the 32-bit libc, you need to run "make libc_32".

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Building Multilib Modules

- Module definition in Android.mk

  Set LOCAL_MULTILIB to build for 64-bit and/or 32-bit archs. It overrides the global TARGET_PREFER_32_BIT.

  - LOCAL_MULTILIB := first, build module for the first arch (64-bit on a 64-bit target, 32-bit on a 32-bit target). Same as LOCAL_NO_2ND_ARCH := true
  - LOCAL_MULTILIB := 32, build only 32-bit, same as LOCAL_32_BIT_ONLY := true
  - LOCAL_MULTILIB := 64, build only 64-bit.
  - LOCAL_MULTILIB := both, build for both architectures on a Multilib target.
  - LOCAL_MULTILIB := “”, build depends on other global or LOCAL_* module-scoped variables.

Building Multilib Modules

- Local build variables:

  To set up a custom local build env, use the LOCAL_* variables.

  - Set an arch-specific variable, LOCAL_ variable with a target arch suffix i.e. LOCAL_*_$(TARGET_ARCH) and LOCAL_*_$(TARGET_2ND_ARCH).
    - For example:

      ```
      LOCAL_CFLAGS_arm64 += -DARCH_ARM64_HAVE_NEON
      LOCAL_SRC_FILES_arm := xyz_arm.c
      ```

  - Or set LOCAL_ variable with a _32 or _64 suffix based on whether to build for 32-bit or 64-bit, independent of target arch.
    - For example:

      ```
      LOCAL_CFLAGS_64 += -DARCH_GENERIC_HAVE_ABC
      LOCAL_SRC_FILES_32 += xyz_generic.c
      ```

  Note: Not all LOCAL_ variables support arch/target specific variants. Refer to build/core/clear_vars.mk for an up-to-date list.

Building Multilib Modules

- Building for specific arch(s):
  To drive an arch-specific build, use the following variables.
  - LOCAL_MODULE_TARGET_ARCH and LOCAL_MODULE_UNSUPPORTED_TARGET_ARCH specifies that a module can or cannot be built for one or more architectures.

    ```
    LOCAL_MODULE_TARGET_ARCH := “arm arm64 x86_64”
    LOCAL_MODULE_UNSUPPORTED_TARGET_ARCH := “arm arm64 ..”
    ```

  - LOCAL_MODULE_TARGET_ARCH_WARN and LOCAL_MODULE_UNSUPPORTED_TARGET_ARCH_WARN are same, but warn that the arch is not supported, which is useful for modules that are critical but not yet working.

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Building Multilib Modules

- Installation Path:
  - Libraries: /system/lib always host 32-bit libraries, and /system/lib64 64-bit libraries.
  - Executables: If you build an executable as both 32-bit and 64-bit, then either set LOCAL_MODULE_STEM_{32,64} to distinguish the installed file name, or set LOCAL_MODULE_PATH_{32,64} to distinguish the install path.
  - In multilib builds the install location depends on the CPU target. Set LOCAL_MODULE_RELATIVE_PATH to set the install location instead of LOCAL_MODULE_PATH.
    - For example, HALs will generally use: LOCAL_MODULE_RELATIVE_PATH := hw

Building Multilib Modules

- Handling pre-built Multilib modules:
  - Set LOCAL_SRC_FILES_$(ARCH_SUFFIX) to point to arch specific prebuilt binaries, similarly LOCAL_SRC_FILES_{32,64} can be used for arch independent target binaries.
  - $(TARGET_ARCH) and $(TARGET_2ND_ARCH) can't be used reliably to tell the build system what arch the prebuilt binary is targeted for. Use LOCAL_MODULE{,_UNSUPPORTED}_TARGET_ARCH local variables instead.
  - All the build rules for Multilib executables hold true for pre-built executables as well. For example: if you don't provide LOCAL_MODULE_STEM_{32,64} or LOCAL_MODULE_PATH_{32,64}, then _32 executable will override the _64 executable in /system/bin.

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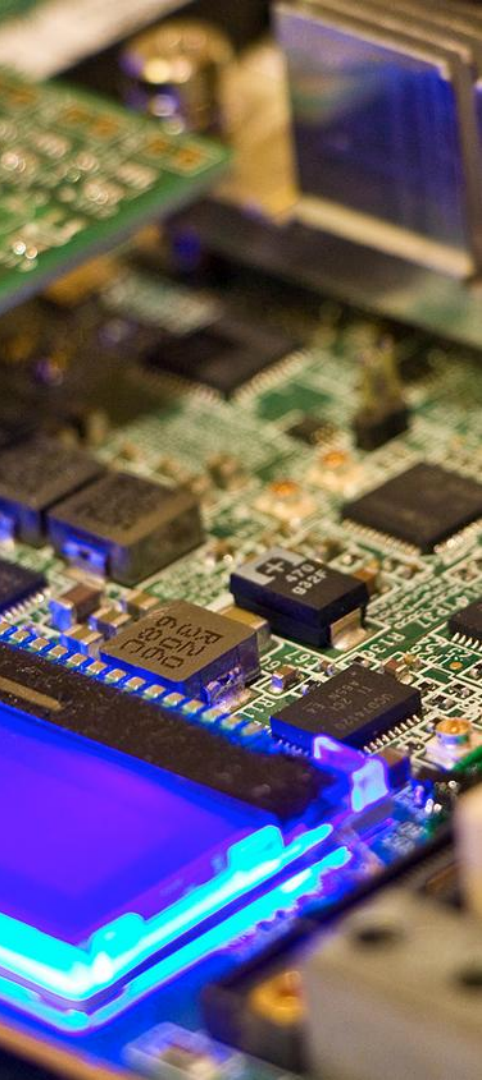
Building Multilib Modules

- Dex-preopt:
  - By default Multilib build generate both 32-bit and 64-bit odex files for the boot image and any Java libraries.
  - For APKs, by default odex files are generated only for the primary 64-bit arch.
    - If the app can be launched in both 32-bit and 64-bit processes, then set `LOCAL_MULTILIB := both` to make sure both 32-bit and 64-bit odex files are generated.
    - `LOCAL_MULTILIB := both` also include both 32-bit and 64-bit JNI libraries in the build, if the app has any.

Building Multilib Modules

- Generated sources:
  - In Multilib, intermediate generated source files will be required by both 32-bit and 64-bit builds.
  - Legacy $(local-intermediates-dir) and $(intermediates-dir-for) variables do not work reliably. Use $(local-generated-sources-dir) and $(generated-sources-dir-for) instead.
  - If a source file is generated to the new dedicated directory and picked up by LOCAL_GENERATED_SOURCES, it is built for both 32-bit and 64-bit build.



Multilib Examples From AOSP

- device/htc/flounder/Boardconfig.mk
  - Device config example
- system/core/debuggerd/Android.mk
  - Local or Module scoped build variables example

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```
TARGET_ARCH := arm64
TARGET_ARCH_VARIANT := armv8-a
TARGET_CPU_ABI := arm64-v8a
TARGET_CPU_ABI2 :=
TARGET_CPU_VARIANT := denver64

TARGET_2ND_ARCH := arm
TARGET_2ND_ARCH_VARIANT := armv7-a-neon
TARGET_2ND_CPU_ABI := armeabi-v7a
TARGET_2ND_CPU_ABI2 := armeabi
TARGET_2ND_CPU_VARIANT := denver
```

```
TARGET_USES_64_BIT_BCMDHD := true
TARGET_USES_64_BIT_BINDER := true

TARGET_USES_LOGD := true
BOARD_WIDEVINE_OEMCRYPTO_LEVEL := 1

# HACK: Build apps as 64b for volantis_64_only
ifneq (,$(filter ro.zygote=zygote64, $(PRODUCT_DEFAULT_PROPERTY_OVERRIDES)))
TARGET_PREFER_32_BIT_APPS :=
TARGET_SUPPORTS_32_BIT_APPS :=
TARGET_SUPPORTS_64_BIT_APPS := true
endif
```

- 64_32 device config: Flounder
  device/htc/flounder/BoardConfig.mk
  - Set Primary, Secondary CPUs and supported ABIs
  - TARGET_USES_64_BIT_BINDER should be set even while doing a 32-bit only build for a 64-bit arch.
  - TARGET_SUPPORTS_{64,32}_BIT_APPS, target support 64-bit applications only.

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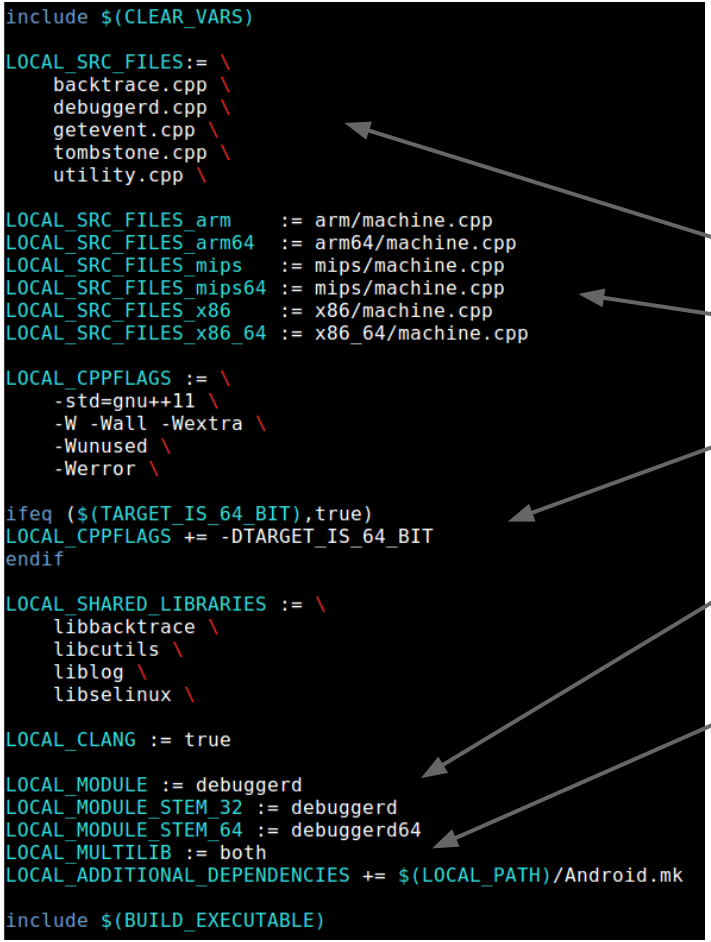

- Multilib Android Module: debuggerd system/core/debuggerd/Android.mk
  - LOCAL_SRC_FILES, common src
  - LOCAL_SRC_FILES_*, arch specific src
  - TARGET_IS_64_BIT, true if TARGET_ARCH is 64-bit i.e. {arm64, x86_64 or mips64}.
  - LOCAL_MODULE_STEM_*, install executables at same location i.e. /system/bin with different names.
  - LOCAL_MULTILIB, build module for both the archs.

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References

- AOSP changelog
- [android-64] New variables and macros of make system in android 64/32-bit build
- Android Platform 64-bit Build Instructions


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