Rockchip Android 14 GKI Developer Guide

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Preface

Overview

This document introduces the development process and attention points of Android 14 GKI.

Intended Audience

This document (this guide) is mainly intended for:

Technical support engineers

Software development engineers

Revision History

Version	Author	Date	Change Description
V1.0.0	Wu Liangqing	2023-11-16	Initial version
V1.1.0	Wu Liangqing	2024-04-15	Modify the GKI compilation method to no longer pre-compile kernel modules
V1.1.1	Wu Liangqing	2024-12-13	Add a reminder to update modules.load.

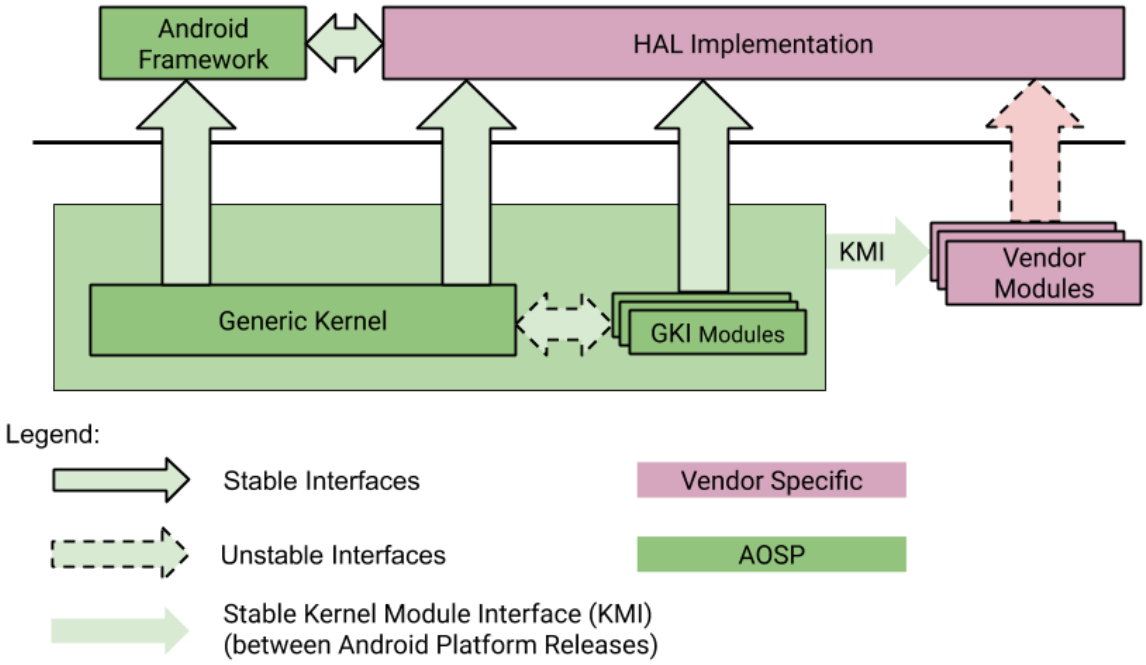
Contents

1. GKI Introduction

1.1 What is GKI

GKI：Generic Kernel Image

One of the difficulties of Android 14 GMS and EDLA authentication is that google mandates to support GKI. GKI is designed by google for solving the problem of kernel fragmentation by providing an unified core kernel and moving SOC and board-level drivers from core kernel into the loadable modules. The core kernel provides a stable kernel module interface for the driver module, and the driver and the kernel can be updated independently. The kernel interface can by extended by upstream. SOC and board-level vendors need use the kernel interfaces defined when developing, if you want to add core kernel interfaces, you need to submit to google, which will be a long time, so you need to make preparation in advance.



1.2 What products need GKI

- The products that use Android14 and require GMS and EDLA certifications
- The products that use Android13 and require GMS and EDLA certifications
- The products that use Android12 RK3588/RK3588S and require GMS and EDLA certifications
- The products without GMS and EDLA certifications are not forced to use GKI

1.3 The difference of GKI and non-GKI

- Generic Kernel boot.img

GKI	non-GKI
Google releases boot.img regularly, you can not modify the code	RK provides the kernel sources to compile, you can modify by yourselves freely

- Driver Module

GKI	non-GKI
Load in the form of KO, and the kernel interface invoked must be included in boot.img published by google	Embedded in boot, RK provides the kernel sources to compile, you can modify and add the kernel interfaces freely

- kernel code

GKI	non-GKI
Load in the form of KO, and the kernel interface invoked must be included in boot.img published by google	Embedded in boot, RK provides the kernel sources to compile, you can modify and add the kernel interfaces freely

- uboot supports head4
- Partition difference

GKI adds vendor_boot、init_boot、resource partitions

- Enable AB partition

2. Rockchip Android14 GKI Adaptation

The kernel version is 6.1.

Chipset	Whether the adaptation is complete
RK3562	Yes
RK3568	Yes
RK3566	Yes
RK3588	Yes
RK3588S	Yes
RK3326	Yes
PX30	Yes
RK3399	Yes
RK3576	Yes

3. Google upstream kernel download and compile

The boot.img provided by google publishes regularly, and the time interval is relatively long. We can download the google upstream kernel to compile boot.img by ourselves to verify and debug.

Google Upstream kernel download link:

```
repo init -u https://android.googlesource.com/kernel/manifest -b common-android14-6.1
```

Need to link google server to download.

Compile:

```
tools/bazel run //common:kernel_aarch64_dist -- --dist_dir=out
```

Generate boot.img

```
out/boot.img
```

4. Introduction to GKI related directories of Rockchip SDK

- kernel KO file path

```
mkcombinedroot/vendor_ramdisk/lib/modules/
```

- Google boot.img path

```
mkcombinedroot/prebuilts/boot-6.1.img
```

- The protected KO file path published by Android AOSP

```
kernel/prebuilts/6.1/arm64/
```

- KO loading sequence configuration file compiled by Kernel-6.1 source

```
mkcombinedroot/res/vendor_ramdisk_modules.load
```

- KO loading sequence configuration file loaded during Android Init stage

```
mkcombinedroot/res/vendor_modules.load
```

5. Requirements for GKI Compilation Environment

- Ubuntu version needs to be 20.04 or higher.
- pahole version needs to be 1.25 or higher.

6. Rockchip GKI Compile

6.1 Code Modify

Configure the GKI options in the device products directory of Android.

```
~/a2_Android14_sdk/device/rockchip/rk3562$ git diff
diff --git a/rk3562_u/BoardConfig.mk b/rk3562_u/BoardConfig.mk
old mode 100644
new mode 100755
index 50da541..06da5f3
--- a/rk3562_u/BoardConfig.mk
+++ b/rk3562_u/BoardConfig.mk
@@ -15,10 +15,21 @@
 #
 include device/rockchip/rk3562/BoardConfig.mk
 BUILD_WITH_GO_OPT := false
-BOARD_BUILD_GKI := fasle
+BOARD_BUILD_GKI := true
```

NOTE: the configuration of RK3562 UGO is enabling GKI by default, you needn't configure additionally.

If you compile uboot solely, you need to modify config to open AB configuration. If you compile fully by build.sh, then no need to modify, which will add AB macro configuration automatically during compiling.

- uboot need open AB configuration

```
~/a2_Android13_sdk/u-boot$ git diff
diff --git a/configs/rk3568_defconfig b/configs/rk3568_defconfig
index fbd9820acc..e23e438792 100644
--- a/configs/rk3588_defconfig
+++ b/configs/rk3588_defconfig
@@ -207,6 +207,7 @@ CONFIG_RSA_N_SIZE=0x200
CONFIG_RSA_E_SIZE=0x10
CONFIG_RSA_C_SIZE=0x20
CONFIG_SHA512=y
CONFIG_LZ4=y
CONFIG_LZMA=y
CONFIG_SPL_GZIP=y
@@ -220,3 +221,4 @@ CONFIG_RK_AVB_LIBAVB_USER=y
CONFIG_OPTEE_CLIENT=y
CONFIG_OPTEE_V2=y
CONFIG_OPTEE_ALWAYS_USE_SECURITY_PARTITION=y
+CONFIG_ANDROID_AB=y
```

6.2 Compile

Full compilation mode is the same to that of non-GKI.

```
source  build/envsetup.sh
lunch rk3562_ugo-userdebug
./build.sh -ACUKup
```

Note: The kernel compiled here is only for generating the resource.img. The kernel source code will be compiled into KO files and packaged into vendor_boot.img. The kernel part uses the boot.img released by Google, and the specific path is in mkcombinedroot/prebuilts/boot-6.1.img.

Flash directly after compiling: `rockdev/Image-rk3562_ugo/update.img`

Compiling vendor_boot.img solely is also supported during debugging.
Compile command：

```
make installclean;make vendorbootimage -j12
```

Flash directly after compiling:

```
out/target/product/rk3562_ugo/vendor_boot.img
```

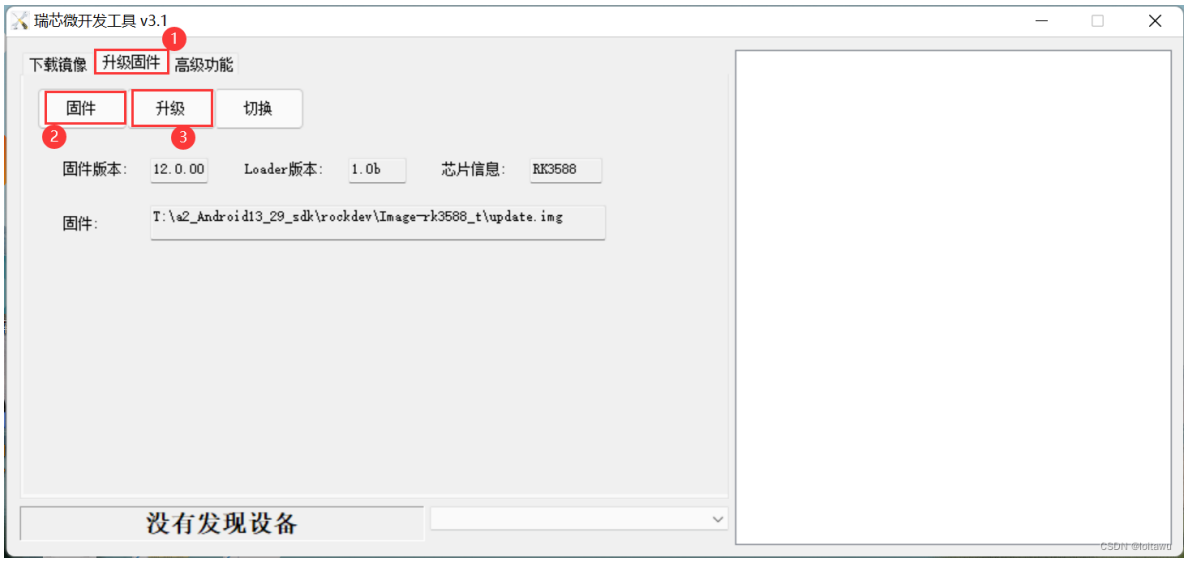
6.3 Firmware Flash

There are 2 ways to flash the firmware:

- Complete package update.img

Firmware path:

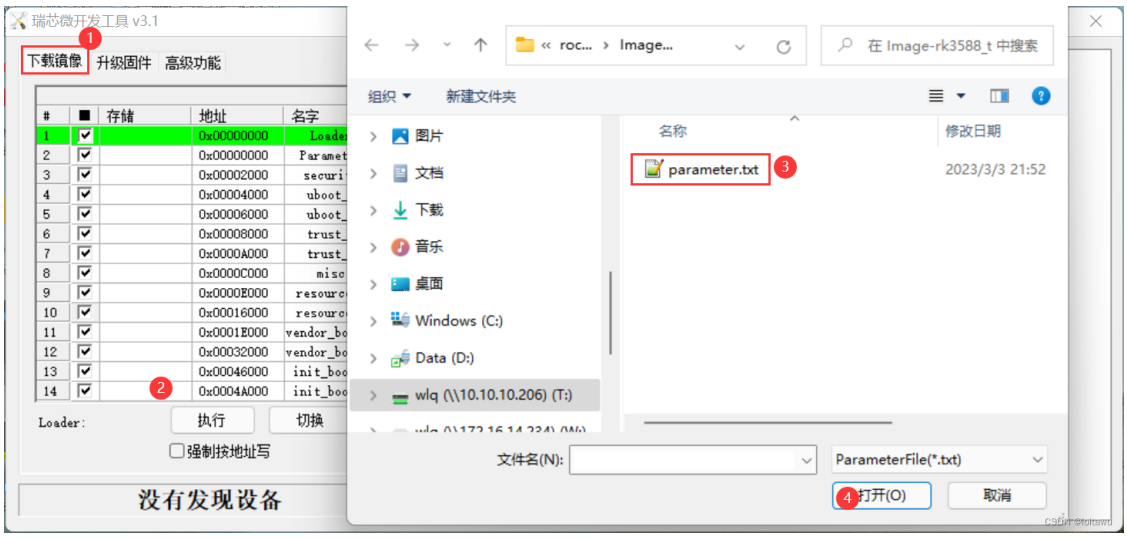
```
rockdev/Image-rk3562_ugo/update.img
```



You can flash through RK tools.

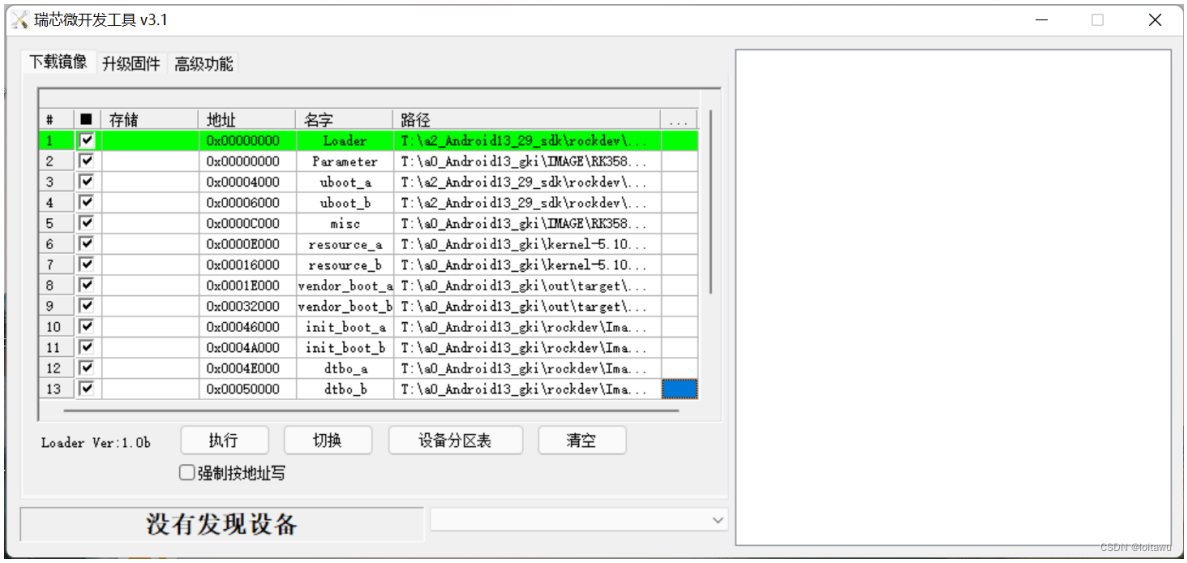
- Dispersive package to flash

  First, import the configuration files, method: right click on the space of the tool-import configuration-select to import txt file-select parameter.txt.



Then select the img files corresponded to rockdev/Image-rk3588_t/ one by one to flash, the firmwares imported by partition A and B are the same.

```
rockdev/Image-rk3562_ugo
├── baseparameter.img
├── boot.img
├── dtbo.img
├── init_boot.img
├── MiniLoaderAll.bin
├── misc.img
├── parameter.txt
├── resource.img
├── super.img
├── uboot.img
├── update.img
├── vbmeta.img
└── vendor_boot.img
```



7. KO Compile and Modify

7.1 Method of adding new module drivers

1. Put the driver codes into the corresponding directory of kernel-6.1, take adding touchscreen driver gt1x as an example:

Put gtlx driver into `drivers/input/touchscreen/`, and add corresponding `Makefile` and `Kconfig`.Here we follow kernel standard method to do.

2. Add an own config file, and new-create a `xxx_gki.config` under `arch/arm64/configs/`, and add `CONFIG_TOUCHSCREEN_GT1X=m` (m means being compiled into ko)to `xxx_gki.config`.
3. Add the KO file names to mkcombinedroot/res/vendor_ramdisk_modules.load or mkcombinedroot/res/vendor_modules.load.

`.load` file name	**Corresponding partition**	**makefile analysis**	**Load time**
vendor_ramdisk_modules.load	vendor_boot	vendor_ramdisk_gki.mk	ramdisk init stage
vendor_modules.load	vendor	vendor_gki.mk	android startup
recovery_modules.load	recovery	recovery_gki.mk	recovery stage

If the driver has no requirement for load time, it can be loaded in android stage, such as touchscreen driver, sensor driver and so on, detailed modification is followed:

- Enter mkcombinedroot directory

```
cd mkcombinedroot
```

- Add the ko name which needs to be compiled into vendor to res/vendor_modules.load, such as xxx_tp.ko

```
diff --git a/res/vendor_modules.load b/res/vendor_modules.load
index e69de29..a53449f 100644
--- a/res/vendor_modules.load
+++ b/res/vendor_modules.load
@@ -0,0 +1,4 @@
pcie-dw-rockchip.ko
cfg80211.ko
+xxx_tp.ko
```

- Compile and flash super.img after finishing addition.

  When adding KO files to `res/vendor_modules.load`, they will be compiled into the `vendor_dlkm/lib/modules/` directory. Therefore, during debugging, you can directly push the compiled KO files to the `vendor_dlkm/lib/modules/` directory on the device. Afterward, reboot the device, and the KO files will be automatically loaded during boot.

Note : The mkcombinedroot/res/vendor_ramdisk_modules.load file is crucial for the loading order of drivers. Please do not modify the original order, as it may cause the system to fail to boot!!! New KO files are not recommended to be placed here unless absolutely necessary, as loading more KO files through vendor_ramdisk_modules.load will slow down the system startup. It is recommended to add new KO files to mkcombinedroot/res/vendor_modules.load, which is loaded during the Android boot stage and has a relatively minor impact on boot time.

4. Compile

For kernel modifications, it's advisable to use the build.sh -K script for compilation. When using build.sh -K, the script automatically copies KO files to the temporary directory mkcombinedroot/vendor_ramdisk/lib/modules during kernel compilation. In a complete compilation, the KO files from this directory will be packaged into vendor_boot.img or super.img.
If you compile the kernel separately in the kernel directory, the generated KO files will not be automatically copied to mkcombinedroot/vendor_ramdisk/lib/modules. In this case, you will need to manually navigate to the mkcombinedroot directory and execute the ./copy_modules.sh script to copy the KO files.

5. Compile vendor_boot.img in the project root directory, the command is as followed. This step is to pack KO file to vendor_boot.img, then flash it into the device.

```
make installclean;make vendorbootimage -j12
```

Flash vendor_boot.img solely, and the vendor_boot.img path after finishing compiling is followed:

```
out/target/product/rk3562_ugo/vendor_boot.img
```

NOTE: If the ko is compiled to vendor, then you need to compile super.img completely and flash super.img.

6. Verify

- Flash `out/target/product/rk3562_ugo/vendor_boot.img` file to the device for boot verifying.
- If the ko is put in vendor partition, then it can be push into the vendor partition of device directly after system boot, and mount manually to verify.
- If it's related to the modification of dts, then you need flash `resource.img` under kernel-6.1.

Attach：Various ko loading stages defined by AOSP

Boot mode	Storage	Display	Keypad	Battery	PMIC	TP	NFC/Wi-Fi/BT	Sensors	Camera
Recovery	Y	Y	Y	Y	Y	N	N	N	N
Charger	Y	Y	Y	Y	Y	N	N	N	N
Android	Y	Y	Y	Y	Y	Y	Y	Y	Y

8. Uboot log verification

8.1 uboot stage

Content	header version
vendor_ramdisk(v-ramdisk)	V3+
bootconfig	V4+

```
## Booting Android Image at 0x003ff000 ...
Kernel: 0x00400000 - 0x03088ffc (45604 KiB)
v-ramdisk:  0x0a200000 - 0x0a6944c8 (4690 KiB)
ramdisk:    0x0a6944c8 - 0x0a7e54df (1349 KiB)
bootconfig: 0x0a7e54df - 0x0a7e559c (1 KiB)
bootparams: 0x0a7e559c - 0x0a7e759c
```

8.2 Android stage

GKI version： `Linux version 5.10.117-android13-9-00037-gbc08447eb7bd`

```
[    0.000000][    T0] Booting Linux on physical CPU 0x0000000000 [0x412fd050]
[    0.000000][    T0] Linux version 5.10.117-android12-9-00037-gbc08447eb7bd
(build-user@build-host) (Android (7284624, based on r416183b) clang version
12.0.5 (https://android.googlesource.com/toolchain/llvm-project
c935d99d7cf2016289302412d708641d52d2f7ee), LLD 12.0.5
(/buildbot/src/android/llvm-toolchai
n/out/llvm-project/lld c935d99d7cf2016289302412d708641d52d2f7ee)) #1 SMP PREEMPT
Thu Aug 25 15:24:20 UTC 2022
```

Kernel command line：Command line parameter such as androidboot.xxx can not exist in Header V4, this kind of parameters should be in bootconfig, which can be verified by `cat /proc/bootconfig`.

```
[    0.000000][    T0] Kernel command line: stack_depot_disable=on
kasan.stacktrace=off kvm-arm.mode=protected cgroup_disable=pressure
cgroup.memory=nokme
m storagemedia=emmc console=ttyFIQ0 firmware_class.path=/vendor/etc/firmware
init=/init rootwait ro loop.max_part=7 bootconfig buildvariant=userdebug earl
ycon=uart8250,mmio32,0xfeb50000 irqchip.gicv3_pseudo_nmi=0
```

8.3 KO loading

When starting to load ko, you can see the log:

```
[    1.034730][    T1] Run /init as init process
[    1.036190][    T1] init: init first stage started!
[    1.040534][    T1] init: Loading module /lib/modules/io-domain.ko with args
''
[    1.042038][    T1] init: Loaded kernel module /lib/modules/io-domain.ko
```

8.4 KO loading error

Use an unexported symbol, and restart with errors:

```
[    0.805736][    T1] cryptodev: Unknown symbol crypto_ahash_final (err -2)
[    0.806383][    T1] cryptodev: Unknown symbol sg_nents (err -2)
[    0.806972][    T1] cryptodev: Unknown symbol crypto_alloc_akcipher (err -2)
[    0.819768][    T1] Kernel panic - not syncing: Attempted to kill init!
exitcode=0x00007f00
```

NOTE: Normally, this problem doesn't occur, please refer to `Noun explanation phase - ABI` .

8.5 bootcmdline parsing error

Error log

```
Failed to parse bootconfig: Value is redefined at 416.
```

Phenomenon: unable to boot or boot into recovery.
Reason: The fields in cmdline are duplicated, resulting in a parsing cmdline error. You can press crtl+p in the serial port when booting to uboot, and all cmdline information will be printed, and check which field is duplicated from the printed cmdline information. Then find the corresponding definition in the codes and delete the corresponding field. cmdline is defined in the dts of device and kernel, so you can search for the duplicated field in both directories.

8.6 Fail to load Mali KO

The performance of Mali KO loading failure is unable to boot and the boot screen locking in the logo of 'Rockchip kernel'. You can fine the surfaceflinger crash in logcat.

```
04-27 22:45:27.653   366   366 F DEBUG   : *** *** *** *** *** *** *** *** ***
*** *** *** *** *** *** ***
04-27 22:45:27.653   366   366 F DEBUG   : Build fingerprint:
'rockchip/rk3562_t/rk3562_t:13/TQ2A.230305.008.F1/eng.wlq.20230427.101925:userde
bug/release-keys'
04-27 22:45:27.653   366   366 F DEBUG   : Revision: '0'
04-27 22:45:27.653   366   366 F DEBUG   : ABI: 'arm64'
04-27 22:45:27.653   366   366 F DEBUG   : Timestamp: 2023-04-27
22:45:27.509738048+0000
04-27 22:45:27.653   366   366 F DEBUG   : Process uptime: 2s
04-27 22:45:27.653   366   366 F DEBUG   : Cmdline: /system/bin/surfaceflinger
04-27 22:45:27.653   366   366 F DEBUG   : pid: 335, tid: 360, name:
surfaceflinger  >>> /system/bin/surfaceflinger <<<
04-27 22:45:27.653   366   366 F DEBUG   : uid: 1000
04-27 22:45:27.653   366   366 F DEBUG   : tagged_addr_ctrl: 0000000000000001
(PR_TAGGED_ADDR_ENABLE)
04-27 22:45:27.653   366   366 F DEBUG   : signal 6 (SIGABRT), code -1
(SI_QUEUE), fault addr --------
04-27 22:45:27.653   366   366 F DEBUG   : Abort message: 'no suitable EGLConfig
found, giving up'
04-27 22:45:27.653   366   366 F DEBUG   :     x0  0000000000000000  x1
0000000000000168  x2  0000000000000006  x3  000000710899d340
04-27 22:45:27.654   366   366 F DEBUG   :     x4  7568661f2b636d74  x5
7568661f2b636d74  x6  7568661f2b636d74  x7  7f7f7f7f7f7f7f7f
```

```
04-27 22:45:27.654   366   366 F DEBUG   :     x8  00000000000000f0  x9
000000739bcbda00  x10 0000000000000001  x11 000000739bcff6a0
04-27 22:45:27.654   366   366 F DEBUG   :     x12 000000710899d310  x13
0000000000000027  x14 000000710899d4e0  x15 00000000197b1a4f
04-27 22:45:27.654   366   366 F DEBUG   :     x16 000000739bd6dd58  x17
000000739bd48770  x18 0000007108812000  x19 00000000000000ac
04-27 22:45:27.654   366   366 F DEBUG   :     x20 00000000000000b2  x21
000000000000014f  x22 0000000000000168  x23 00000000ffffffff
04-27 22:45:27.654   366   366 F DEBUG   :     x24 b4000071bbca60b0  x25
000000710899dcb0  x26 000000710899dff8  x27 00000000000fe000
04-27 22:45:27.654   366   366 F DEBUG   :     x28 000000710899daf0  x29
000000710899d3c0
04-27 22:45:27.654   366   366 F DEBUG   :     lr  000000739bcef3f4  sp
00000071089ndroid.runtime/lib64/bionic/libc.so (__pthread_start(void*)+208)
(BuildId: e2429c64ab29f2d0ffc5a8f42c0c1b80)
04-27 22:45:27.655   366   366 F DEBUG   :       #09 pc 0000000000054c50
/apex/com.android.runtime/lib64/bionic/libc.so (__start_thread+64) (BuildId:
e2429c64ab29f2d0ffc5a8f42c0c1b80)
```

This is because the ko of GPU is not match, you need recompile the ko file of GPU, and copy to the corresponding directory under vendor/rockchip/common/gpu, the detail is as followed:

Modify kernel config in the product directory of device: PRODUCT_KERNEL_CONFIG := gki_defconfig rockchip_gki.config. And add the GPU configuration corresponding to the chip:

```
RK3588:
PRODUCT_KERNEL_CONFIG := gki_defconfig rockchip_gki.config
RK356X/RK3562:
PRODUCT_KERNEL_CONFIG := gki_defconfig rockchip_gki.config rk356x.config
RK3326/RK3326-S:
PX30/PX30-S:
PRODUCT_KERNEL_CONFIG := gki_defconfig rockchip_gki.config rk3326.config
RK3399:
PRODUCT_KERNEL_CONFIG := gki_defconfig rockchip_gki.config rk3399.config

rk3399.config should be modified as followed:
wlq@sys2_206:~/a0_Android13_gki/mkcombinedroot$ git diff configs/
diff --git a/configs/rk3399.config b/configs/rk3399.config
old mode 100644
new mode 100755
index 0d66674..a003ba5
--- a/configs/rk3399.config
+++ b/configs/rk3399.config
@@ -1,4 +1,11 @@
-CONFIG_MALI_MIDGARD=y
+CONFIG_MALI_MIDGARD=m
+CONFIG_MALI_PLATFORM_THIRDPARTY_NAME="rk"
+CONFIG_MALI_PLATFORM_THIRDPARTY=y
+CONFIG_MALI_DEBUG=y
+CONFIG_MALI_DEVFREQ=y
+CONFIG_MALI_DT=y
+CONFIG_MALI_EXPERT=y
+CONFIG_MALI_SHARED_INTERRUPTS=y
```

Then execute./build.sh -CK to compile kernel.

After finishing compiling, copy the corresponding mali ko to the vendor, please refer to above sections for specific path.

8.7 kernel compiling error

Compiling error log：

```
BTF     .btf.vmlinux.bin.o
Segmentation fault (core dumped)
LD      .tmp_vmlinux.kallsyms1
KSYMS   .tmp_vmlinux.kallsyms1.S
AS      .tmp_vmlinux.kallsyms1.S
LD      .tmp_vmlinux.kallsyms2
KSYMS   .tmp_vmlinux.kallsyms2.S
AS      .tmp_vmlinux.kallsyms2.S
LD      vmlinux
BTFIDS  vmlinux
FAILED: load BTF from vmlinux: Unknown error -22Makefile:1293: recipe for target
'vmlinux' failed
make[1]: *** [vmlinux] Error 255
arch/arm64/Makefile:214: recipe for target 'rk3588-evb1-lp4-v10.img' failed
make: *** [rk3588-evb1-lp4-v10.img] Error 2
failed to build some targets (21 seconds)
```

Resolution:

- Update latest pahole

  `git clone https://git.kernel.org/pub/scm/devel/pahole/pahole.git`

- Compile pahole

Install and compile dependency librariy.
`sudo apt-get install cmake`
`sudo apt-get install libdw-dev`

If you have installed pahole before, you need to uninstall it first.
`sudo apt-get --purge remove dwarves`

- Begin to compile

Execute in the ahole directory.
`mkdir build`
`cd build/`
`cmake -D__LIB=lib -DBUILD_SHARED_LIBS=OFF ..    Configure static compilation`
`sudo make install`

pahole --version to check the version to make sure that it is installed sucessfully.

9. GKI compilation environment requirements

- Ubuntu version requires 20.04 and above
- pahole version requires 1.25

10. Debugging skills

10.1 Print more logs loaded by KO

Modify the value of ratelimit to print more logs of init, in order to debug the problems. If init informations are few, the error informations loaded by ko will be hided.

```
xxx@sys2_206:~/a0_Android13_gki/device/rockchip/common$ vim BoardConfig.mk
xxx@sys2_206:~/a0_Android13_gki/device/rockchip/common$ git diff
diff --git a/BoardConfig.mk b/BoardConfig.mk
index 0d1c886..1761ed0 100755
--- a/BoardConfig.mk
+++ b/BoardConfig.mk
@@ -392,3 +392,5 @@ ifeq ($(strip $(BOARD_BASEPARAMETER_SUPPORT)), true)
     endif
         BOARD_WITH_SPECIAL_PARTITIONS := baseparameter:1M
 endif
+
+BOARD_KERNEL_CMDLINE += printk.devkmsg=on
```

10.2 Compile GKI boot.img in RK kernel package

Compile kernel according to normal steps first, then generate arch/arm64/boot/Image.
Pack boot.img by following commands:
mkbootimg --kernel arch/arm64/boot/Image --header_version 4 --output ../mkcombinedroot/prebuilts/boot-6.1.img

10.3 Check the kernel interface published by google

The standard kernel interface definition is in the android directory:

```
:~/a5_google_kenrel/common$ tree a
android/ arch/
wlq@sys2_206:~/a5_google_kenrel/common$ tree android/
android/
├── abi_gki_aarch64
├── abi_gki_aarch64_core
├── abi_gki_aarch64_db845c
├── abi_gki_aarch64_exynos
├── abi_gki_aarch64_fips140
├── abi_gki_aarch64_galaxy
├── abi_gki_aarch64_generic
├── abi_gki_aarch64_hikey960
├── abi_gki_aarch64_rockchip
├── abi_gki_aarch64_type_visibility
├── abi_gki_aarch64_virtual_device
├── abi_gki_aarch64.xml
├── abi_gki_modules_exports
├── abi_gki_modules_protected
```

```
├── gki_aarch64_fips140_modules
├── gki_aarch64_modules
└── gki_system_dlkm_modules
```

11. How to submit the kernel interface to upstream

If you need to add a new kernel interface, you can generate the corresponding patch, and submit the patch to rockchip redmine to be examined and then submit it to google uniformly.

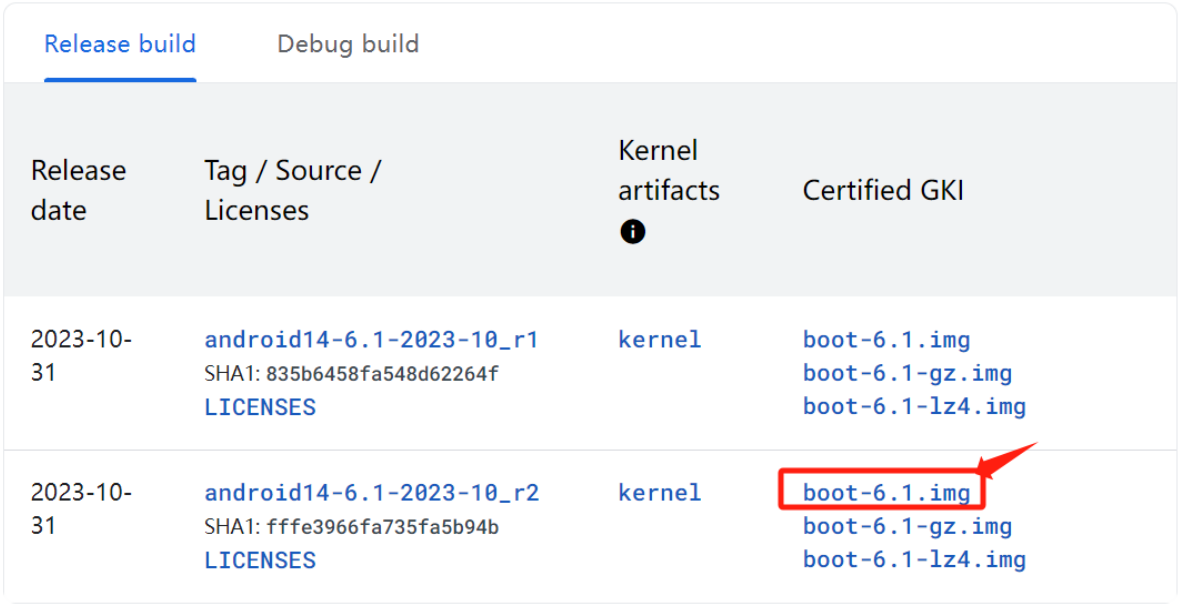
```
diff --git a/android/abi_gki_aarch64_rockchip b/android/abi_gki_aarch64_rockchip
index 85bd8bc134cf..3344cf064e06 100644
--- a/android/abi_gki_aarch64_rockchip
+++ b/android/abi_gki_aarch64_rockchip
@@ -2144,6 +2144,15 @@
   mmc_pwrseq_register
   mmc_pwrseq_unregister

+# required by r8168.ko
+  pci_set_mwi
+  pci_clear_mwi
+  proc_get_parent_data
+  skb_checksum_help
+  __skb_gso_segment
+  remove_proc_subtree
+  pci_choose_state
+
 # required by reboot-mode.ko
   devres_release
   kernel_kobj
```

12. How to update boot.img published by AOSP

Android AOSP updates boot.img and corresponding protected KO file regularly, the Android release link is as followed:

https://source.android.com/docs/core/architecture/kernel/gki-android14-6_1-release-builds

After openning the link, find the latest release version of Android14-6.1, and then click corresponding boot-6.1.img to download, as the picture shows:

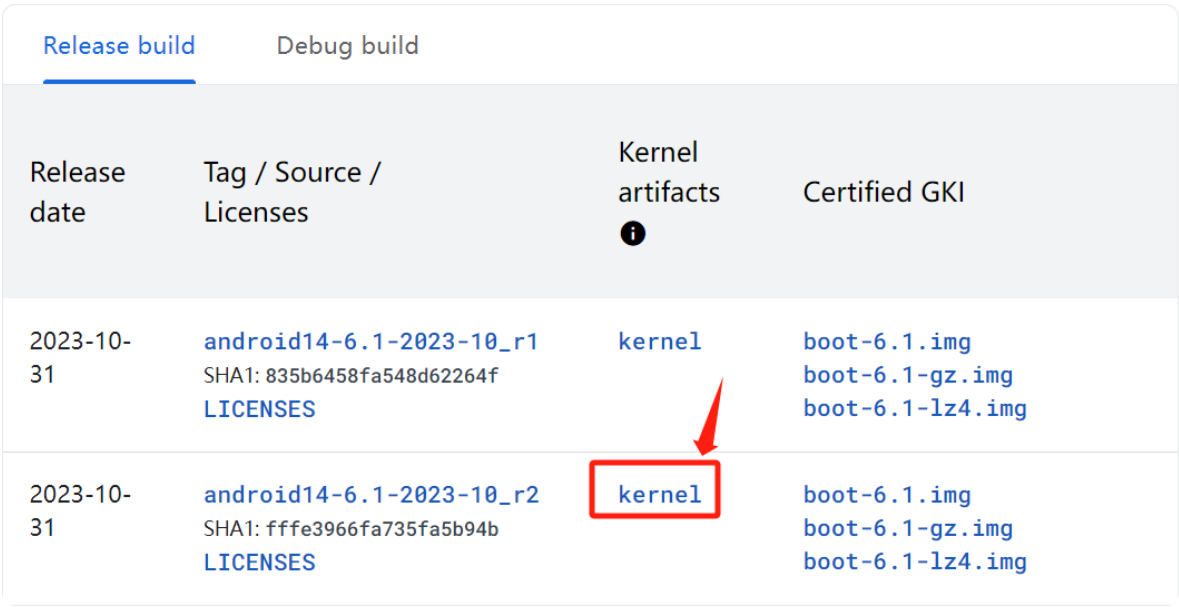


After downloading the boot-6.1.img, copy it to:

```
mkcombinedroot/prebuilts/boot-6.1.img
```

From Android14, AOSP publishes protected ko module synchronously, which needs to be download together, and this ko file need to match with boot.img to load correctly.

Click the kernel link in the following picture to download system_dlkm_staging_archive.tar.gz.



Download and unzip system_dlkm_staging_archive.tar.gz, and copy the unzipped ko file in flatten\lib\modules\ to:

```
kernel/prebuilts/6.1/arm64/
```

Note: Do not update the kernel/prebuilts/6.1/arm64/modules.load file, as doing so may cause the ko modules to fail to load. The modules.load file might be overwritten when decompressing and replacing ko modules. Be sure to check it after replacing.

13. How to pack vendor_boot.img solely

- Step1: compile the corresponding ko file in kernel.
- Step2: copy ko file into mkcombinedroot directory.
- Step3: copy vendor_boot.img into mkcombinedroot directory.
- Step4: enter the mkcombinedroot directory and execute mkgki4.sh script, then update ko and compile it to vendor_boot.img.
- Step5: flash vendor_boot.img to the device.

  Now we introduce each steps in the following:

13.1 Step1: compile ko in kernel

- Enter kernel directory

Android14 + kernel6.1

```
cd kernel-6.1
```

- Export clang to the environment

```
export PATH=../prebuilts/clang/host/linux-x86/clang-r487747c/bin:$PATH
```

- Compile KO

```
make CROSS_COMPILE=aarch64-linux-gnu- LLVM=1 LLVM_IAS=1 ARCH=arm64 gki_defconfig
rockchip_gki.config && make CROSS_COMPILE=aarch64-linux-gnu- LLVM=1 LLVM_IAS=1
ARCH=arm64 rk3562-rk817-tablet-v10.img -j32
```

13.2 Step2: copy ko file into mkcombinedroot directory

```
llvm-objcopy --strip-debug  drivers/xxx.ko
../mkcombinedroot/vendor_ramdisk/lib/modules/xxx.ko
```

13.3 Step3: copy vendor_boot.img into mkcombinedroot directory

Compiling vendor_boot.img solely needs to copy a vendor_boot.img base pack, just like that compiling boot.img solely needs a boot_sample.img. This vendor_boot.img needs to be the same with the vendor_boot.img in the device you prepare to update, which can be copied from GKI firmware.

13.4 Step4: enter the mkcombinedroot directory and execute mkgki4.sh script, then update ko and compile it to vendor_boot.img

```
cd ../mkcombinedroot/
```

Compile vendor_boot.img, thereinto:

- DTS=board-level dts name, dts needs to use the load name defined in res/board/.

```
./mkgki4.sh DTS=rk3568-evb1-ddr4-v10
```

After compiling, there will be new_vendor_boot.img generated in the mkcombinedroot root directory.

13.5 Step5: flash vendor_boot.img to the device

- Flash `mkcombinedroot/new_vendor_boot.img` file to the device and boot to verify.
  Generally, GKI firmware is AB firmware, so when flashing new_vendor_boot.img, you need update vendor_boot_a and vendor_boot_b partitions at the same time. If the device has been in fastboot mode due to multiple abnormal restarts before flashing, you need to flash misc.img at the same time. Only the mark in misc partition is cleaned, can the device boot, the reference commands of flash tools in ubuntu are as followed:

```
sudo ./upgrade_tool di -vendor_boot_a
mkcombinedroot/new_vendor_boot.img/vendor_boot.img
sudo ./upgrade_tool di -vendor_boot_b
mkcombinedroot/new_vendor_boot.img/vendor_boot.img;
sudo ./upgrade_tool rd
```

- If the ko is put in vendor partition, then it can be pushed to the vendor partition of device directly after system enabled, and mount manually to verify.
- If it's related to dts modification, you need to flash `resource.img` in kernel-6.1.