Linux A/B System

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前言

概述

Linux A/B System 介绍。

产品版本

芯片名称	U-Boot版本
所有芯片	next-dev

读者对象

本文档（本指南）主要适用于以下工程师:

技术支持工程师

软件开发工程师

修订记录

版本号	作者	修改日期	修改说明
V1.0.0	朱志展	2019-01-25	初始版本
V1.1.0	朱志展	2019-07-04	修订系统升级章节
V1.1.1	黄莹	2021-03-02	修改格式
V1.2.0	朱志展	2022-05-26	修改文件标识

目录

1. 引用参考

《Rockchip-Secure-Boot2.0.md》

《Rockchip-Secure-Boot-Application-Note.md》

《Android Verified Boot 2.0》

2. 术语

3. 简介

所谓的 A/B System 即把系统固件分为两份，系统可以从其中的一个 slot 上启动。当一份启动失败后可以从另一份启动，同时升级时可以直接将固件拷贝到另一个 slot 上而无需进入系统升级模式。

4. AB 数据格式及存储

存储位置为 misc 分区偏移 2KB 位置。

```
/* Magic for the A/B struct when serialized. */
#define AVB_AB_MAGIC "\0AB0"
#define AVB_AB_MAGIC_LEN 4

/* Versioning for the on-disk A/B metadata - keep in sync with avbtool. */
#define AVB_AB_MAJOR_VERSION 1
#define AVB_AB_MINOR_VERSION 0

/* Size of AvbABData struct. */
#define AVB_AB_DATA_SIZE 32

/* Maximum values for slot data */
#define AVB_AB_MAX_PRIORITY 15
#define AVB_AB_MAX_TRIES_REMAINING 7

typedef struct AvbABSlotData {
  /* Slot priority. Valid values range from 0 to AVB_AB_MAX_PRIORITY,
   * both inclusive with 1 being the lowest and AVB_AB_MAX_PRIORITY
   * being the highest. The special value 0 is used to indicate the
   * slot is unbootable.
   */
  uint8_t priority;
```

```
  /* Number of times left attempting to boot this slot ranging from 0
   * to AVB_AB_MAX_TRIES_REMAINING.
   */
  uint8_t tries_remaining;

  /* Non-zero if this slot has booted successfully, 0 otherwise. */
  uint8_t successful_boot;

  /* Reserved for future use. */
  uint8_t reserved[1];
} AVB_ATTR_PACKED AvbABSlotData;

/* Struct used for recording A/B metadata.
 *
 * When serialized, data is stored in network byte-order.
 */
typedef struct AvbABData {
  /* Magic number used for identification - see AVB_AB_MAGIC. */
  uint8_t magic[AVB_AB_MAGIC_LEN];

  /* Version of on-disk struct - see AVB_AB_{MAJOR,MINOR}_VERSION. */
  uint8_t version_major;
  uint8_t version_minor;

  /* Padding to ensure |slots| field start eight bytes in. */
  uint8_t reserved1[2];

  /* Per-slot metadata. */
  AvbABSlotData slots[2];

  /* Reserved for future use. */
  uint8_t reserved2[12];

  /* CRC32 of all 28 bytes preceding this field. */
  uint32_t crc32;
} AVB_ATTR_PACKED AvbABData;
```

对于小容量存储，没有 misc 分区，有 vendor 分区，可以考虑存储到 vendor。

在此基础上增加 lastboot，标记最后一个可启动固件。主要应用于低电情况或工厂生产测试时 retry 次数用完，而还没有进入系统调用 boot_ctrl 服务。

参考如下：

```
typedef struct AvbABData {
  /* Magic number used for identification - see AVB_AB_MAGIC. */
  uint8_t magic[AVB_AB_MAGIC_LEN];

  /* Version of on-disk struct - see AVB_AB_{MAJOR,MINOR}_VERSION. */
  uint8_t version_major;
  uint8_t version_minor;

  /* Padding to ensure |slots| field start eight bytes in. */
  uint8_t reserved1[2];
```

```
  /* Per-slot metadata. */
  AvbABSlotData slots[2];

  /* mark last boot slot */
  uint8_t last_boot;
  /* Reserved for future use. */
  uint8_t reserved2[11];

  /* CRC32 of all 28 bytes preceding this field. */
  uint32_t crc32;
} AVB_ATTR_PACKED AvbABData;
```

同时在 AvbABSlotData 中增加 is_update 标志位，标志系统升级的状态，更改如下：

```
typedef struct AvbABSlotData {
  /* Slot priority. Valid values range from 0 to AVB_AB_MAX_PRIORITY,
   * both inclusive with 1 being the lowest and AVB_AB_MAX_PRIORITY
   * being the highest. The special value 0 is used to indicate the
   * slot is unbootable.
   */
  uint8_t priority;

  /* Number of times left attempting to boot this slot ranging from 0
   * to AVB_AB_MAX_TRIES_REMAINING.
   */
  uint8_t tries_remaining;

  /* Non-zero if this slot has booted successfully, 0 otherwise. */
  uint8_t successful_boot;

  /* Mark update state, mark 1 if the slot is in update state, 0 otherwise. */
  uint8_t is_update : 1;
  /* Reserved for future use. */
  uint8_t reserved : 7;
} AVB_ATTR_PACKED AvbABSlotData;
```

最后表格来说明各个参数的含义：

AvbABData：

参数	含义
priority	标志 slot 优先级，0 为不可启动，15 为最高优先级
tries_remaining	尝试启动次数，设置为 7 次
successful_boot	系统启动成功后会配置该参数，1：该 slot 成功启动，0：该 slot 未成功启动
is_update	标记该 slot 的升级状态，1：该 slot 正在升级，0：该 slot 未升级或升级成功

AvbABSlotData：

参数	含义
magic	结构体头部信息：\0AB0
version_major	主版本信息
version_minor	次版本信息
slots	slot 引导信息，参见 AvbABData
last_boot	上一次成功启动的 slot，0：slot A 上次成功启动，1：slot B 上次成功启动
crc32	数据校验

5. 启用配置

5.1 pre-loader 说明

目前 pre-loader 支持 A/B slot 分区和单 slot 分区。

5.2 uboot 配置

```
CONFIG_AVB_LIBAVB=y
CONFIG_AVB_LIBAVB_AB=y
CONFIG_AVB_LIBAVB_ATX=y
CONFIG_AVB_LIBAVB_USER=y
CONFIG_RK_AVB_LIBAVB_USER=y
CONFIG_ANDROID_AB=y
```

5.3 system bootctrl 参考

目前 system bootctrl 设计两套控制逻辑，bootloader 全支持这两种逻辑启动。

5.3.1 successful_boot 模式

正常进入系统后，boot_ctrl 依据 androidboot.slot_suffix，设置当前 slot 的变量：

```
successful_boot = 1;
priority = 15;
tries_remaining = 0;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

升级系统中，boot_ctrl 设置：

```
升级的slot设置:
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 1;
lastboot = 0 or 1;     :refer to androidboot.slot_suffix

当前slot设置:
successful_boot = 1;
priority = 15;
tries_remaining = 0;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

升级系统完成，boot_ctrl 设置：

```
升级的slot设置:
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
lastboot = 0 or 1;     :refer to androidboot.slot_suffix

当前slot设置:
successful_boot = 1;
priority = 14;
tries_remaining = 0;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

5.3.2 reset retry 模式

正常进入系统后，boot_ctrl 依据 androidboot.slot_suffix，设置当前 slot 的变量：

```
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

升级系统中，boot_ctrl 设置：

```
升级的slot设置:
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 1;
lastboot = 0 or 1;     :refer to androidboot.slot_suffix

当前slot设置:
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

升级系统完成，boot_ctrl 设置：

```
升级的slot设置:
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
lastboot = 0 or 1;     :refer to androidboot.slot_suffix

当前slot设置:
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
last_boot = 0 or 1;     :refer to androidboot.slot_suffix
```

5.3.3 两种模式的优缺点

1. successful_boot 模式

优点：只要正常启动系统，不会回退到旧版本固件，除非 system bootctrl 配置

缺点：设备长时间工作后，如果存储某些颗粒异常，会导致系统一直重启

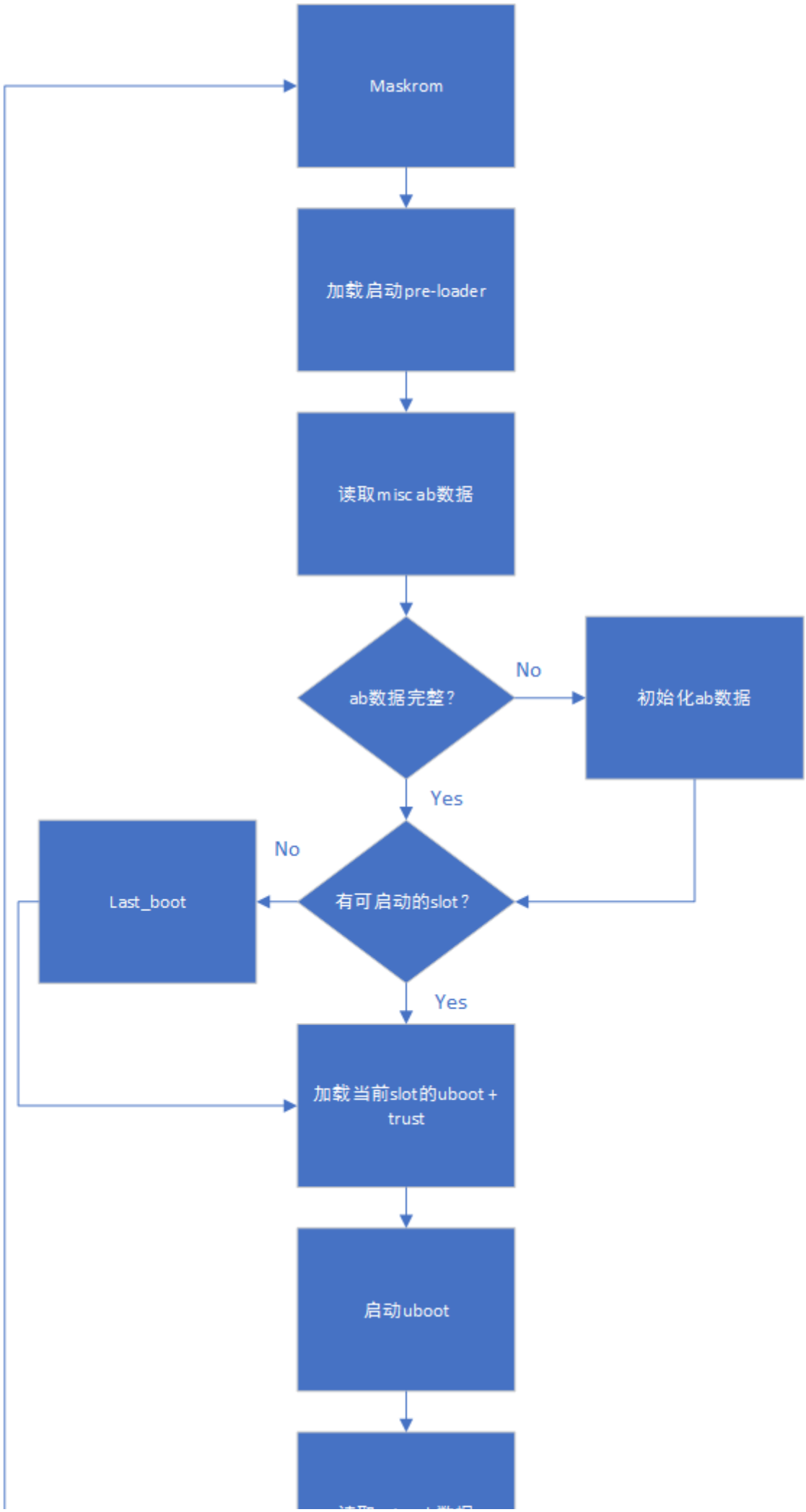
2. reset retry 模式

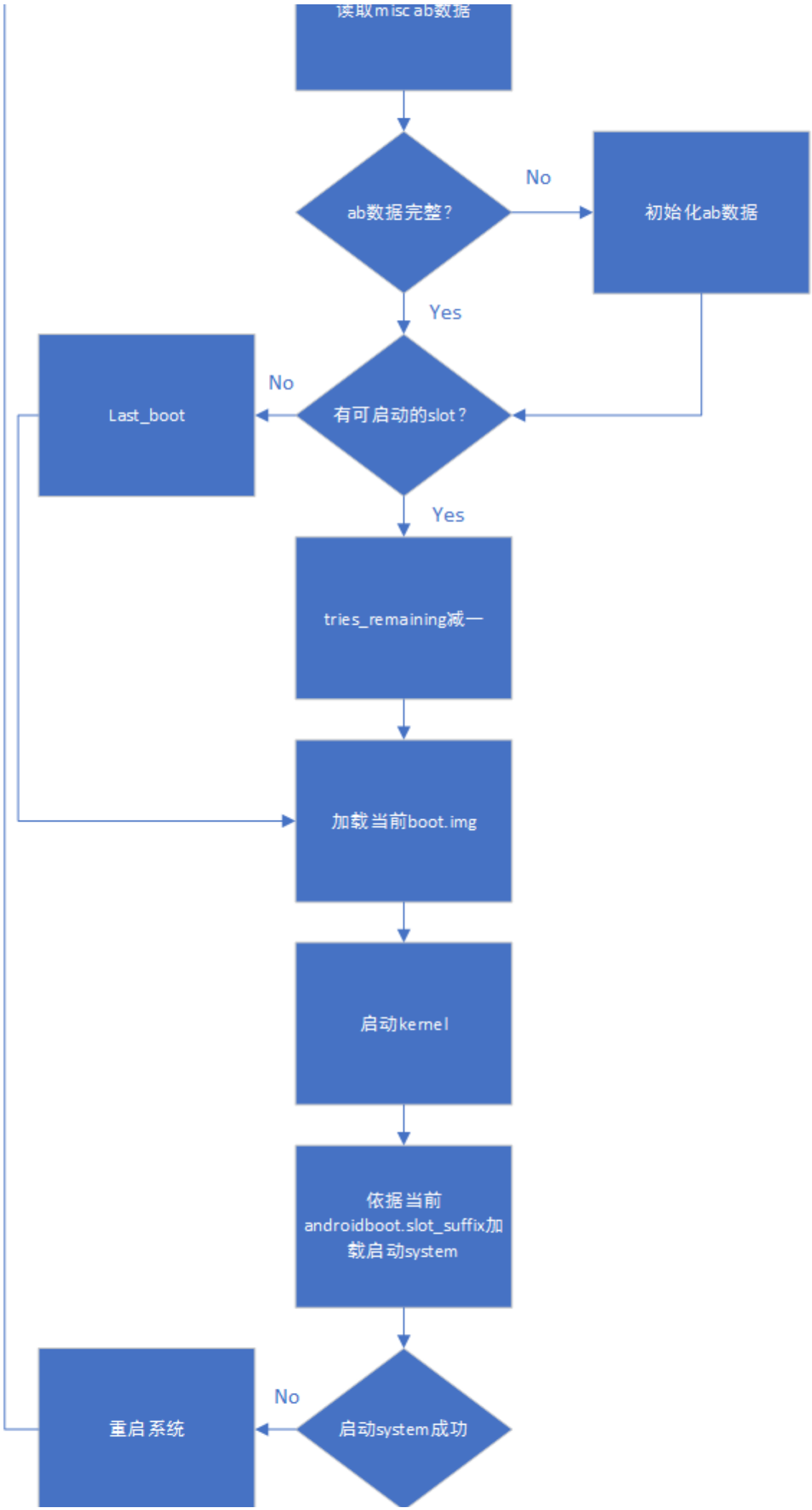
优点：始终保持 retry 机制，可以应对存储异常问题

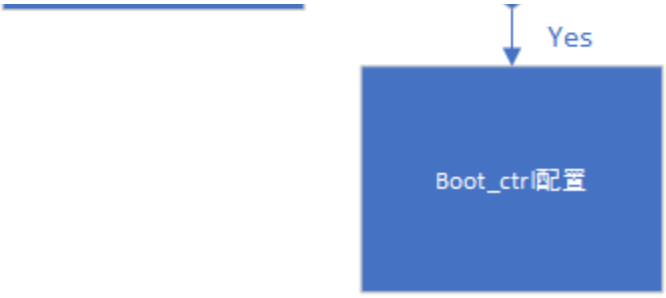
缺点：会回退到旧版本固件

6. 流程

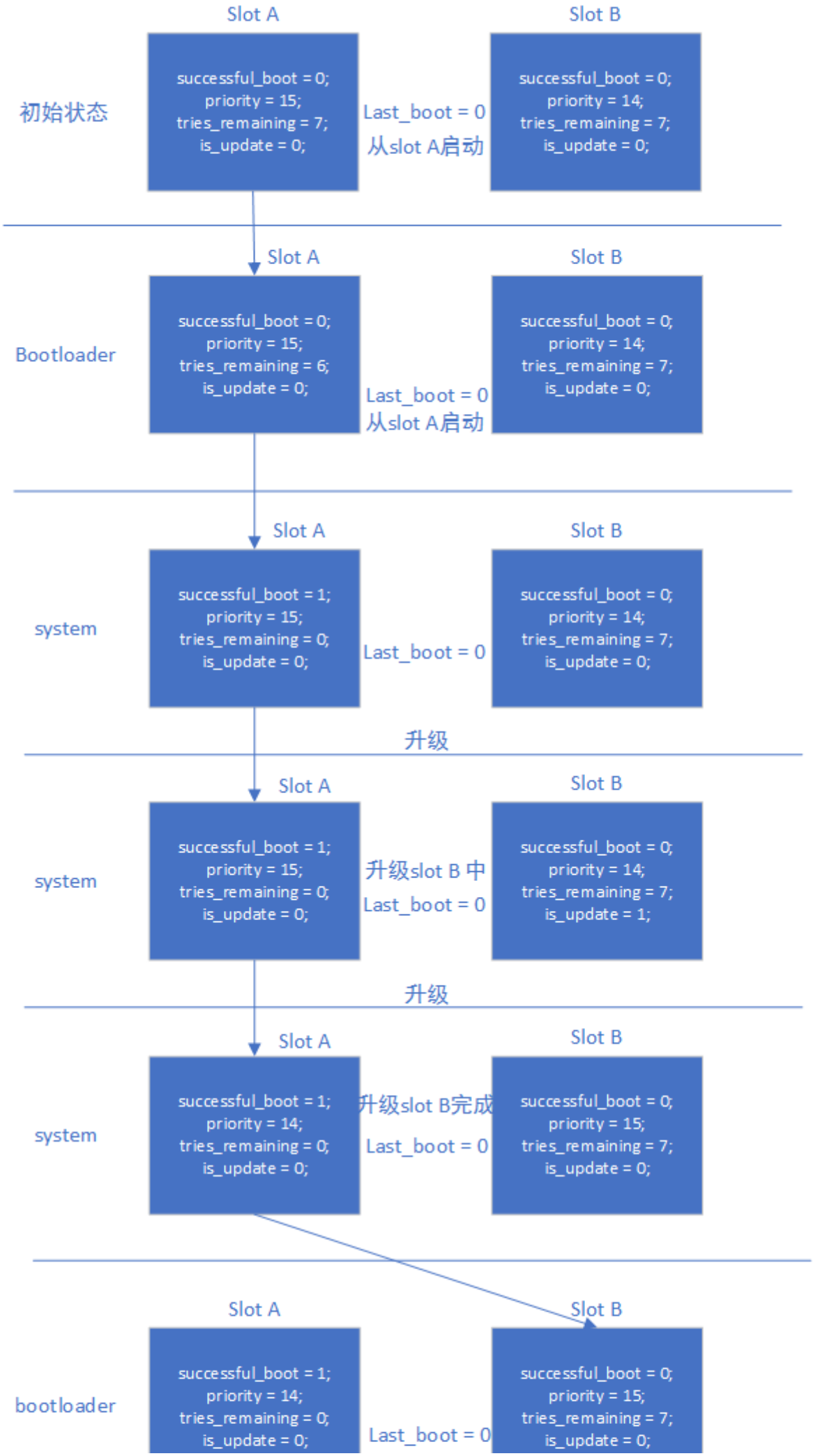
启动流程：

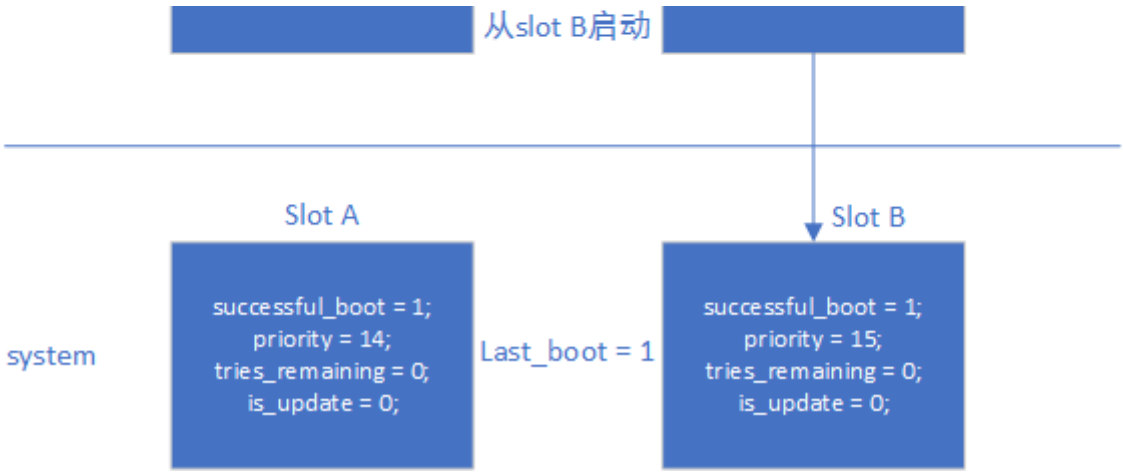

Maskrom
加载启动pre-loader
读取misc ab数据
ab数据完整？
No
初始化ab数据
Yes
有可启动的slot？
No
Last_boot
Yes
加载当前slot的uboot + trust
启动uboot


读取misc ab数据
ab数据完整?
No
初始化ab数据
Yes
有可启动的slot?
No
Last_boot
Yes
tries_remaining减一
加载当前boot.img
启动kernel
依据当前androidboot.slot_suffix加载启动system
启动system成功
No
重启系统

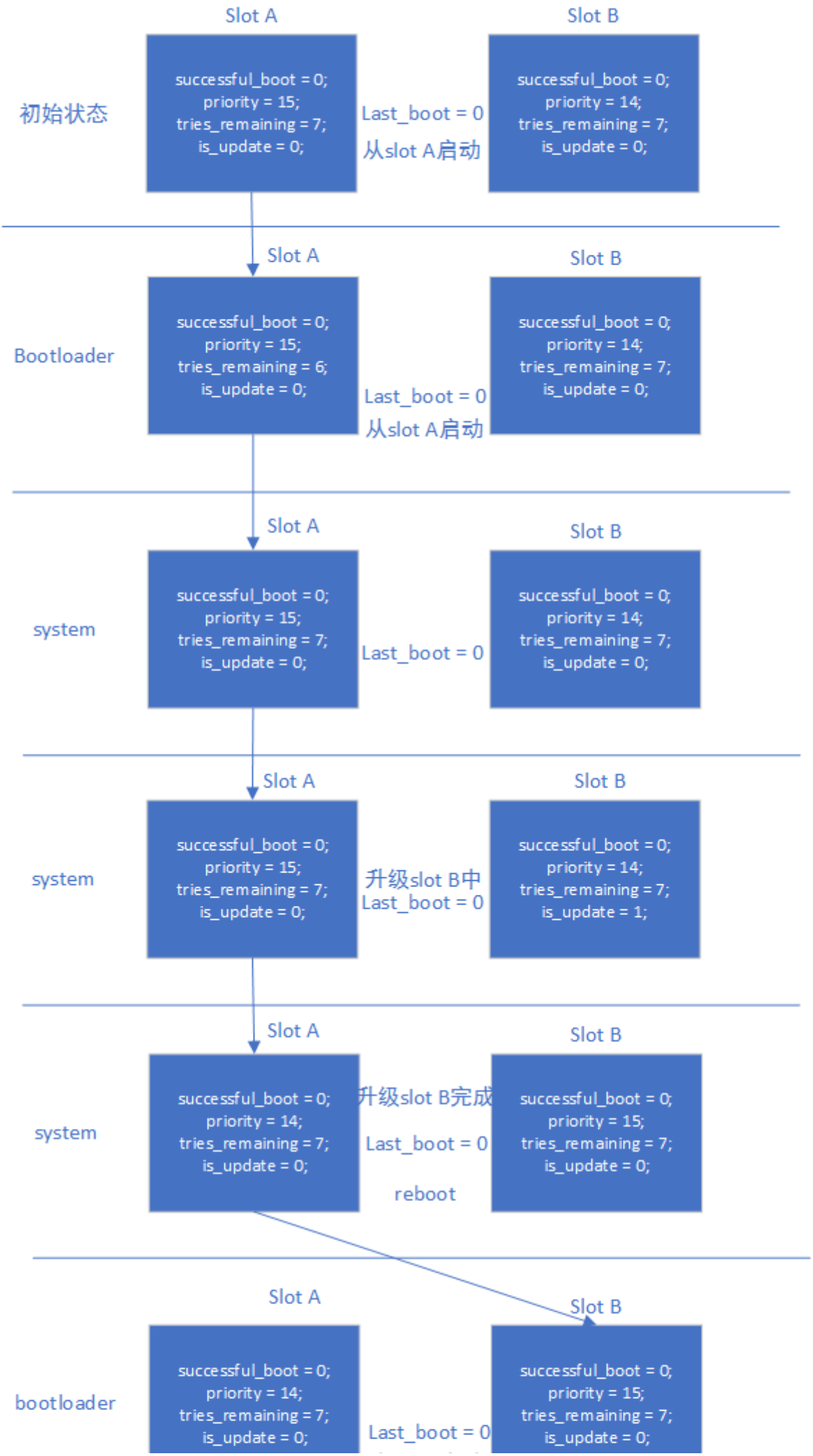


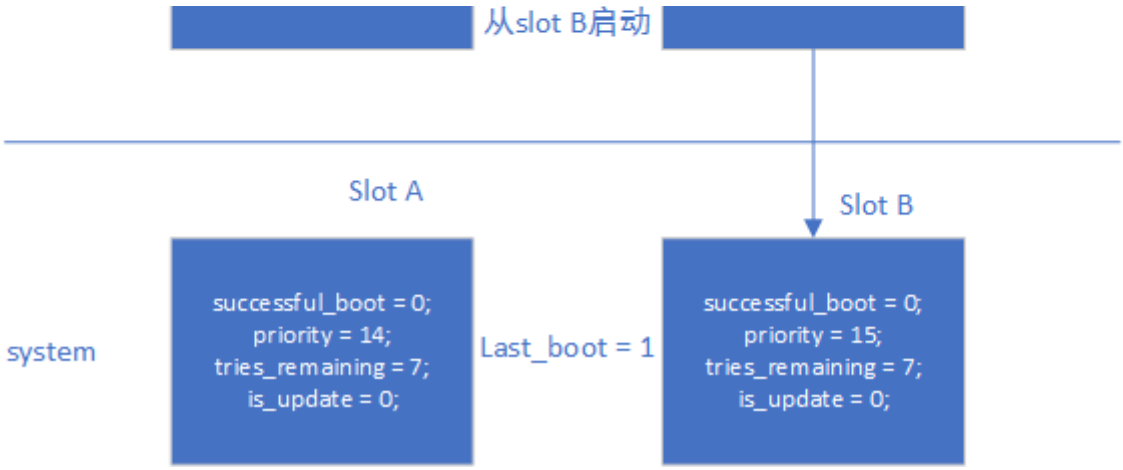
AB successful_boot 模式数据流程：


Slot A
Slot B
初始状态
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
Last_boot = 0
从slot A启动
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
Bootloader
successful_boot = 0;
priority = 15;
tries_remaining = 6;
is_update = 0;
Last_boot = 0
从slot A启动
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
system
successful_boot = 1;
priority = 15;
tries_remaining = 0;
is_update = 0;
Last_boot = 0
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
升级
Slot A
Slot B
system
successful_boot = 1;
priority = 15;
tries_remaining = 0;
is_update = 0;
升级slot B 中
Last_boot = 0
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 1;
升级
Slot A
Slot B
system
successful_boot = 1;
priority = 14;
tries_remaining = 0;
is_update = 0;
升级slot B完成
Last_boot = 0
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
bootloader
successful_boot = 1;
priority = 14;
tries_remaining = 0;
is_update = 0;
Last_boot = 0
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;



AB reset retry 模式数据流程:


Slot A
Slot B
初始状态
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
Last_boot = 0
从slot A启动
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
Bootloader
successful_boot = 0;
priority = 15;
tries_remaining = 6;
is_update = 0;
Last_boot = 0
从slot A启动
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
system
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
Last_boot = 0
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
system
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
升级slot B中
Last_boot = 0
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 1;
Slot A
Slot B
system
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
升级slot B完成
Last_boot = 0
reboot
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;
Slot A
Slot B
bootloader
successful_boot = 0;
priority = 14;
tries_remaining = 7;
is_update = 0;
Last_boot = 0
successful_boot = 0;
priority = 15;
tries_remaining = 7;
is_update = 0;



7. 升级及升级异常处理参考

7.1 从系统升级

参考《Rockchip Linux 升级方案开发指南》。

7.2 从 recovery 升级

AB system 不考虑支持 recovery 升级。

8. 分区参考

```
FIRMWARE_VER:8.1
MACHINE_MODEL:RK3326
MACHINE_ID:007
MANUFACTURER: RK3326
MAGIC: 0x5041524B
ATAG: 0x00200800
MACHINE: 3326
CHECK_MASK: 0x80
PWR_HLD: 0,0,A,0,1
TYPE: GPT
CMDLINE:
mtdparts=rk29xxnand:0x00002000@0x00004000(uboot_a),0x00002000@0x00006000(uboot_b)
,0x00002000@0x00008000(trust_a),0x00002000@0x0000a000(trust_b),0x00001000@0x0000c
000(misc),0x00001000@0x0000d000(vbmeta_a),0x00001000@0x0000e000(vbmeta_b),0x00020
000@0x0000e000(boot_a),0x00020000@0x0002e000(boot_b),0x00100000@0x0004e000(system
_a),0x00300000@0x0032e000(system_b),0x00100000@0x0062e000(vendor_a),0x00100000@0x
0072e000(vendor_b),0x00002000@0x0082e000(oem_a),0x00002000@0x00830000(oem_b),0x00
10000@0x00832000(factory),0x00008000@0x842000(factory_bootloader),0x00080000@0x00
8ca000(oem),-@0x0094a000(userdata)
```

9. 测试

准备一套可测试 AB 的固件。

9.1 测试successful_boot 模式

1. 只烧写 slot A，系统从 slot A 启动。设置从 slot B 启动，系统从 slot A 启动。测试完成，清空 misc 分区
2. 烧写 slot A 与 slot B，启动系统，当前系统为 slot A。设置系统从 slot B 启动，reboot 系统，当前系统为 slot B。测试完成，清空 misc 分区
3. 烧写 slot A 与 slot B，迅速 reset 系统 14 次后，retry counter 用完，还能从 last_boot 指定的系统启动，即能正常从 slot A 启动。测试完成，清空 misc 分区
4. 烧写 slot A 与 slot B，启动系统，当前系统为 slot A。设置系统从 slot B 启动，reboot 系统，当前系统为 slot B。设置系统从 slot A 启动，reboot 系统，当前系统为 slot A。测试完成，清空 misc 分区

9.2 测试reset retry 模式

1. 只烧写 slot A，系统从 slot A 启动。设置从 slot B 启动，系统从 slot A 启动。测试完成，清空 misc 分区
2. 烧写 slot A 与 slot B，启动系统，当前系统为 slot A。设置系统从 slot B 启动，reboot 系统，当前系统为 slot B。测试完成，清空 misc 分区
3. 烧写 slot A 与 slot B，迅速 reset 系统 14 次后，retry counter 用完，还能从 last_boot 指定的系统启动，即能正常从 slot A 启动。测试完成，清空 misc 分区
4. 烧写 slot A 与 slot B，其中 slot B 的 boot.img 损坏，启动系统，当前系统为 slot A。设置系统从 slot B 启动，reboot 系统，系统会重启 7 次后，从 slot A 正常启动系统。测试完成，清空 misc 分区
5. 烧写 slot A 与 slot B，启动系统，当前系统为 slot A。设置系统从 slot B 启动，reboot 系统，当前系统为 slot B。设置系统从 slot A 启动，reboot 系统，当前系统为 slot A。测试完成，清空 misc 分区