A Study of User Data Integrity During Acquisition of Android Devices

By

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Agenda

1. Introduction
2. Related Work
3. Background
4. Process of User Data Acquisition
5. Android Extractor
6. Experiment using Android Extractor
7. Demonstration
8. Conclusion

Introduction

- **Android**
- **Booting Mode**

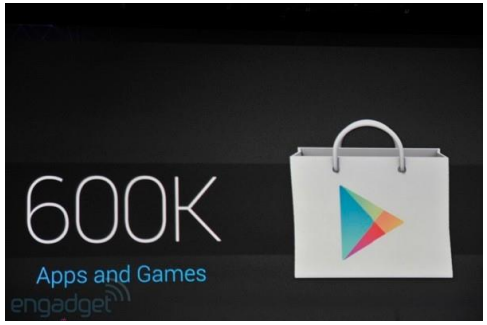
Android Forensics

- **Android OS Market Share (Q3, 2013)**

Top Six Smartphone Mobile Operating Systems, Shipments, and [illegible]inary)
(Units in Millions)

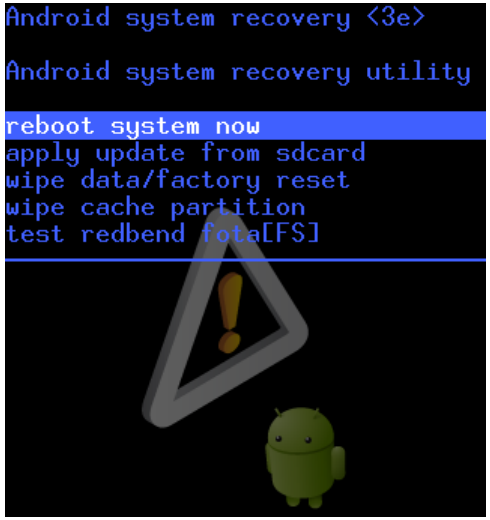
Operating System	3Q12 Shipment Volumes	3Q
Android	1	
iOS		
BlackBerry		
Symbian		
Windows Phone 7/ Windows Mobile		
Linux		
Others		
Totals		

- **600,000 Apps & inst**
  - 50 app installs per Android d



Booting Mode

Recovery Mode



- **A sort of standard booting mode**
  - Holding keys during boot process
    - Ex) volume key + power key + …
- **Feature**
  - wiping partitions, install an system application, etc…
  - Not mount userdata partition
- **We use recovery mode for acquisition user data**
  - DFRWS 2011 : “Toward a general collection methodology for Android devices”, Vidas

Related Work

- Logical Method of Data Acquisition
- Physical Method of Data Acquisition
- Commercial Tools

Logical Method of Data Acquisition

Content Provider

- **Data sharing interface for application level**
  - Supporting data between different applications
- **Android use a Sandbox mechanism for security**
  - An application can not approach another application data
    - Have to know application's URI for access application's data
    - Google make public android default application's URI
      - Call history, Contacts, SMS/MMS, etc..
- **Have to install an application contain the content provider**
  - For acquisition other application data
  - User data area could be altered

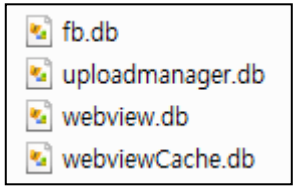
Logical Method of Data Acquisition

ADB (Android debug Bridge) protocol

- **File unit, partition**

```
# ls -l
ls -l
drwxr-xr-x app_0    app_0          2010-07-19 12:14 com.sec.mms
drwxr-xr-x app_1    app_1          2010-07-19 12:12 com.sec.android.app.appinstaller
drwxr-xr-x app_131  app_131        2011-01-02 16:00 com.sec.android.app.dlna
drwxr-xr-x app_2    app_2          2010-07-19 12:12 com.sec.android.app.drmua
drwxr-xr-x app_3    app_3          2010-07-19 12:12 com.svox.pico
drwxr-xr-x radio    radio          2010-07-19 12:12 com.android.stk
```

```
E:₩>adb pull /data/data/com.facebook.katana/databases .₩facebook_file
pull: building file list...
pull: /data/data/com.facebook.katana/databases/webviewCache.db -> .₩facebook_file/webviewCache.db
pull: /data/data/com.facebook.katana/databases/webview.db -> .₩facebook_file/webview.db
pull: /data/data/com.facebook.katana/databases/uploadmanager.db -> .₩facebook_file/uploadmanager.db
pull: /data/data/com.facebook.katana/databases/fb.db -> .₩facebook_file/fb.db
4 files pulled. 0 files skipped.
1375 KB/s (277504 bytes in 0.197s)
```



Logical Method of Data Acquisition

Rooting

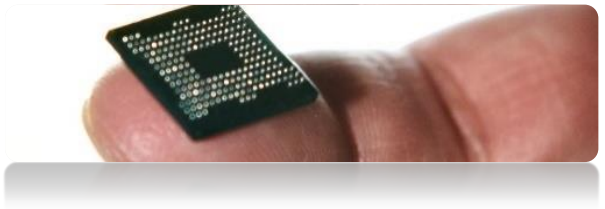
- **Temporary Rooting**
  - Using by exploit
    - psneuter, regeagainstthecase, zergRush, and so on…
- **Full Rooting**
  - Using by custom booting kernel image
- **Possible to get all data from android device**
  - Imaging partitions, copying files
    - Using ADB protocol and DD binaries

    ➔ Faster than JTAG

Physical Method of Data Acquisition

Chip-off

- **Directly separates flash memory**
  - From embedded device board



- **Possible to get damaged in process of separating Flash memory**
  - Smartphone, Flash memory

- **Necessary to data reconstruction (File System)**
  - Raw data → logical data
  - Ext file system

Physical Method of Data Acquisition

JTAG

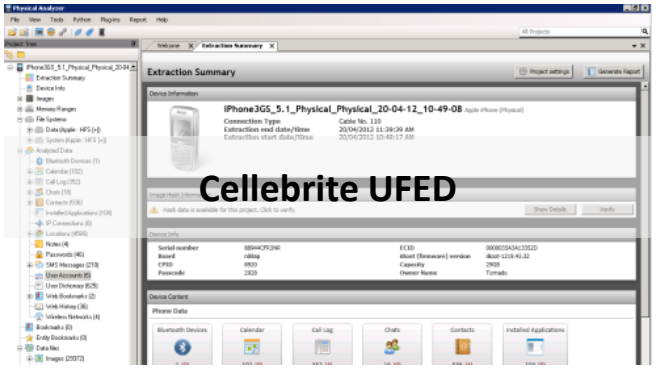
- **Via JTAG debug port**

- **Can acquisition all flash memory data**
  - 0x00 offset – 0xEnd offset

- **But..!**
  - Take so long time to extract data
    - 1GB / 1hour
  - Have to detect JTAG debug port
    - Some android smartphone don’t have a JTAG debug port

Commercial Tools

- **Cellebrite UFED**
  - Use an exploit for rooting
    - To data partition
    - So, data partition can be altered



- **XRY**
  - Data acquisition is possible only when device rooted

Background

- File System of Android Device
- Data Integrity

File System of Android Device

File System

- **YAFFS2 (Yet Another Flash File System2)**
  - Motorola smartphone
- **RFS (Robust File System)**
  - A few SAMSUNG smartphone
    - Galaxy S, Galaxy Tab
- **ExtX (Extended File System X) : Ext3/4**
  - After Gingerbread (Android 2.3) use Ext4
    - 83.2% of Android devices use Gingerbread or above as of Oct.2012

File System of Android Device

Feature of Ext3/4

- **Ext3/4 File System has a journaling function**
  - So, unallocated and journal areas are altered when a partition is mounted
    - Data structure for the ExtX Superblock

Byte Range	Description
12-15	Number of unallocated blocks
16-19	Number of unallocated inodes
24-27	Block Size
44-47	Last mount time
48-51	Last written time
52-53	Current mount count
88-89	Size of each inode structure
208-223	Journal ID
224-227	Journal inode

Data Integrity

Mount as read-only and Turn off the Android Device

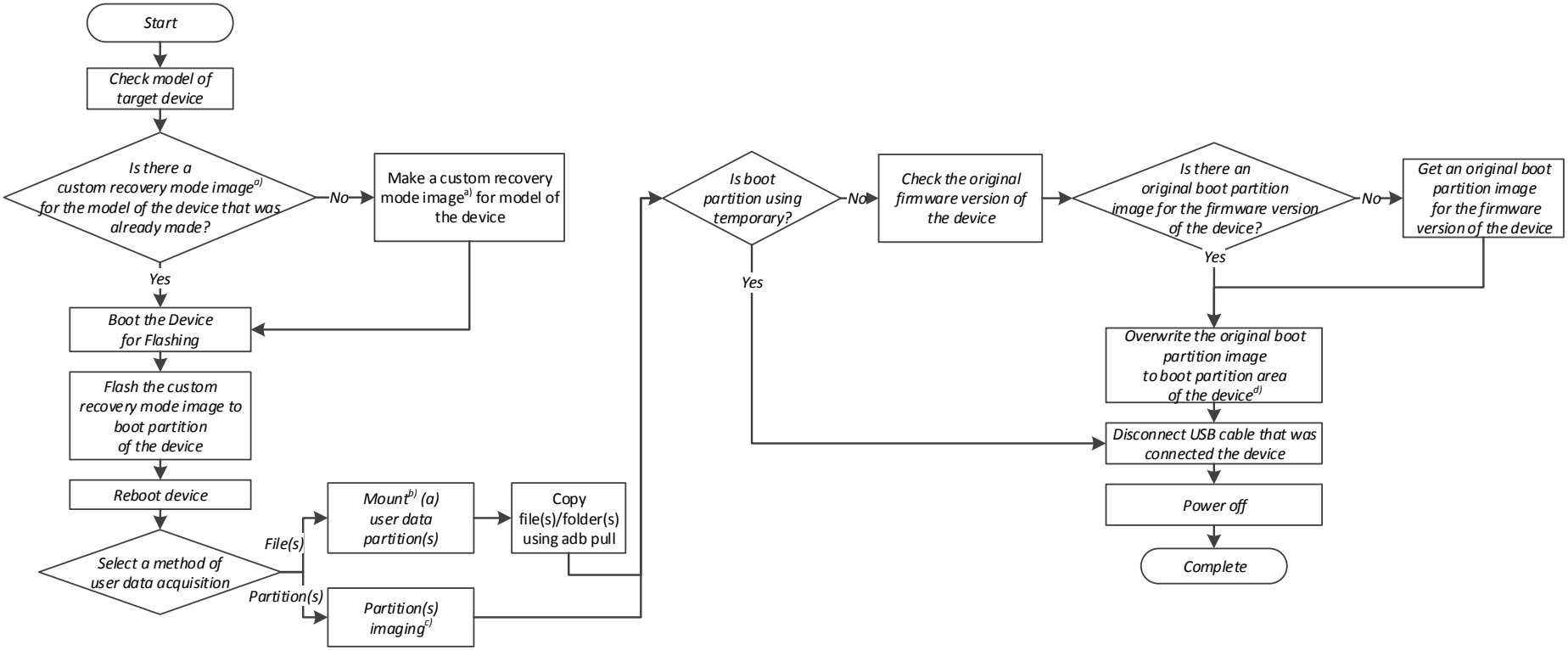
- **Data Integrity is most important for Digital Forensics**

- **Have to prevent alteration**
  - Partition mount as read-only
    - Unallocated area and metadata(superblock) are not altered
  - Turned off the Android device
    - Prevent partition mounting from booting process

Process of User Data Acquisition

- Prepare the Custom Recovery Mode Image (CRMI) (1/6)
- Boot the Device for Flashing (2/6)
- Flash the CRMI to Boot Partition of the Device (3/6)
- User Data Acquisition (4/6)
- Return to Former State (5/6)
- Restoring a Device to Its Original State (6/6)

Process of User Data Acquisition



a) It has to satisfy below conditions.
- Include a busybox binary, enable adb service, has root authority and mount rootf partition as read/write mode

b) The partition(s) has(have) to mount as read only mode.

c) Using adb & dd(cat) or buxybox nanddump(if destination partition is using yaffs2) & busybox netcat

d) Using adb push and dd(cat) or busybox nanddump (if destination partition is using yaffs2)

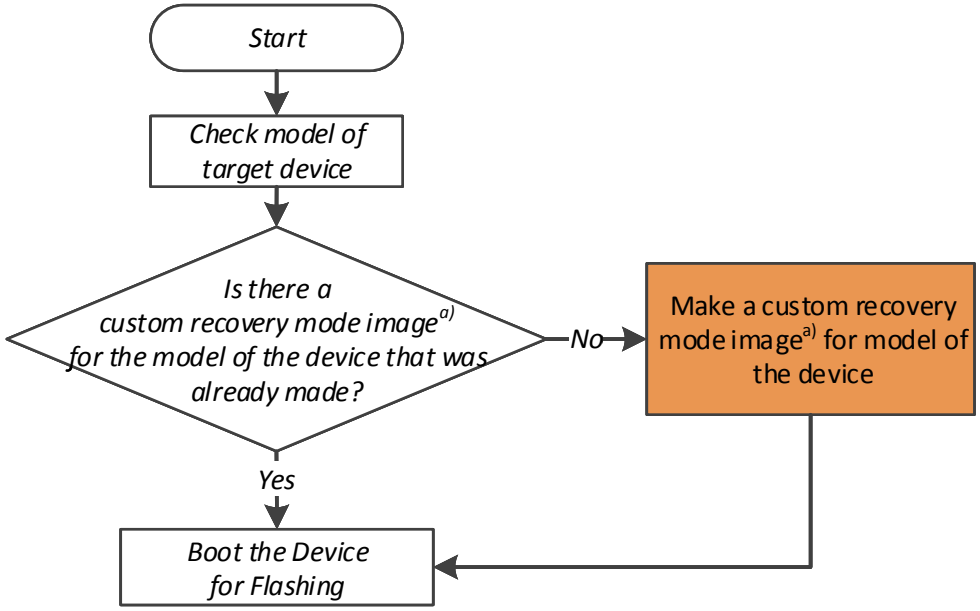
Prepare the Custom Recovery Mode Image (CRMI) (1/6)

1. **Checking the model name of the target device**

2. **Check whether or not the ready Custom Recovery Mode Image (CRMI) for the model**

   ➔ **move next step**

3. **Make a CRMI for model of the device**

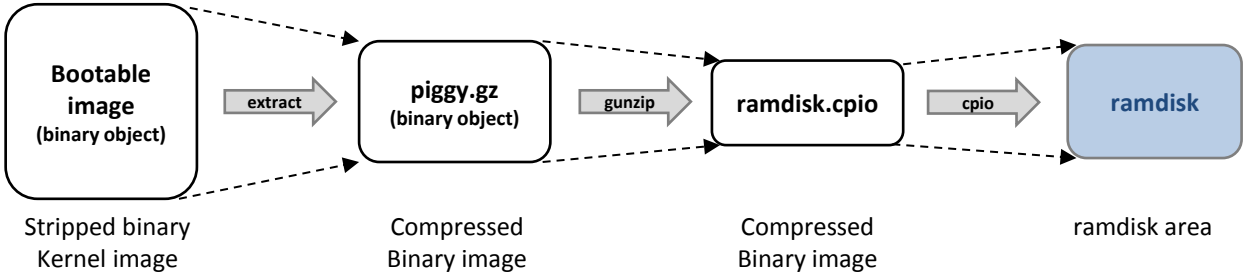


Prepare the Custom Recovery Mode Image (CRMI) (1/6)

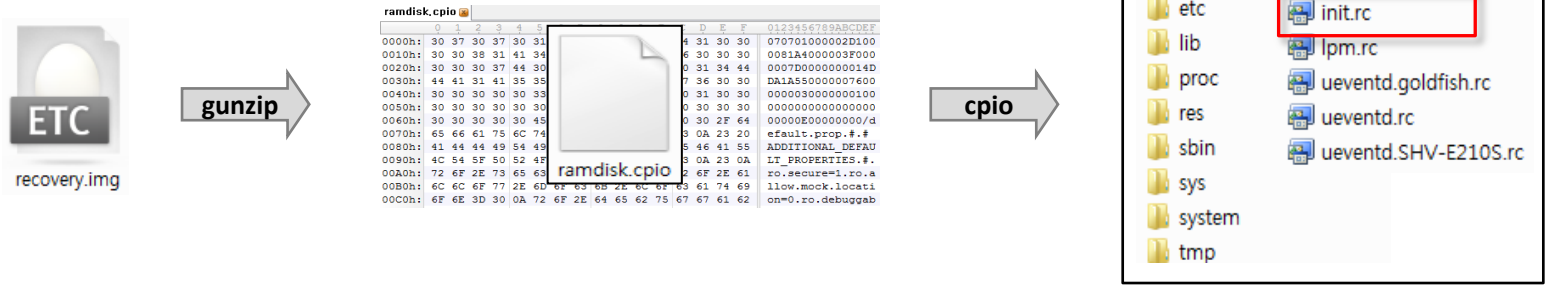
Make a CRMI for Data Integrity

- **Edit a recovery partition ramdisk (modify init.rc, default.prop, adbd file…)**
  - Enable root authority and ADB protocol
  - User data partition unmounts

[Structure of bootable Image of Android]



[Extract ramdisk area]



Prepare the Custom Recovery Mode Image (CRMI) (1/6)

Make a CRMI for Data Integrity

- **Edit a recovery partition ramdisk (modify init.rc, default.prop, adbd file…)**
  - Delete the not related files to booting (resource…)
    - CRMI size should equal the size of the boot partition
      - CRMI should be used for the boot partition
    - Moslty, the size of recovery and boot partition are the same
    - But, some of Android device's recovery partition is bigger than boot partition

Device	Size(Kb)	
	Boot Partition	**Recovery Partition**
Droid (A855)	3584	**4608**
Galaxy S2 (SHW-M250S)	8192	**8192**
Galaxy Nexus (SHW-M420K)	8192	**12224**
Galaxy Note (SHV-E160S)	10240	**10240**
Galaxy S3 (SHV-E210S)	8192	**8192**
Galaxy Note 2 (SHV-E250S)	8192	**8192**
Vega LTE (IM-A800S)	**10240**	**10240**

Boot the Device for Flashing (2/6)

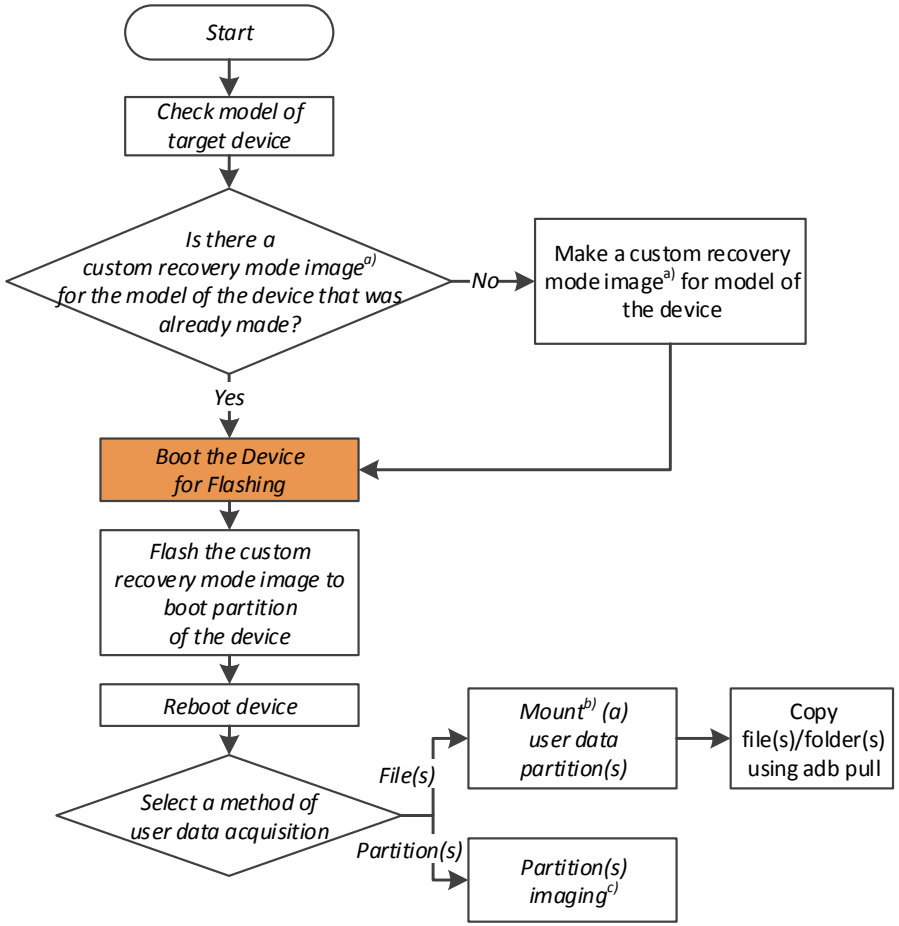
1. **Boot the device in flashing mode for flash the CRMI**

   - Use ADB protocol

     ex) adb reboot download

❖ **Method for entering flashing mode varies for each model**

ex) power key + volume down key + home key



Flash the CRMI to Boot Partition of the Device (3/6)

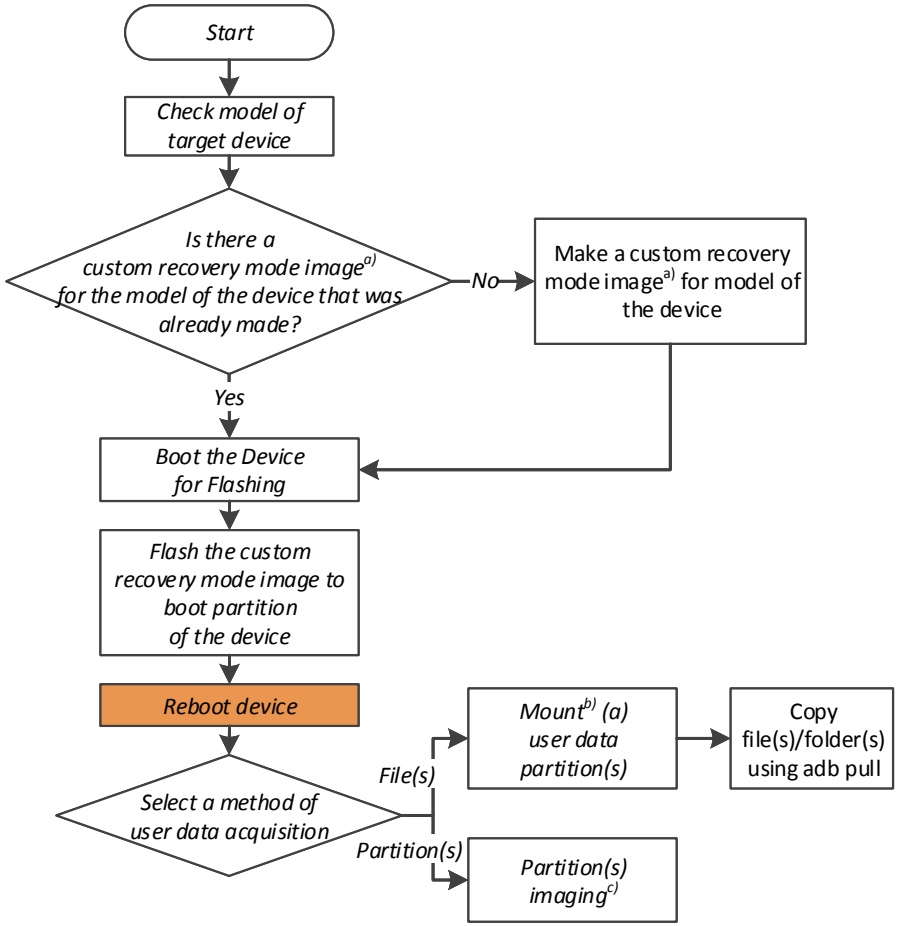
1. **Flash the CRMI to boot partition**

   ➔ Use Odin program

2. **Reboot device**

   ➔ Device is booted recovery mode using CRMI after flashing is finished

   ➔ Acquire root authority



User Data Acquisition (4/6)

1. **Select a method of user data acquisition**

   ➔ Partitions / Files

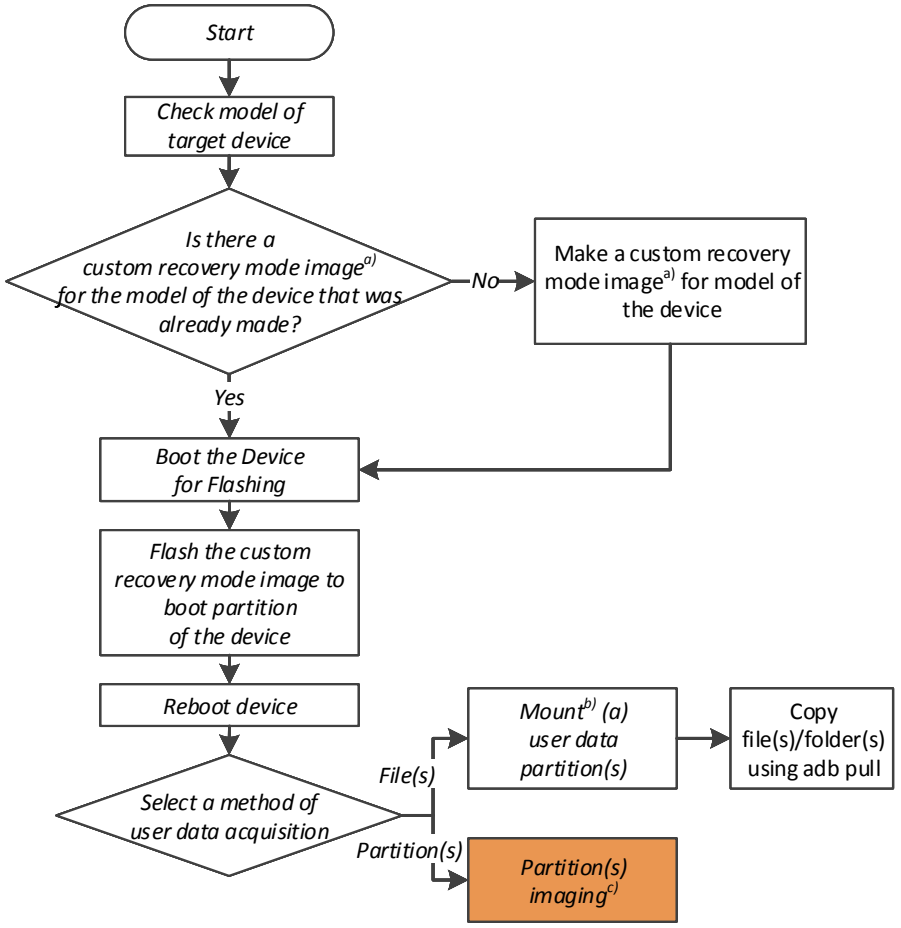
2. **If select a file acquisition**

   - Mount a user data partition (read-only)
   - Copy files in data partition using ADB protocol

     ex) adb pull /data/data/com.android/databases/xxx.db

3. **If select a partition acquisition**

   - Imaging data/SDcard partition
   - Use DD, NC binary



Return to Former State (5/6)

1. **Check the original firmware version of the device**

   ➔ /system/build.prop file

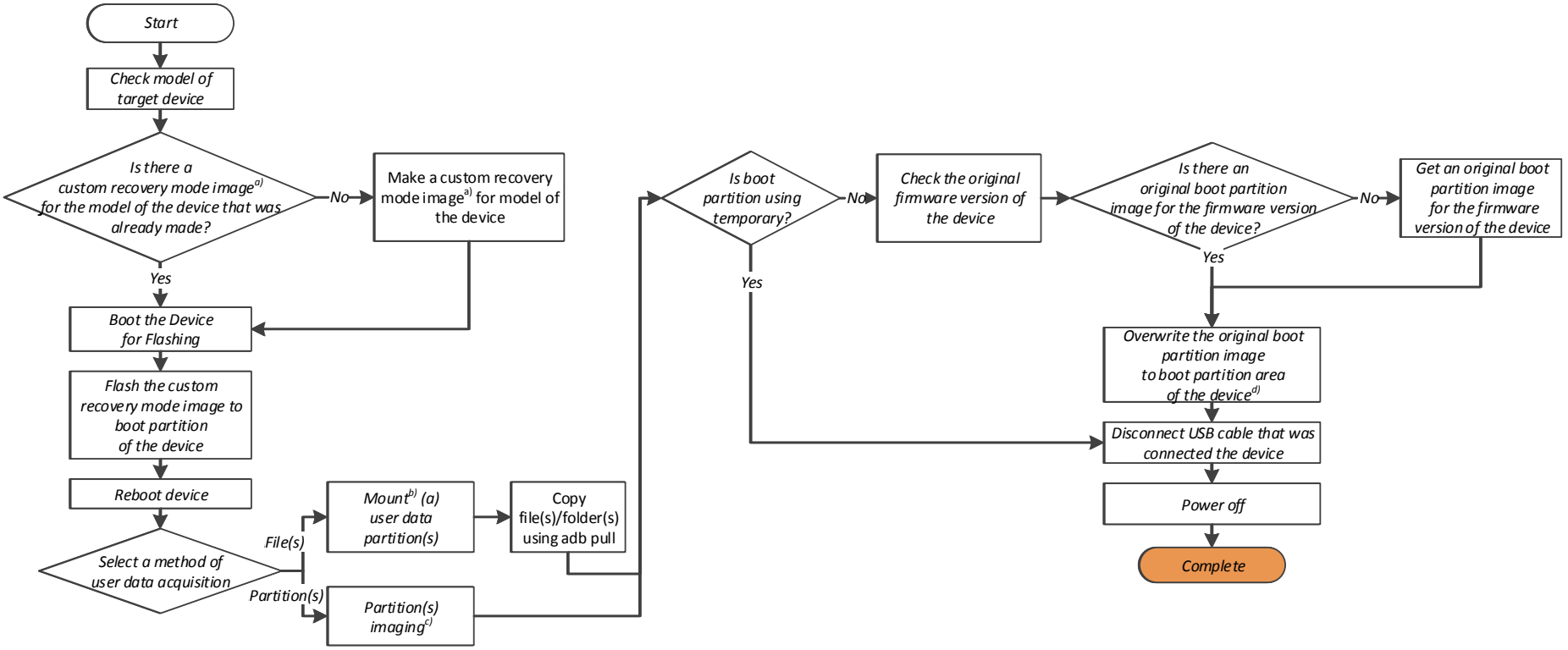
2. **Overwriting the original boot image to boot partition by using DD binary**

   ➔ copy the boot partition to the device by using ADB push

Device	Boot block name
Droid (A855)	/dev/block/mtdblock5
Galaxy S2 (SHW-M250S)	/dev/block/mmcblk0p5
Galaxy Nexus (SHW-M420K)	/dev/block/mmcblk0p7
Galaxy Note (SHV-E160S)	/dev/block/mmcblk0p8
Galaxy S3 (SHV-E210S)	/dev/block/mmcblk0p5
Galaxy Note 2 (SHV-E250S)	/dev/block/mmcblk0p8
Vega LTE (IM-A800S)	/dev/block/mmcblk0p8

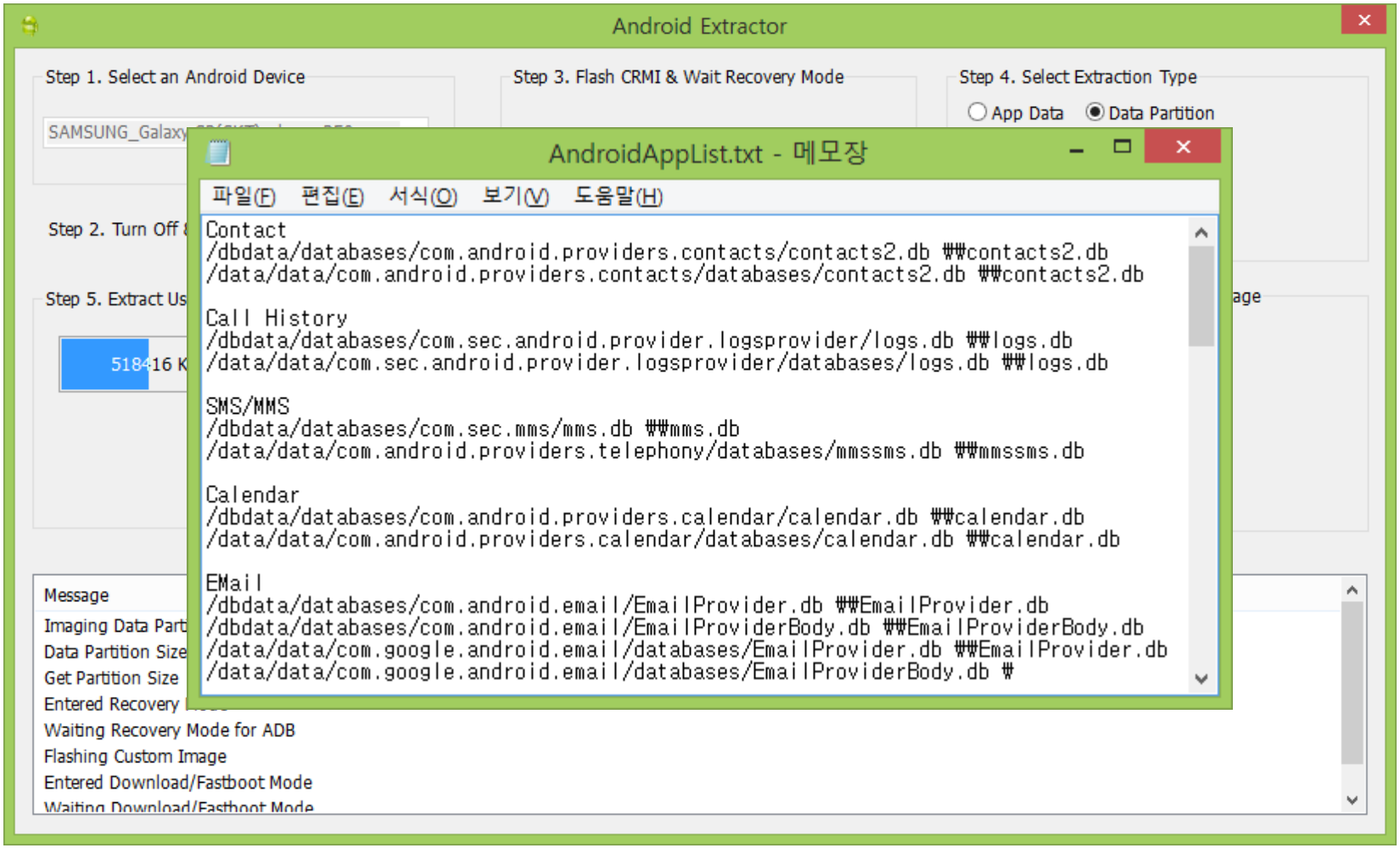
Restoring a Device to Its Original State (6/6)

1. **Disconnect the USB Cable**
2. **Battery remove in order to prevent data modification**
   - Sequence is very important (disconnect the USB cable → remove the battery)
   - Certain devices (ex: Galaxy S2) mount the data partition by only cable power



Android Extractor

Introduce an Android Extractor tool



Experiment using Android Extractor

- **Experiment Method**
- **Experiment Result**

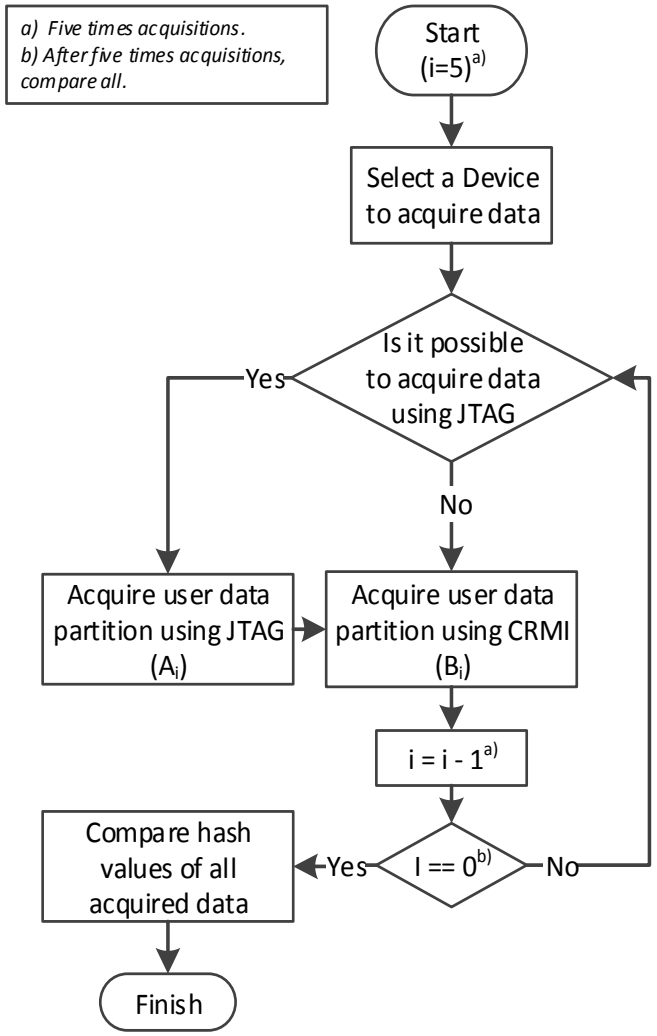
Experiment Method

Test user data integrity during the acquisition process

- **Select seven different Android devices for test**

Device	JTAG to CRMI	CRMI to CRMI
Droid (A855)		√
Vega LTE (IM-A800S)		√
Galaxy S2 (SHW-M250S)		√
Galaxy Nexus (SHW-M420K)		√
Galaxy S3 (SHV-E210S)		√
Galaxy Note (SHV-E160S)	√	
Galaxy Note 2 (SHV-E250S)	√	

- **Repeating the process multiple(5) times**



Experiment Result

- **Confirm the hash value are same in all observations**
  - JTAG to CRMI
  - CRMI to CRMI
- **Suggested data acquisition method preserves the integrity of the data**
  - JTAG also preserve integrity

Demonstration

Conclusion

Conclusion

- **This study explained a method of preserving integrity at the time of user data acquisition**
  - by using the previously studied Recovery Mode

- **Result of the experiment**
  - Method of user data acquisition using CRMI preserve integrity
    - JTAG also preserve integrity of user data
  - Faster than JTAG

Conclusion

- **In order to return to the former state after flashing the CRMI and acquiring data**
  - Need an original boot partition from the firmware version
  - If you do not have an original boot partition
    - Flashing the CRMI to recovery partition instead boot partition

- **There are several limitations, but..**
  - The CRMI method is more efficient
    - compared to other existing methods of forensically sound data acquisition from Android devices.

Q & A

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