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Security Analysis of Android Factory Resets

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Talk outline

- Background
- Methodology
- Results
- Practical recovery
- FR alternatives

Background

- Second-hand phone market growth
  - 57M, 2014 (Gartner)
  - 2/3 second life, 2015 (Gartner)
  - 150-250M traded by 2018
- Data recovery success reported
  - Avast, BBC news, etc

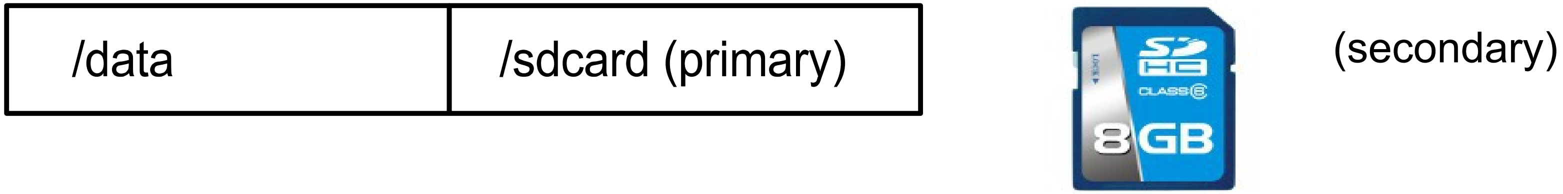
Secure Deletion

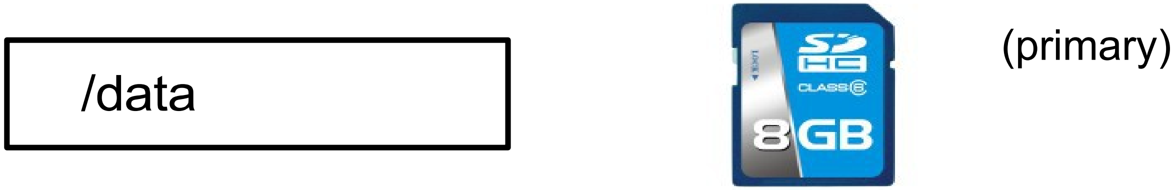
- *Logical Sanitisation*: data cannot be recovered via standard hardware interfaces like standard eMMC commands
- *Digital Sanitisation*: data cannot be recovered via any digital means, including the bypass or compromise of the device’s controller or firmware, or via undocumented drive commands
- This talk: *logical sanitisation*

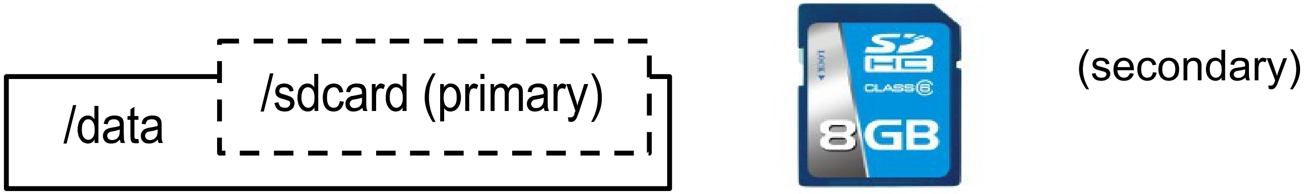
Data Storage Locations

- *Data partition* mounted on /data
  - Sensitive info, ext4 (eMMC), yaffs2 ("raw flash")
- *Internal (primary) "SD card"*: mounted on /sdcard
  - Music, pictures, FAT, emulated (FUSE)
- *External SD card*: removable
  - Same as internal one, FAT
  - Secondary SD card, or primary if no internal one

Data Storage Locations

- 
  /data
  /sdcard (primary)
  (secondary)

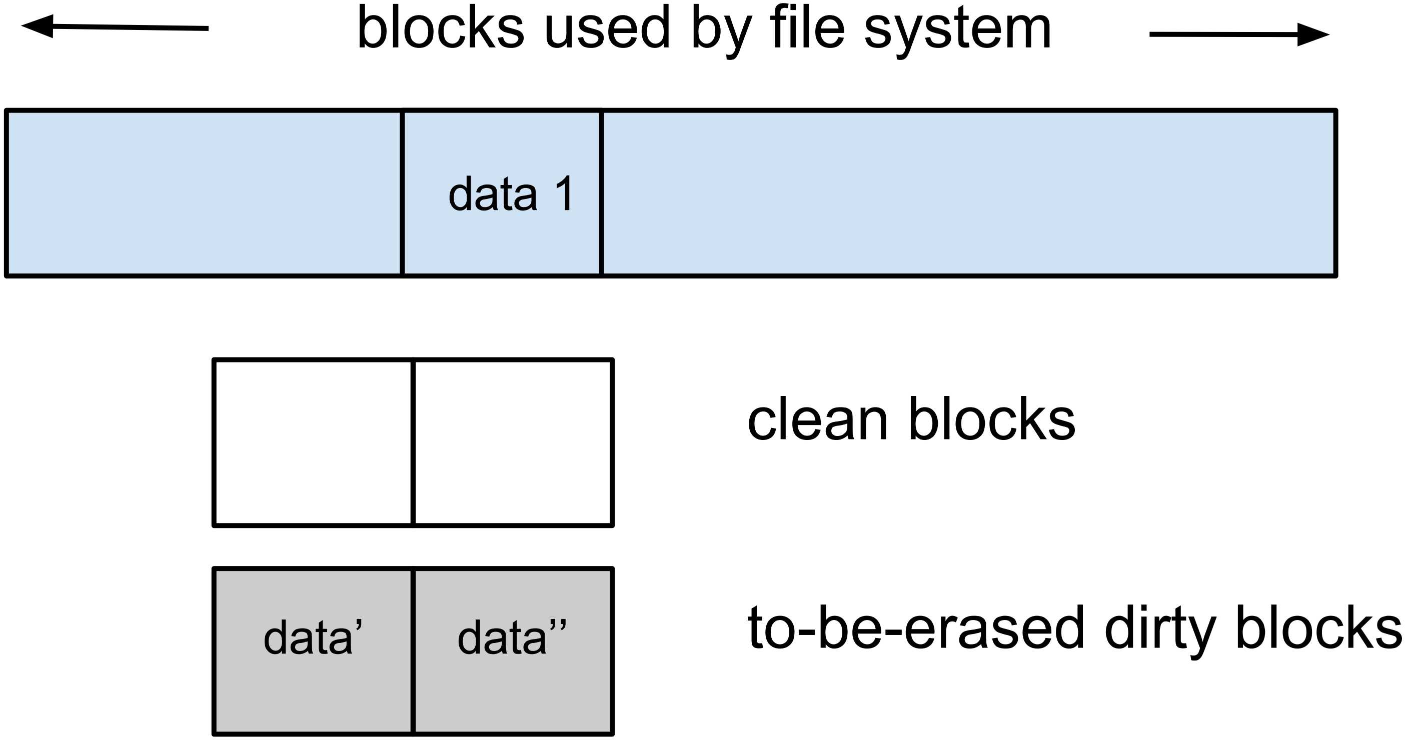
- 
  /data
  (primary)

- 
  /data
  /sdcard (primary)
  (secondary)

Flash Memory - Overview

- Unlike HDDs, Solid State Storage (SSD) supports a limited number of erase cycles (10000)

  => memory management, wear-leveling algo



blocks used by file system

data 1

clean blocks

data’

data’’

to-be-erased dirty blocks

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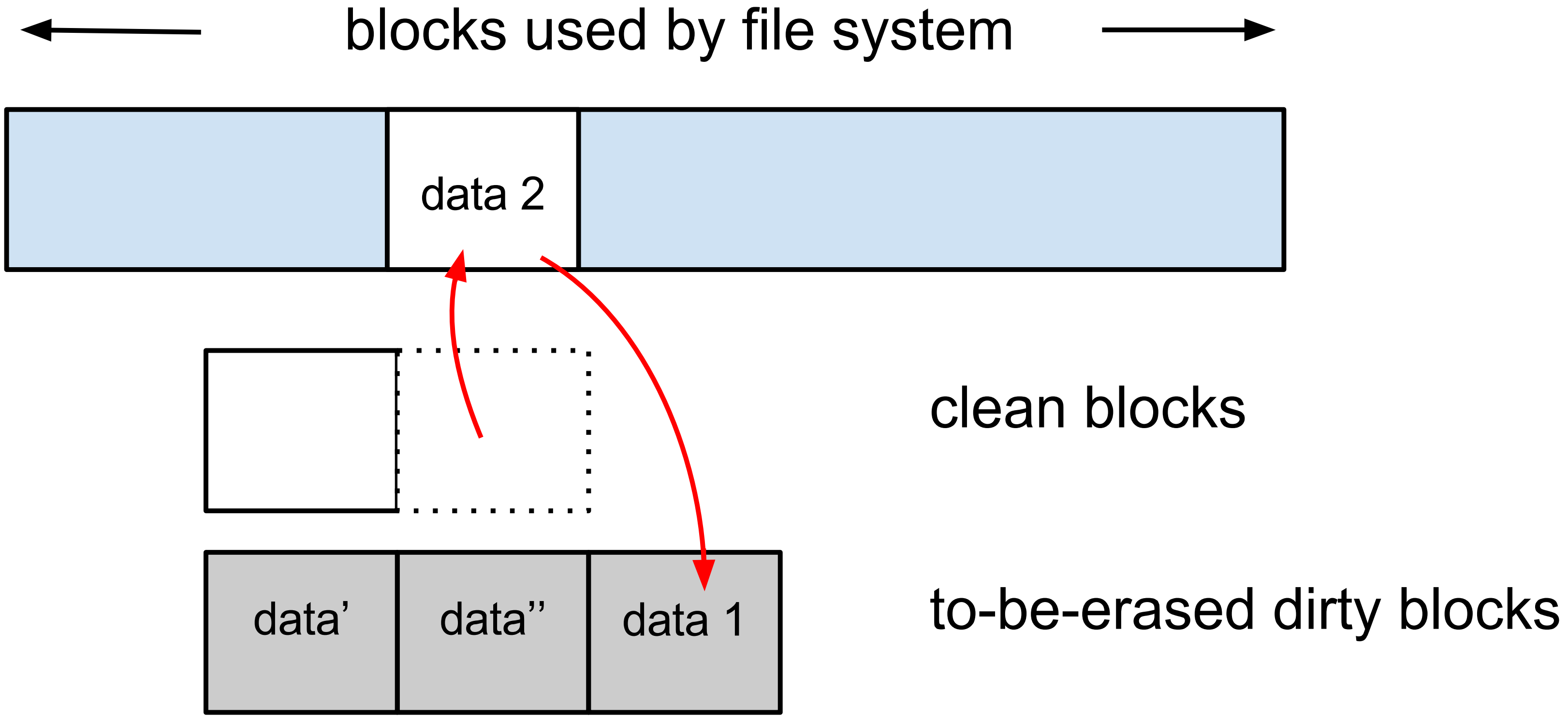
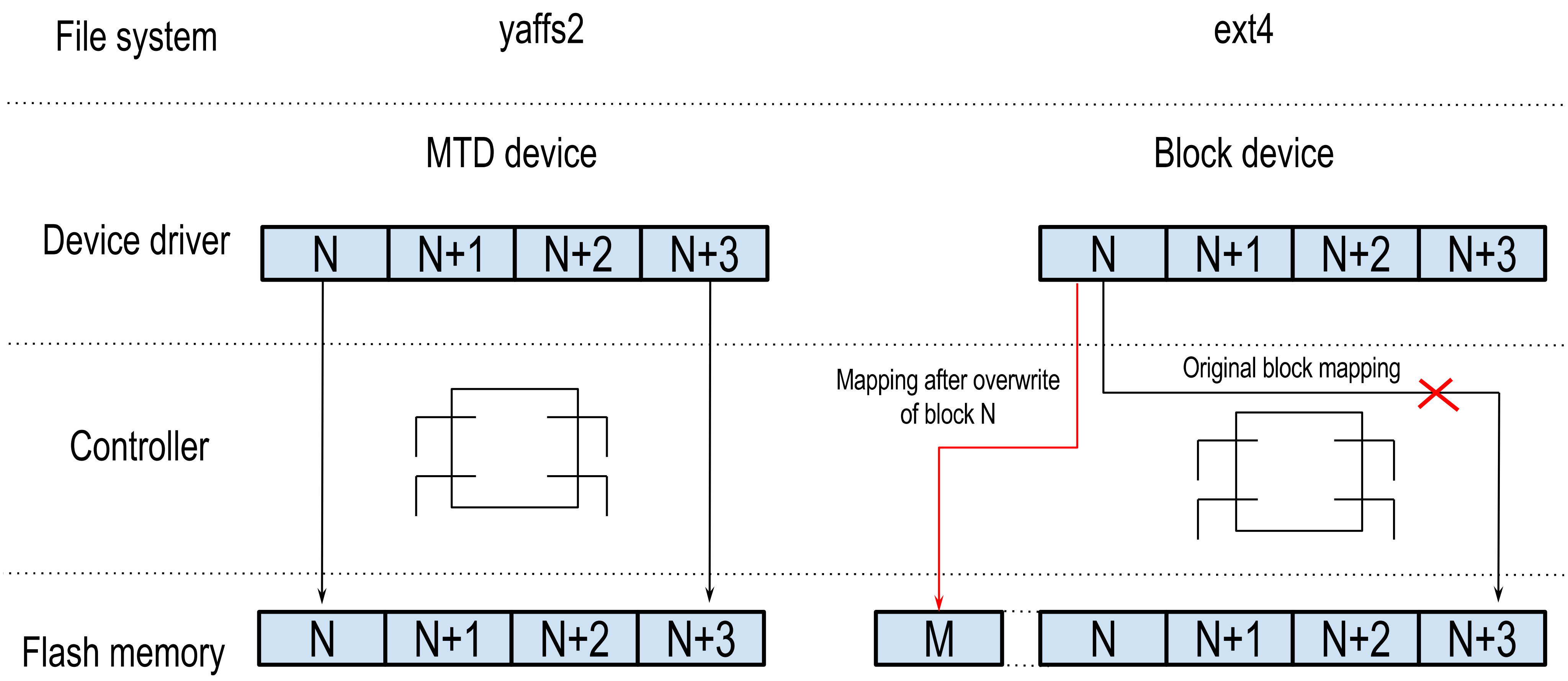


Flash Memory – File Systems

- Software: flash-aware file system yaffs2
- Hardware: eMMC (logical view for OS)



How to securely delete?

- Yaffs2:

  Exposed via ioctl(fd,MEMERASE,blk_num)

- eMMC: special commands to send to the chip

  Exposed via:

  - ioctl(fd, BLKDISCARD, blknum)
  - ioctl(fd, BLKSECDISCARD, blknum)

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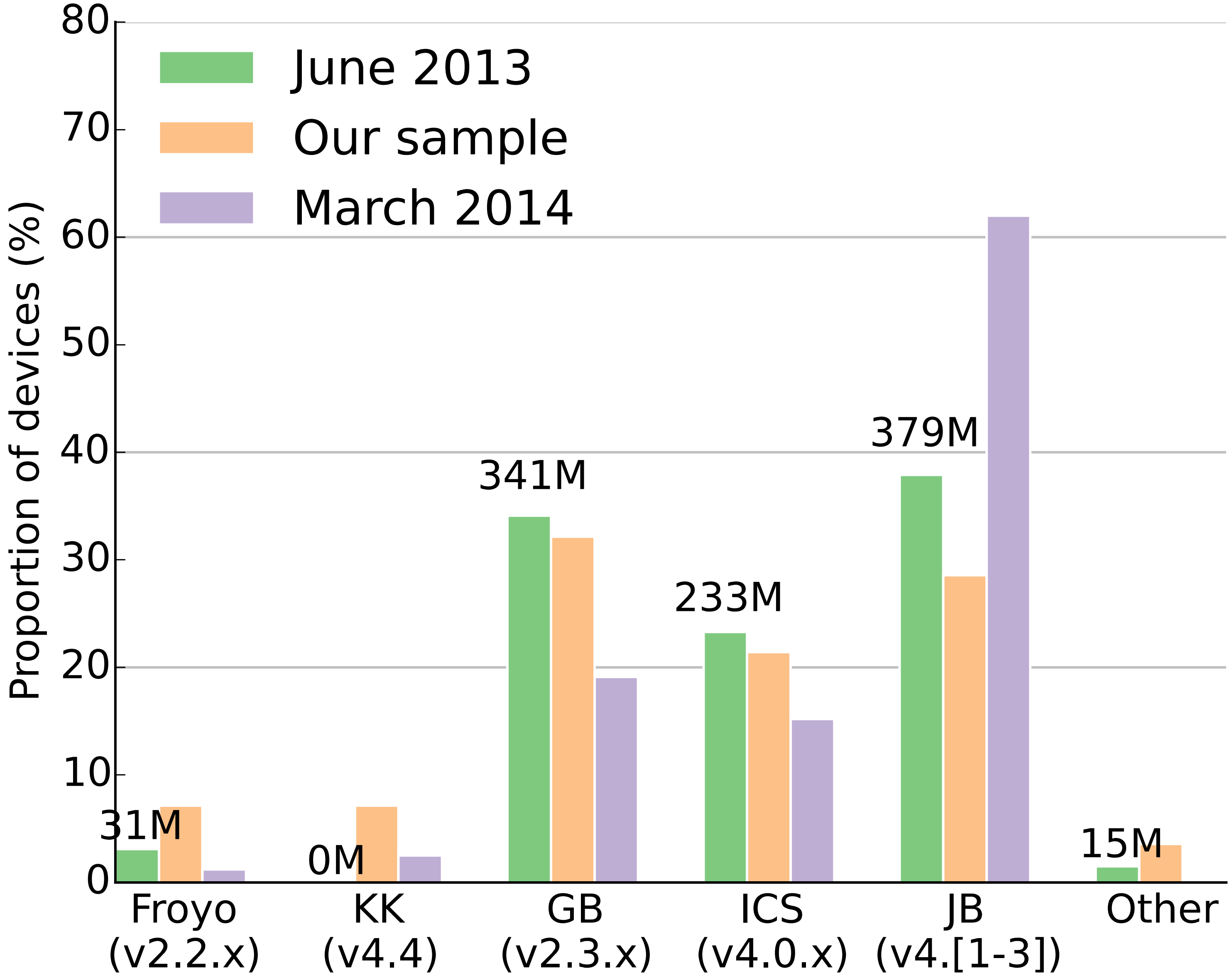
Phone Acquisition



Setup

- Overwrite "bit-by-bit" partitions (data, primary and secondary SD card) with identifying patterns
  - Bit-by-bit = lower level possible (dd-like)
  - Identifying patterns = unique ID
- Factory Reset
- Pattern recovery and identification

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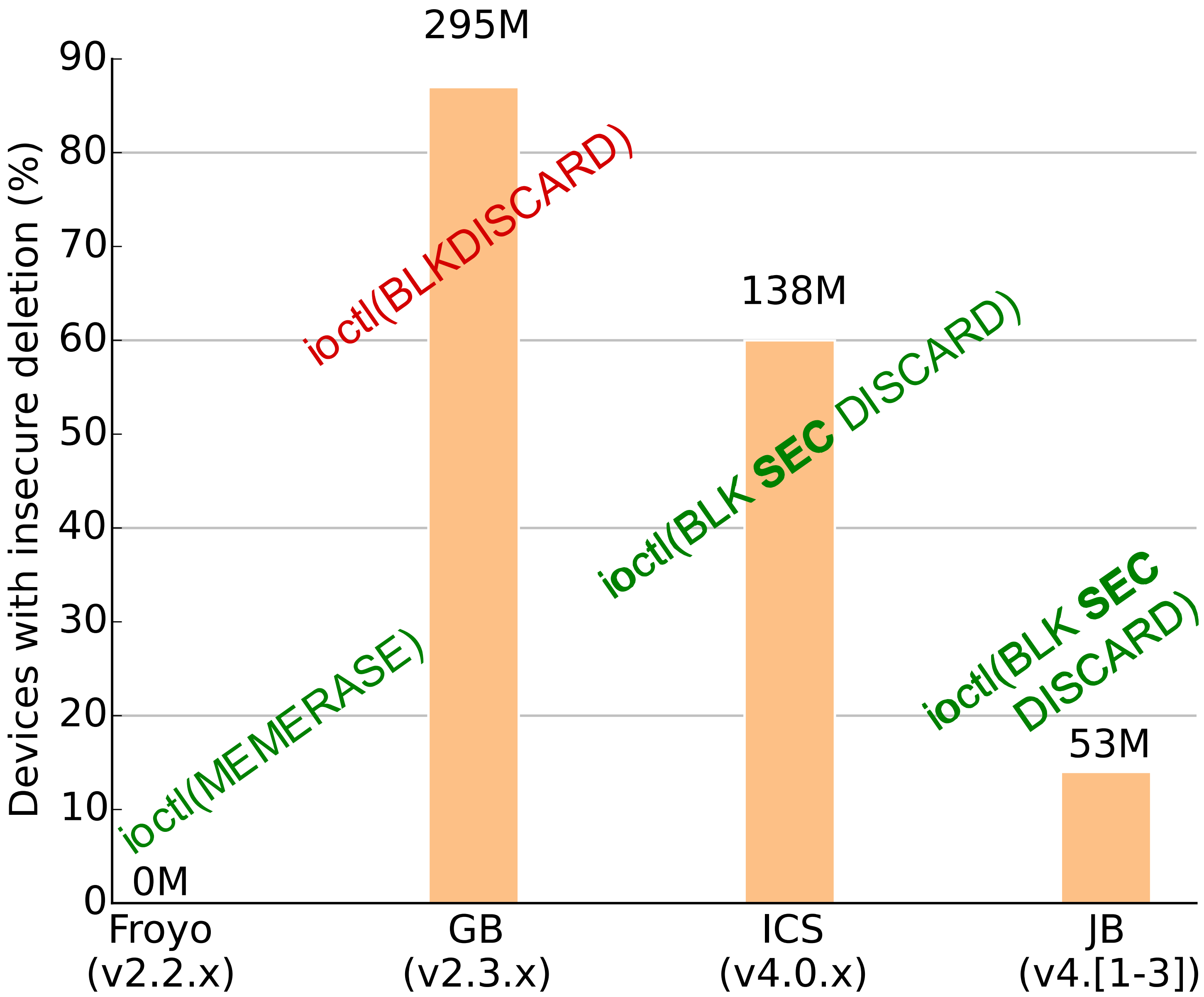
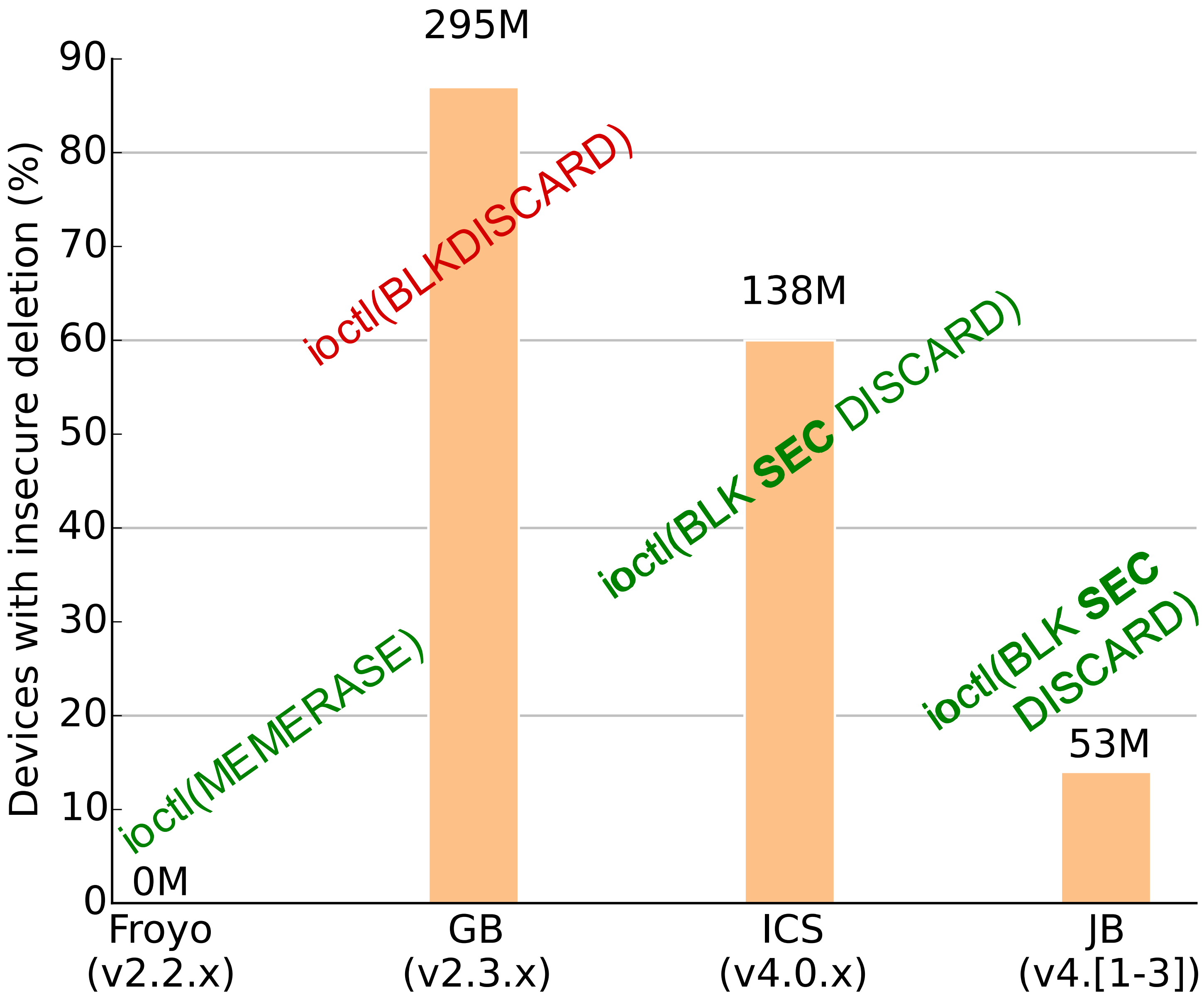
Results: Data partition



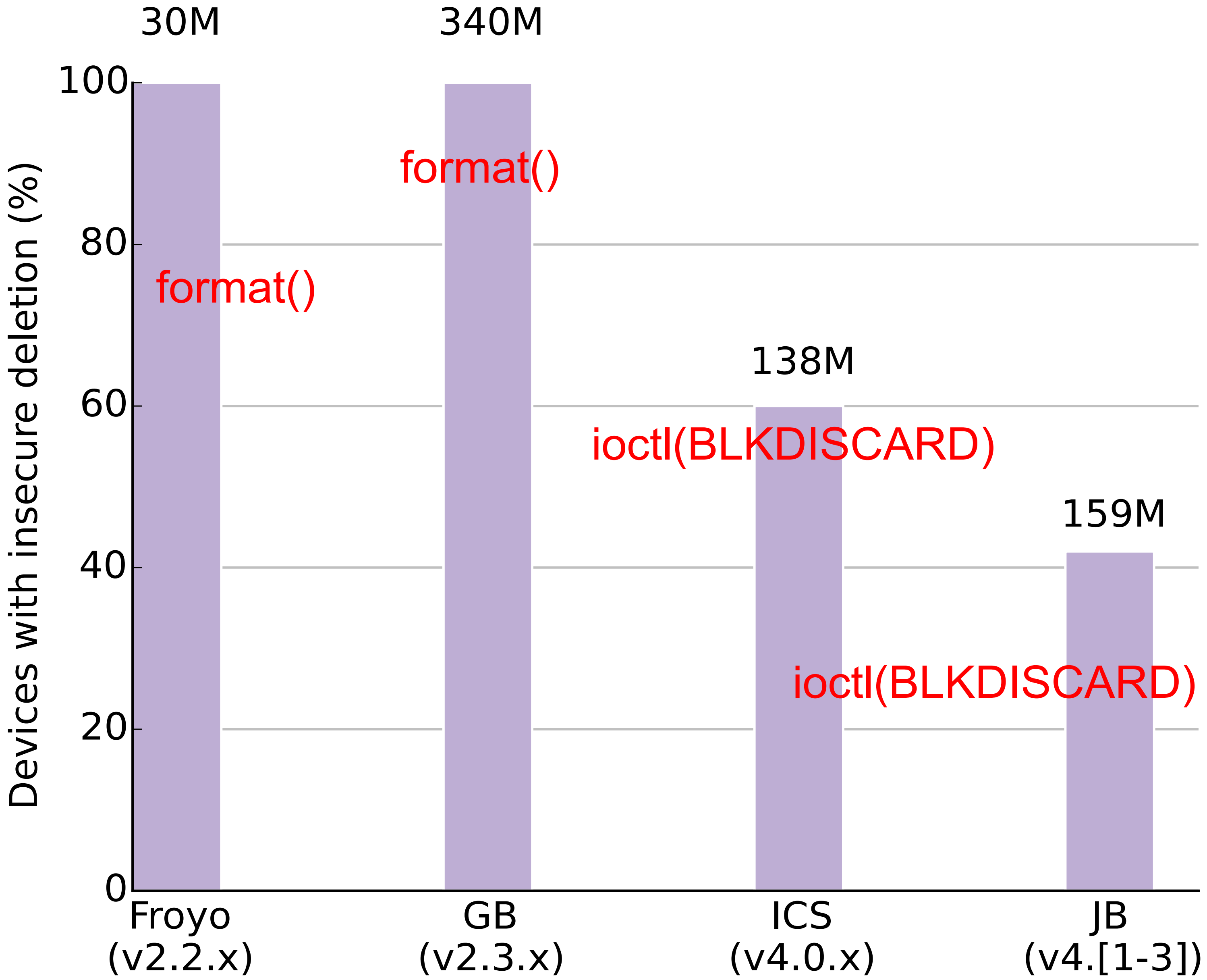
Results: Data partition (Cont'ed)

- Upgrade from GB (2.3.x) to ICS (4.0.x)
  - ioctl(BLKSECDISCARD) return errno 95 EOPNOTSUPP
- 2007 eMMC standard has compulsory support for logical sanitisation
- HTC Sensation XE correctly wipes data partition in Bootloader mode but not for Android Factory Reset

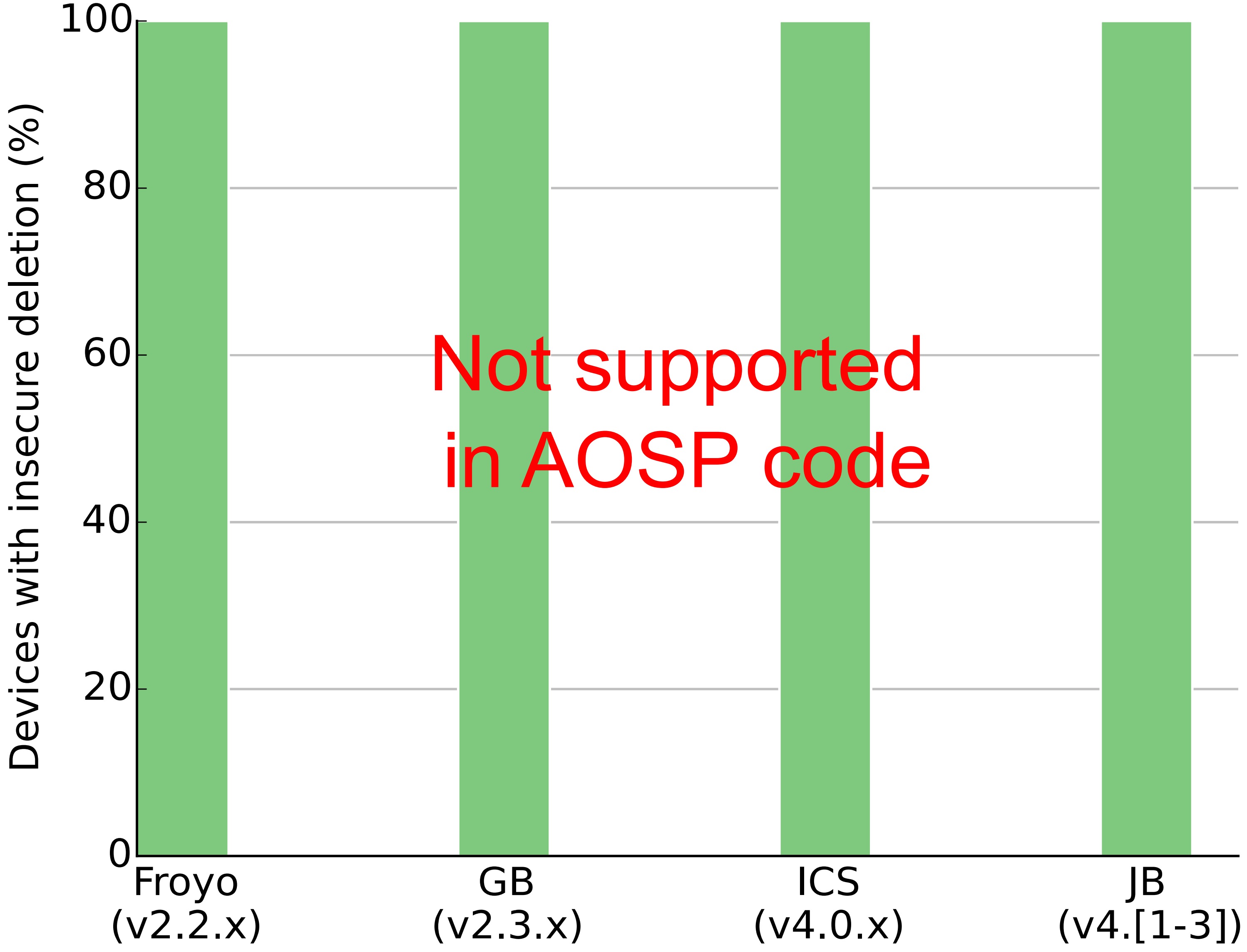
Results: Data partition



Results: Primary SD card



Results: Secondary SD card



Not supported in AOSP code

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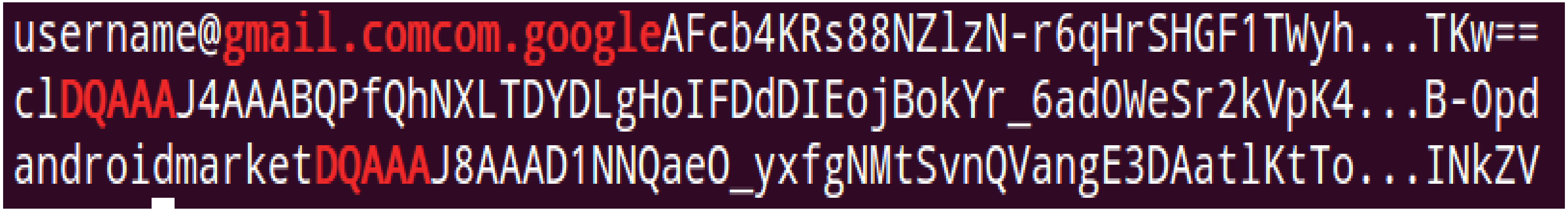
Practical Recovery

- Contact (Facebook, Phonebook, WhatsApp, etc)
- Conversation (emails, SMSs, Facebook & WhatsApp chats, etc)
- Browsing history
- Credentials (Facebook cookies, etc)
- Multimedia

Practical Recovery (Cont'ed)

- Android (master) auth token(s)
- Master token can be used to get other tokens from Google
- Tokens recovered 100% of the time, master one 80%



```
username@gmail.comcom.googleAFcb4KRs88NZlzN-r6qHrSHGF1TWyh...TKw==
clDQAAAJ4AAABQPfQhNXLTDYDLgHoIFDdDIEojBokYr_6ad0WeSr2kVpK4...B-0pd
androidmarketDQAAAJ8AAAD1NNQae0_yxfgNMtSvnQVangE3DAatlKtTo...INkZV
```

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Alternatives to built-in FR

- Overwrite bit-by-bit: one pass enough to provide logical sanitisation
- Filling unallocated space (create files) to overwrite: discarded because:
  - Extra level of indirection
  - File systems vary (ext4, FAT, FUSE, Samsung's proprietary RFS)

Alternatives to built-in FR (Cont'ed)

- Full Disk Encryption (FDE), >= ICS only (v4.0.x)

  => not possible on GB (2.3.x) vulnerable devices

- Ony support for data partition
- Encryption key stored encrypted using user's PIN in so called "crypto footer"
  - Cryptp footer not sanitised with flawed FR
  - Crypto footer allows PIN brute-force
- Android lollipop (5.x): default encryption has hardcoded password "default_password"

Conclusion

- Android FR in messy state
- Android code, vendors' customisations and lack of proper testing
- Mostly available on the second-hand market NOW
- Paper provides engineering design suggestions to reduce this problem in future handsets. Have a look!

Thanks!

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