



# Things You May Not Know About Android (Un)Packers: A Systematic Study based on Whole-System Emulation

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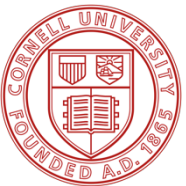


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# Motivation

- **What is Android packing?**
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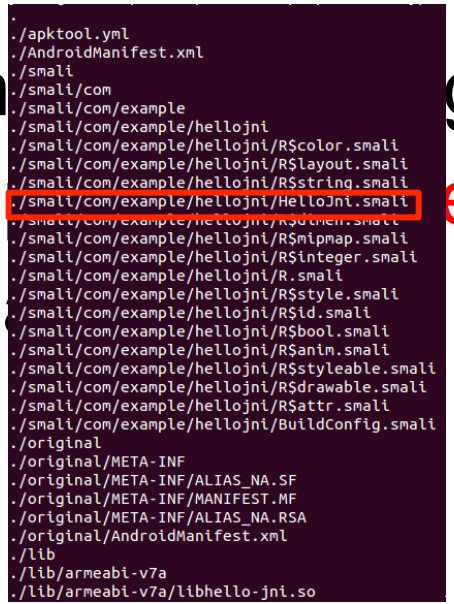
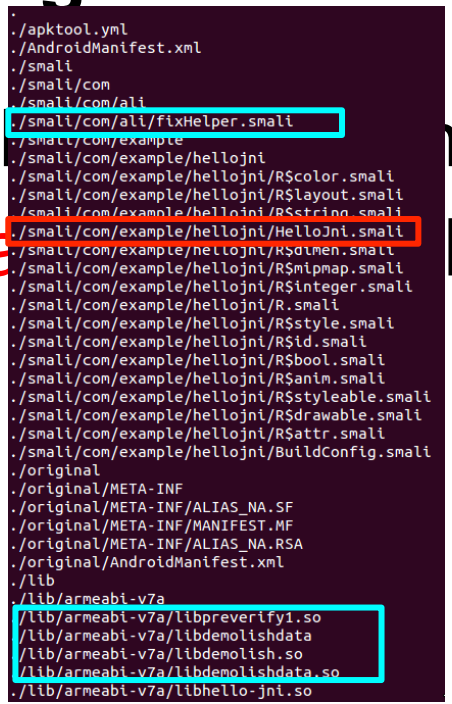


# Motivation

- **Why important to security community?**
- Packing techniques can indeed help malware sneak into Google Play[1][2].

Report from Checkpoint[2]

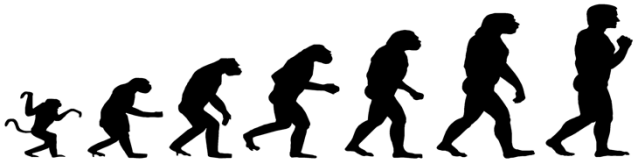
Most malware found on Google Play contains only a dropper that later downloads the real malicious components to the device. Charger, however, uses a heavy packing approach which it harder for the malware to stay hidden, so it must compensate with other means. The developers of Charger gave it everything they had to boost its evasion capabilities and so it could stay hidden on Google Play for as long as possible.

# Motivation

- We performed the first large-scale measurement study to better understand Android packing.
  - ***7*** popular commercial packers including Ali, apkprotect, baidu, Bangcle, ijiami, Qihoo and Tencent
  - ***5*** recent malicious apps
  - ***93,910*** Android malware from VirusTotal
  - ***5*** representative apps, consider them as ground truth and perform diff analysis
  - ***3*** state-of-the-art Android unpackers

# What do we want to study?

- Question set 1: High Level Landscape
- Question set 2: Detailed Behavioral Analysis
- Question set 3: Evolution of Android packing
- Question set 4: Existing defeating techniques

# Challenges

- ***NO*** existing tool can be directly leveraged to conduct this study.
- We need a tool that could provide
  - reliable and generic unpacking unknown packers
  - correctly handle native, Java as well as JNI
  - be able to understand behaviors

# Challenges

- Based on our study, state-of-the-art Android unpackers have fundamental design limitations.
  - Signature-based: Kisskiss[9]
  - Hooking-based: DexHunter[7]
  - Dalvik data structure dumping: AppSpear[8]
- Limitations
  - signatures are not reliable
  - cannot handle multi-layer unpacking
  - cannot support ART

# DroidUnpack System

- Key idea
  - Generic unpacking based on memory operation monitoring
  - Reconstruct Java level execution
  - VM based approach

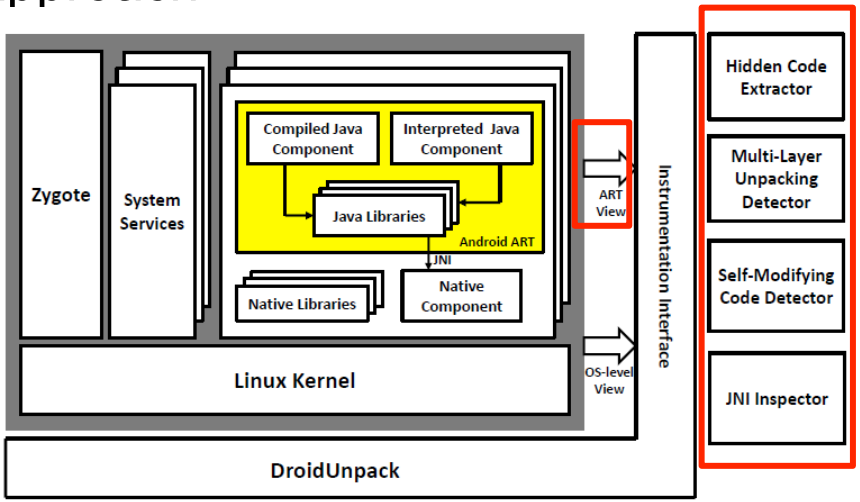


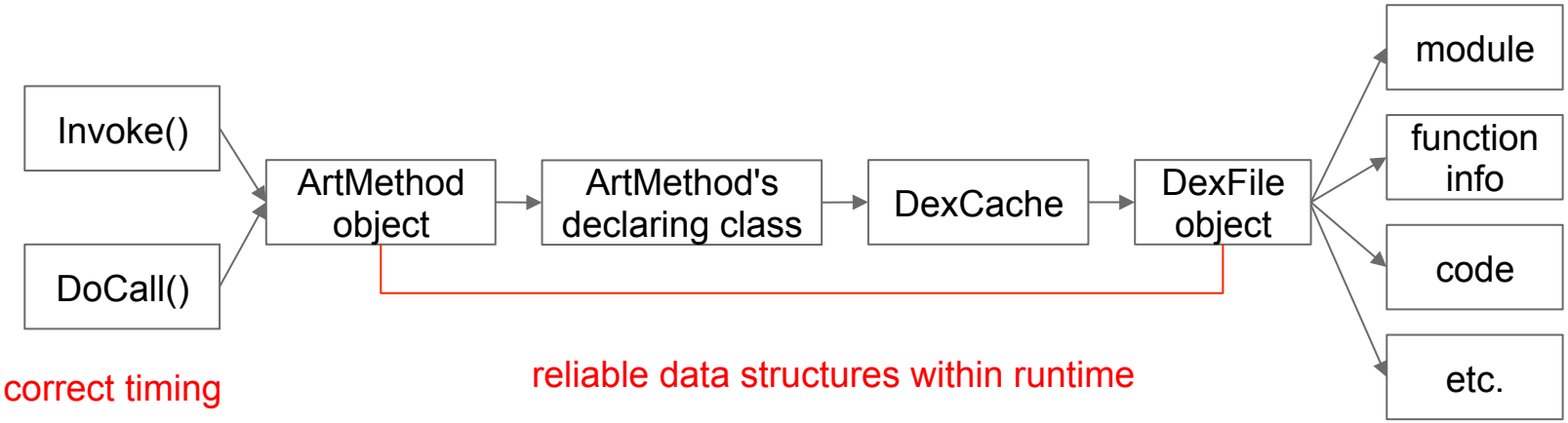

Fig. 1: Overview of DROIDUNPACK.

# DroidUnpack System

- Compared to Renovo[5]
  - reconstruct Java level info
- Compared to Droidscope[6]
  - retrieve ART view

# DroidUnpack System

- Reconstructing ART Semantic View
  - Compiled Java functions
  - Interpreted Java functions



# **Findings** - High level landscape

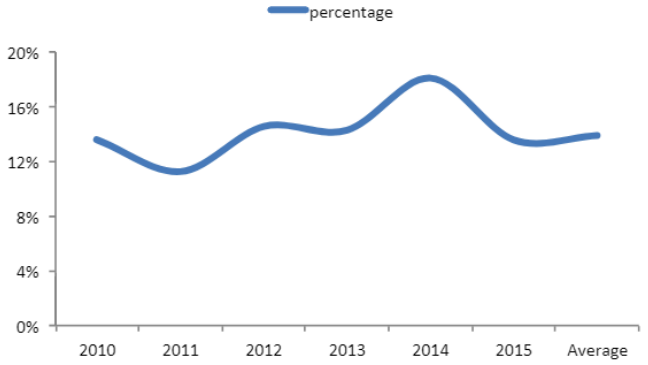



Fig. 2: Yearly distribution.

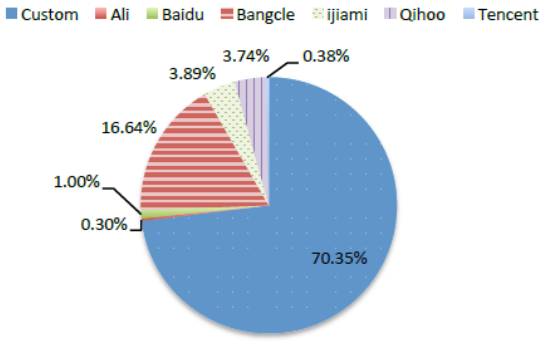



Fig. 3: Packer distribution.

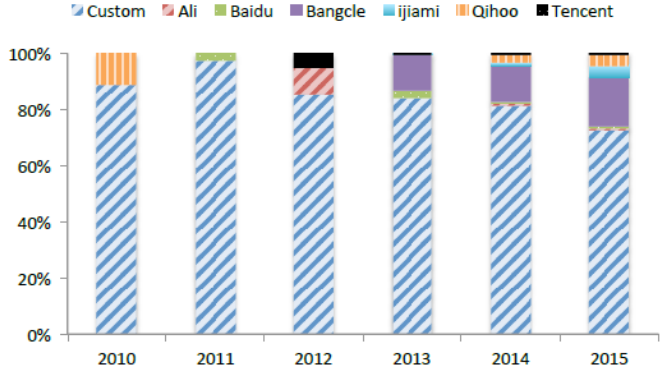



Fig. 4: Trend of packer distribution.

# **Findings -** Detailed analysis

- Detailed analysis: Commercial packers have adopted many unique yet unreported features for anti-unpacking.

TABLE I: Commercial packer behavior.

| | apkprotect | Ali | Bangcle | ijiami | Qihoo | Tencent |
|---|---|---|---|---|---|---|
| Context switching via JNI | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ |
| Native/DEX obfuscation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Pre-compilation | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ |
| Multi-layer unpacking | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| libc.so hooking | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Self modification | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Component hijacking vulnerability | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ |
| Information leakage | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |

# **Findings -** Detailed analysis

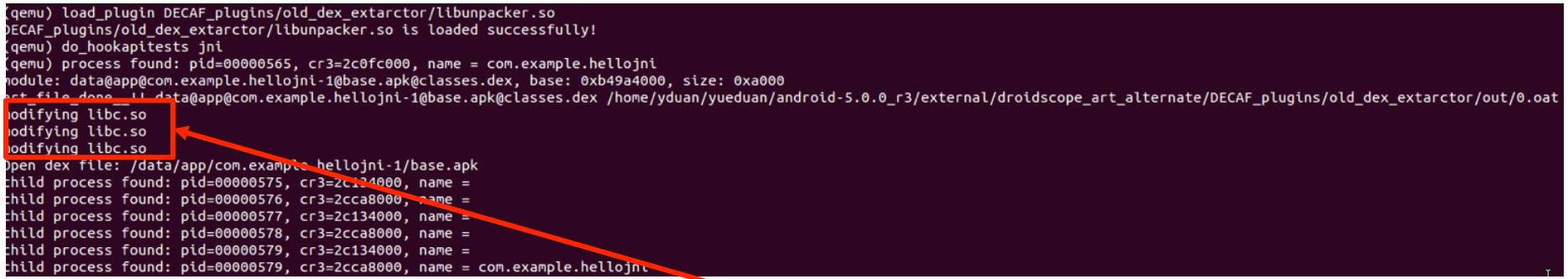
- multi-layer unpacking
  - not necessarily a one-time effort

TABLE II: Multi-layer unpacking.

| | # of layers |
|---|---|
| apkprotect | 1 |
| Ali | 1 |
| Bangcle | 9 |
| ijiami | 4 |
| Qihoo | 4 |
| Tencent | 40 |

# **Findings -** Detailed analysis

- libc hooking (Bangcle)
  - a way of defeating unpackers.
  - packers are evolving to defeat unpackers




memory operation monitoring using VMI

# **Findings -** Detailed analysis

- Commercial packers have led to severe security vulnerability and data breach.
  - Upon packing, commercial packers change the behaviors of the program
  - Key idea: Is the change secure?

# **Findings -** Detailed analysis

- Component hijacking vulnerability (Qihoo)
  - one vulnerable component is packed  and added by the packer into the app
  - analyze the hidden component extracted by DroidUnpack
  - turn a perfectly secure app into a vulnerable app
  - acknowledged by Qihoo and awarded ~$8000

# **Findings -** Detailed analysis

- Component hijacking vulnerability
  - can arbitrarily replace any file within a packed app from a designated server

```
Intent intent =  new Intent();

intent.setClassName("com.example.hellojni", "com.qihoo.util.CommonService");
intent.setAction("com.qihoo.commonservice.SERVICE_download");


Bundle bundle = new Bundle();
bundle.putString("md5", "E695392B43690F52752AD0D675E73427");
bundle.putString("url", "our server");
bundle.putString("name", "libjiagu.so");    //exetuable
bundle.putString("path", "/data/data/com.example.hellojni/.jiagu/");
bundle.putLong("contentLength", 40544412);
bundle.putBoolean("init_only", false);
intent.putExtra("download", bundle);

startService(intent);
```

# **Findings -** Detailed analysis

- Information leakage* (Tencent)
  - upon packing, it adds six new permissions to the original apps
  - ***collect*** sensitive user data and ***send*** them back via an insecure HTTP connection
  - utilize DroidUnpack to dump the hidden code
  - used FlowDroid to analyze

*This issue was identified by static analysis. We tried to contact Tencent to confirm but no reply so far.

# **Findings -** Detailed analysis

- Impact of the security issues
  - Component Hijacking Vulnerability
    - Gaode Navi is actively used by more than **500 million** users as their daily navigation app.
    - Qianniuniu finance has been downloaded for more than **3 million** times
  - Information Leakage
    - QQ has more than **800 million** active users

# **Findings -** Detailed analysis

- Since everyone can use commercial packers, can they be exploited?

  Protection technique claimed! However..

TABLE III: Security scrutiny.

| | apkprotect[1] | Ali | Bangcle | ijiami | Qihoo | Tencent |
|---|---|---|---|---|---|---|
| Malware defense failure | 5/5 | 0/5 | 2/5 | 2/5 | 0/5[2] | 1/5 |
| Plagiarism detection failure | 3/3 | 3/3 | 3/3 | 3/3 | 3/3 | 3/3 |

[1] apkprotect is not on-line service and has no prevention for malware or plagiarism.
[2] Qihoo detected first attempt and blocked further malware submission.

TABLE IV: Malware detection rate comparison.

| Malware name | Original detection rate | Packed detection rate |
|---|---|---|
| Android.Malware.at_plapk.a | 61.67% | 26.67% |
| Android.Troj.at_fonefee.b | 66.67% | 35% |
| braintest | 63.33% | 37.29% |
| ghostpush* | 70% | N/A |
| candy_corn | 68.33% | 38.98% |

* All commercial packers can successfully detect it as malware.

# **Findings -** Evolution

- Evolution: Android packers have been evolving very fast in the last few years.
  - Number of unpacking layers.

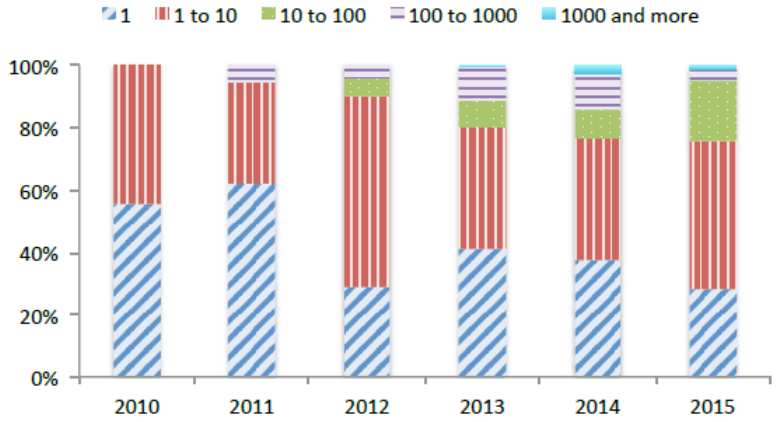



Fig. 5: Layer distribution.

# Conclusion

- We conduct the first large-scale study on Android packers
  - commercial packers have been increasingly abused
  - severe security issues are introduced by packers
  - Android Packers are quickly evolving
- We design and implement DroidUnpack and it will be released later

***THANK YOU!!***

# Reference


[1] “ValerySoftware McAfee,” https://securingtomorrow:mcafee:com/mcafee-labs/obfuscated-malware-discovered-google-play/, 2016

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[3] Ugarte-Pedrero, Xabier, et al. "SoK: deep packer inspection: a longitudinal study of the complexity of run-time packers." Security and Privacy (SP), 2015 IEEE Symposium on. IEEE, 2015.

[4] SophosLabs, “Anti-emulation techniques,” https://news.sophos.com/en-us/2017/04/13/android-malware-anti-emulation-techniques/, 2017

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[6] Yan, Lok-Kwong, and Heng Yin. "DroidScope: Seamlessly Reconstructing the OS and Dalvik Semantic Views for Dynamic Android Malware Analysis." USENIX security symposium. 2012.

[7] Zhang, Yueqian, Xiapu Luo, and Haoyang Yin. "Dexhunter: toward extracting hidden code from packed android applications." *European Symposium on Research in Computer Security*. Springer, Cham, 2015.

[8] Yang, Wenbo, et al. "Appspear: Bytecode decrypting and dex reassembling for packed android malware." *International Workshop on Recent Advances in Intrusion Detection*. Springer, Cham, 2015.

[9] https://github.com/strazzere/android-unpacker/tree/master/native-unpacker

# **DroidUnpack System -** Discussion

- Data Compression and Encoding
- Supporting Android versions
- Emulation Detection

# Motivation

- **Why Android?**
- Android is popular + it has design issues.
  - **iOS** enforces code signing to prohibit app from any modification since it was last signed.
  - **Android** allows the code to be modified even after installation.

# DroidUnpack System

- Code Behavior Analysis
  - Hidden OAT/DEX code extraction
  - Self-modifying code detection
  - Multi-layer unpacking detection
  - Java native interface inspection