ADAM:
An Automatic & Extensible Platform
To
Stress Test Android Anti-Virus Systems

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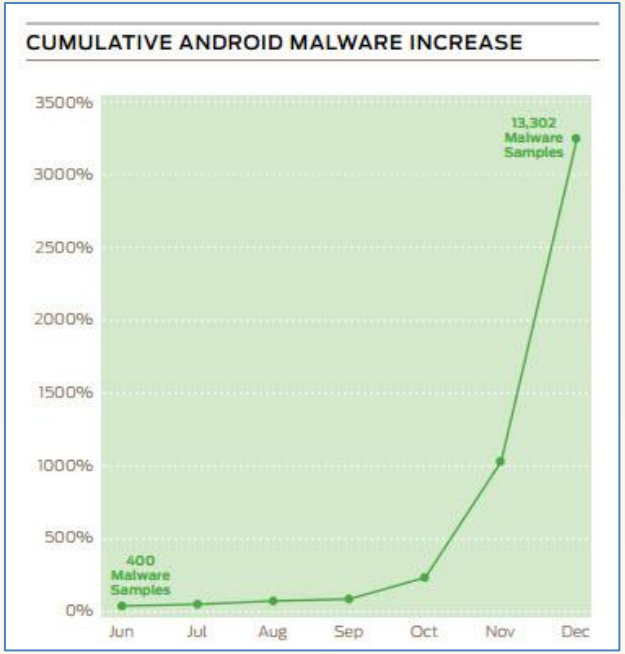
Android Malware
Up 3,325% in 2011

1. This past year, we saw a significant increase in mobile malware.

   A. Juniper Networks Mobile Threat Center: 400 to 13,302.
   B. Antiy: 12,000.
   C. Tencent: 10,000.

2. Spyware and premium rate SMS Trojans are the most popular Android malware.



Motivation
Of ADAM System

Both academic community and commercial anti-virus companies proposed many methodologies and products.

how to assess the effectiveness of these defense mechanisms?

Especially malware mutation.

Related Work Of ADAM System

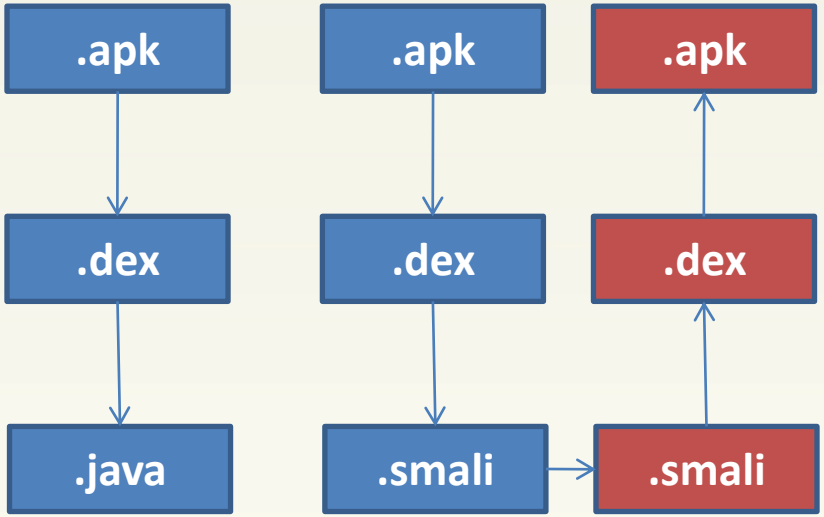
1. No byte code level obfuscation research on Android malware before.
   e.g. Jha, Testing Malware Detectors, 04; Moser, Limits of Static Analysis for Malware Detection. ACSAC 07
2. No large-scale evaluation on 40+ anti-virus and 200*8+ malware on Android before.
   e.g. Felt. A survey of mobile malware in the wild, SPSM 11
3. No automatic Anti-virus test system on Android before.
   e.g. Jiang, Dissecting Android Malware, Oakland12.

Our Work
Of ADAM System

We propose:
ADAM which can automatically transform an original sample to different variants via repackaging and obfuscation techniques. Then stress test anti-virus products.

Introduction
To Apk and Disassemble

1. The .apk file contains all of the information necessary to run the application on a device or emulator, such as compiled .dex file, a binary version of the AndroidManifest.xml file, compiled resources (resources.arsc) and uncompiled resource files for your application.
2. The disassemble process takes the Dalvik opcodes of a .dex file and converts them into low-level and human readable instructions. Typically, the decoded .smali files can be rebuilt again back to a .dex file.



System Design Of ADAM

1. **Security analysis.**
   For original sample and variants.

2. **Automated transformation.**
   no source code need.

3. **Extensibility.**
   Plug-in new detection systems or obfuscation techniques.

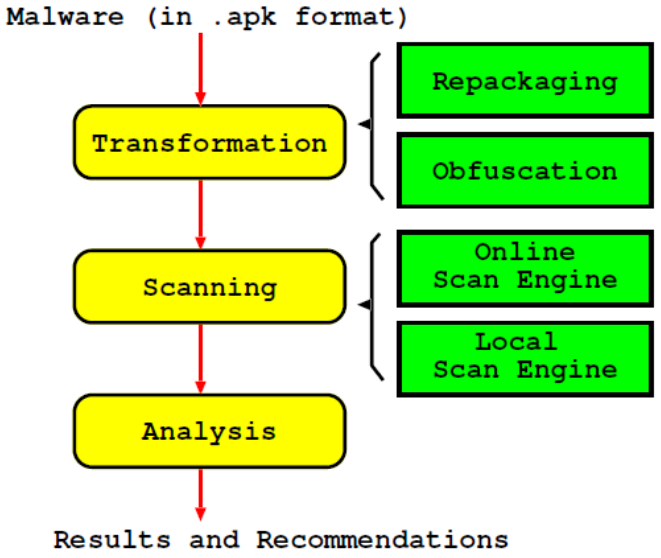


Fig. 1. Design flow of ADAM.

Obfuscation Technique Of Repackaging

Repackaging methods that work directly on an input .apk file and regenerate a different .apk file without modifying the source code of the input .apk file.

<1>. Alignment.

The process only changes the cryptographic hash of the .apk file.

<2>. Re-sign.

An .apk file can be re-signed multiple times with different certificates.

<3>. Rebuild.

Disassembles an .apk file and rebuilds the assembly code (without being modified) into another .apk file.

Evaluation Of Repackaging

1. We collect a total of 222 distinct Android malware samples.

2. Online Engine: VirusTotal.

3. Note that VirusTotal hosts over 40 anti-virus products, and our study only focuses on the top 10 products.

AV Products	Original	Alignment	Re-sign	Rebuild
F-Secure	93.24%	95.28%	94.59%	89.05%
Kaspersky	93.24%	90.09%	89.64%	62.38%
Emsisoft	90.99%	90.09%	87.84%	61.90%
Ikarus	90.99%	90.09%	87.84%	61.43%
GData	88.74%	92.45%	91.44%	86.67%
Sophos	88.74%	86.32%	86.49%	68.10%
Antiy-AVL	86.04%	75.00%	73.42%	54.76%
TrendMicro	85.59%	75.94%	74.32%	53.81%
Fortinet	79.28%	68.87%	68.47%	43.33%
NOD32	77.93%	55.66%	52.25%	35.24%
Overall Average	87.48%	81.98%	80.63%	61.67%

Repackaging, October 2011

Analysis
Of Rebuild Technique

	Original	Rebuild
Class 0:	public final mars.testbc.R$attr	public final mars.testbc.R$attr
Class 1:	public final mars.testbc.R$drawable	public mars.testbc.TestActivity
Class 2:	public final mars.testbc.R$id	public final mars.testbc.R$id
Class 3:	public final mars.testbc.R$layout	public final mars.testbc.R$drawable
Class 4:	public final mars.testbc.R$string	public mars.testbc.TestReceiver
Class 5:	public final mars.testbc.R	public final mars.testbc.R$layout
Class 6:	mars.testbc.TestActivity$Broadcast	mars.testbc.TestActivity$Broadcast
Class 7:	public mars.testbc.TestActivity	public final mars.testbc.R$string
Class 8:	public mars.testbc.TestReceiver	public final mars.testbc.R

Obfuscation Technique
Of Code Obfuscation

Code obfuscation changes the size and content of the .apk file by rebuilding the assemble code, but without modifying the logical behavior.

<1>. Inserting defunct methods.

The rationale of this obfuscation technique is to modify the method table in the Dalvik bytecode.

<2>. Renaming methods.

We obfuscate the method name with a different string, and hence change the signature that is generated by the method name.

Obfuscation Technique
Of Code Obfuscation

<3>. Changing control flow graphs.

we modify the CFG without changing the logic behavior of a .smali file and so as to change its CFG signature.

<4>. Encrypting constant strings.

We encrypt all constant strings that we find in a .smali file, and decrypt them when they are being processed by modifying the invoking instructions.

Analysis
Of Encrypt Technique

We can encrypt a string "DecryptString" in a TextView control by subtracting all bytes by 10. The encrypted string will become ":[YhofjIjh_d]".

We then add the decryption method decrypt (i.e., by adding all bytes by 10) before the TextView control is called.

```
#direct methods
.method public static DecryptString\
(Ljava/lang/String;)Ljava/lang/String;
...
const-string v1, ":[YhofjIjh_d]"
...
invoke-static { v1},\
Lcom/test;->DecryptString\
(Ljava/lang/String;)Ljava/lang/String;
move-result-object v1
invoke-virtual {v0, v1}, Landroid/\
widget/TextView;->setText\
(Ljava/lang/CharSequence;)V
```

Fig. 5. Encrypting a constant string.

Evaluation Of Repackaging and Code Obfuscation

AV Products	Original	Alignment	Re-sign	Rebuild
Kaspersky	95.95%	94.34%	94.59%	94.76%
F-Secure	95.50%	95.75%	95.05%	91.90%
Emsisoft	94.59%	93.87%	93.69%	75.24%
Ikarus	94.59%	94.34%	93.69%	75.24%
GData	94.14%	93.87%	93.69%	90.95%
TrendMicro	94.14%	91.98%	92.79%	77.62%
NOD32	92.79%	88.68%	88.29%	95.24%
Sophos	92.79%	94.81%	94.14%	78.10%
Antiy-AVL	92.34%	91.98%	89.19%	72.38%
Fortinet	90.99%	89.15%	88.74%	71.43%
Overall Average	93.78%	92.88%	92.39%	82.29%

repackaging

AV Products	Insert	Rename	Change CFG	Str. Encrypt
Kaspersky	93.81%	73.33%	94.76%	90.95%
F-Secure	90.00%	90.00%	90.48%	68.57%
Emsisoft	83.81%	26.67%	82.86%	25.24%
Ikarus	83.81%	26.67%	83.33%	25.24%
GData	90.95%	90.48%	91.43%	88.10%
TrendMicro	61.90%	61.90%	63.81%	35.71%
NOD32	95.24%	91.90%	95.24%	90.48%
Sophos	54.29%	54.29%	54.76%	49.05%
Antiy-AVL	70.00%	19.05%	67.14%	19.52%
Fortinet	48.57%	15.71%	42.86%	16.67%
Overall Average	77.24%	55.00%	76.67%	50.95%

code obfuscation

November 2011

Discussion
Of ADAM System

1. **Signature coverage.**
   We cannot verify if all anti-virus systems that we tested on VirusTotal apply the same detection logic as in their mobile versions.

2. **Distribution model.**
   It is generally difficult to distribute malicious applications through the official AndroidMarket. However, we believe that hackers can upload any malware to the third-party markets.

Future Work
Of ADAM System

1. We try to extend our system to support mobile version anti-virus products and dynamic analysis system.

2. We try to add a new function that explore the logic of anti-virus engine.

3. Source code:
   http://ansrlab.cse.cuhk.edu.hk/software/adam/