Andrubis – 1,000,000 Apps Later
A View on Current Android Malware Behaviors

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Android Malware Pandemic?

TrendMicro: The Mobile Landscape Roundup 1H 2014
Mobile Malware and High-Risk App Total Count

McAfee Labs Threats Report June 2014

PC and Mobile Malware Growth Rate
Enter Sandbox

SandDroid - An automatic Android application analysis sandbox.

An Android Application Sandbox System for Suspicious Software Detection

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ANANAS – A Framework For Analyzing Android Applications

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Tracedroid
A System Call-Centric Analysis and Stimulation Technique to Automatically Reconstruct Android Malware Behaviors

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DroidScope: Seamlessly Reconstructing the OS and Dalvik Semantic Views for Dynamic Android Malware Analysis

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Visual Threat

CopperDroid
Mobile-Sandbox: Having a Deeper Look into Android Applications

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Building Analysis Datasets and Gathering Experience Returns for Security (BADGERS), September 2014
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MOBILE SECURITY

Visual Threat

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Our Contributions

• Take advantage of our existing Anubis infrastructure

• Build an Android analysis sandbox that …
  – is suitable for large-scale analysis
  – allows us to collect a comprehensive dataset of Android malware and goodware
  – can be easily integrated into other tools and services
  – is publicly available
    ▪ As a web service: https://anubis.iseclab.org
    ▪ For batch submissions via API: http://anubis.iseclab.org/Resources/submit_to_anubis.py
    ▪ As a mobile app: https://play.google.com/store/apps/details?id=org.iseclab.andrubis
Outline

• **Andrubis System Overview**

• Andrubis As A Service

• Android Malware Landscape

• Future Work and Conclusion
System Overview
Public Analysis Features

• Static Analysis
  - Parse meta information from Android manifest
    ▪ Requested permissions
    ▪ Activities
    ▪ Services
    ▪ Registered Broadcast Receivers
  - Extract available methods from bytecode
    ▪ Used permissions
    ▪ Use of DEX and native code loading
  - Useful during stimulation
Public Analysis Features

- **Dynamic Analysis**
  - Run app in QEMU-based environment
  - Instrumented Dalvik VM
    - Log file system, network, phone (calls & SMS), crypto and dynamic code loading activity
  - Taint tracking to identify data leaks
  - Stimulation
    - Invoke all Activities, Services and Broadcast Receivers
    - Simulate common events (e.g. SMS receipt)
    - Application Exerciser Monkey

- **Auxiliary Analysis**
  - Network capture outside QEMU
  - Extraction of high-level network protocol features
Advanced Analysis Features

- **Method Tracing**
  - Extension of the Dalvik VM profiler
  - Outputs list of executed methods
  - Use Cases:
    - Basic code coverage computation
    - Permissions actually used during dynamic analysis
    - Behavioral signatures and classification

- **System-Level Analysis**
  - QEMU VMI
  - Outputs list of executed system calls
  - Use Cases:
    - Analysis of native libraries, e.g. root exploits
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Submission Statistics

• Online since June 2012
• 1,778,997 submissions
  – 95.82% from bulk submitters
• 1,034,999 unique apps
  – 5% of total samples submitted to An(dr)ubis
• Throughput of 3,500 apps per day
Deployment Considerations

• OS version = trade-off between running …
  – Old version to observe root exploits
  – New version to analyze current apps

• Maintenance effort of constant updates
  – Focus on implementing new features instead

• Andrubis supports API level ≤ 10 (Gingerbread)

• Unsupported API level mainly a concern for GW:
  – 2.11% of benign apps with API level > 10
  – 0.10% of malicious apps of API level > 10
  – Maximize potential “user base” of malware
Our Dataset

• Samples from a variety of sources
  - Google Play and alternative market crawls (AndRadar)
    ▪ Main distribution vector for Android apps
  - Torrents & Direct Downloads
  - Sample exchange with other researchers
  - VirusTotal
  - Malware Corpora
    • Genome Project, Contagio, Drebin
  - Anonymous submissions

• Comparison to other tools
  - Based on public malware corpora (mostly outdated)
  - (Subset of) our dataset
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Dataset Classification

• No ground truth for majority of samples
  – Besides public malware corpora
• Andrubis itself performs no classification
  – Although we are experimenting with machine-learning approaches
• We rely on AV labels for this evaluation
  – Goodware: 27.90%
  – Malware: 41.15%
  – Unlabeled: 30.95%
• Unlabeled set contains mainly adware
  – Also possible false positives
• Very inconsistent AV labeling
  – Found even Google app labeled as MW by AVs
Dataset by Release Date

- Based on four dates:
  - Last modification date of the APK file (ZIP header)
  - Release date of the minimum required SDK
  - Publication date in alternative markets/Google Play
  - First submission date to Andrubis
Key Observations

• Trends in MW/GW development from 2010-2014
• Static analysis alone becomes increasingly difficult
  – Ubiquitous use of reflection, especially in GW
  – Increasing use of dynamic code loading

• Common assumptions about MW/GW:
  – Malicious apps request more permissions than benign apps, but use less of them
  – Dynamic code loading is an indicator for malware
Requested/Used Permissions

- MW requests 12.99 permissions, uses 5.31 of them
- GW requests 5.85 permissions, uses 4.50 of them
- Requested permissions increased for both
- Decreased permission usage ratio
  - Only 13.38% in GW in 2014
  - Side-effect of dynamic code loading
  - Bad development practices
- Numbers based on static extraction of used permissions
  - Permissions used during dynamic analysis from method tracer logs
App Interdependencies

- Apps can share their UID
  - Share data, run in the same process and inherit permissions
- Allows collusion attack
  - Spread malicious payload over benign looking apps
- Allows privilege escalation by taking advantage of already installed benign apps
  - Circumvent signature system with Master Key vulnerability
  - Use publicly available test keys
  - Even gain system privileges with android.uid.system UID
- Only used in few GW (1.14%) and MW (0.29%) app
Other Findings from Static Analysis

• Application names
  – MW often uses legitimate looking package names
    ▪ Repackaging/posing as popular benign apps
    ▪ Generic names (e.g., com.app.android)
  – “Random” names (e.g.; rpyhwytfsyl.uikbvktgwp) reused amongst thousands of apps

• Decreasing use of public test keys to sign apps
  – Should not be used by legitimate developers
  – 8.92% of MW (down from 65.29% in 2010), 2.26% of GW

• Master Key vulnerabilities not widely exploited
  – Only ~1.500 MW samples
Dynamic Code Loading

• Significantly increased, especially in GW
  – 30% of GW load DEX classes
  – 20% of GW load native code
  – 13% of MW load DEX or native code

• Static detection of dynamic code loading important for selecting samples
  – Successful in detecting DEX loads (>97% of apps)
  – Less successful in detecting native code (54% GW, 83% MW)

• Custom libraries more dangerous than libraries shipped with the OS
  – GW increasingly ships its own native libraries (84%)
Dynamic Code Loading Trend

- DEX All
- DEX GW
- DEX MW
- Native All
- Native GW
- Native MW

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Other Findings from Dynamic Analysis

- Increasing use of external storage (SD card)
  - Contrary to Google’s policy
  - Especially prevalent in malware (30%)
    - New monetization vector (Cryptolocker)

- Almost no apps perform phone calls
  - Not revealed by static analysis in any app

- Almost no benign apps send SMS (0.26%)

- Unsurprisingly 15% of MW send SMS
  - Only revealed through static analysis in ~ 80% of apps
  - Up to 120 SMS to premium number during one analysis run
Other Findings from Dynamic Analysis

- More MW than GW leak data: 43% vs. 14%
  - Mostly to the network, very few per SMS
  - Recently MW started leaking information per e-mail
    - Forwarding incoming SMS
    - Leaking contacts
- Data leakage increased overall from 14% to 50%
- Increased usage of crypto API in GW (11% to 79%)
- MW adopting stronger cryptographic algorithms
  - DES almost completely replaced with AES and Blowfish
- Static analysis determined crypto usage in 43% of MW
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• **Future Work and Conclusion**
Limitations and Future Work

- Dynamic analysis evasion
- GUI Stimulation
  - More intelligent, user-like input
  - Targeted input for phishing attempts of banking apps, ...
- Lack of metadata
  - Crawling markets with AndRadar
- Lack of ground truth
  - Classification of Android malware
- Dated public datasets and lack of comparability
  - Planning to release public dataset
  - Sharing of samples and/or reports on request
Conclusion

- Large-scale analysis system for Android apps
- Static and dynamic analysis on Dalvik VM and system level
- Publicly available at [https://anubis.iseclab.org](https://anubis.iseclab.org) and via our Android app
- Operating for the past 2+ years
- Dataset of > 1,000,000 Android apps
- Identified trends in the Android malware landscape
- Dynamic analysis increasingly important
Questions?

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