Andrubis – 1,000,000 Apps Later

A View on Current Android Malware Behaviors

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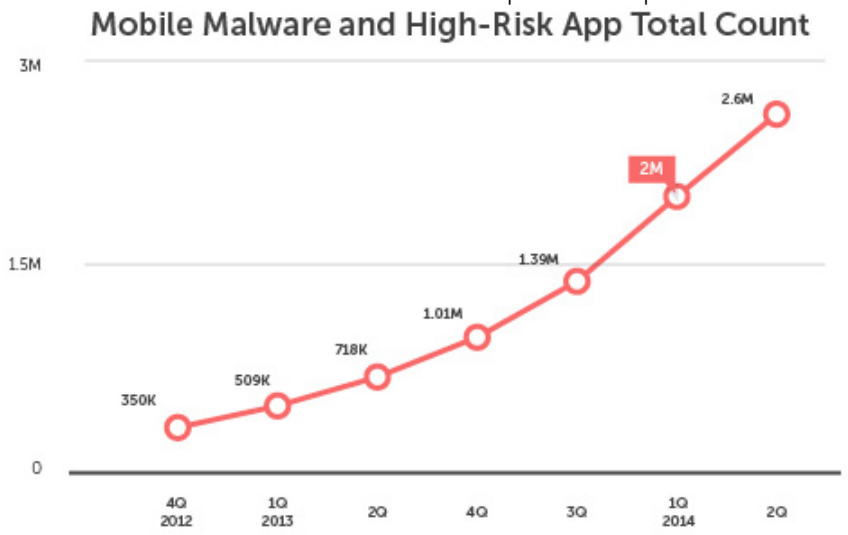
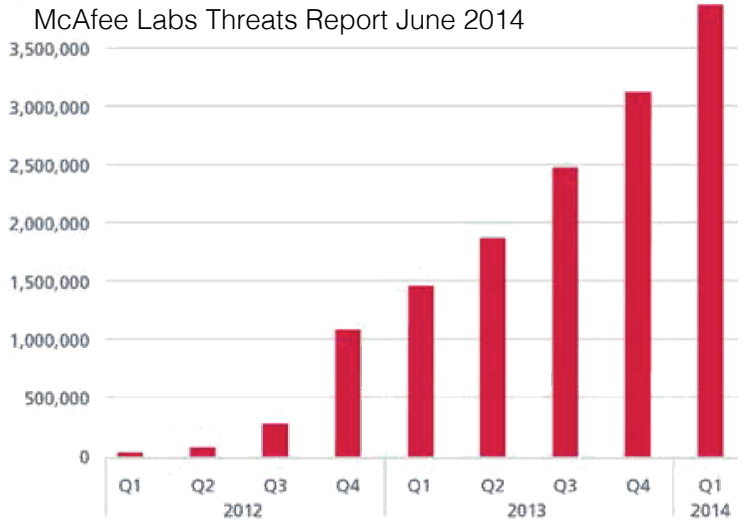
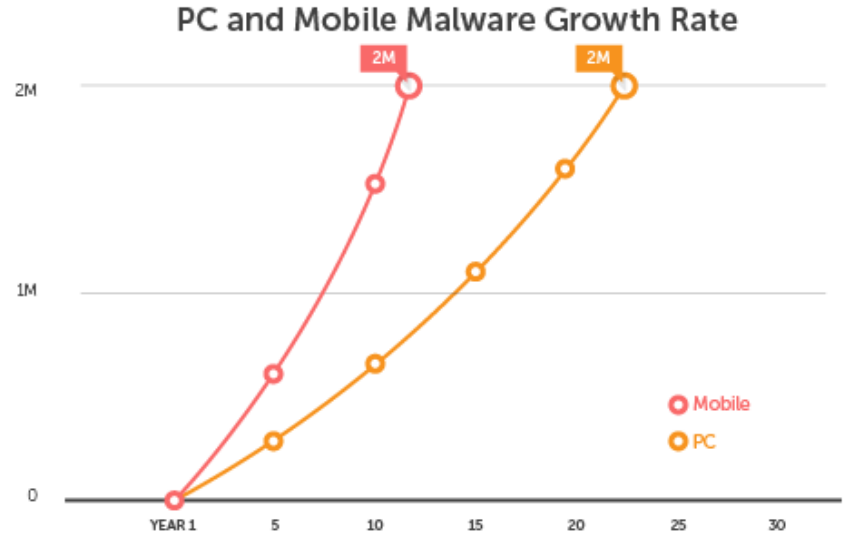
Android Malware Pandemic?

TrendMicro: The Mobile Landscape Roundup 1H 2014



McAfee Labs Threats Report June 2014





Enter Sandbox

iseclab

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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FORESAFE MOBILE SECURITY

VisualThreat

CopperDroid

MS

Mobile-Sandbox: Having a Deeper Look into Android Applications

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

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JoeSandbox Mobile

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Our Contributions

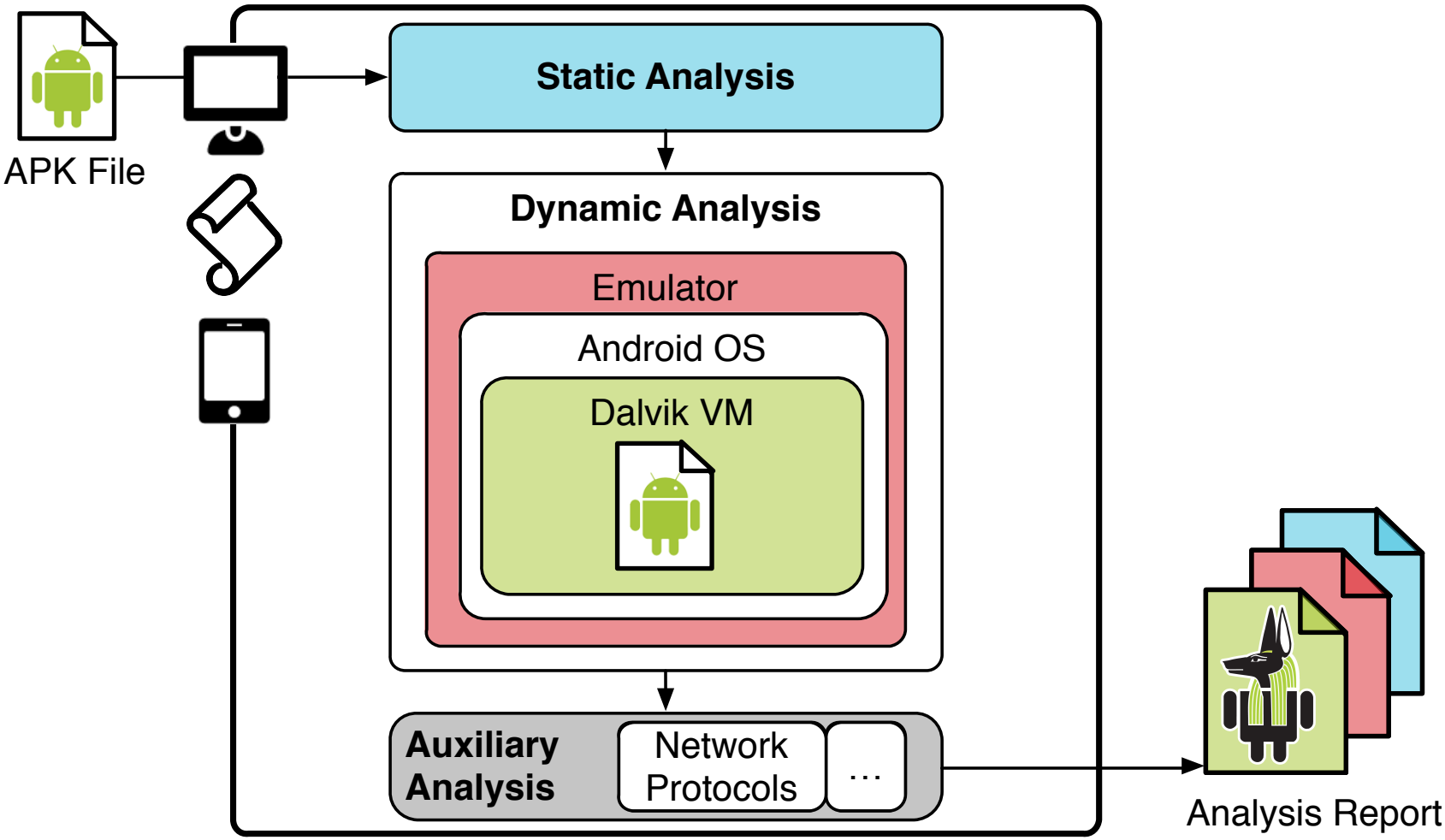
- Take advantage of our existing Anubis infrastructure

- 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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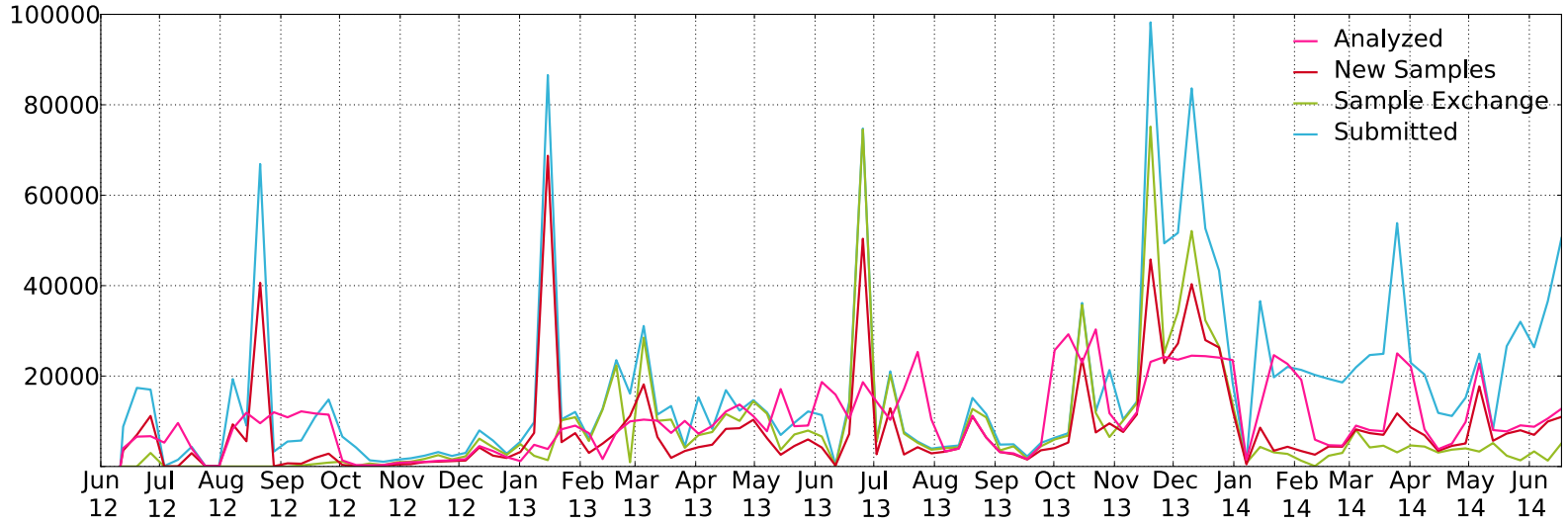
Submission Statistics

- 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

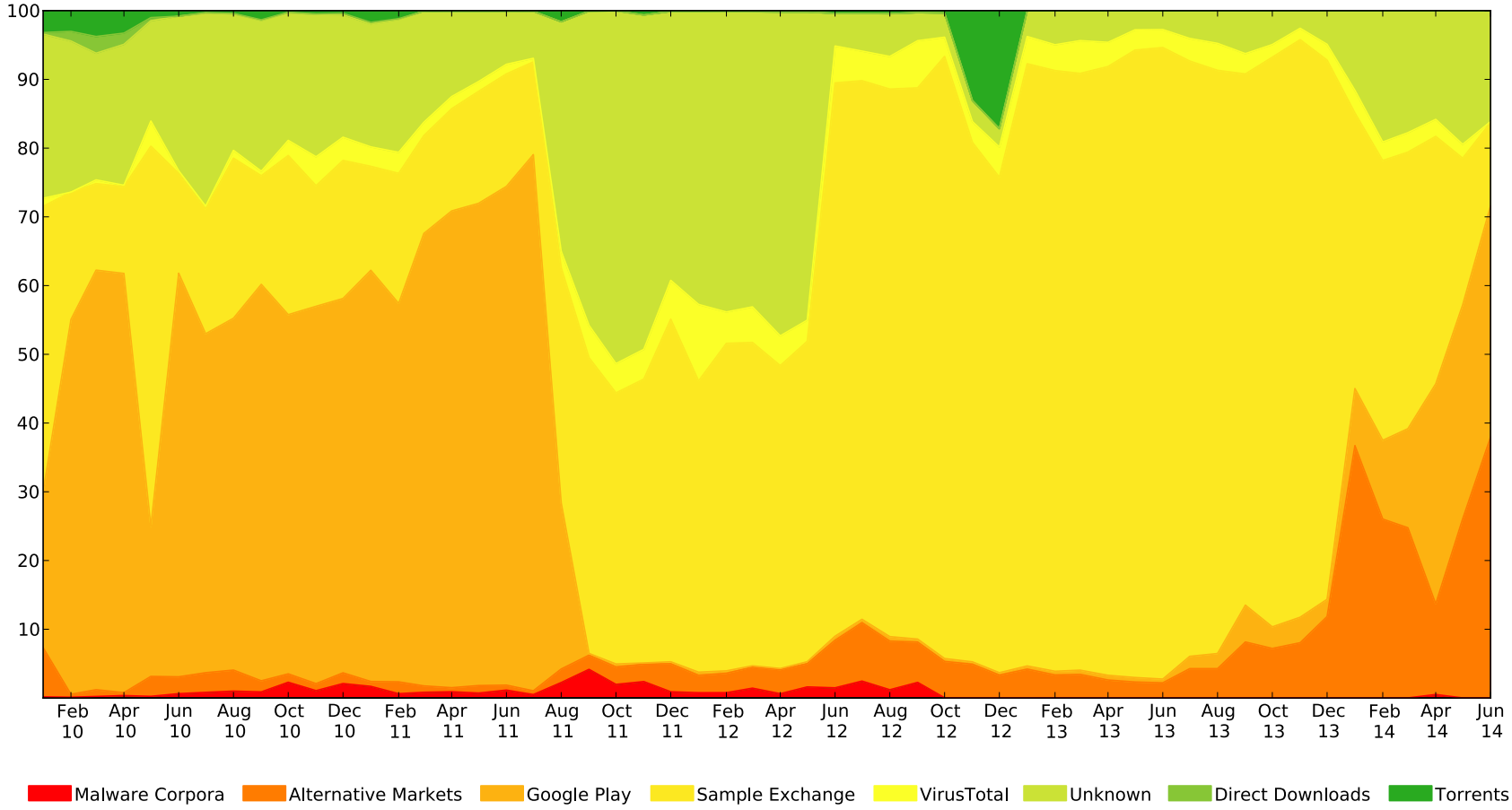
- OS version = trade-off between running …
  - Old version to observe root exploits
  - New version to analyze current apps
- Maintenance effort of constant updates
  - Focus on implementing new features instead
- Andrubis supports API level ≤ 10 (Gingerbread)
- Unsupported API level mainly a concern 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

Sample Age by Source



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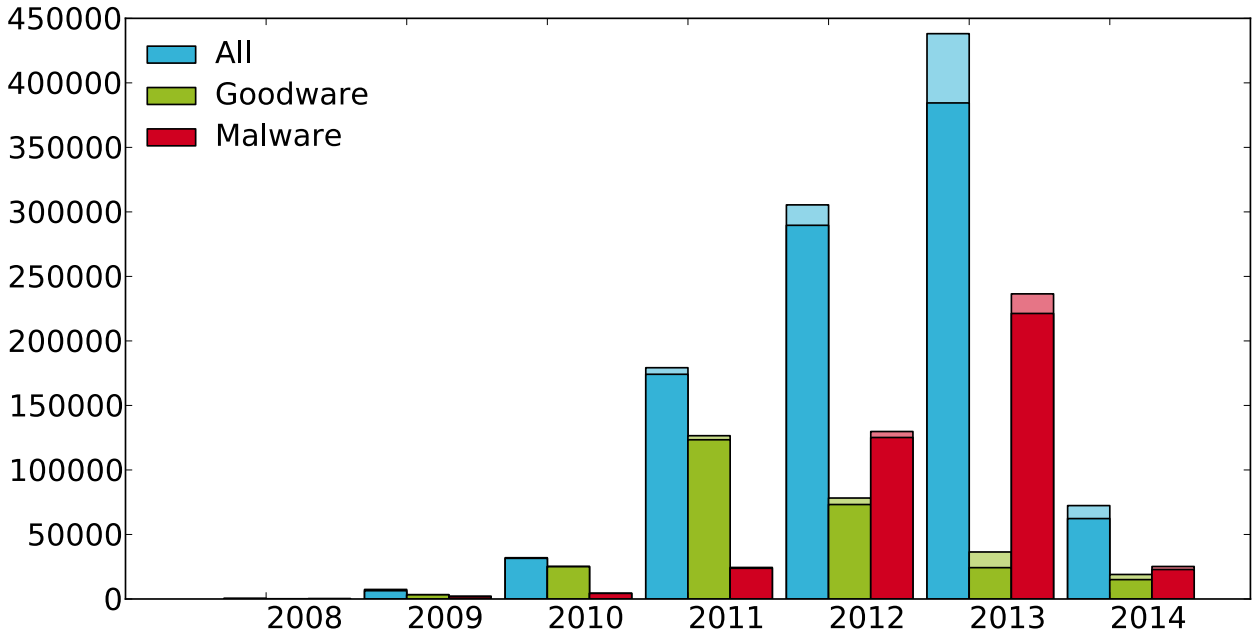
Dataset Classification

- 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.; rpyhwytfysl.uikbvktgwp) reused amongst thousands of apps

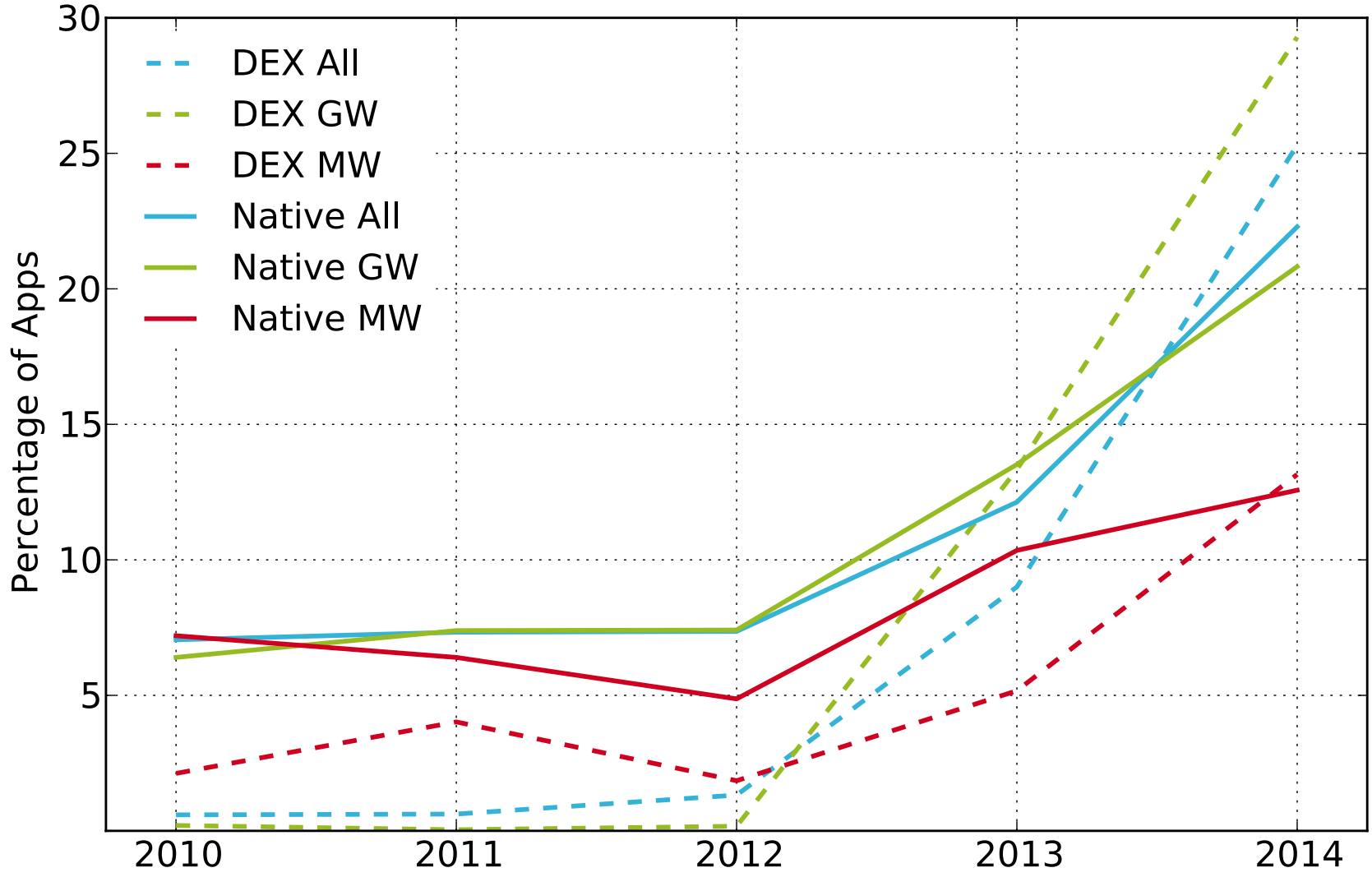
- Decreasing use of public test keys to sign apps
  - Should not be used by legitimate developers
  - 8.92% of MW (down from 65.29% in 2010), 2.26% of GW

- 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



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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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 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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