CuriousDroid:

Automated User Interface Interaction for Android Application Analysis Sandboxes

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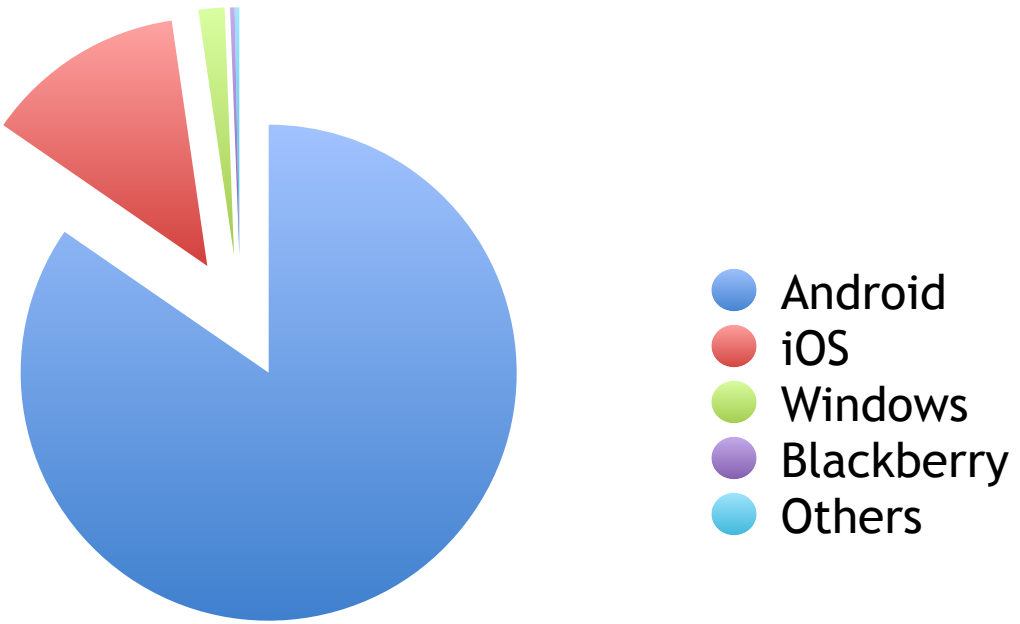
Android

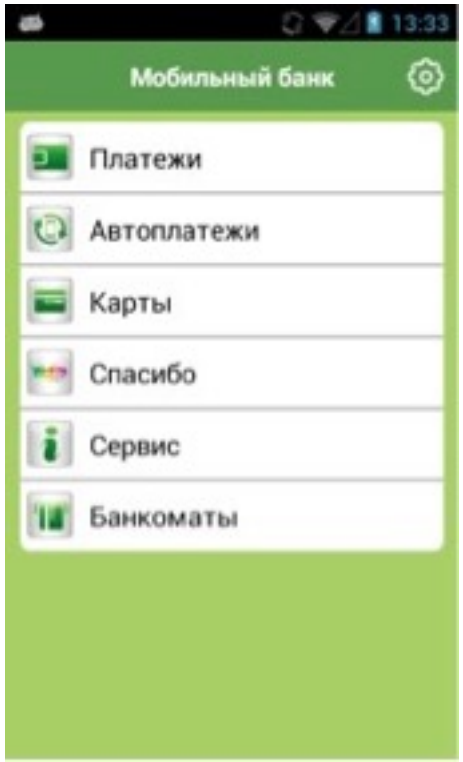


- Most popular mobile OS
  - 84.7% of 2015 Q3 mobile device sales
  - 48.6% 2014 total device sales

* Gartner

Android Malware

- Apps appear normal to user
  - Malicious functionality hidden from user



- Russian banking malware
  - Send SMS
  - Capture images
  - Record Audio
  - Track GPS
  - Address book
  - List of recent calls
  - Etc.

Android Security

- Google Play Store
  - Google Bouncer
  - Doesn't protect against 3rd party sources
- Anti-Malware applications
  - Generally looking for malware signatures
- User defenses
  - Permissions
  - Avoid 3rd party sources
- A more robust malware analysis is necesarry

Malware Analysis

- Static analysis
  - Safely approximates all behaviors
  - False positives more likely
- Dynamic Analysis
  - High-fidelity results
  - Coverage is hard!

Android Dynamic Malware Analysis

- Coverage is even harder!
  - All Android apps are event/GUI based
- Exercising application UIs is imperative for increased coverage
  - Cannot drive execution of application forward without exercising the UI

Android Test Generation

- De facto tools for exercising application UIs are the Monkey and MonkeyRunner (Google)
  - Monkey: fuzzer
  - MonkeyRunner: requires source code and knowledge of application to build test applications
- Other exercisers require either source code (instrumentation) or take a long time to generate exploration paths

CuriousDroid

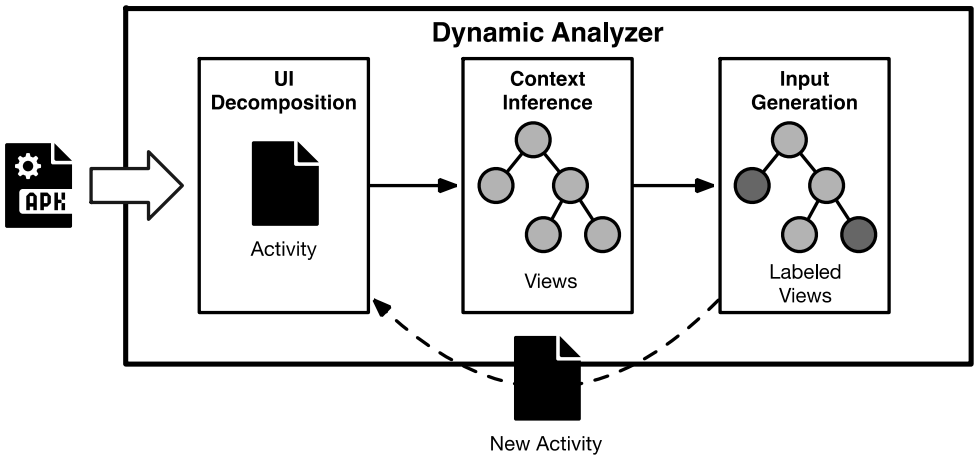
- Android UI stimulation for malware sandbox environments
  - Fully automated: No human in loop
  - No source code or prior knowledge of application is necessary
  - Runs on devices in addition to emulators
    - Needs root
- Emulates human interactions

Dynamic Dalvik Instrumentation

- Method for injecting arbitrary code into a running process
  - Add additional class files to Dalvik VM
- Allows us to overwrite application and framework methods:
  - Application code is not modified
  - No need to disassemble

System Overview

Three Phases of CuriousDroid



UI Decomposition

- Extract hierarchy of UI elements
- Label interactive elements

Input Inference

- Determine what type of input each element takes (if any)
- Determine order of interaction

Input Generation

- Translate inputs to physical interactions
- Inject inputs into application/OS

Android UI

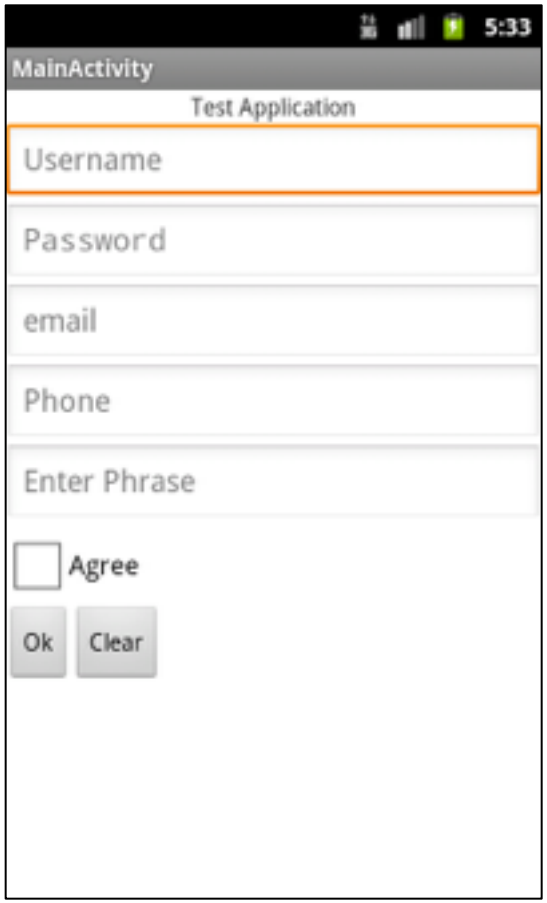
- *Activity* class is a way for a user to interact with an application
  - Provides window and contains the UI elements

- UI composed of different elements:
  - Containers
  - *Views*
    - Interactive: Buttons, text fields, etc
    - Non-interactive: text labels, etc

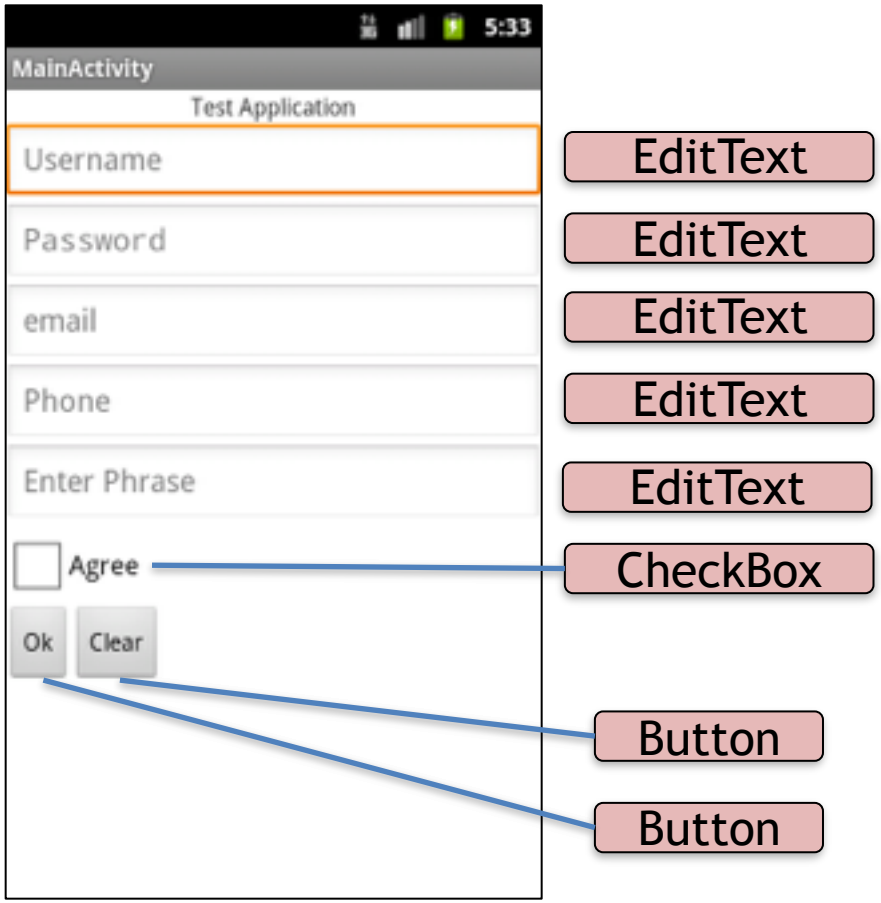
User Interface Decomposition

- Overwrite Activity method **onWindowFocusChanged()**
  - Called *after* Views drawn to screen
- Starting with the root view, recursively examine each sub-view until all views are examined
  - As each view is examined compile list of interactive views or "widgets"

Input Inference

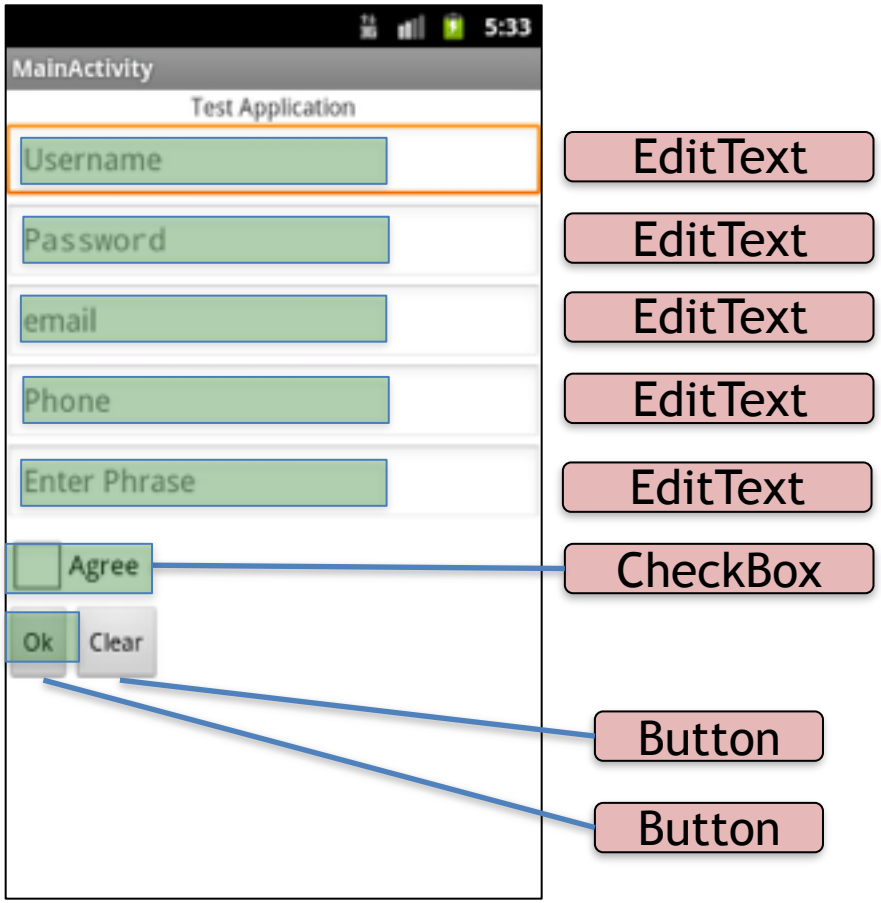


Input Inference



- Examine each widget to determine type of interaction
  - Text fields take crafted input
  - Buttons take taps, etc.

Input Inference



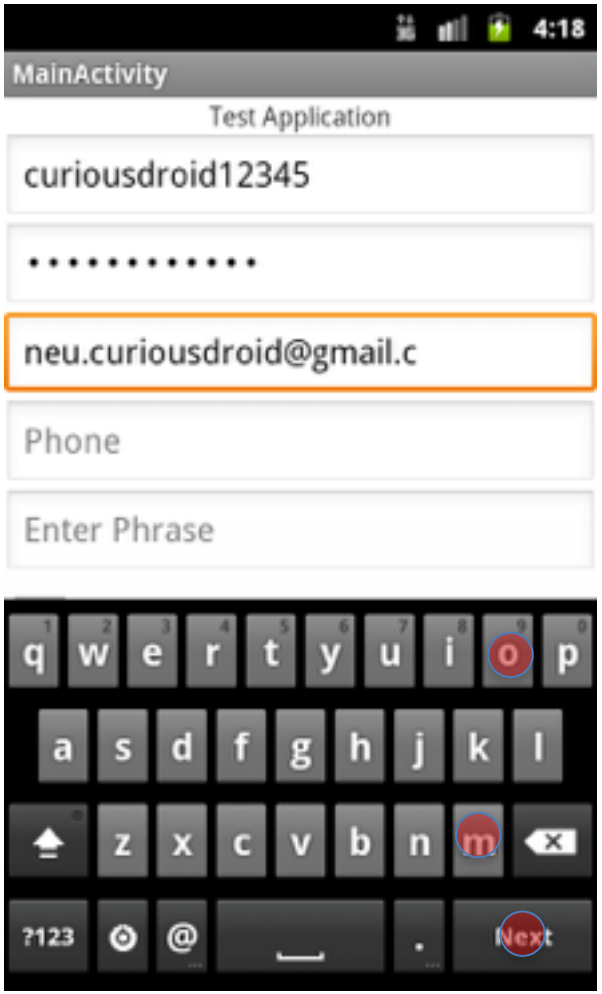
- Use hints to determine context
  - Text labels or textfield “hints”
  - Compare to list of keywords
- Draw from list of predefined input values

Input Inference

- Determine order to interact with widgets
  - Top-down left-right
  - nextFocus property
- Always press buttons last!

Input Generation

- Translate ordered inputs into physical interactions
  - Generate data representing gesture
- Separate process writes data directly to input driver



Evaluation

- Does better input generation improve dynamic analysis?
  - Dynamic behavior
  - Activity Coverage
- In total 38,572 applications tested
  - Apps pulled from Andrubis database
  - Compare results generated by Andrubis where input generation system is varied

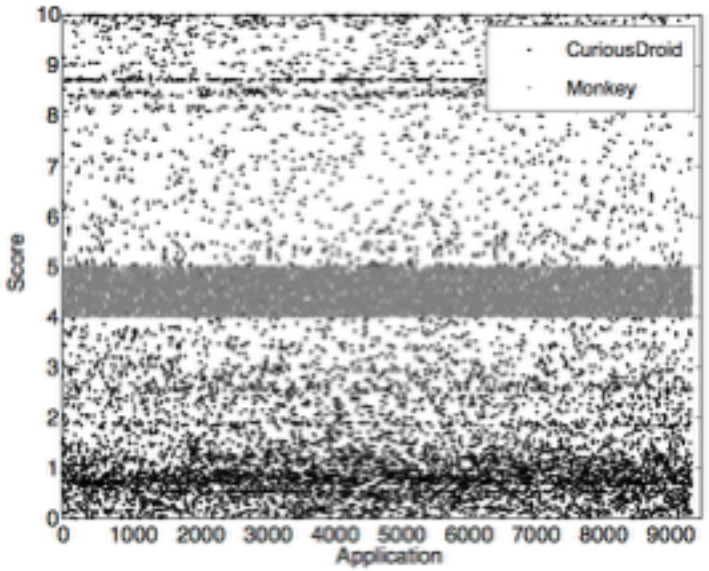
Andrubis

- Android malware analysis system:
  - Static and Dynamic analysis
    - Static: requested permissions, services, broadcast receivers. API calls used.
    - Dynamic: data leaks, filesystem activity, Phone and SMS, dynamic code loading, JNI
- Assigns score (0 – 10) for each application:

www.anubis.org

Results: Borderline Classification

Borderline Score



- 8827 Apps chosen with score from 4-5
- Majority of apps reclassified to benign
- Change in score driven by increase in number of dynamic features generated

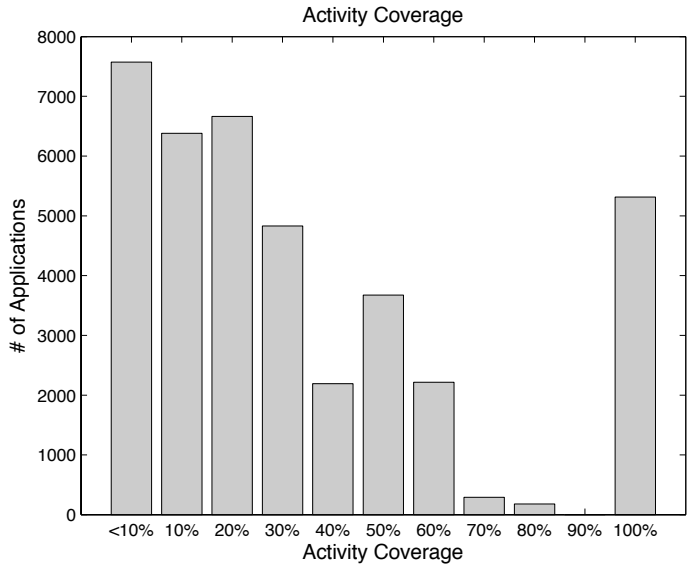
Results: Dynamic Behaviors

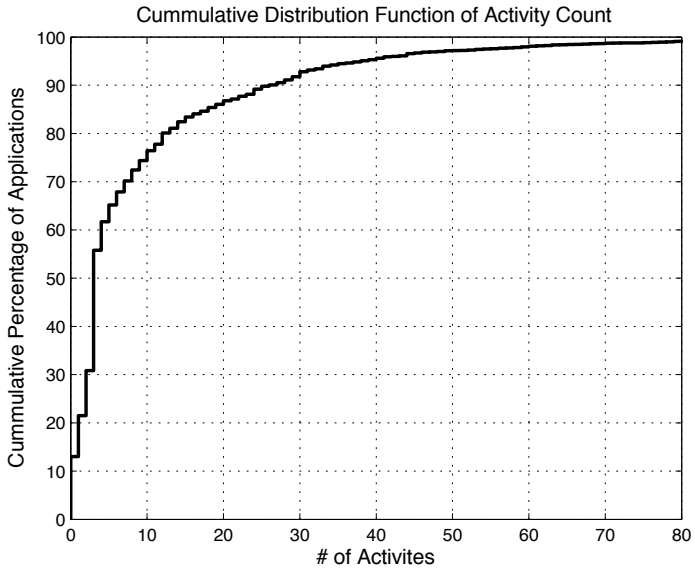
Observed Dynamic Behaviors

Category	# Apps	# Triggered	% Triggered
SMS	6871	440	6.40%
Dynamic Code	8371	358	4.28%
Native Code	7669	1945	25.36%
Networking	7134	2650	37.15%

- Applications chosen for each category contain bytecode for a given behavior that was not exercised by Monkey
- These behaviors often seen in malware

Results: Activity Measurements





- Activity coverage:
  - Some applications have high number of Activities (up to 287)
  - Some Activities only triggered under certain circumstances
    - SMS received, network data
- How Activities triggered is more important!
  - Valid form data passed from one to another

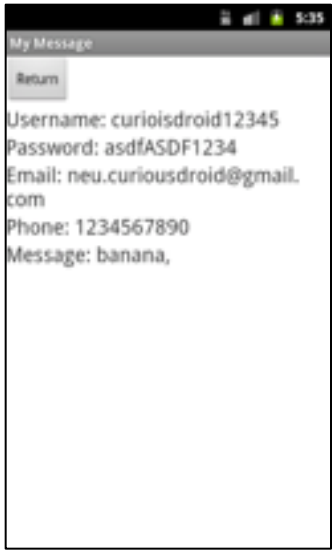
Conclusion

- CuriousDroid: a tool for automated execution of Android Applications in an intelligent and human-like fashion
- Geared towards high-volume malware analysis systems that require no prior knowledge of apps
- Our results show improved performance over black-box fuzzing

Questions?

Test Application Execution

1



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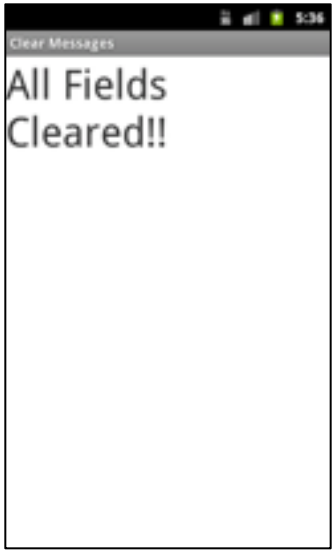

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5

Input Generation

- Event injection mechanism running in separate process
  - Takes output from Input Generator
  - Writes directly to the touchscreen input driver
- Mimics actual touch events which are then passed to applications through the Android framework
- OS cannot tell difference between real and simulated touch events