Scalable Software Testing for Android: Challenges & Opportunities

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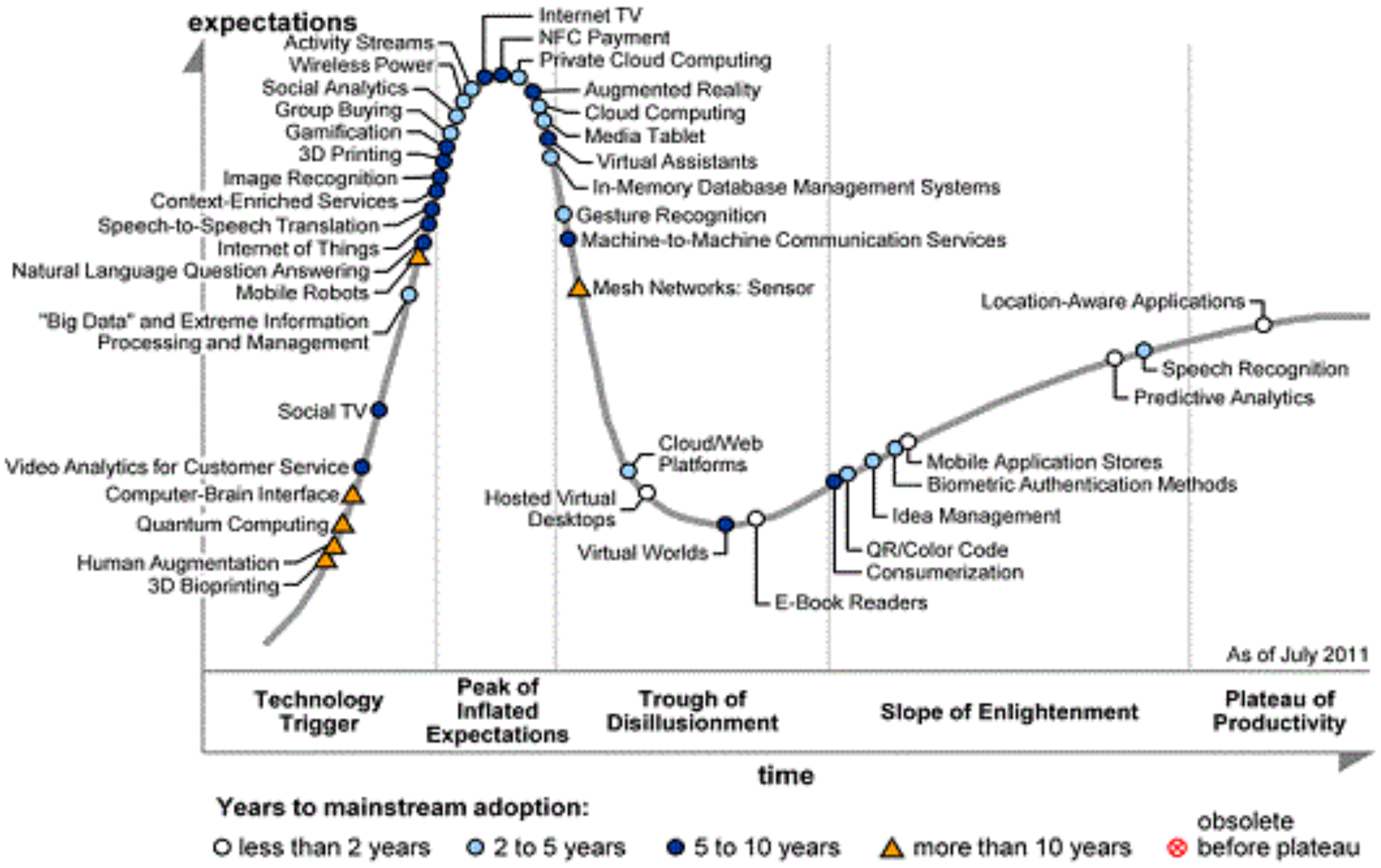
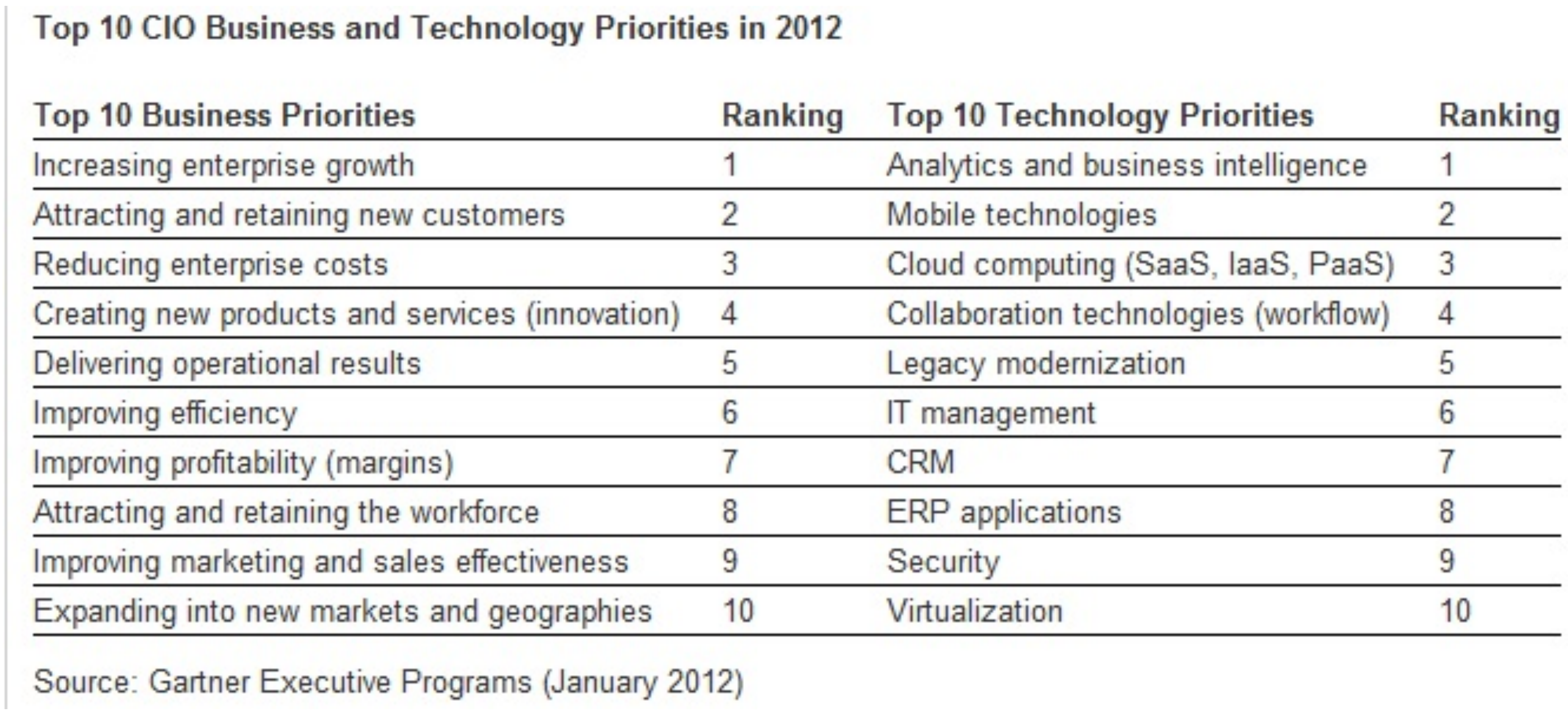
Maturity of Technologies (source Gartner)



CIO Business Priorities

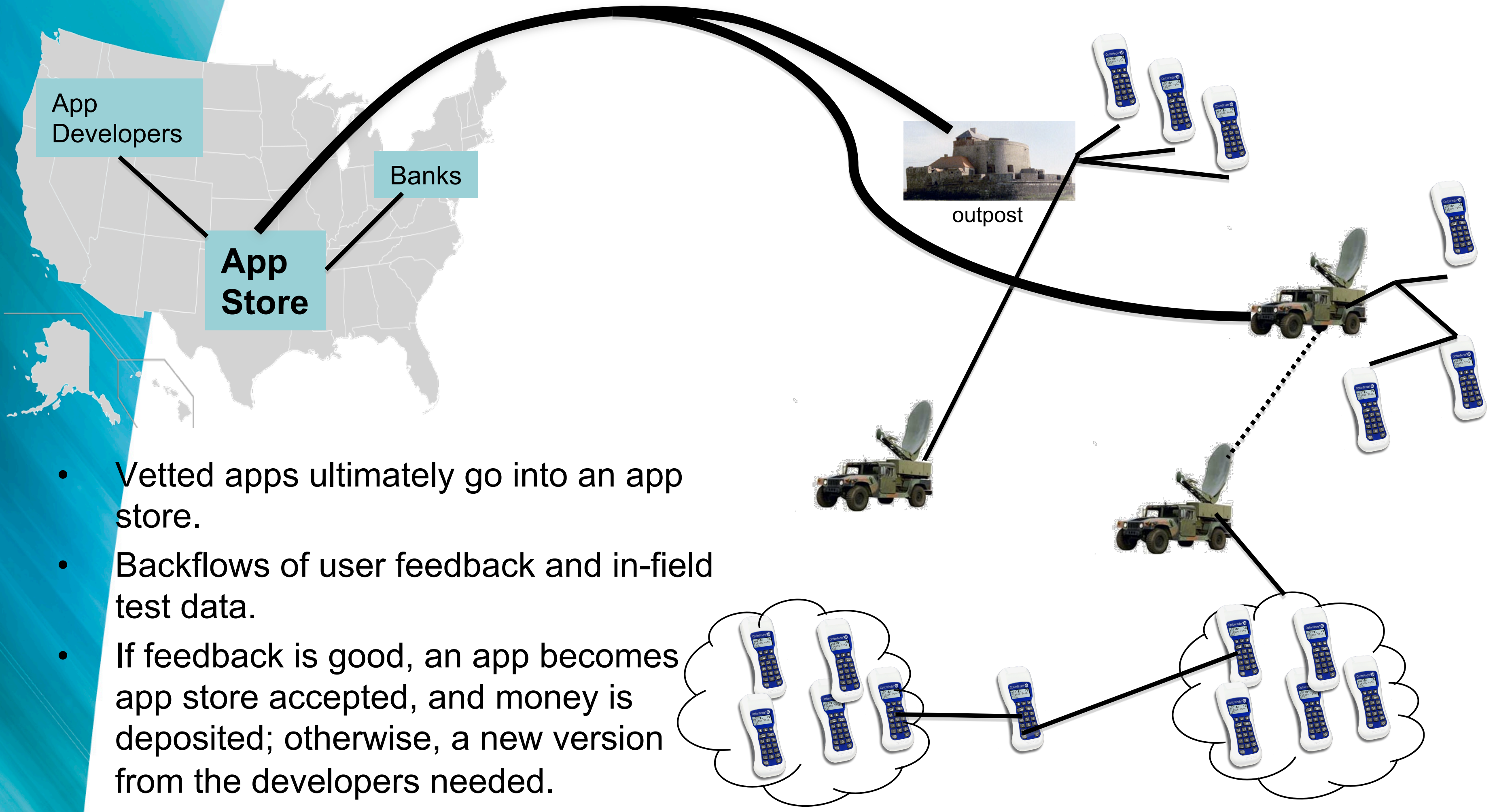


Top 10 CIO Business and Technology Priorities in 2012

Top 10 Business Priorities	Ranking	Top 10 Technology Priorities	Ranking
Increasing enterprise growth	1	Analytics and business intelligence	1
Attracting and retaining new customers	2	Mobile technologies	2
Reducing enterprise costs	3	Cloud computing (SaaS, IaaS, PaaS)	3
Creating new products and services (innovation)	4	Collaboration technologies (workflow)	4
Delivering operational results	5	Legacy modernization	5
Improving efficiency	6	IT management	6
Improving profitability (margins)	7	CRM	7
Attracting and retaining the workforce	8	ERP applications	8
Improving marketing and sales effectiveness	9	Security	9
Expanding into new markets and geographies	10	Virtualization	10

Source: Gartner Executive Programs (January 2012)

High-Level Project Overview



- Vetted apps ultimately go into an app store.
- Backflows of user feedback and in-field test data.
- If feedback is good, an app becomes app store accepted, and money is deposited; otherwise, a new version from the developers needed.

Why Do I Care?

Commercial Mobile Devices have access to a wide-range of functionality and ship with complex code-base:

- Fully Functional Linux system
- Proprietary device drivers with NO access to code
- Permissive policy model
- Capability to perform a wide range of operations
  - 3 (three) different types for location tracking
  - Many more through meta-data (geo-tagging)

BUT, I am secure: I am using Anti-Virus!!! Right?

Current Mobile Anti-Virus

Commercial AV vendors are not ready for mobile:

- Drain battery quickly
- Similar Results with their Desktop Counterparts
- There are no guaranteed for success in detection
  - Cannot Identify non-preclassified threats
  - CarrierIQ is an example, a “benign” and “legitimate” application
  - Some of them “call-back” home and require constant updates

But is it that bad?

The real picture: **Malicious Apps exist...**

Analyzed ~267,000 Applications from the Google Android Market

- Thousands with incorrect/permissive manifest
- Hundreds with excessive functionality that can be constituted as malicious
- Hundreds of Trojans (i.e. take over existing, legitimate applications)
  - Who will download these apps?
  - People who use SEARCH to find apps
  - Virtually everyone…
  - Two infection vectors:
    - Regular Web Search
    - Search inside the Mobile App Market

The real picture: **Malicious Apps exist...**

A multifaceted problem:

- Developers maybe well-intended but…
  - They do not necessarily understand the mission or the security/policy requirements
  - They make mistakes
  - They use third-party libraries and code
- The Android permission model is **neither sound nor complete**
  - Intentions, Reflection, JNI, Webkit, others…
  - Android permissions are enforced inside Dalvik not everywhere in the device

What about existing Analysis Tools?

- Commercial application testing tools cover regular, non-Android specific Bugs:
  - No Security Analysis of the Code Functionality
  - No Power Analysis of the Application components and code
  - No Profiling of the resource consumption of individual applications
  - Cannot Regulate/Deny the access and use of phone subsystems (Camera, Microphone, GPS..)
- Existing tools **do not cover Program Functionality**
  - We reveal the application capabilities and access

Application Testing Framework

Application Static Analysis does not cover
Program Functionality

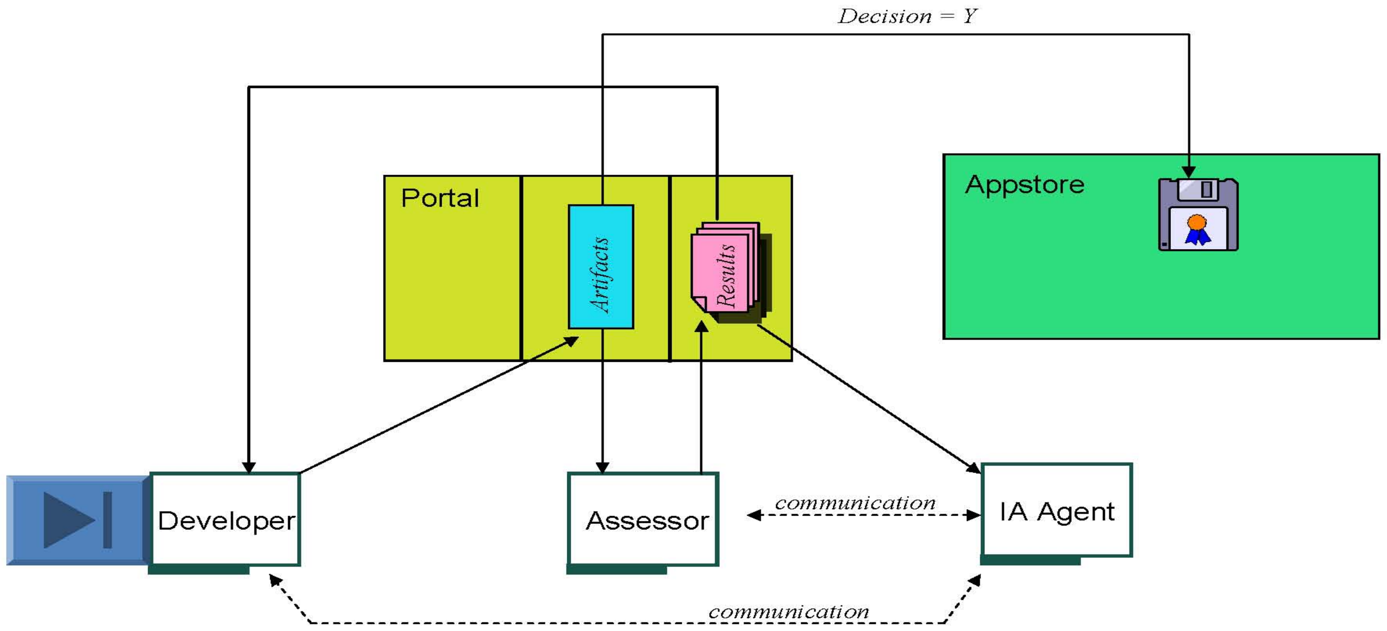
Fortify, Coverity, and other application testing tools cover regular, non-Android **specific Bugs:**

- No Security Analysis of the Code Functionality
- No Power Analysis of the Application components and code
- No **Profiling** of the resource consumption of individual applications
- **Cannot Regulate/Deny** the access and use of phone subsystems (Camera, Microphone, GPS..)

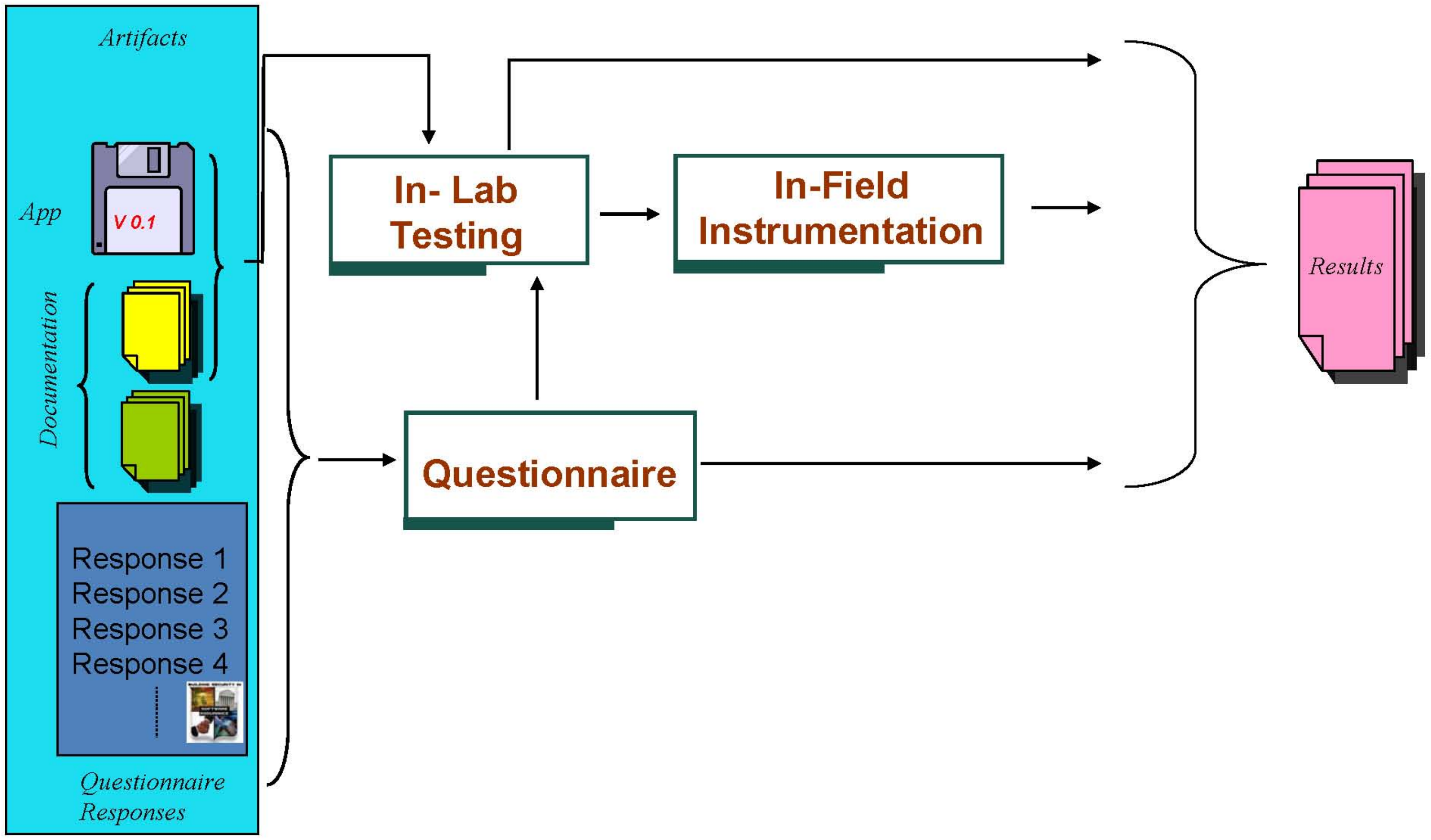
App Vetting & Control

- App Signing – Prevent unauthorized App Execution
  - Approved Apps are signed by the program designated approval authority
  - Only program signed Apps can be installed on the device
    - Customizations made to Android package framework
- App Analysis & Testing
  - All Apps are analyzed for malware and potential vulnerabilities
    - AV Scans
    - Vulnerability Scans (Fortify)
  - Expose hidden & unwanted functionality
    - Hidden in Native Libraries
    - Dynamic or obfuscated code
  - Permissions manifest reconciliation against code

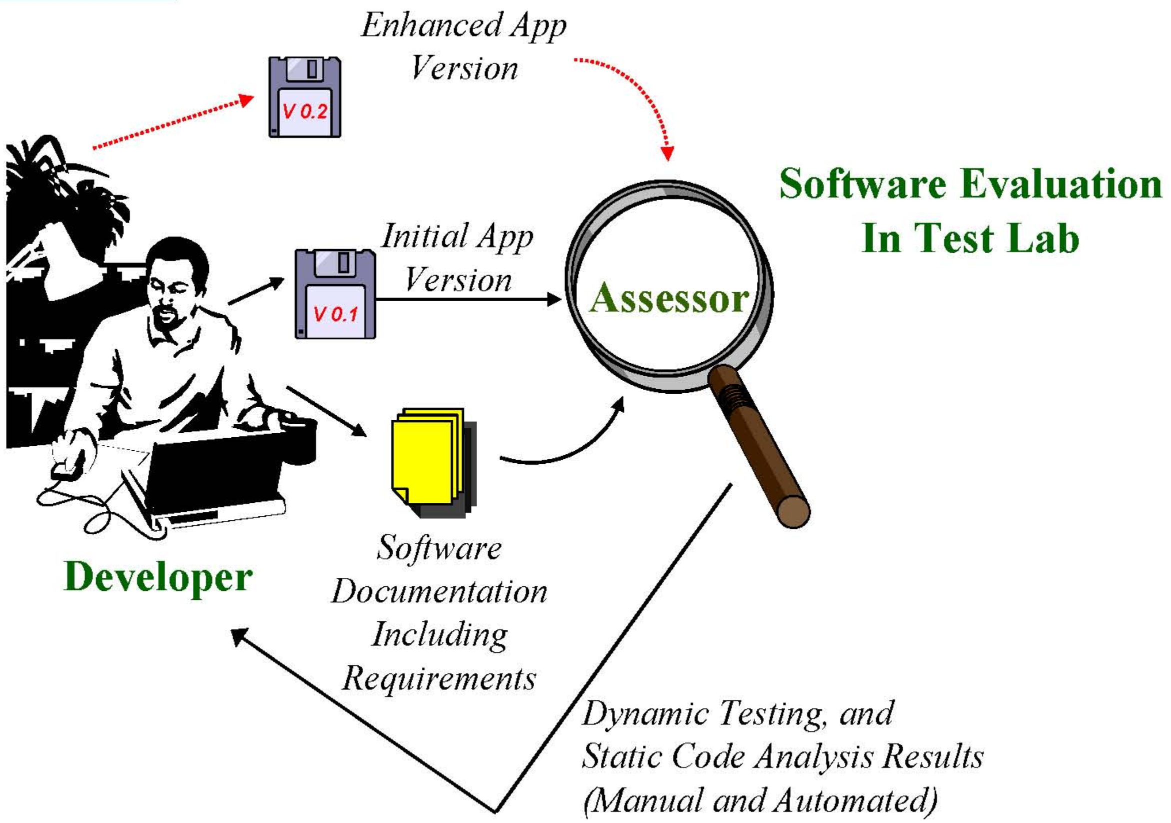
Application Vetting: Big Picture



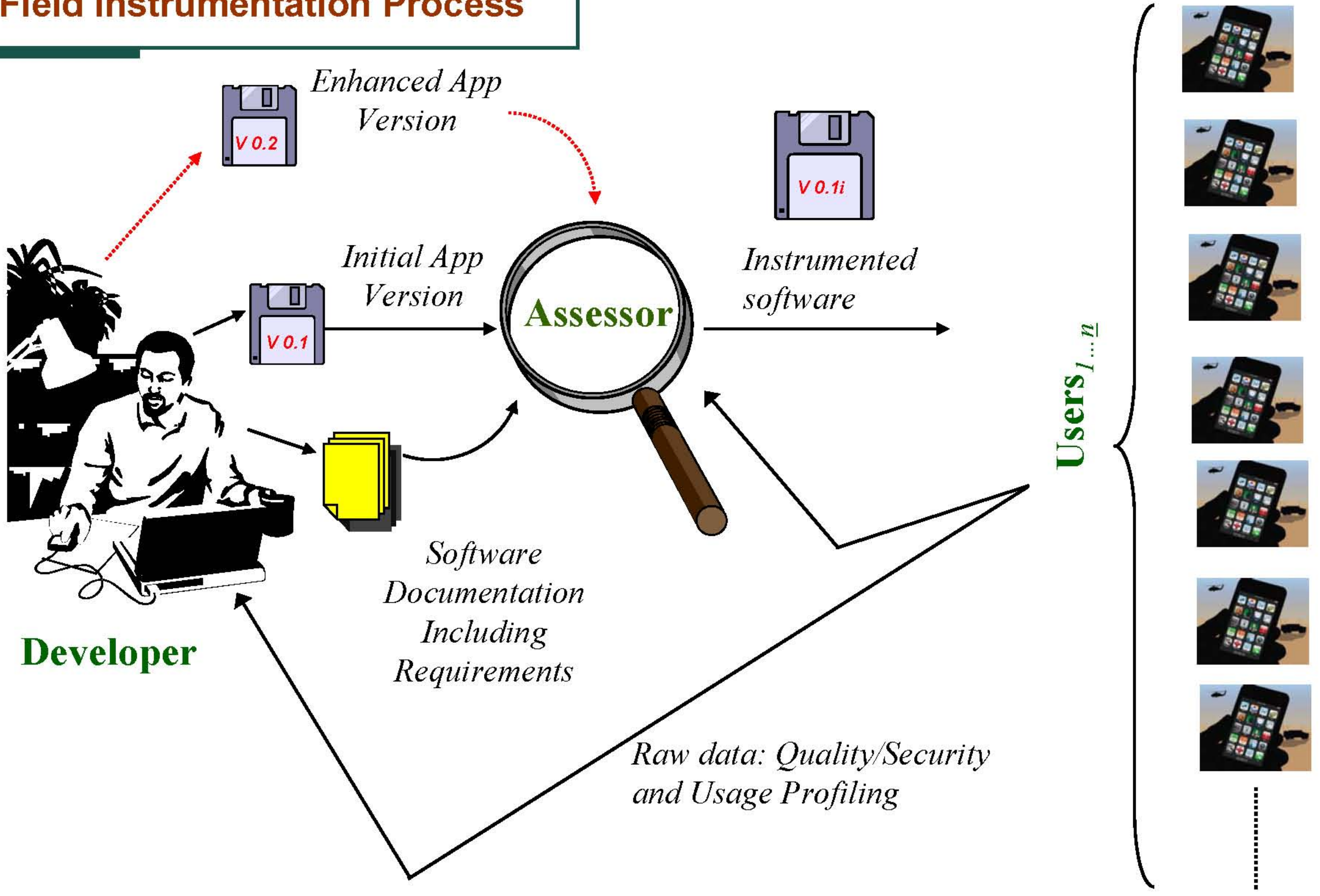
Progression of Testing



In-Lab Testing Process


Enhanced App Version
V 0.2
Software Evaluation In Test Lab
Initial App Version
V 0.1
Assessor
Developer
Software Documentation Including Requirements
Dynamic Testing, and Static Code Analysis Results (Manual and Automated)

In-Field Instrumentation Process



Android Application Control

- Application Signing – Prevent unauthorized App Execution
  - Approved Apps are signed by the program designated approval authority
  - Only program signed Apps can be installed on the device
    - Customizations made to Android package framework
- Application Stress Testing
  - Measure Power Consumption
  - Identify Input Errors / Find UI bugs

Application Analysis Framework

- Android Specific Analysis includes analysis of the Application Security Manifest
  - Tailored to the Android Permission Model
- Verify if the requested permissions are warranted by the submitted code
  - Remove excessive permissions & enforce a tighter security model
- Regulate access to critical/restricted resources
  - Modifications on the Android Engine to enable dynamic policies
  - Control the underlying Dalvik engine to report absence/depletion of resources instead of lack of permissions

Application Policy Enforcement

Solution: Per Application Policy Enforcement

Provide Dalvik mechanisms to

- Enforce application Access & Capabilities
  - Tailored to specific Location or Time
  - Tailored to specific Mission
- Application can still be installed but deprived access to resources and data selectively

Policy Enforcement paired with Device Security can significantly reduce the risk of **Data Exfiltraction**

Application Testing Framework

Android Specific Analysis includes analysis of the Application Security Manifest (not supported by third-party vendors)

- **Tailored to the Android Permission Model**
- Verify if the requested permissions **are warranted** by the submitted code
- Curtails excessive permissions and enforces a tighter security model

Modifications on the Android Engine to enable dynamic policies

- Control the underlying Dalvik engine to report **absence/depletion of resources** instead of lack of permissions
- Regulate access to critical/restricted resources

Power Metering Framework

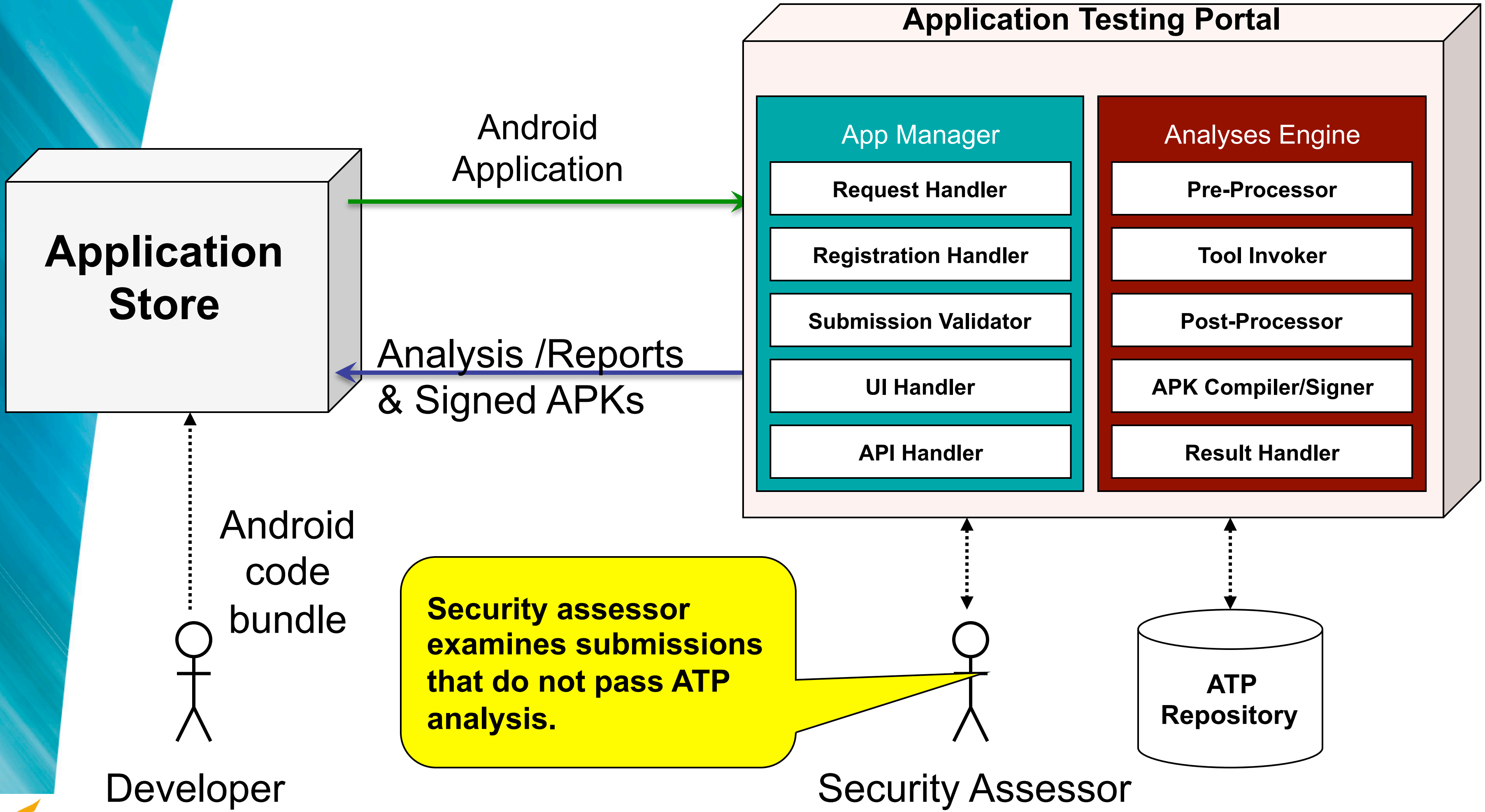
- Design & Implement an accurate model for accounting and policing energy consumption

- Two-pronged approach
  - Meter the per-process CPU & Device utilization over time
  - Identify the relative impact of each device component on energy consumption

- Design an Android kernel subsystem to estimate energy
  - Meter energy consumption for each App/process
  - Use for characterizing application behavior
  - This behavior is Application dependent
  - Sometimes the behavior is also User dependent

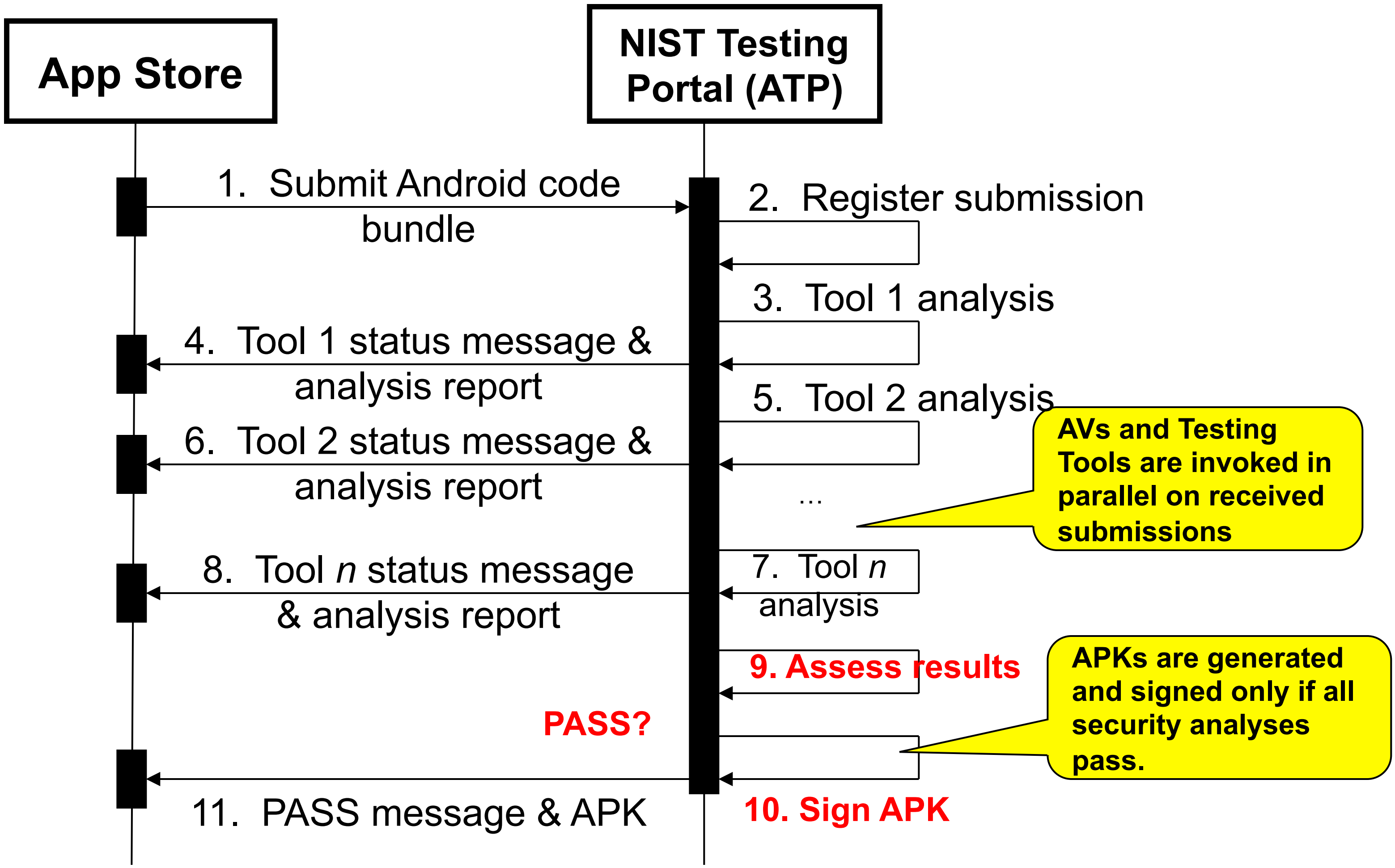
ATP Architecture

ATP analyzes Android code bundles and returns messages, analysis reports, and signed APKs



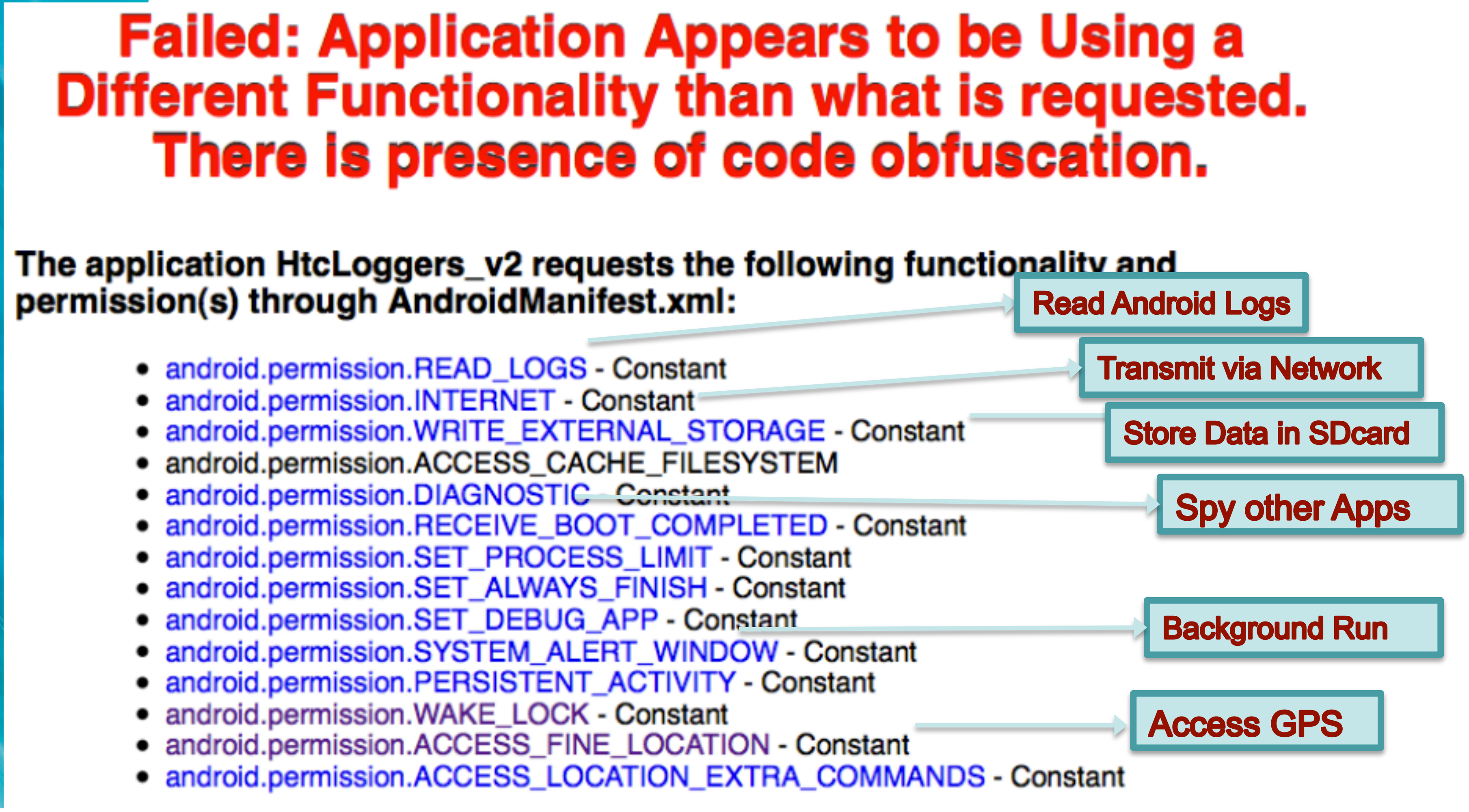
Mobilize-ATP Workflow (PASS Use-Case)

ATP applies Testing to Analyze Android code bundles



App Store
NIST Testing Portal (ATP)
1. Submit Android code bundle
2. Register submission
3. Tool 1 analysis
4. Tool 1 status message & analysis report
5. Tool 2 analysis
6. Tool 2 status message & analysis report
...
AVs and Testing Tools are invoked in parallel on received submissions
7. Tool n analysis
8. Tool n status message & analysis report
9. Assess results
PASS?
APKs are generated and signed only if all security analyses pass.
11. PASS message & APK
10. Sign APK

Analysis of HTC Logger (CarrierIQ)

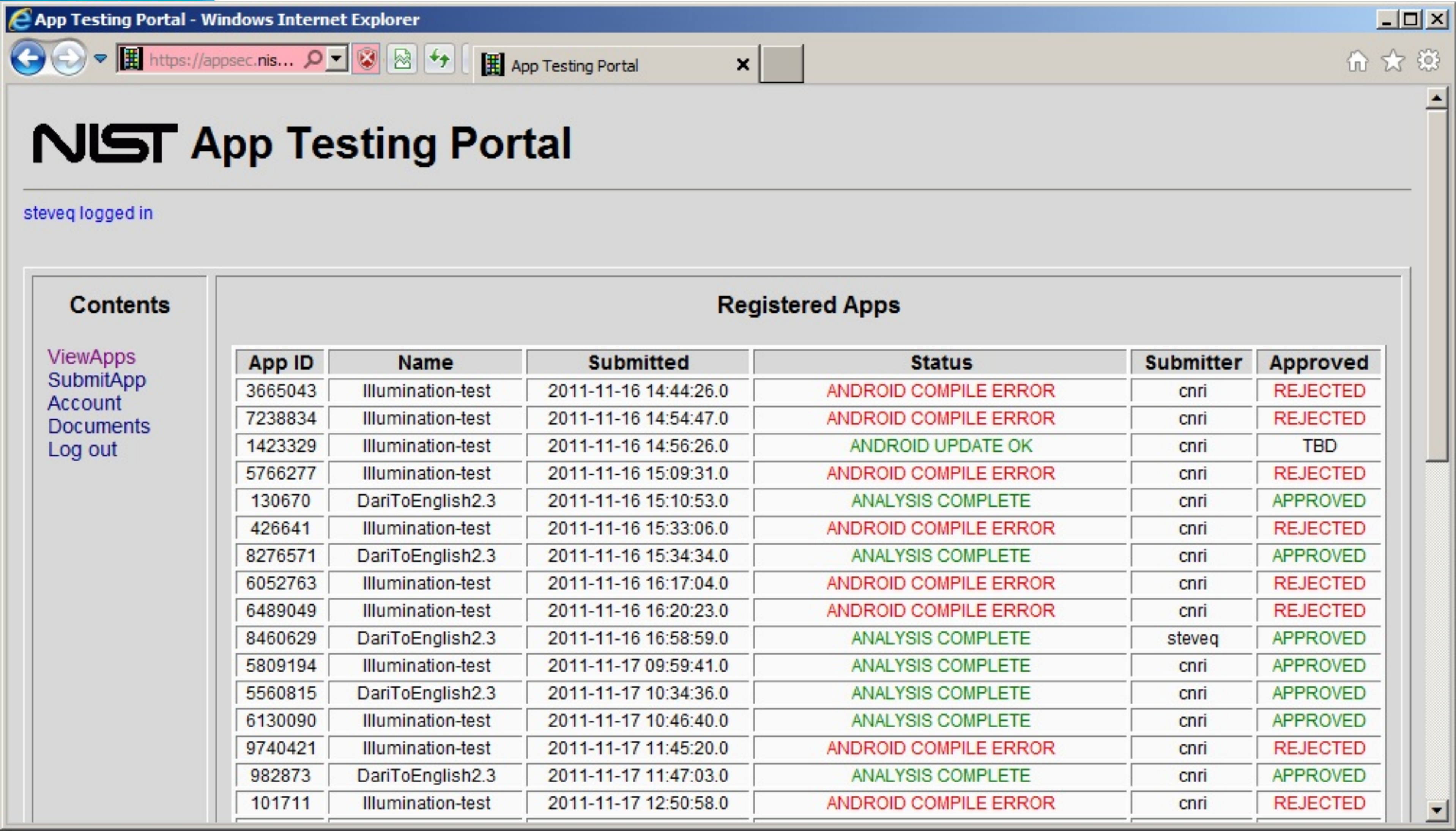


Failed: Application Appears to be Using a Different Functionality than what is requested. There is presence of code obfuscation.

The application HtcLoggers_v2 requests the following functionality and permission(s) through AndroidManifest.xml:

- android.permission.READ_LOGS - Constant
- android.permission.INTERNET - Constant
- android.permission.WRITE_EXTERNAL_STORAGE - Constant
- android.permission.ACCESS_CACHE_FILESYSTEM
- android.permission.DIAGNOSTIC - Constant
- android.permission.RECEIVE_BOOT_COMPLETED - Constant
- android.permission.SET_PROCESS_LIMIT - Constant
- android.permission.SET_ALWAYS_FINISH - Constant
- android.permission.SET_DEBUG_APP - Constant
- android.permission.SYSTEM_ALERT_WINDOW - Constant
- android.permission.PERSISTENT_ACTIVITY - Constant
- android.permission.WAKE_LOCK - Constant
- android.permission.ACCESS_FINE_LOCATION - Constant
- android.permission.ACCESS_LOCATION_EXTRA_COMMANDS - Constant

ATP Monitor



NIST App Testing Portal

steveq logged in

Contents

- ViewApps
- SubmitApp
- Account
- Documents
- Log out

Registered Apps

App ID	Name	Submitted	Status	Submitter	Approved
3665043	Illumination-test	2011-11-16 14:44:26.0	ANDROID COMPILE ERROR	cnri	REJECTED
7238834	Illumination-test	2011-11-16 14:54:47.0	ANDROID COMPILE ERROR	cnri	REJECTED
1423329	Illumination-test	2011-11-16 14:56:26.0	ANDROID UPDATE OK	cnri	TBD
5766277	Illumination-test	2011-11-16 15:09:31.0	ANDROID COMPILE ERROR	cnri	REJECTED
130670	DariToEnglish2.3	2011-11-16 15:10:53.0	ANALYSIS COMPLETE	cnri	APPROVED
426641	Illumination-test	2011-11-16 15:33:06.0	ANDROID COMPILE ERROR	cnri	REJECTED
8276571	DariToEnglish2.3	2011-11-16 15:34:34.0	ANALYSIS COMPLETE	cnri	APPROVED
6052763	Illumination-test	2011-11-16 16:17:04.0	ANDROID COMPILE ERROR	cnri	REJECTED
6489049	Illumination-test	2011-11-16 16:20:23.0	ANDROID COMPILE ERROR	cnri	REJECTED
8460629	DariToEnglish2.3	2011-11-16 16:58:59.0	ANALYSIS COMPLETE	steveq	APPROVED
5809194	Illumination-test	2011-11-17 09:59:41.0	ANALYSIS COMPLETE	cnri	APPROVED
5560815	DariToEnglish2.3	2011-11-17 10:34:36.0	ANALYSIS COMPLETE	cnri	APPROVED
6130090	Illumination-test	2011-11-17 10:46:40.0	ANALYSIS COMPLETE	cnri	APPROVED
9740421	Illumination-test	2011-11-17 11:45:20.0	ANDROID COMPILE ERROR	cnri	REJECTED
982873	DariToEnglish2.3	2011-11-17 11:47:03.0	ANALYSIS COMPLETE	cnri	APPROVED
101711	Illumination-test	2011-11-17 12:50:58.0	ANDROID COMPILE ERROR	cnri	REJECTED

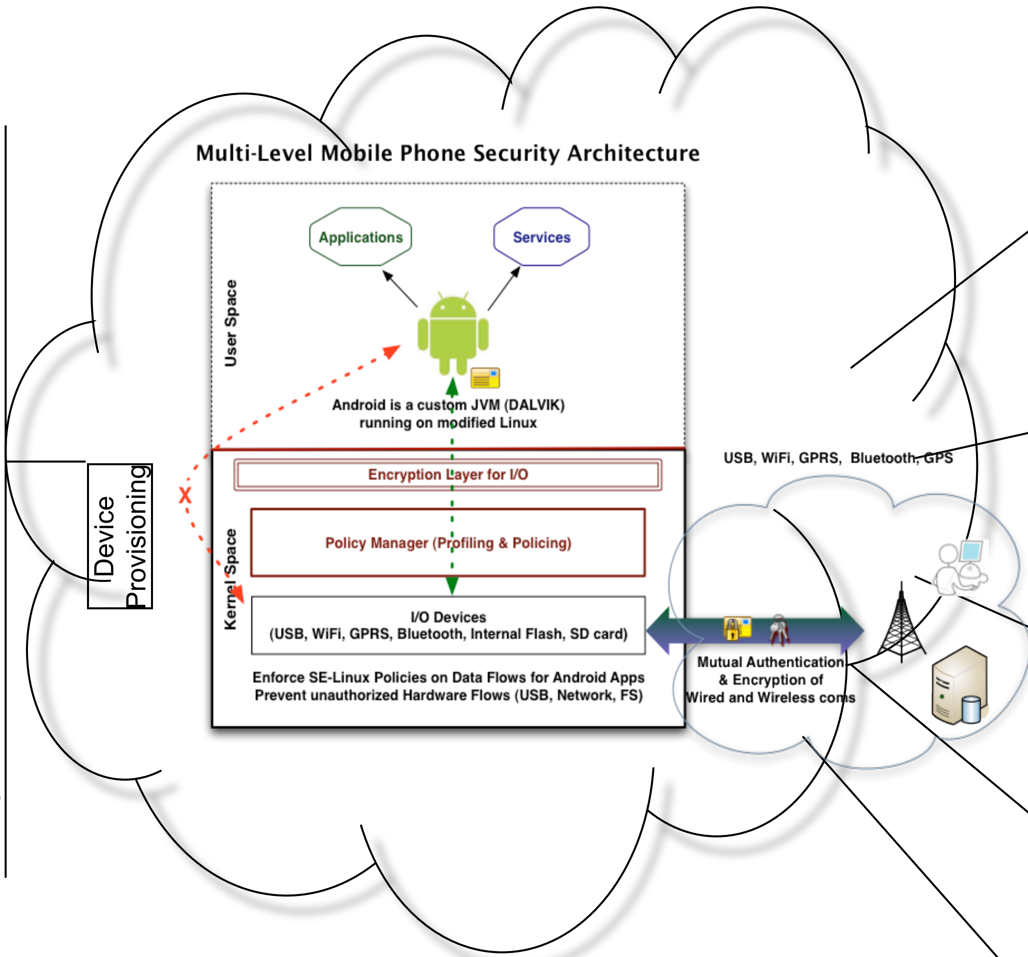
Defense in-Depth: Multiple Levels of Security

- ❖ Application Vetting & Testing
- ❖ Device Lock-down and Encryption of ALL Data and Communications
- ❖ Enforcement of Security Policies in the Android Framework
- ❖ Second-level Defenses placed in the Android Linux Kernel
  - ❖ Prevent Attacks that bypass Android Security Framework
  - ❖ Android has Inherited some (if not all) of the Linux Vulnerabilities
  - ❖ **Java Native Interface to Linux Libraries a potential Avenue for Exploitation**

Risks in Mobile Security Supply Chain

Devices

MDM/Middleware Providers



Device Provisioning
Multi-Level Mobile Phone Security Architecture
User Space
Applications
Services
Android is a custom JVM (DALVIK) running on modified Linux
X
Kernel Space
Encryption Layer for I/O
Policy Manager (Profiling & Policing)
I/O Devices (USB, WiFi, GPRS, Bluetooth, Internal Flash, SD card)
Enforce SE-Linux Policies on Data Flows for Android Apps
Prevent unauthorized Hardware Flows (USB, Network, FS)
Mutual Authentication & Encryption of Wired and Wireless coms
USB, WiFi, GPRS, Bluetooth, GPS

Enterprise Security

Enterprise Security

Enterprise Security

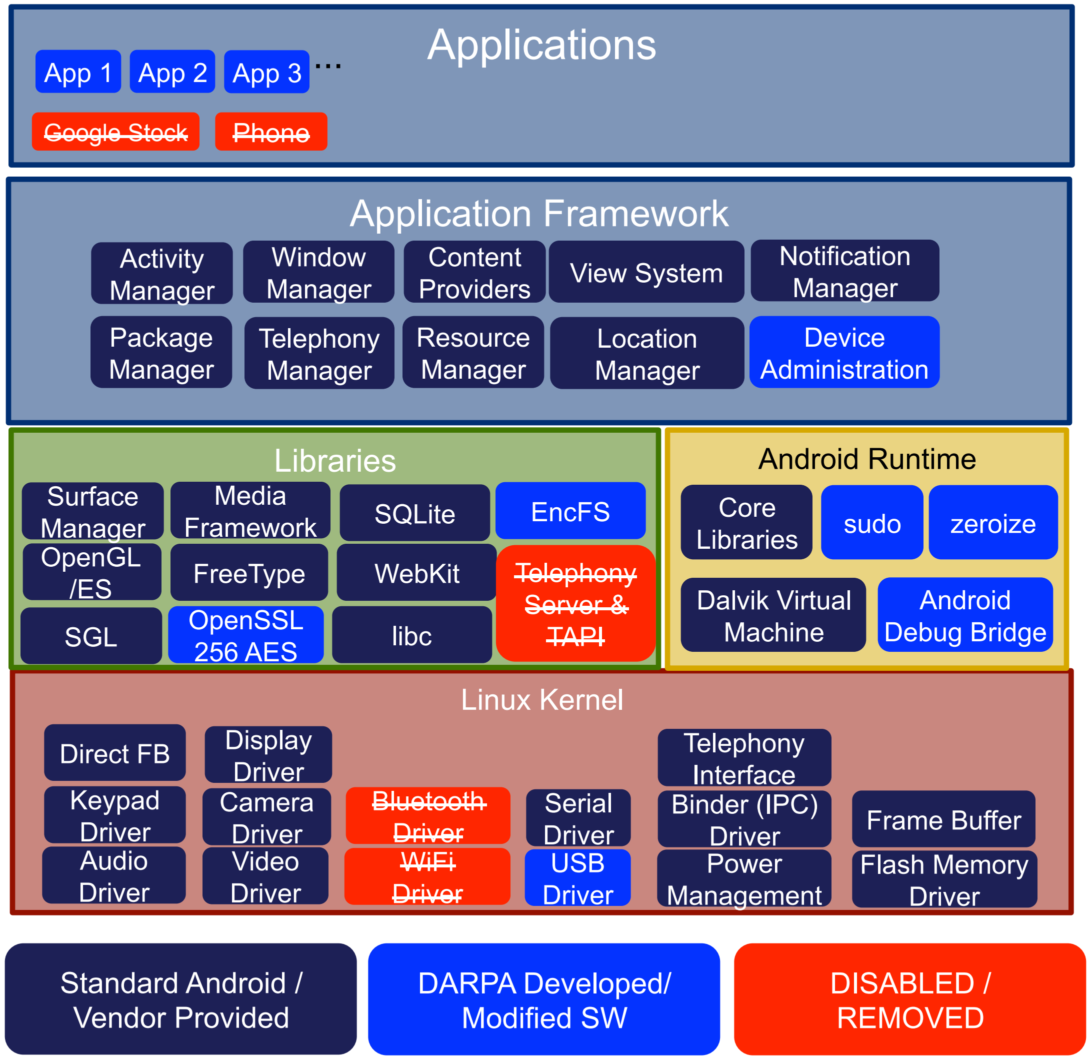
Enterprise Security

Enterprise Security

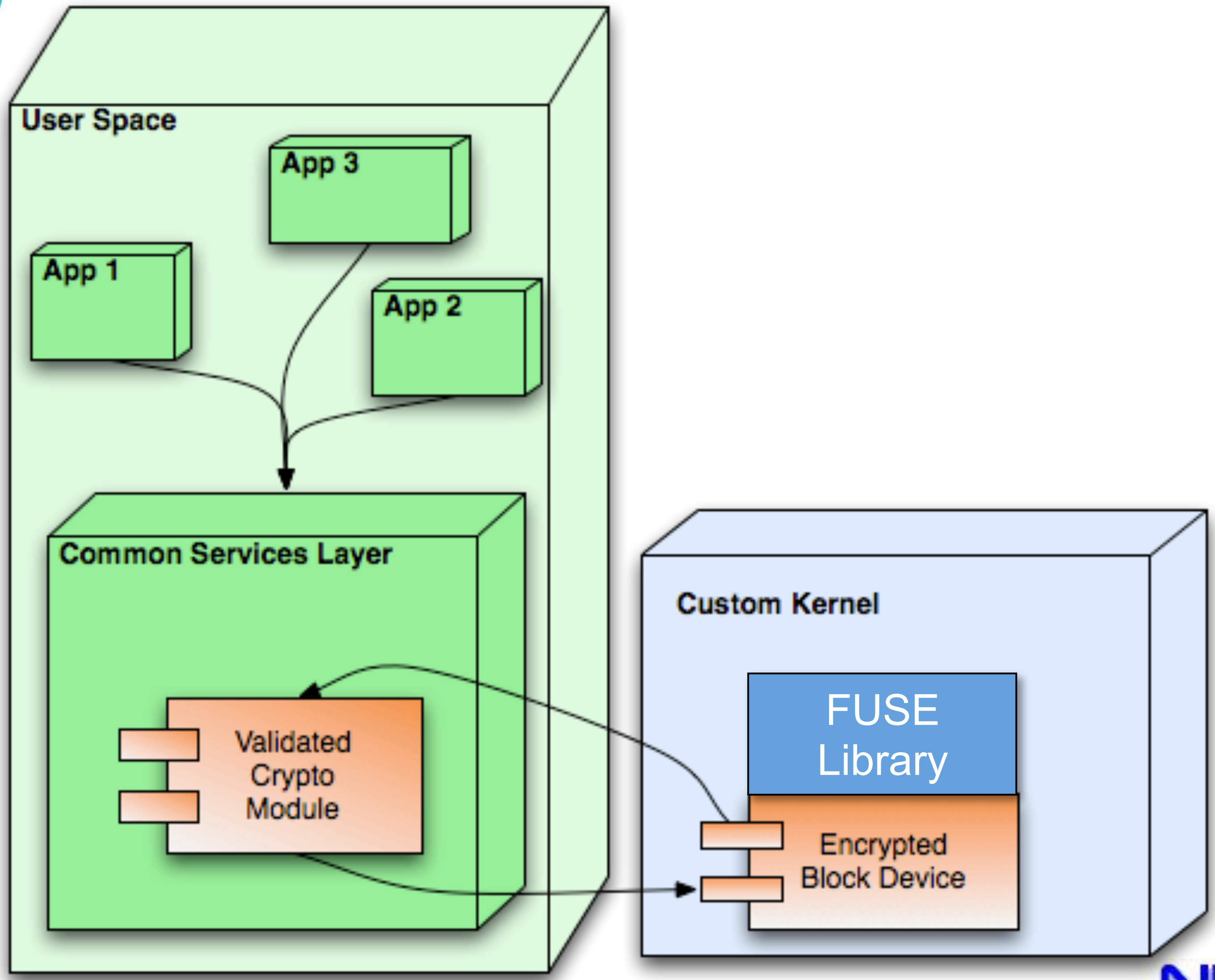
Secure Verify Test Deploy

Hardened Android Platform

- **Custom modified Android OS and Linux Kernel**
  - Additions, deletions, and modifications
  - Preference towards Open Source Solutions
- **Security Stack**
  - Data At Rest Encryption
  - Data In Transit Protections
  - Authentication
  - App Vetting and Control
  - Device Integrity Checks



Encrypted File System



Application Policy Enforcement

Ultimately the Testing assists in POLICY Enforcement

- **Tailored to the Android Permission Model**
- Can allow **Location-Based** Policies
- Curtails excessive permissions and enforces a tighter security model

Modifications on the Android Engine to enable dynamic policies

- Control the underlying Dalvik engine to report **absence/depletion of resources** instead of lack of permissions
- Regulate access to critical/restricted resources

Conclusions

Assuring the Secure Operation of Smart Devices has a wide-range of requirements

- Application Testing
  - Static & Dynamic
  - In-Field Instrumentation
  - Power Behavior Metering & Policing

- Physical Device Security
  - Lock-Down of the Device I/O (USB, WiFi, etc.)
  - Encryption of Data both on the Phone & Network
  - Securing Provisioning Process

Thank you!

Questions ?