Deep Dive Android

Agenda

- Introduction to Android
- Android Tamer
- Application Architecture
- Pentesting
- Pentesting with Android

Trainer Profile

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Primary focus area's include Web and mobile.

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Introduction

Agenda

- What is Android?
- The system architecture
- The application model
- The security model
- Custom ROM's
- ADB
- Getting the Android source
- Setting up the environment

Android

- Android Inc. founded in 2003 in Palo Alto, California by Andy Rubin, Rich Miner, Nick Sears and Chris White.
- Acquired in August 2005 by Google Inc. Key employees retained.
- Design continued on a Linux powered mobile device. Marketed by Google to carriers as a flexible and easily upgradable OS.
- On November 5, 2007, a consortium of mobile operators, software companies commercialization companies, semiconductor companies and handset manufacturers formed the Open Handset Consortium, with the stated aim of developing open standards for mobile devices.
- On the same day, they released their first product ……. Android.

Why Android

56% Smartphone market share – Gartner May12

Sources Available free of cost

Minimal license cost for developers.

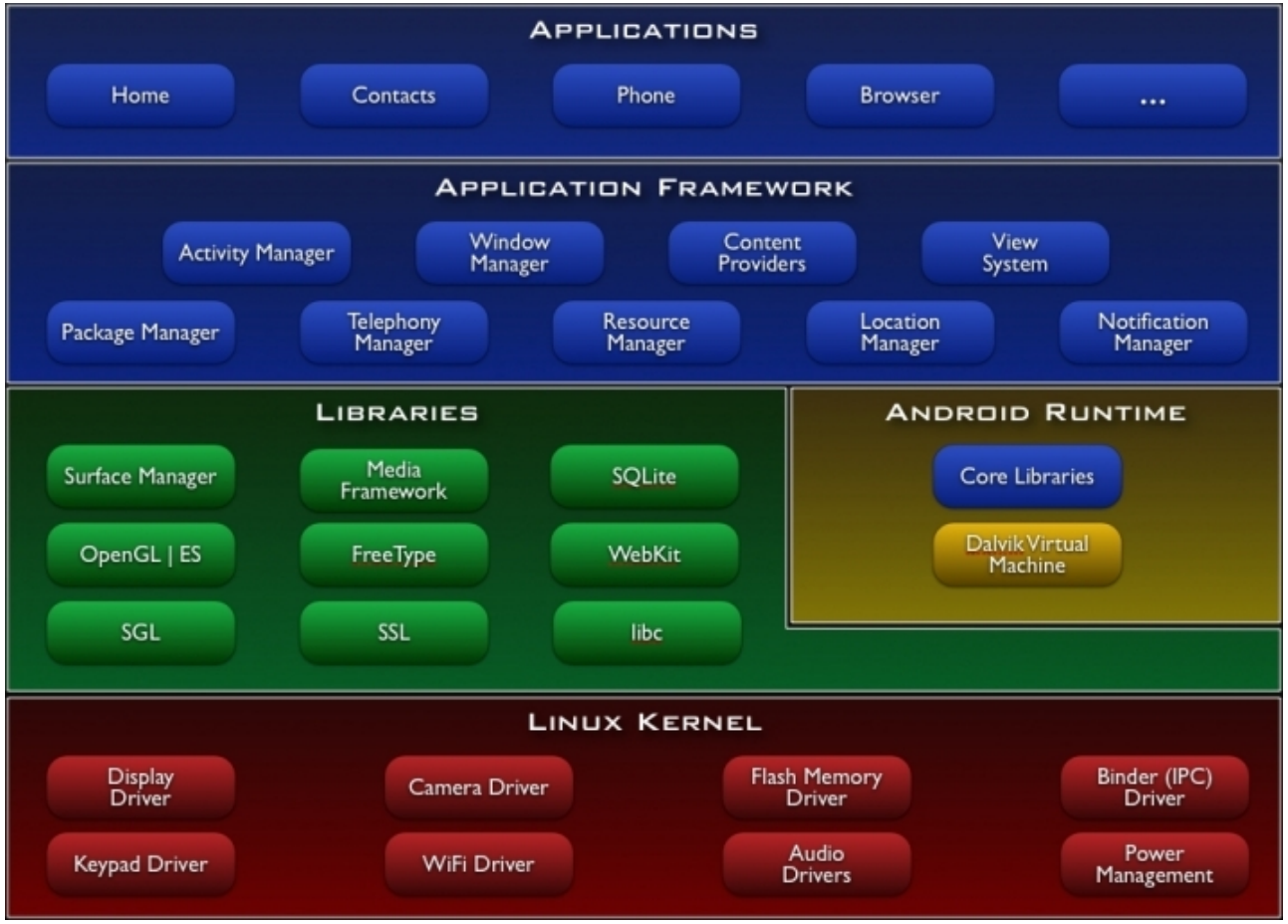
Easy to setup development environment.

Based on Linux

App-stores filled with large number of apps.

By 2014, mobile internet to take over desktop internet usage (Source: Microsoft Tag, 2012)

System Architecture



- A software stack for mobile devices.
- Linux-based kernel (merged back to mainstream in 3.4)
- Middleware, libraries and APIs in C.
- Java-based application framework.
- Custom Dalvik virtual machine with a JIT Java compiler.
- Applications coded primarily in Java.

File System

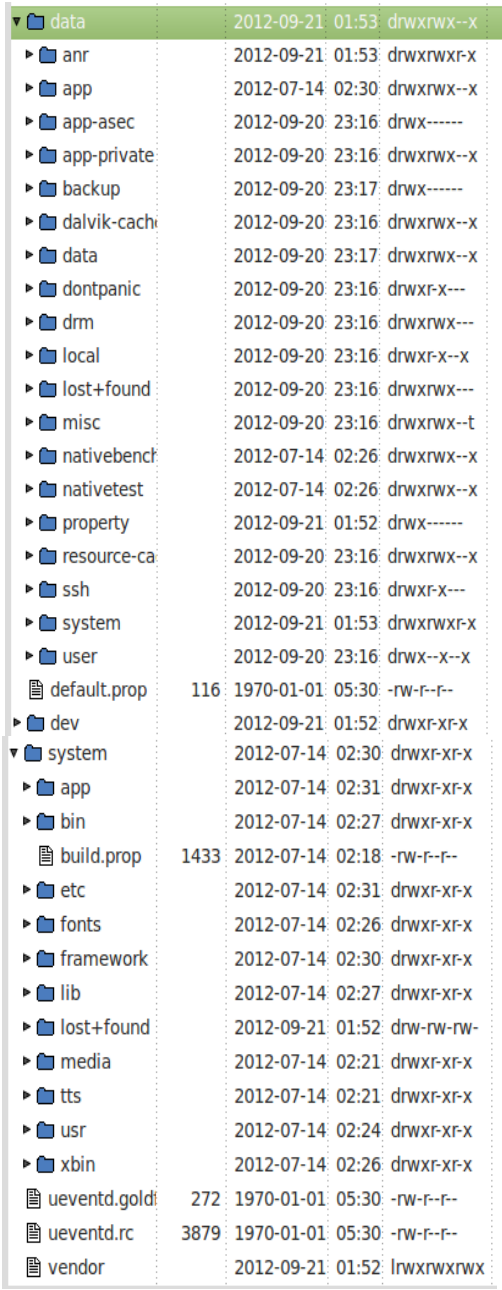
Block Devices are available as /dev/block/mtdblock*

Three main partitions for this course

/system – contains the OS image
/data – contains the user-data
/sdcard – SD card storage is mounted at this location

/system and /data are generally yaffs2 or ext3/4.
/sdcard is kept as vfat as it allows for quick mounting to PC.
(newer nexus devices don't have separate /sdcard rather a folder which is mounted as MTP when connected to desktop)

Note : a detailed description of all files and folders is available here
http://anantshri.info/andro/file_system.html



Application Structure

Written in Java

GUI is represented in XML file : (res/layout)

AndroidManifest.xml : contains project related information

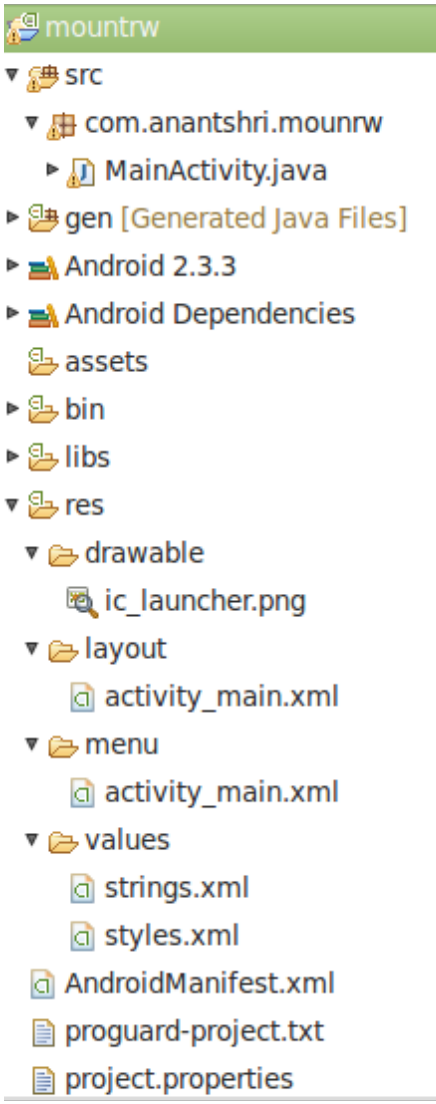
- Permissions requested
- Intents given to apps
- Author Version and name of application

Src : folder contains java code.

Drawable : contains your icons

Menu : Menu to be displayed.

Proguard* : obfuscation Engine.



Security model

System level

Unix permission based restriction.

SE Linux (4.3 onwards : Permissive mode in 4.3 plans to go enforced in next release)

App sandboxing

each application a unique id

Permission Model

Permission need to be taken first time

(AppOps introduced as hidden feature in market and can be leveraged to fine tune the permission model)

Note : Security model will be covered in details in Module 6

Custom Rom's

Due to Open nature people have started creating there own version of android.

AOSP – so far only Google devices + Xperia S

Cyanogenod (CM) – enhancement of AOSP

KANG – enhancement over CM

MIUI – Iphonish look for android (initial fork from CM)

And many more

xda-developers is one hot spot for all of them

Custom Roms

The GOOD

Faster Update Cycle

OTA update without data erase (mostly)

Better performance and efficiency

Latest Version

Pre Rooted

The BAD

Flashing is a tricky process

First install needs a full format of device

Warranty generally is considered void when you use custom rom's.

Features might be missing then the stock ROM

ADB : Android Debug Bridge

ADB has ability to perform operations on android device remotely.

Adb client -> adb server -> adb daemon

(Development machine) -> (device)

Some common usage

push : Push data inside Device

pull : Pull data from Device, file / folder

install : Install software in device. (apk)

logcat : realtime debug messages

With Recent version’s adb connects only to verified devices. (verification taken on first connect)

Android : source

Environment setup.

- Python
- GNU Make
- SUN JDK 6
- Git 1.7

Download Source (14 GB + counting ᄊ GITᄊ)

- Setup repo and download source

Build

- modify where ever you need changes and then compile (depending on processor core will take 1hr to 10hrs)

Android : setup

In order to work on android you need following

1) **Android SDK**
2) **Android NDK**
3) **Eclipse + ADT plugin**
4) **Arm compiler**
5) **SUN-JDK**

OR

ANDROIDTAMER

alone should be sufficient

Alternate Android VirtualMachines

- Geanymotion (recommanded)
- Virtualbox x86 version of Android
- Jar of Beans (community project)
- And many more

Android Tamer

Agenda

- What is Android Tamer
- Tool List
- Android Emulator
- Pentesting Toolset
- Rooting Kits
- ROM Modding
- Reverse Engineering
- Malware Analysis

What is Android Tamer

- VM / Live ISO / Installable environment.
- Specific focus on Android Security.

- First Launched in Dec 2011 @ Clubhack 2011.
- Second Release with large set of enhancement

- Provides the most extensive Collection of tools for android security.

More

- Based on Ubuntu 12.04 Linux Mint 13 – supported till 2017.
- Environment customized to keep all tools in path.
- Browser loaded with Pentesting toolkit + Bookmarks
- All non essential software's removed. But could be added once installed on local machine.
- Next updates will be through repositories only.

Tools List

- ROM Modding
  - Rom kitchen
  - Flashing utility
- Rooting
  - Zergrush (GB)
  - adb restore (ICS / JB)
  - APK based rooting options
- Development
  - Eclipse + ADT
  - SDK + NDK
  - Codesourceory c++
- Pentesting
  - OWASP ZAP proxy
  - BURP proxy
  - Firefox + pentest plugins
  - W3af
- RE and malware Analysis
  - Mercury
  - Androguard
  - Dex2Jar
  - JD-GUI
  - APKtool
  - Baksmali / smali
  - Bulb Pentesting Framework
- Wireless Capture
  - Wireshark
  - Tcpdump
- Forensics
  - AF logical OSE
  - Sleuthkit
- Practice Lab
  - Security Compass Lab
  - Paladian Lab

Rooting kits

- ZergRush – Valid for GingerBread
- Superoneclick
  - Zergrush
  - psneuter
- Gingerbreak
- Z4root
- superandRoot

ROM Modding

- ROM Kitchen
  - Allows to modify existing ROMs add or remove content or modify settings (ro.secure=?)
- Flashing Utilities
  - Flashtool :SONY Xperia Series
  - Heimdall : SAMSUNG Galaxy Series
  - SBP_flash : MOTOROLA phones
- Single Click ADB SHELL and LOGCAT access

Reversing toolset

- JD-GUI
- JED
- DEX2JAR
- Smali / Baksmali
- APKtool

Malware Analysis

- DroidBox
- Mercury
- Androguard

More to come

- Android Tamer has its own space now

  http://androidtamer.com

- Keep watching the space for more updates in forms of
  - Tutorials
  - How-to's
  - New tools.

Android Application Architecture

Agenda

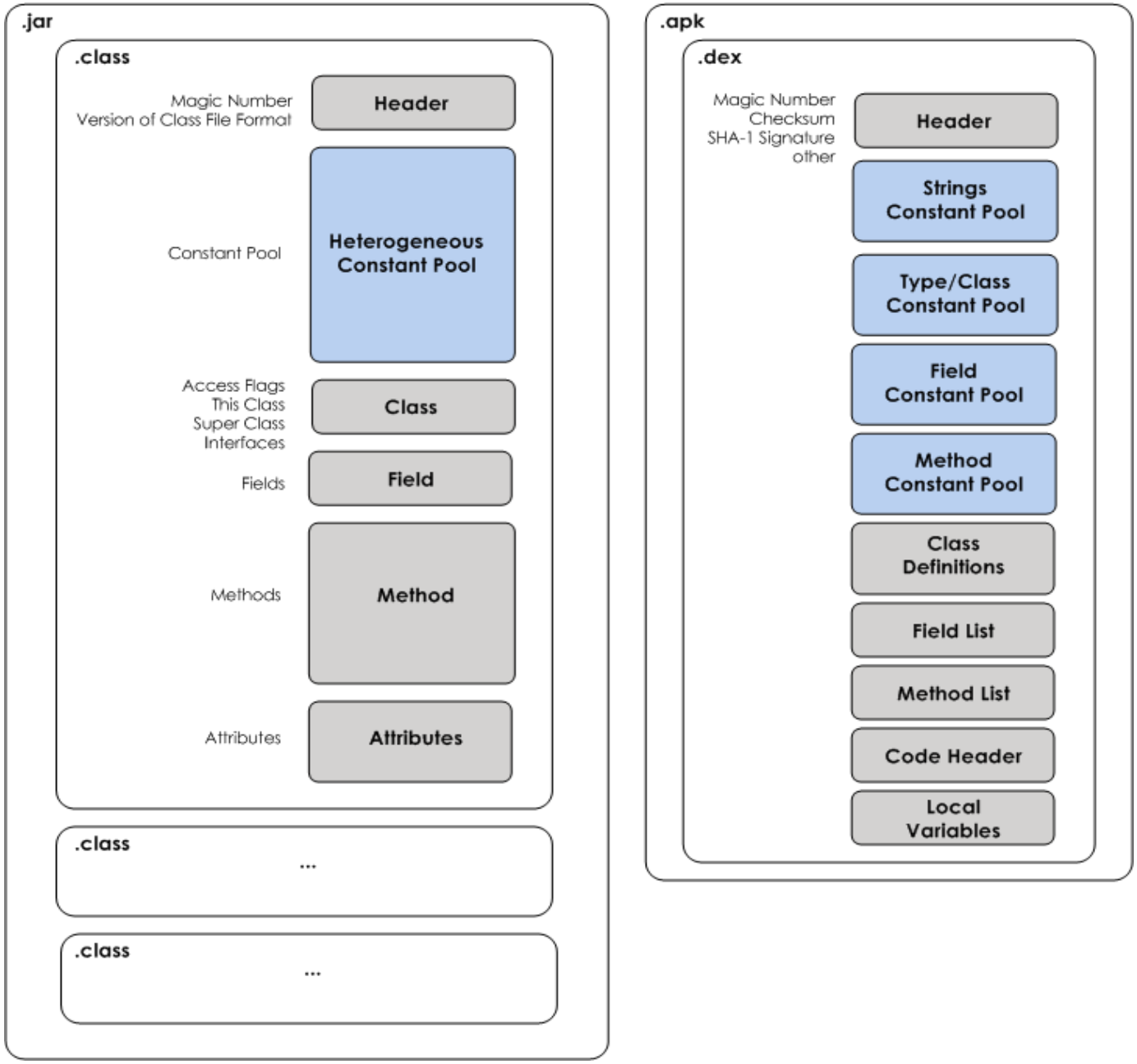
- Dalvik Virtual machine
- App components
- Android SDK, NDK and tools
- Hello World App

Dalvik Virtual Machine

- Designed and written by Dan Bornstein
- Virtual machine for running android apps
- Android apps written in Java, compiled and converted to Dalvik bytecode format (dex – Dalvik Executable)
- Dalvik bytecode different from Java bytecode
- Dalvik was created to for computers with memory and performance constraints
- Dalvik is a register-based VM as apposed to stack based VM for Java and uses a different instruction set

Dex

- Dex file format details: http://www.dalvikvm.com/
- Dex format is optimized for minimal memory footprint
- Dex contains multiple classes per file as opposed to one class per .java file
- Uses shared type-specific constant pools to conserve memory by decreasing redundancy


.jar
.class
Magic Number
Version of Class File Format
Header
Constant Pool
Heterogeneous Constant Pool
Access Flags
This Class
Super Class
Interfaces
Class
Fields
Field
Methods
Method
Attributes
Attributes
.class
...
.class
...
.apk
.dex
Magic Number
Checksum
SHA-1 Signature
other
Header
Strings Constant Pool
Type/Class Constant Pool
Field Constant Pool
Method Constant Pool
Class Definitions
Field List
Method List
Code Header
Local Variables

Zygote

- It is the VM process that starts at boot time
- Initializes core library classes and shares them across different forked VMinstances.
- Listens on UDS /dev/socket/zygote for VMs (app) to fork and launch.
- Also sets appropriate UID/GID and groups based on the arguments and the requester
- Code
  - dalvik/*
  - dalvik/vm/*
  - frameworks/base/core/java/com/android/internal/os/Zygote*.java
  -

Agenda

- Dalvik Virtual machine
- **App components**
- Android SDK, NDK and tools
- Hello World App

App components

- Activity
- Intent
- Service
- AndroidManifest.xml

Activities

- UI component for one focused task
- Usually a single screen in your application
- Stack based approach where visible activity/screen is topmost activity on stack.
- Activity association is defined in the AndroidManifest.xml

```java
package nullcon.xah.test2;

import android.os.Bundle;
import android.app.Activity;

public class MainActivity extends Activity {

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);
     }

}
```

```xml
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="nullcon.xah.test2" android:versionCode="1" android:versionName="1.0" >
    <uses-sdk
        android:minSdkVersion="8"
        android:targetSdkVersion="15" />
    <application android:icon="@drawable/ic_launcher" android:label="@string/app_name"
        android:theme="@style/AppTheme" >
        <activity
            android:name=".MainActivity" android:label="@string/title_activity_main" >
        </activity>
    </application>
</manifest>
```

Intent

- Intents ==Operations / Actions
- Defined in Manifest (AndroidManifest.xml)
- application → activity → intent-filter

Intents Sample

Main Activity plus Launcher Entry

```
    <action android:name="android.intent.action.MAIN" />
    <category android:name="android.intent.category.LAUNCHER" />
```

Registering yourself as browser

```
<activity android:name=".BrowserActivitiy" android:label="@string/app_name">
  <intent-filter>
     <action android:name="android.intent.action.VIEW" />
     <category android:name="android.intent.category.DEFAULT" />
     <data android:scheme="http"/>
  </intent-filter>
</activity>
```

Service

- Background Jobs
- No UI
- Long running process. No effect on response.
- Declare Service application → service

  <service android:name=".ExampleService" />
- extends IntentService
- protected void onHandleIntent(Intent intent)

Android Manifest.xml

- XML structure defining properties including
  - Activities
  - Intents
  - User-permissions

Android Manifest.xml

<uses-permission /> - list of **required** permissions from OS.

<permission /> - list of permission calling party must have.

<uses-sdk /> - min max and target sdk versions.

<uses-configuration /> - hard and software configuration

<uses-feature /> - specific features (filters)

<application>

<activity> - activities provided by the application

<intent-filter> - various intents raised by application

<service> - background activity.

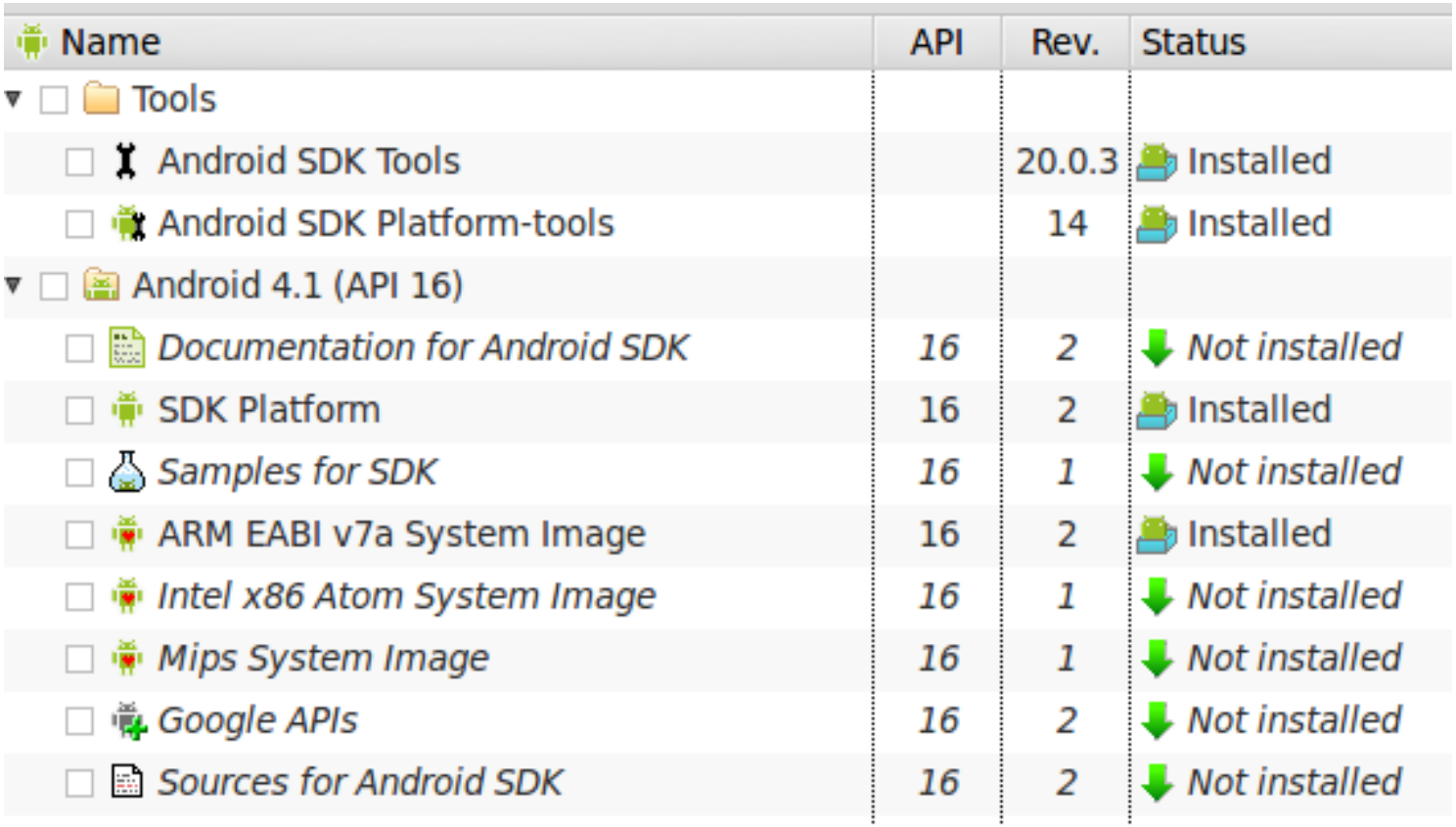
<receiver> - catch holder for system / broadcast intents.

Agenda

- Dalvik Virtual machine
- App components
- **Android SDK, NDK and tools**
- Hello World App

Android SDK, NDK and tools

- SDK – Software Development Toolkit.



Name	API	Rev.	Status
Tools			
Android SDK Tools		20.0.3	Installed
Android SDK Platform-tools		14	Installed
Android 4.1 (API 16)			
Documentation for Android SDK	*16*	*2*	*Not installed*
SDK Platform	16	2	Installed
Samples for SDK	*16*	*1*	*Not installed*
ARM EABI v7a System Image	16	2	Installed
Intel x86 Atom System Image	*16*	*1*	*Not installed*
Mips System Image	*16*	*1*	*Not installed*
Google APIs	*16*	*2*	*Not installed*
Sources for Android SDK	*16*	*2*	*Not installed*

Android SDK, NDK and tools

- NDK – native development kit
  - Allows development of components in C / C++.
  - allows reuse existing code libraries.
  - possibly increased performance.
- Typical usage
  - self-contained,
  - CPU-intensive operations,
  - signal processing,
  - physics simulation
  - GAMES

Tools provided by SDK / NDK

- GCC compiler for ARM (usage will be covered in ARM assembly primer)
- Tools → android → sdk/avd manager
- Tools → ddms → debugging tool
- Tools → emulator → emulator executable
- Platform-tools → adb → debug bridge
- Platform-tools → fastboot → flashing utility

Agenda

- Dalvik Virtual machine
- App components
- Android SDK, NDK and tools
- **Hello World App**

Hello World App

- Exercise

- A simple application which prints hello world using a label with eclipse

References

- Dalvik VM: http://davidehringer.com/software/android/The_Dalvik_Virtual_Machine.pdf
- https://developer.android.com/guide/

Pen Testing

Agenda

- Understanding Mobile Security Issues
- Setup Pen testing environment

Mobile Security Issues

Agenda

Data / Activity Sniffing
Unauthorized access to telephony layer (dialing, sms etc)
Unauthorized network access
Unsafe Data at transit / rest (XML / SQlite)
Hardcoded values Password / key / salt Untrusted inputs / intents
Data leakage Side channel
Information Disclosure
Logic / Time Bomb
UI impersonation
Rooting
Application Security update cycles
OS level security updates
HTML 5 attacks
SQLi
Click / Tap jacking
Playing with Javascript

Data / Activity Sniffing

- Data and activities could be monitored on real time
  - Messaging (SMS and Email)
  - Audio (calls and open microphone recording)
  - Video (still and full-motion)
  - Location
  - Contact list
  - Call history
  - Browsing history
  - Input
  - Data files
- Example :Secret SMS Replicator

Access to telephony layer

- Malware now a days are targeting SMS / Calls.
- Premium SMS / Call -> high charge
- USSD based purchases
- Location specifics

- Example
  - FakePlayer : Premium SMS sending app

Unsafe data at transit

- Data Transmitted using insecure Channels.
  - HTTP
  - FTP
  - Unsigned XML
- Protection : Use HTTPS
- Ever Heard of sslstrip ?

Hardcoded values

- Reverse Engineer the source Code and check for hardcoded values
  - Db connection strings
  - Api keys for third party apps.

Side channel leakage

- Data leakage occurring through residual data like cache or temp files or keylogers.
- Root Cause
  - Bad coding practice from developer.
  - Inherent OS specific features.
- Identification Techniques
  - Before launching application take a snapshot of system. Launch application perform all operations and then again take a snapshot. Find the change in system look for residual file and data specially in temporary folders.
- Action / Remediation:
  - Avoid web data caching by setting proper headers.

Information disclosure

This risk is based on the fact that many developers hardcode the API or password, also lots of applications are now shifting business logic to client side.

- Root Cause
  - Most of the web applications could be easily reverse engineered.
  - Hardcoded API Keys, passwords and other sensitive information.
  - Embedding business logic in client code.
- Identification Techniques
  - Decompile application and check if some hardcoded values are visible and if business logic could be altered. (especially in case of financial applications)
- Action / Remediation:
  - Values should not be hardcoded.
  - Business logic should be kept separate at server side only.

Logic / Time Bomb

- Code to be activated
  - Specific dates
  - connecting to a network
  - Dialing a number
  - Receiving an sms
  - You can think of some more …….

UI Impersonation

- Application Posing as a known legitimate Apps or websites.

- Prevention : Google app store has started rejecting and banning applications performing such tactics. (other app stores ??? And side loading)

Rooting

- Devices are by default running in a restricted user environment (refer permissions section)
- Root user holds ultimate authority over system.
- All released android versions are vulnerable.
- Exploits used to gain root access are
  - OS based (Os level binary flaws)
  - Devices specific files

Application Updates

- Application Updates are send over the air.
- If update happening over Wifi sniffing is easy.

- Google play store may apply security. But not all stores are having all securities in place.
- Play store is only available with Google authorized phone manufacturers

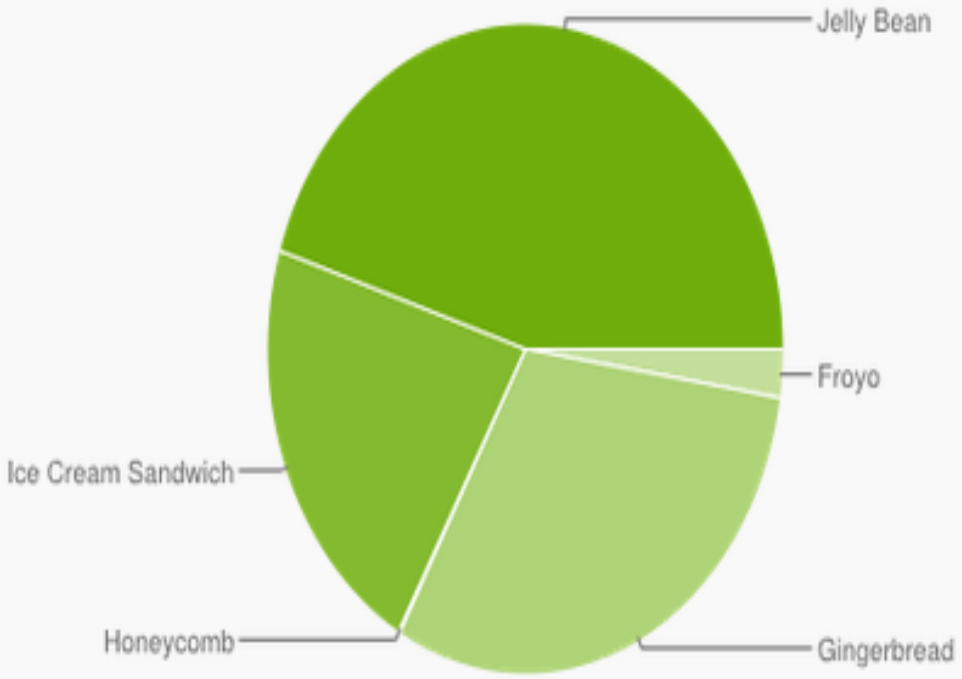
OS level updates

- Android updates are largely carrier and manufacturer dependent.
- Google updates AOSP others (manufacturers and carriers) download and distribute.

- Only independent devices as of now
  - Google nexus series
  - Xperia S (experimental)

Current OS distribution

Version	Codename	API	Distribution
2.2	Froyo	8	2.4%
2.3.3 - 2.3.7	Gingerbread	10	30.7%
3.2	Honeycomb	13	0.1%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	21.7%
4.1.x	Jelly Bean	16	36.6%
4.2.x		17	8.5%



Data collected during a 7-day period ending on September 4, 2013.
Any versions with less than 0.1% distribution are not shown.

SQLi

- Large amount of application have backend running on a web server + db server backend.
- So tradition SQLi still works the deal is to find the backend.

Click / Tap jacking

- Clickjacking for mobile is Tap jacking.
- Simmilar techniques like clickjacking.

- Transparent frame placed on top of legitimate looking button’s.
- Could be used to earn ad revenue on clicks.

Javascript

- Javascript is the new playground.
- Iframes and various javascript calls are hard to detect on mobile browser.
- With HTML5 in picture now the vectors availability has increased multifolds.

Setup Pentesting Environment

Setup

- Static Analysis Tools
  - Reversing the apk
    - Dex2jar + Jd-gui / jad
    - Smali
- Network traffic interception
  - OWASP ZAP
  - Burp suite
- Backend and frontend scanning
  - Emulator as isolated environment.
  - Server side scanning (nikto, w3af, nmap)

Reversing the APK

- APK == JAR == TAR
- .dex ~~~ .classes merged
- Simplest process
  - Unzip
  - Dex2jar convert .dex to jar file
  - Jd-gui / jad to decompile jar.
  - Apktools : extract resources and correct binary xml

Network traffic interception

- Using emulator or device define proxy.
- Emulator –http-proxy http://127.0.0.1:8080 –avd <name>
- Settings -> networks -> access point -> proxy host -> port

- For emulator localhost / base machine's ip = 10.0.2.2

Network interception cont…

- Issues in listed approach

1) SSL traffic most of the time will not be intercepted and app will crash with connection failure due to invalid certification.
    1) Solution is to import the certificate of the proxy server.
    2) Export proxy cert from application
    3) Adb push .cer /sdcard/
    4) Settings -> security -> install from sdcard
        1) Will have to set a pin for device.

Network traffic interception cont..

- Application traffic not proxified

For emulator’s

this is applicable till 2.3.3 emulator.

Tested above settings on 4.0 and 4.1 series and all apps are by default proxified.

Frontend / device scanning

- Data by app stored in
  - /data/data/<app_package_name>
- /sdcard content.
- Look for xml or db's for unencrypted data

- File system could be scanned for changes before and after install / usage / removal of application

Backend Scanning

- During Network interception you can easily identify the backend server ip’s / url’s
- nmap,w3af,nikto scan on backend could be made to assess it.

- Server side flaws need not be web flaws only, any service running of server could be our potential target.

Summery

- APK ▭ decompiling – dex2jar ▭ jd-gui
- |
- ▭ dynamic analysis ▭ exec app in emulator
- ui / filesystem / ▭ |
- | network traffic ▭
- |
- | ▭ backend scanning

Excercise

- App Protector.
  - Protects your phone specific functions from unauthorized access
  - Or does it.
  - Refer : /data/data/com.ruimaninfo.approtect/
- Defender
  - A simple application where you can play and earn powers at offline level and then compete with opponent online.

Pentesting Frameworks

- Mercury / Drozer
- AFE (Android Framework for Exploitation)
- Smartphone Pentest Framework

Pentesting Through Android

Available Toolset

- DroidSheep
- Dsploit
- Interceptor
- Network Discovery
- Shark
- Network Tools
- zAnti

Pentesting through Android

- Setup Environment
  - SL4A
  - Py4a
  - Pl4a
  - setup standalone shell for them
  - write basic scripts for python to perform basic operations
    - username password bruteforce attack
    - task automation using python
    - username enumeration wordpress script
  - creating packages from scripts

Thank You